0030559

From:	Jack Kumer
To:	Mike Murray
Cc:	Britta Muiznieks; Darrell Echols; Tami Pearl; Thayer Broili
Subject:	Re: ASIS 2010 PIPL Report
Date:	02/07/2011 01:32 PM
Attachments:	Schupp_2010 Rest Overwash for habitat.pdf 2008 Proposed alterations to the constructed berm.pdf 2009 North End Restoration Annual Report.pdf

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Superintendent Murray,

I appreciate your interest in the information contained in the annual ASIS Plover monitoring report. The update regarding the north Assateague restoration project is a work in progress, while we wait for USFWS to sign off on the project's biological assessment. Mechanical manipulation the site began in 1998, and became an official cooperative project with the Corp of Engineers and other entities in 2002. The modifications referenced in this year's Plover report reflect efforts to correct project construction deficiencies that degraded desired (plover) habitat conditions. The modifications were deemed too risky by local partners who wanted to avoid the risk of breaching. COE models suggested that storm flow through the modified areas would have a widening effect and not cut deeper troughs. When coastal fronts resulted in washover events during the fall of 2009, the modified areas neither deepened not widened, but did result in a flow which produced overwash fans similar to areas of the island with a natural berm. Results contrary to the COE model was the paradigm shift.

Early documentation of the project (through 2006) are available at http://www.nps.gov/asis/naturescience/resource-management-documents.htm .Courtney Schupp, ASIS Geologist, is on maternity leave, but I have attached three of her documents. If your staff has a plotter available, the 'Schupp' file is a poster that very nicely presents the berm portion of the larger restoration project. The '2008' proposal highlights the modifications made in 2008 & 09. The 2009 annual report covers an update for the entire project, since the 2010 report has not be finalized.

Schupp_2010 Rest Overwash for habitat.pdf 2008 Proposed alterations to the constructed berm.pdf

2009 North End Restoration Annual Report.pdf

Please review the files and then contact us for further information or clarifications. I am the Park's wildlife management specialist, and Carl Zimmerman, the former Chief of Resources Management is currently in an Administrative Management position. Either of us can probably answer or find the answer for any specific information. Neil Winn is our GIS Specialist who would supply any physical/GIS data or archived reports related to the subject. That includes the EIS (1998) with its support documentation, and a number of documents covering status reports and management decisions.

Please let us know how we can be of further help.

Jack Kumer
Natural Resource Specialist

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▼ Mike Murray/CAHA/NPS

Mike Murray/CAHA/NPS	To	Tami Pearl/ASIS/NPS@NPS
02/04/2011 04:00 PM	cc	Jack Kumer/ASIS/NPS@NPS, Britta Muiznieks/CAHA/NPS@NPS, Thayer Broili/CAHA/NPS@NPS, Darrell Echols/CAHA/NPS@NPS
	Subject	Re: ASIS 2010 PIPL Report

Tami,

Thank you for copying me on your report. I am very interested in hearing more about the storm berm modification project that is described on page 15 of the report (text pasted below), because beach nesting bird habitat at CAHA has been significantly impacted by man-made berms installed by the CCC's in the 1930's then maintained by NPS until the early 1970's. I am curious what you mean by the section highlighted in **BLUE** below. What did you expect would happen and how was the result different from what you expected? What is the paradigm shift (or what is the new paradigm)? If there is more documentation on the project, such as a project proposal, research permit, environmental compliance (such as a cat-X or EA), or a results report, I would greatly appreciate it if you could email me copies of such information (or direct me to the appropriate website site if the material is posted on-line). In any case, I do appreciate receiving your report and would like to learn from your experience with the berm modification project.

> Beginning in 2007, a series of experimental modifications were made to the storm berm in an effort to create sections that mimic the island's natural beach topography and in theory would be more susceptible to the influences of storm tides. By October 2009, a total of 16 modified notches had been graded across the storm berm. In November 2009, a tropical storm and a nor'easter combined to create storm-surge which affected the entire mid-Atlantic area. Analysis of the storm berm notches after the November 2009 storm revealed several findings. First, as a result of the storm berm manipulation, washover occurred across 22% of the storm berm length. New overwash fans were only created in areas where storm berm manipulation had transpired. Second, LiDAR results show that at locations along the island where washover occurred, the island interior just west of the natural berm gained approximately 0.5 m in elevation. The notches and deposited fans west of the storm berm experienced a similar increase in elevation. Lastly, none of the notches appeared to have increased in width after the storm event. **This finding was important to managers, as it**

created a paradigm shift. However, despite the notches not responding to the washover event as expected, it has been determined that the notches are fully functioning, and no further management actions are planned at this time.

Thanks,

Mike Murray
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▼ Tami Pearl/ASIS/NPS

Tami Pearl/ASIS/NPS

02/04/2011 03:30 PM

To: ruth.boettcher@dgif.virginia.gov, jocohen1@vt.edu, Amanda_Daisey@fws.gov, fraser@vt.edu, anne_hecht@fws.gov, scott.melvin@state.ma.us, andy_moser@fws.gov, holly.niederriter@state.de.us, Dave Avrin/GATE/NPS@NPS, Robert Cook/CACO/NPS@NPS, Bruce Lane/GATE/NPS@NPS, Michael Rikard/CALO/NPS@NPS, dbrinker@dnr.state.md.us, Michele Batcheller/PHILADELPHIA/NPS@NPS, Michael Bilecki/FIIS/NPS@NPS, Thayer Broili/CAHA/NPS@NPS, Mary Hake/CACO/NPS@NPS, Allison Murray/NERI/NPS@NPS, Mike Murray/CAHA/NPS@NPS, Matthew.Bailey@state.de.us, ABALDWIN@dnr.state.md.us, SKnipe@dnr.state.md.us, Jon Altman/CALO/NPS@NPS, ldavidson@dnr.state.md.us, louis_hinds@fws.gov, Christopher.C.Spaur@nab02.usace.army.mil, gtherres@dnr.state.md.us, cwazniak@dnr.state.md.us, Kevin Holcomb/R5/FWS/DOI@FWS

cc:

Subject: ASIS 2010 PIPL Report

Attached is the 2010 report on the management and monitoring of piping plovers at Assateague Island National Seashore. Please send any questions or comments to myself or Jack Kumer.

