Prime Hook NWR – Wetland Management Challenges – Background Information

History of Refuge Wetlands & Wetland Management

Geographically, the refuge can be depicted as an elongated coastal strand covering 10,132 acres that lies parallel to the Delaware Bay. To organize management operations, the refuge is divided into four management units using existing roads that track across refuge lands as divisional features, which run perpendicular to the bay, were built prior to the establishment of Prime Hook. (Map 1-1).

UNIT I. This area comprises the northern most end of the refuge and is delineated by Slaughter Beach Road as its northern boundary, overwashed barrier dunes and a portion of the Slaughter Beach community houses on the east, Fowler Beach Road on the south, and an upland fringe of scrub-shrub areas on the western boundary. There is currently no water level management capability in Unit I, which contains about 1,400 acres of salt marsh. Tidal salt water is the primary source of water for the unit, which flows approximately two miles from the DE Bay through the Cedar Creek at the Mispillion Inlet and into Slaughter Canal . An overwash formed on the coast of Unit I in 2006, creating a small inlet, creating more direct flow of saline bay water into Unit I. The overwash opened further in 2008 and 2009.

UNIT II. This management unit is just south of Unit I. It is bounded by Fowler Beach Road on the north, artificial barrier dunes and a sand dike connected to the Prime Hook beach community on the east, Prime Hook Road on the south, an upland interface on the west. It has been historically managed as a freshwater impoundment. During storm tides, this sand dune system has been breached several times and washouts have deposited sand and salt water into the Unit II impoundment, now with every tide.

UNIT III. Management Unit III is bounded by Prime Hook Road on the north, Route 16 (Broadkill Beach Road) on the south, upland edge on the western boundary, and the Prime Hook and Broadkill Beach developments immediately adjacent to the refuge's eastern boundary. Unit III consists of roughly 3,600 acres, which includes impounded freshwater emergent marsh, Red Maple-Seaside Alder Swamp, low lying farmed areas, brush, barrier beach on the east, and 140 acres of flowage easement on the southeastern boundary of Unit III. This flowage easement drains directly into Prime Hook Creek and flows south to the water control structure of this watercourse. Unit II and Unit III are connected by water exchange through culverts under Prime Hook Road.

UNIT IV. Management Unit IV is surrounded by Rt. 16 on the north, the Broadkill Beach community on the east, the Broadkill River on the south and west, and the upland edge on the west. The majority of water and tidal action associated with Unit IV is provided by the Broadkill River, whose salinity ranges from 10 to 30 ppt. Prior to Service ownership, this marsh had been excessively drained by man-made ditches. Rainfall and excessive runoff from Unit III are other sources that provide fresh water. Due to the strong influence of the Broadkill River, this impounded area has a more brackish character with salinities ranging from five to twenty ppt.

The wetlands on and around the refuge have been shaped by many natural and human-caused factors over the last century. The history is summarized briefly below:

Prior to Refuge Establishment

Over the last 2,000 years, sedimentation filled a lagoonal area, producing the Refuge's marsh (Hoyte 1980). Hoyte (1980) extracted nine stratigraphic cores on PHNWR along the Slaughter and Prime Hook Creeks (Units II and III) and has suggested that lagoons behind barrier beaches changed from fresh water over the past 500 years to more saline conditions. About 150 years ago, Unit III was a tidal marsh system with several small creeks and abundant potholes where Prime Hook Creek and Deep Hole Creek drained directly into the Delaware Bay (1.5 miles north of current Prime Hook Creek water control structure).

At the turn of the 20th century, Prime Hook Creek and the Broadkill River emptied into the Delaware Bay along what is now the refuge's eastern boundary. In the early part of the century, both outlets were closed by a storm. The Broadkill River meandered to a new outlet further south, and Prime Hook Creek ended in what is now Unit III, with Petersfield Ditch taking over as the major water outlet emptying into the Broadkill River.

Historically, the majority of Unit II wetlands were tidal brackish marsh. Slaughter Creek was the most significant watercourse in the unit, flowing southeasterly across the entire Unit II to Prime Hook Creek south to Prime Hook Road. Until 1900, Unit II marshes remained relatively unchanged. Landowners drained the marsh and dug Slaughter Canal in the early 1900s to improve drainage of their upland areas by channelizing water north to Cedar Creek. The construction of Slaughter Canal vastly increased drainage in Unit II marshes, lowered water tables in upland areas, and significantly altered tidal exchange. In 1906 the Slaughter Canal dredging reached into Unit II. Portions of Unit II were also heavily grid ditched during the 1930's for mosquito control. To maintain water on the marsh during the fall and winter for muskrat trapping and waterfowl hunting, private owners built water control structures at Fowler Beach Road, Oak Island, and near the bridge at Slaughter Creek to hold water.

In 1934, a dike was dug along the eastern edge of the marsh from Slaughter Beach to Prime Hook Beach to prevent the bay from washing into the marshes. The deep barrow ditch is still evident today but several sections have been filled by washouts. Until the 1950s, access to Prime Hook Beach was possible only by boat or during the dry summer by horse or vehicle. In 1953, a gravel roadway was constructed across the marsh and today this roadway, now called Prime Hook Road, is paved. Although not formally engineered for water management, it has acted as a dike between Units II and III with eight small culverts under the roadway resulting in the exchange of water between the units. All of these human activities have significantly altered the hydrology of Unit II wetlands.