[attachment "Plover_Report_2010.pdf" deleted by Mike Murray/CAHA/NPS]
****

Tami Pearl
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Proposal to Create Flow Paths through the Constructed Berm at Assateague Island National Seashore

March 10, 2008

Following powerful storms in 1998, a constructed berm was emplaced on Assateague Island National Seashore (ASIS) in an area starved of sediment by updrift jetties. The constructed berm persisted over time, and was reconfigured in 2002 during the first phase of the Assateague Island North End Restoration project. The structure was designed to reduce the potential for island breaching while allowing some overwash, but instead it has proved impenetrable, resulting in undesired ecosystem developments that include altered vegetation communities, interruption of the dynamic morphological processes that stimulate this barrier island ecosystem, and reduced habitat availability for piping plover, a threatened migratory bird. Monitoring data demonstrate that a significant reduction in the abundance of sparsely vegetated habitats has occurred in the project area. These habitats are essential to piping plovers and other rare species, and their level of reduction has exceeded the threshold of acceptable change established in the Project Management Plan.

The berm was constructed as a temporary measure to accommodate ongoing beach erosion until mechanical sand bypassing efforts began. The expected lag time between berm placement and long-term sand bypassing was five years, but instead bypassing began only one year later, in January 2004. This shortened time period between construction of the berm and initiation of sand bypassing resulted in a larger-than-anticipated distance between the constructed berm to the ocean shoreline at the time that bypassing activities began. Furthermore, volumetric change calculations show that in August 2004 the North End of Assateague Island had 1,247,624 m^3 more sand than it did just after the 1998 storms; approximately 60% of this volume gain was in the length of the island containing the constructed berm. Since the commencement of mechanical sand bypassing activities, the area in front of the constructed berm has gained a large volume of sand, and beach accretion is evident. In summary, the area no longer exhibits the inherent vulnerability that led to construction of the berm in 1998.

In January 2005, the constructed berm was altered to increase the potential for water to overtop the constructed berm during moderate storms and stimulate habitat change needed to maintain conditions for piping plover. Six notches, each 40 m wide, were created through the crest of the constructed berm in an effort to lower the crest elevation to 2.7 m NAVD88 in three locations and to 2.9 m NAVD88 in the other three locations. Three years after their creation, these notches are indistinguishable from the surrounding topography, and they have proved to be insufficient to allow water to flow to the west side of the constructed berm, although flow to the island interior has occurred along other parts of the North End of ASIS.

In February 2007, the constructed berm was altered again towards the same goal of allowing habitat change through storm processes. Two pathways, each 120 m wide, were created through the constructed berm, with a natural slope extending from the desired elevation (2.16 m NAVD88) at the seaward edge of the berm downward towards the bay. The locations, elevation, slope, and width of the pathways were based on SBEACH models that incorporated tide and weather data to predict two overwash events each year, and on topographic data (lidar and RTK-GPS, including post-storm topography) quantifying elevations, locations, and widths of areas that experienced water flow to the island interior over the past decade. Although the natural beach profile was used as a model for height and slope, it was shifted westward to be superimposed on the constructed berm, and was therefore located farther away from the shoreline than a natural low beach profile would be. One year after their creation, these pathways have yet to allow flow across the constructed berm, though overwash to the island interior has occurred along other parts of the North End.

Proposed Alterations to the Constructed Berm

In order to mitigate the impacts of the berm on habitat quality, natural processes and piping plover reproductive success, we propose to stimulate the return of overwash processes to the area of the constructed berm by recreating natural beach profiles in multiple locations. It is not the intention of ASIS to pursue the topography seen in early 1998. Rather, our goal is to allow overwash to flow westward in multiple locations at a frequency that approximates rates observed elsewhere on the North End. An island breach is considered highly unlikely due to the post-1998 volume increases and shoreline accretion described above.

The details and methods of the proposal outlined here intend to recreate a natural beach overwash profile, as surveyed and documented along multiple flow paths following multiple storm events, through the constructed berm. These flow paths would be superimposed on the island in their natural location relative to the ocean shoreline, not shifted westward or vertically upward as in the previous two berm alteration efforts. The two existing pathways created in February 2007 will remain undisturbed and will offer opportunities to compare the performance of known elevations and cross-island profiles in future tidal events.

We propose to create 14 flow paths, each 30 m wide, through a total of 420 m, or 17%, of the length of the existing constructed berm. The proposed locations of these flow paths (Figure 1) were chosen based on several considerations: the potential benefit to plover habitat; the distance from the edges of the constructed berm; and field observations and GIS-based identification of potential flow paths that take advantage of existing topographical features and avoid dunes and other topographic impediments. All of the 30- m-wide flow paths would be located more than 200 m from both the northern and southern limits of the constructed berm, and sand from the flow paths would remain in the immediate area. Based on post-construction survey of the previous two alterations, it is expected that sand slumping from the sides of each new flow path will extend outward up to 5 m on each side, reducing the 30 m flow path to a width of 20 m at base elevation.

To determine the appropriate profile for the proposed flow paths, ASIS staff relied on elevation data from several sources:

- August 2004 lidar elevations of North End overwash channels that are known to experience overwash and that are visible in September 2003 aerial photos;
- elevations of overwash channels created on the North End during Tropical Storm Ernesto (2006) and several berm overtopping events in the spring and fall of 2006; and
- a decade of biannual topographic profiles collected in a location (GPS 3) that experiences mid-island (but not cross-island) overwash approximately once every other year.

After superimposing all of these flow path profiles, we noted similarities in shape, slope, and relative elevations. We identified significant breaks in slope and found average heights for and distances between these vertices, thereby creating an idealized profile (Figure 2). The peak elevation in this idealized profile is 2.16 m NAVD88 (7.09 ft NAVD88). Figures 3 and 4 illustrate the idealized natural profile overlaid on representative cross-island profiles of the constructed berm (measured by extracting elevations from September 2005 lidar surveys).

Due to the date of the lidar data and to topographic variations within each proposed flow path location, the proposed profiles may not be replicated precisely as illustrated in the graphics, which capture only a few cross-sections of the proposed pathways.

Post-alteration monitoring and management

Pre-alteration baseline elevations for the constructed berm will be obtained from September 2005 lidar data. New flow path locations and areas with displaced sand will be surveyed with an ATV-mounted RTK-GPS just before construction, immediately following construction, and one month after construction to capture any changes due to sand settling and Aeolian transport. (Monthly surveys of the notches created in January 2005 demonstrated that after the first month following construction, notch elevations and slopes do not change absent any severe wind or overwash events.)

To the extent possible, ATV-mounted RTK-GPS surveys will also follow overwash events that affect the constructed berm. This will result in an XYZ point grid across the overwashed area, indicating the elevation and alongshore width of the feature. Additionally, a cross-island topographic profile will be surveyed in each overwash area to capture the beach-through-berm path of the overwash flow.

Should the frequency of future overwash exceed desirable rates, sand could be moved into the flow path from adjoining areas of the constructed berm to increase elevation.

Attached Figures

The attached figures show 14 proposed locations of flow paths; some survey sources of the idealized cross-berm overwash profile; and the cross-island profiles (from September 2005 lidar) at representative locations, with the idealized overwash profile superimposed in black line.

Figure 1. Proposed locations for the 14 natural beach profiles, each 30 m wide (blue). The two pathways created in February 2007 are shown in green. The red lines indicate the locations of cross-island elevation profiles shown in the following figures.

Proposed 30 m Flow Paths

February 2008

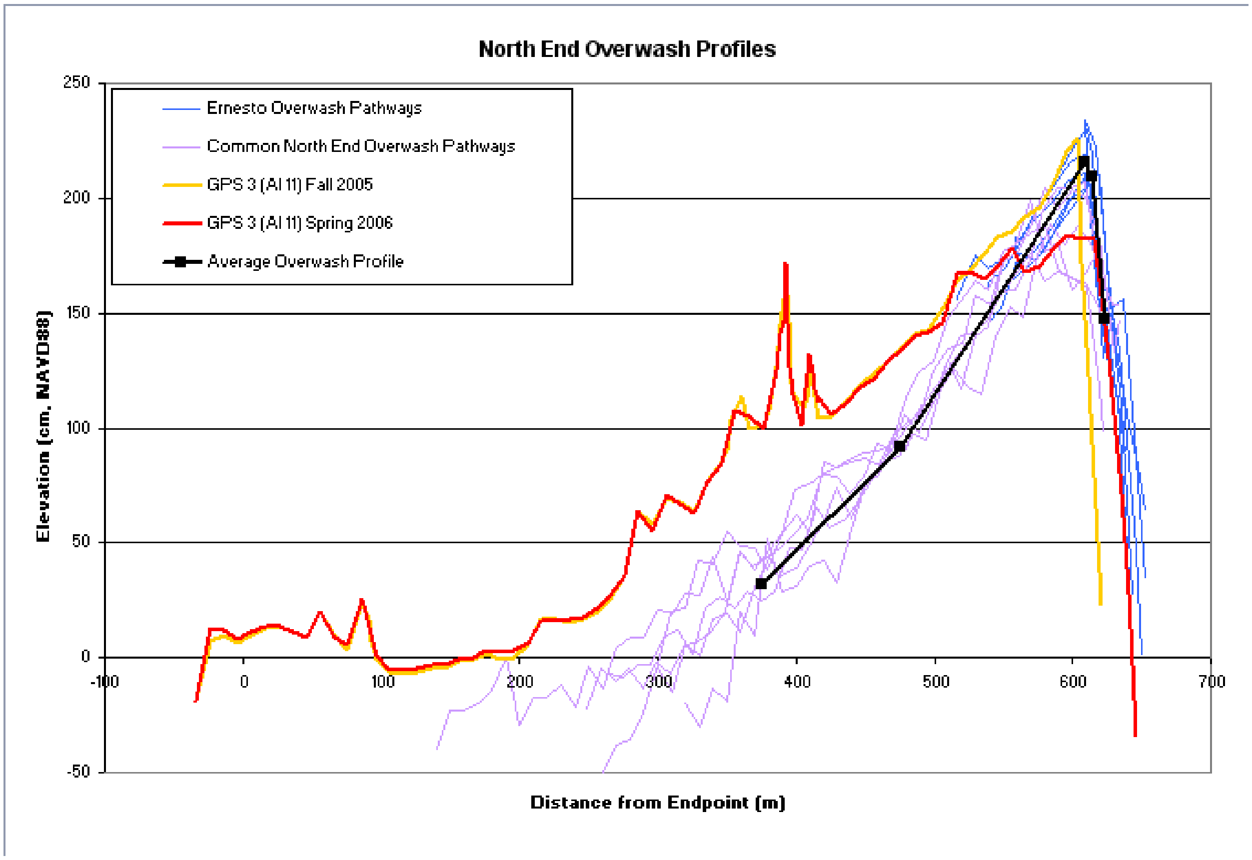
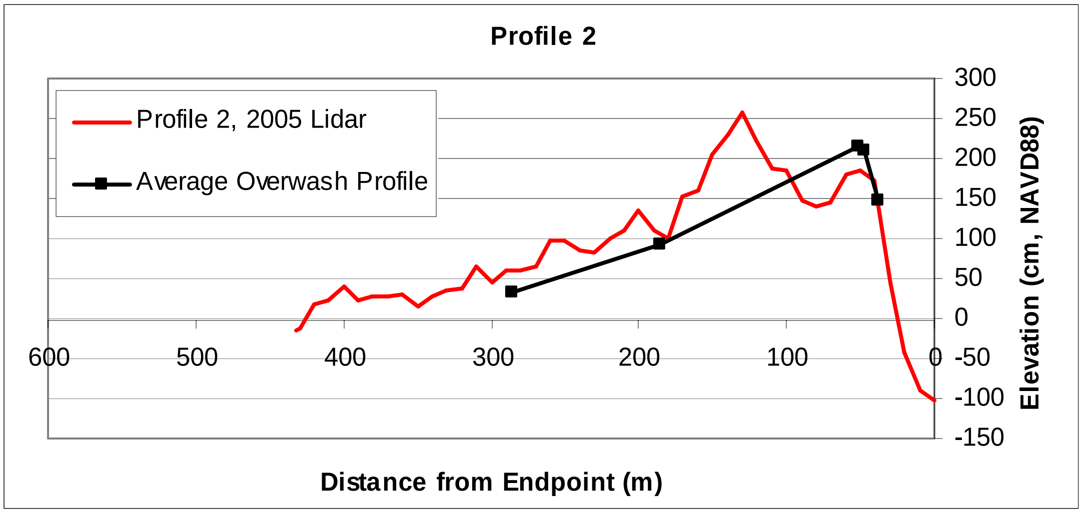
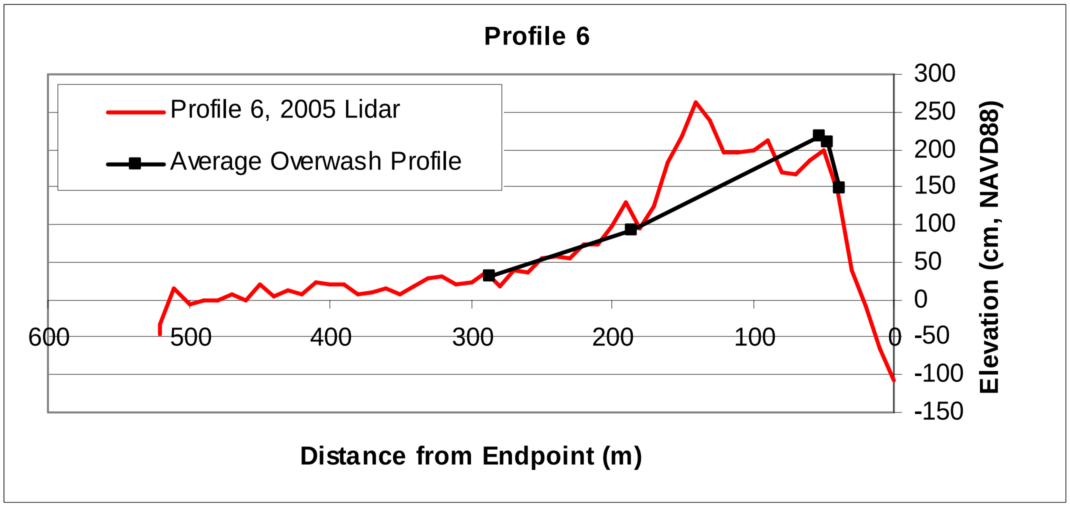
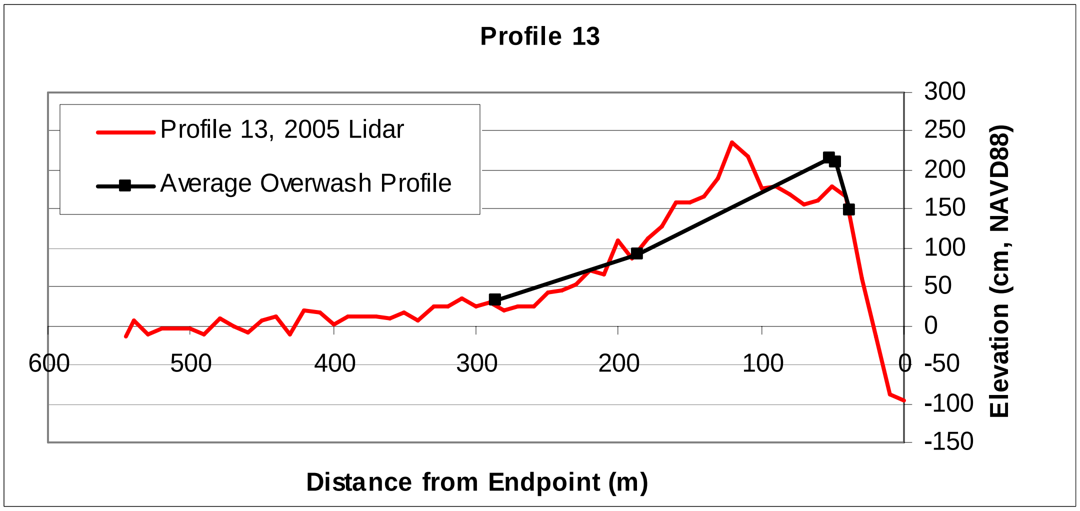


Figure 2. Idealized overwash profile (dark black line) was created based on inflection points, elevations, and slopes of typical overwash pathways along the North End of the island.

Figures 3-5. Cross-berm elevation profiles at proposed notch locations, with the idealized beach profile (black line) superimposed. Elevations are extracted from September 2005 lidar surveys.







North End Restoration Project Annual Report: 2009
Courtney Schupp, Assateague Island National Seashore
March 3, 2010

Overview

The North End Restoration Project is a comprehensive restoration plan that focuses on restoring Assateague Island to as natural a condition as possible, mitigating the sediment starvation of Assateague Island caused by the 1934 stabilization of the Ocean City Inlet. Project partners are the U.S. Army Corps of Engineers (USACE), Assateague Island National Seashore (ASIS), the state of Maryland, Maryland Department of Natural Resources, Worcester County Maryland, and the Town of Ocean City Maryland.

The project has two phases. The first, or short-term, phase of the restoration program was designed to provide a one-time infusion of sand to replace a portion of the sediment lost over the past 60 years due to the effects of the jetties; that phase was completed in 2003. The second phase, the long-term sand management component, began in January 2004 and addresses the ongoing and future effects of the jetties by re-establishing a "natural" sediment supply for northern Assateague that reflects historic, pre-inlet rates.

This report documents the efforts made in 2009 to evaluate and restore the island's North End as part of the long-term sand management phase of the project. The report does not serve as a synthesis of project performance to date, but rather lists the major events, collected datasets, and documents created in 2009 and related to the North End Restoration project.

Team Meetings

A subset of the North End Restoration Team participated in a conference call on March 6, 2009, to designate dredge and placement sites. Bill Grosskopf (OCTI) noted that the November 2008 nearshore profiles indicated a steepening shoreface in the placement area; further, the minimal change in the shoreline at mile 4 indicated a nodal point (divergence of transport direction) at that location, while at mile 5.5 there appeared to be a finger shoal running offshore to the north and refracting waves to the north. Considering the accretion and steepening noted in the placement area over the last few years, in addition to the transit time required by the dredge vessel, the Team agreed to place the dredged sediment in two new areas, one between profile lines NPS 2.25 and NPS 2.5 (just to the north of the usual placement area) and one between lines NPS 3.5 and NPS 3.75 (just to the south of the usual placement area). The Team also agreed to focus dredging primarily on areas A and C (north of the inlet) during the spring bypassing beginning on March 11.

A subset of the Team participated in a conference call on June 10, 2009 to designate dredge and placement sites and to discuss nearshore multibeam survey time periods. The Team agreed to dredge primarily areas A and C (north of the inlet) during the fall bypassing effort, and to place the material in the same two locations as during the spring bypassing, slightly north and slightly south of the original placement area. Due to scheduling demand, it was agreed that the Currituck could start bypassing sand on August 21 and work two 12-hour shifts per day for 40 days. A multi-beam survey of the nearshore and tidal deltas was planned for Fall 2009, and cross-island and nearshore profiles were planned for November 2009.

Dredging

Two rounds of dredging delivered an estimated total of 112,257 m^3 to ASIS in 2009. Details of the dredging dates, along with volume sources and destinations, can be found in Table 1.

Pre-Dredging Survey	Dredging	Ebb Shoal Area A: Northern Tongue (cubic meters)	Ebb Shoal Area B: Outer Bar (cubic meters)	Ebb Shoal Area C (cubic meters)	Flood Shoal: Sinepuxent Bay (cubic meters)	Flood Shoal: Isle of Wight Bay (cubic meters)	Inlet Throat (cubic meters)	Clam Dock	Total (cubic meters)	To Assateague	To OC	Post-Dredging Survey
10/27/08 to 10/30/08	3/15/09 to 4/23/09	9588	283	20276	344	680	757	9026	40953	37610	3343	11/3/09 to 11/7/09
11/3/09 to 11/7/09	9/06/09 to 10/19/09	5455	1713	52074	0	0	6460	10666	76368	74647	1720	NA

Table 1. Dates of bathymetry surveys and dredging, and sources and destinations of dredged volumes.

Constructed Berm Alteration

Of the 14 flowpaths proposed for construction in 2008, half were created in fall 2008 and the remaining seven remaining flowpaths were built in mid-November 2009 to replicate the natural topography evident elsewhere on the north end. A 1% slope extended from the natural berm westward 300 feet; a shallower slope then connected that point westward to the easternmost edge of the vegetation. Methods and locations are documented by Schupp (2009). The majority of sand moved out of the flowpaths was pushed seaward of the high water line.

Pre-construction elevation surveys of the seven locations were completed on October 26, 2009. Six of the seven flowpaths were completed, and the seventh was nearly complete, before a Northeaster combined with Hurricane Ida reached Assateague on November 11. There was no elevation survey performed between the time of construction and the time of storm-related overwash. Following construction and overwash, an elevation survey of the entire berm was completed on November 17, 2009. An EAARL lidar survey was conducted over the North End and other portions of Assateague Island on November 28, 2009.

Constructed Berm Behavior

The new flowpath configuration allowed water to flow across the constructed berm during multiple weather events in 2009.

On March 1, flowpath numbers 6, 10, and 14 overwashed due to high tide.

On June 23, some water flowed through flowpath numbers 3, 6, 10, and 11. Overwash through flowpath 11 cut a few inches into the south side of the path. Overwash through flowpath 6 resulted in a 3-inch cut along parts of the flowpath, and a 3-inch thick overwash deposited near (seaward of) the westward edge of the construction area; deposits did not reach the grassy vegetation. Water came up near the top of several other parts of the constructed berm, including an earlier constructed shallow pathway.

Between August 22 and August 27, water flowed through all of the 7 flowpaths and in one of the older pathways.

Between September 8 and September 14, flowpath numbers 3, 6, 11, 12, 13, and 14 experienced overwash.

Between October 15 and October 20, water flowed through all 7 flowpaths, but moved sand and deposited overwash fans only behind flowpath numbers 3 and 6, extending from the western edge of the berm westward approximately 100 feet.

A storm combination of Hurricane Ida and a northeaster affected the island from November 11 through November 13, just after another 7 flowpaths were constructed. During this storm, data from the buoy offshore of Ocean City Inlet show that waves exceeded 1.5 m for an 85-hour period, during which maximum significant wave height was 3.2 m and maximum wave period was 14.2 sec. Wind and water moved significant amounts of sediment. Behind the constructed storm berm, overwash fans were deposited at all 14 flowpath locations and one additional area before the sediment load filled the notches in with new sand. Those fans reached an average of 30 meters west of the constructed storm berm. Initial surveys indicated that the eastern edge of the constructed berm gained up to 0.5 meters in elevation from sediment deposition.

Vegetation Manipulation

Sea beach amaranth plants were mapped; some plants were caged to protect plants from ungulate grazing. Exotic and/or invasive vegetation, including Japanese honeysuckle, Asiatic sand sedge, and the first known occurrence of beach vitex on ASIS, were discovered and treated in 2009.

Assateague State Park Modifications

Following the November 11 storm, Assateague State Park began rebuilding the dune face and installing new fencing and plants.

Datasets

Many spatial datasets were collected in conjunction with the North End Restoration Project, and most are available on the NPS Data Store http://science.nature.nps.gov/nrdata/. This year's activities resulted in the following relevant datasets:

- Digitized maps and contours of 1962 post-storm topography of the North End
- Post-overwash elevation surveys of three flowpaths in constructed berm, March 3, 2009
- Post-overwash elevation surveys of seven flowpaths in constructed berm, September 14, 2009
- Post-overwash elevation surveys of seven flowpaths in constructed berm, October 23, 2009
- Pre-construction elevation surveys of 7 new flowpaths through constructed berm, October 26, 2009
- Planned post-construction surface of 7 new flowpaths through constructed berm
- Post-overwash elevation survey of the entire constructed berm, November 17, 2009
- NOAA true-color orthophotographs, November 16, 2009
- EAARL lidar survey of North End, November 28, 2009
- Sediment Bypassing borrow and placement locations, Spring 2009
- Sediment bypassing borrow and placement locations, Fall 2009
- Topographic-bathymetric profiles of the North End, December 11-13, 2009
- Nearshore bathymetry including entire tidal delta and inlet, November 3-7, 2009
- Topographic profiles, April 2009
- Topographic profiles, September 2009
- High water shoreline position, January 2009
- High water shoreline position, April 2009
- High water shoreline position, July 2009
- High water shoreline position, September 2009
- High water post-storm shoreline position, November 2009
- Wave data as measured at the USACE Off-Shore Wave Gauge
- Weather data from the ASIS Remote Automatic Weather Station
- Environmental and weather data from the NOAA Offshore Buoy 44009
- Tide data from NOAA Tide gauges at Ocean City Inlet and Lewes, DE
- Piping plover nest locations and reproductive success

- Delineation of vegetation types
- Sea beach amaranth locations
- Exotic plants discovered in 2009
- Exotic plants treated in 2009

Documentation and Data Synthesis

Documentation and data synthesis of the North End Restoration efforts have taken several forms:

- Pearl, T. and Kumer, J. *2009 Piping Plover Annual Report*. NPS Internal Report.
- Sherry, E. *2009 Meteorological Monitoring Program Annual Report*. NPS Internal Report.
- Schupp, C. 2009. Summary and Illustration of Proposal to Create Flow Paths through the Constructed Berm. NPS Internal Report.

0030572

Restoration of Natural Geomorphic Processes to Create Barrier Island Habitat on Assateague Island, Maryland

Courtney A. Schupp and Neil T. Winn
Assateague Island National Seashore, Berlin, MD, Courtney_Schupp@nps.gov

Figure 1. Assateague Island is a barrier island that extends 58 km along the coast of Maryland and Virginia.

Abstract

In 1998, multiple northeasters threatened to breach Assateague Island National Seashore, Maryland in an area that was experiencing rapid erosion due to sediment starvation by updrift jetties. To prevent breaching in the interim period before a long-term sediment bypassing project could commence, a constructed foredune was emplaced on the island. This foredune was designed using an engineering model to allow occasional overwash, and was placed at a setback distance equal to the expected interim shoreline erosion. Because the design assumptions did not match the actual meteorological and erosional conditions that followed, the foredune proved impenetrable to overwash and disrupted other morphological processes, resulting in undesirable habitat changes.

The National Park Service partnered with the U.S. Army Corps of Engineers to address these unintended consequences by restoring the natural geomorphologic processes that create and shape barrier island habitats. After analyzing datasets including island topography, overwash frequency, and meteorological conditions, and revising the assumptions and input data used in the engineering model, the team designed and built multiple pathways through the foredune.

These new pathways, which replicate the natural overwash topography found elsewhere on the island, functioned as hoped during a November 2009 northeaster storm, allowing creation of new overwash fans and build-up of the interior island elevation. Habitat response will be quantified over the coming year to evaluate the biological effects of restoring geomorphic processes, and will guide decisions on whether additional management action is necessary.

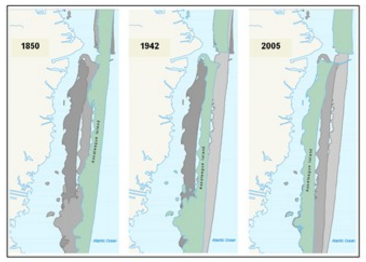


Figure 2. Stabilization of the Ocean City Inlet starved Assateague Island of sediment, leading to rapid landward migration.

Assateague Island is naturally dynamic

Assateague Island National Seashore is responsible for protecting the natural resources, processes, and ecosystems of Assateague Island, a barrier island that extends 58 km along the coast of Maryland and Virginia, and is bounded to the north by the stabilized Ocean City Inlet (Figure 1).

The northern 10 km of Assateague Island is a dynamic environment composed of a beach and low berm on the ocean side of the island, a sparsely vegetated back-barrier flat, and narrow fringing salt marsh and overwash fans bounded by the estuary. The North End experiences frequent overwash, which creates and maintains prime early-successional beach habitat for several state- and federally-listed endangered species, including sea beach amaranth (*Amaranthus pumilus*) and piping plover (*Charadrius melodus*), which nest and forage in overwash fans.

The North End has a fairly low elevation, generally around 2 m (NAVD88), though remnant spoil-sediment dunes may rise up to 6 m high. Cross-island widths range from 260 m to 625 m, and shoreline erosion rates are higher than along the rest of the island. The coastline is classified as wave-dominated (mean significant wave height is 1 m, with predominant wave period ranging between 5 and 7 seconds) and microtidal (0-2 m tide range) with spring tides fluctuating from -1 m to 3 m relative to mean low water (MLW) (Field 1979). Winter storms and high wave energy create a low, flat beach with sand stored in a nearshore sand bar; summer beach profiles are steeper. Net alongshore sediment transport is southward due to strong winter northeasters; in the summer, waves from the southeast drive sand transport less vigorously northward. As a result, the net annual alongshore transport in areas not affected by the inlet is estimated to be between 115,000 and 214,000 m^3/yr toward the south (Underwood and Hiland, 1995).

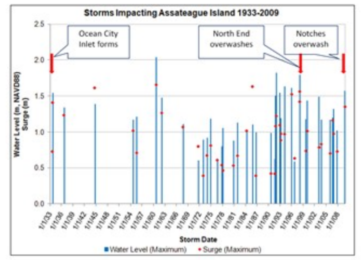


Figure 3. Strong storms impacted Assateague Island from 1991-1998; the following decade was relatively calm. Red arrows indicate major island-shaping events. [1933-1991 hindcasts from Grosskopf, 2005 and Munger and Kraus, 2010. 1991-2009 data from NOAA tide station 8557380 at Lewes, DE.)

Inlet stabilization caused sediment starvation and island migration

The geomorphic vulnerability of the northern end of Assateague Island is due primarily to the interruption in alongshore sediment transport by the jetties built to stabilize Ocean City Inlet in 1935 (Rosati and Ebersole, 1996). After the inlet was stabilized with jetties, the shoreline erosion rate along the northern 10 km of the island doubled, from a pre-inlet rate (1850-1933) of -2.2 m/yr to a post-inlet rate (1942-1997) of -4.3 m/yr. This increase in shoreline erosion corresponds to a volume loss in the active profile (from the beach berm offshore to the depth of closure) from an estimated 150,000 m^3/yr to 370,000 m^3/yr (excluding the 1-km-long portion north of the attachment bar, where inlet hydrodynamics are unique) (Schupp et al., 2007).

During the 70 years following inlet stabilization, the North End migrated almost 500 m westward (Figure 2) through shoreline erosion, overwash, and loss of sediment supply. A 1962 northeaster breached the North End, destroyed private infrastructure on the island, and fueled public support for protection of Assateague Island, which was established as a National Seashore in 1965.

Assateague Island was impacted by a series of strong storms during the period 1991-1998 (Figure 3), and by 1998, the North End was overwashing as much as 20 times per year, with well-defined overwash channels and elevation lower than 2.25 m (NAVD88). During two northeasters in early 1998, a 2.4 km long area experienced sustained overwash that resulted in the creation of a large overwash fan and exposure of peat along the shoreline and within the island's interior.

USACE predicted that without mitigation, the northern end of the island would destabilize and eventually breach during storms in the near future (USACE, 1998). Should this occur, it would have both a significant impact on the values and purpose of Assateague Island National Seashore and serious implications for the adjacent mainland communities, including infrastructure vulnerability, loss of estuarine habitats, and increased maintenance needs for Ocean City Inlet.

Figure 4. Two northeasters in 1998 threatened to breach the island. The foredune constructed in 1998 prevented all overwash, and the area of sparse vegetation declined by more than 25%, meeting the threshold condition for project mitigation. Notches cut into the constructed foredune allowed overwashed during the November 2009 northeaster. (Figure credit: Tami Pearl, Assateague Island N.S.)

Early mitigation aimed for stabilization

To mitigate the loss of natural sand transport processes, local and national government agencies created a comprehensive two-phase restoration plan (Figure 5). The first, short-term phase of the restoration program reduced the immediate breaching risk by building a low foredune in 1998 along the 2.4 km long area most vulnerable to overwash; this was a stopgap measure to preclude massive overwash and breaching in the interim period before implementation of a long-term solution to restore sand transport to northern Assateague Island. In 2002, a one-time beach renourishment widened the beach by 30 m by replacing about 15% (1.4 million m^3) of the sand captured by the inlet since 1934 (USACE, 1998). The second phase, which began in January 2004, restored sediment transport to the nearshore area of the North End through biannual mechanical bypassing of a sand volume equal to the natural pre-inlet alongshore transport rate (144,000 m^3/yr).

The design goals of the constructed foredune were to reduce the likelihood of an island breach before mechanical bypassing began, while still maintaining enough overwash, at least one event per year, to maintain sparsely vegetated habitat.

Two biological threshold conditions were established as conditions which, if *both* were met, would signal the need for mitigation (USACE, 1998).:

1. A reduction in piping plover reproductive success to 1.25 chicks fledged per breeding pair, or a decline in breeding population size of greater than 25% of the population. (N.B.: The desired productivity to maintain a stable population is 1.5 fledged chicks per breeding pair (USFWS, 1996).)
2. A decline of more than 25% of the sparsely vegetated/unvegetated habitat on the North End.

Two geomorphological threshold conditions were established to indicate an unacceptable risk of island breaching:

1. A decrease in foredune elevation to less than 2.36 m NAVD88 (at that time, the estimated height of a natural storm berm) over a contiguous length of greater than 0.5 km.
2. Significant overwash events across the foredune that occur more than four times per year and exceed 0.5 km total or 0.25 km contiguous length.

The constructed foredune was designed by inputting the desired overwash frequency and conditions during two recent storm events (September 1992 and March 1994) into the Storm-Induced Beach Change model (SBEACH). The resulting design specified a crest height of 3.01 m (NAVD88), which required placement of 285,000 m^3 of sediment dredged from an offshore shoal. The constructed foredune setback from the ocean was calculated based with the assumption that recent erosion rates and storm frequency would continue before the long-term sand bypassing phase began. The targeted dredge material for this project was determined to be similar to the native grain sizes (USACE, 2001).

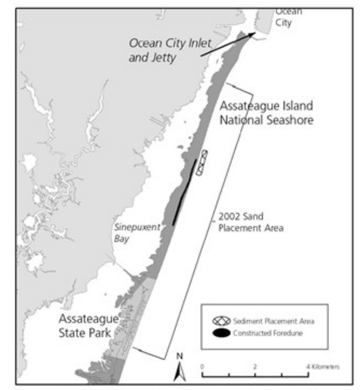


Figure 5. Along the North End of Assateague Island, an ecosystem restoration project has included construction of a low foredune, a one-time beach renourishment, and biannual mechanical sand bypassing to the nearshore.

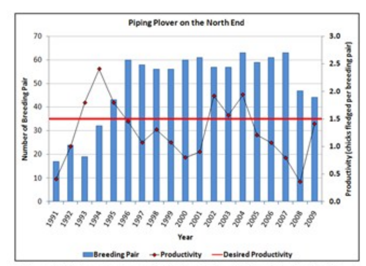


Figure 7. Piping plover productivity declined below the threshold condition for project mitigation.

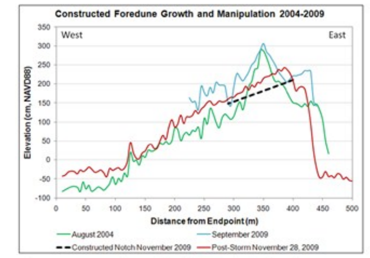


Figure 6. A cross-section profile of the constructed foredune illustrates three project phases. Following construction, the western (bay) side of the constructed foredune gained elevation. Notches were cut into the foredune in 2008 and 2009. A November 2009 northeaster overwashed through the notches, and associated storm winds deposited new sand.

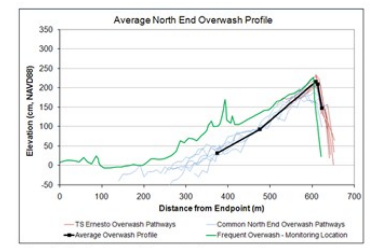


Figure 8. To develop notch construction parameters, an average overwash surface was calculated using lidar and ground-survey data from multiple locations and overwash events along the island.

Stabilization caused habitat loss and triggered threshold conditions

Although the foredune structure was designed to allow some overwash while reducing the potential for island breaching, it has proved impenetrable, resulting in altered vegetation communities, interrupted morphological processes, and reduced habitat availability for piping plover.

Several erroneous assumptions fueled these problems:

1. The construction sediment had a larger proportion of coarse grained materials, including gravel, than the native materials did. Through winnowing by Aeolian processes, this coarse fraction blankets most of the foredune surface, limiting the ability of the underlying sediments to be mobilized during wind and storm events.
2. Post-construction meteorological conditions were much calmer than the modeled storm conditions. Assateague Island did not suffer any major storm impacts during the 1999-2008 period, even despite a notably active hurricane season in the Atlantic basin in 2004 and 2005 (Figure 3).

The constructed foredune had unanticipated consequences. Its design height and setback prevented overwash its entire length, and its shelter fostered an increase in herbaceous vegetation and the growth of embryo dunes (Figure 6).

By 2007, the sparsely vegetated area on the North End (Figure 4) had declined from a pre-construction mean (1996-1998) of 49% of the North End to a post-construction mean (2003-2007) of 32% (Sturm, 2007). This decline exceeded the 25% reduction threshold condition.

Piping plover, which rely on open and sparsely vegetated habitat, similarly declined in productivity in the North End area; since 2005, their productivity has been lower than the desired rate for stable populations of 1.5 fledged chicks per breeding pair (USFWS, 1996) and, from 2005-2008, was also lower than the action threshold established for this project (Figure 7).

Manipulation restores natural overwash

Because the threshold conditions had been met, and because the coastal processes shaping the project area were markedly different than those in the surrounding, non-engineered area, the project team agreed to manipulate the foredune.

To allow portions of the foredune to overwash with the frequency observed elsewhere on the North End, an average overwash surface was modeled using lidar and ground-survey data from multiple locations and overwash events along the island (Figure 8). An initial experiment in 2006 lowered only the crest of the constructed foredune in two areas, each 120 m wide, down to the height (2.16 m NAVD88) of the average overwash beach berm, which forms much closer to the shoreline (Figure 6). These areas did not experience overwash between 2006 and 2009, likely due to a combination of the relatively calm weather and the friction and gravity that water encountered before reaching the foredune crest.

In 2008 and 2009, the average cross-beach overwash profile was built through the constructed foredune at 14 locations, each 20 m wide (Figure 4). Topography of these new notches replicated natural overwash cross-beach profiles with respect to elevation, slope, and the location relative to the shoreline (Figure 6). The foredune was surveyed before and after construction, and after each overwash event.

During a strong northeaster storm in November 2009 (Figure 3), much of the North End experienced overwash, including both the experimental lowered-crest areas and the 14 notches in the constructed foredune (Figure 4). As a result of the foredune manipulation, water flowed westward across 22% of the foredune length and deposited new overwash fans. Lidar results (Figure 9) show that the interior of the island also gained approximately 0.5 m in elevation along the entire North End, including the notches (Figure 6). The sand is believed to have been deposited by Aeolian processes, and so is likely fine-grained and easily mobilized, in contrast to the heavier gravel fraction on the surface of the constructed foredune.

Monitoring efforts during Summer 2010 will evaluate the reproductive success of piping plover and sea beach amaranth in the newly created habitat and along the rest of the island. Topographic surveys following future island overwash events will evaluate whether the notches continue to function as overwash pathways or whether follow-up manipulation is necessary to maintain overwash processes in the project area.

Conclusions

On Assateague Island, the replication of natural topography restored natural overwash processes, and initial results indicate that this effort was successful in restoring habitat.

Establishing measurable biological and morphological threshold criteria at the beginning of the project was fundamental to gaining later consensus on the need for action.

Project success should be measured in terms of natural processes (such as overwash frequency) rather than in terms of traditional steady-state measurements (such as beach width) in the barrier island environment, where dynamic habitats are so crucial to ecosystem health.

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Countless hours of field data collection and processing were accomplished by Assateague Island N.S. staff members Neil Winn and Andrew Roach (geomorphic data), and Tami Pearl (piping plover data). Bill Grosskopf (Offshore & Coastal Technologies, Inc.) provided helpful advice on reducing and displaying storm data.

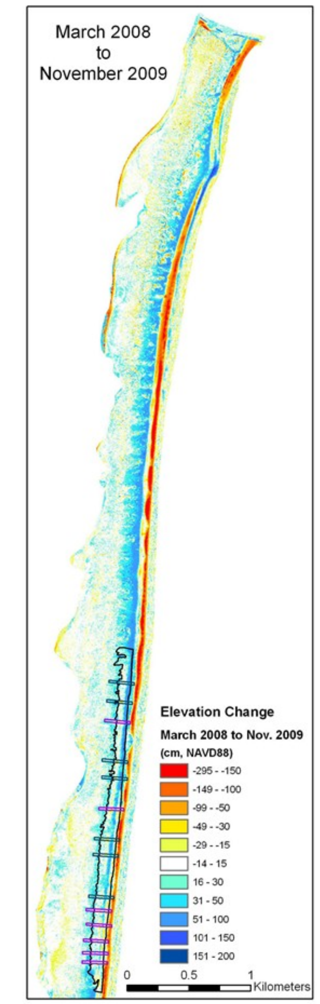

Figure 9. Lidar results illustrate an elevation gain of approximately 0.5 m along the island interior during the November 2009 northeaster storm.

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