During the first half of the century, area landowners and the Civilian Conservation Corps installed water control structures on the central wetlands on the refuge, which at times were then removed by other landowners. In the 1920s, several attempts were made by landowners to create or block drainage within the Unit III area to provide water control. In the 1930s, Unit III marshes were heavily grid ditched for mosquito control. During the 1940s-50s, there was disagreement about how to manage the wetlands of the Prime Hook area, between those who wanted marshes for hunting and trapping and farmers who wanted to drain the upland edges surrounding these wetlands, especially in what is now Unit III.

In the 1950s vegetation coverage in the area east of Petersfield Ditch at the lower end of Unit III consisted of salt hay and cordgrass. *Spartina* grasses were cut for hay and grazed by cattle through the late 1950s. The remainder of Unit III marsh, including much of the marsh west of the ditch was open water with cattail, arrowroot, and pickerelweed as co-dominants. Brush was managed in drier areas by grazing and fire. Trees were mostly absent (USFWS 1982).

Before the refuge was established, private owners maintained pumping stations for ponds in Units III and IV for cattle and to manage waterfowl and muskrats. The vegetation in Unit IV has been predominantly salt marsh cordgrass and salt hay with several patches of high-tide bush, and much of the unit was grid ditched for mosquito control in 1930s. Unit IV was continually grazed by cattle on the Island Farm which was operated as a large cattle feed-lot operation from the early 1950s. Cattle continued to graze in Unit IV even after the refuge was first established, until the early 1970s.

1951 Survey of the Marshes of Delaware

During the 1950s, State surveys were conducted to assess the condition of Delaware's wetlands, including a description of vegetation and use by waterfowl and furbearers. These studies characterized the coastal areas that would later become established as Refuge lands as predominantly salt marsh environments, in a report entitled "A Survey of the Marshes in Delaware" (Chamberlain 1951).

For this survey, the state was divided into marsh "survey work units" which basically followed water courses and watershed delineations. Historic descriptions of the individual survey work units associated with refuge lands (Survey Units 12, 13, & 14) reflect the environmental condition of refuge wetlands sixty years ago. Survey Unit 12 included Prime Hook NWR present management Unit I. Several ponds and smaller streams were also included in this unit. Big cordgrass, saltmarsh cordgrass, salt hay, cattail, feather grass, three-square, panic grass, marsh mallow, high tide bush and groundsel bush were found in these salt marsh areas. In brackish situations duckweeds, pond weeds, bur-reed, cattail, water willow, wild rice, white and yellow pond lilies, rushes and smartweeds were also present in areas away from the saline fringe coastline.

Survey Unit No. 13 included Slaughter Creek, Primehook Creek, three large ponds and dozens of small ponds and potholes in a marsh area that incorporated 6,941 acres contained within the Refuge's Unit III management boundary. The presence of a "high barrier along the coast" was attributed to Unit 13 having less true salt marsh plants than the survey units immediately north and south. This surveyed area was found to support good numbers of waterfowl in 1950/1951 with a high of 2,700 birds in the fall and 1,100 in the spring. The average annual harvest of muskrats was about 25,000 with the following observation: "*This district has become increasingly less productive during recent years, the decrease being attributed to vegetative changes occasioned by the flow of salt water through many breaks in the dunes along the bayshore."* Measurements of water levels also pointed to the lack of "summer water" largely caused by mosquito and agricultural drainage ditches which accelerated the proliferation of feather grass (*Phragmites).*

Survey Work Unit 14 covered the watershed of Broadkill Creek to Canary Creek, which encompasses the current Refuge Management Unit IV. The area supported the typical salt marsh vegetation consisting mostly of salt hay, big and salt marsh cordgrasses, high tide bush, groundsel bush, marsh mallow, and panic grasses. In smaller, isolated fresh water ponds, cattails, smartweeds, swamp dock, water willow, tidemarsh waterhemp, and feather grass were found. Aerial counts showed fair fall migration numbers of waterfowl, about 2,000 birds in 1950 and a spring high (1951) of about 800 waterfowl using the area. Annual muskrat production was low and attributed to the observation that most of the marshes within Work Unit 14 had been ditched for mosquito control, and ditches were cleaned each year to keep them operating, and that as long as this situation prevailed, the production of muskrats and use by waterfowl would remain low (Chamberlain 1951).

1976 Atlas of Delaware Wetlands

Twenty years later, during the 1970s, the Delaware Coastal Management Program, in collaboration with the University of Delaware, College of Marine Studies, conducted a more comprehensive inventory and assessment of the state's wetlands and water resources, published as an "Atlas of Delaware Wetlands" in 1976 (Daiber et al. 1976). Wetlands were classified into eight zones derived from natural associations of plants or human interventions. These wetland zones consisted of six floral zones (Zones I – VI) and two artificial zones (Zone X & Zone X_i). The artificial zones referred to areas that were once natural marsh but had been reclaimed by human activities that eliminated or modified some sate wetland areas through filling, diking, ditching or paving (Zone X) or impounding activities for salt hay production or waterfowl conservation (Zone X_i). Each floral zone was based on "dominant" vegetation of one major wetland plant species that covered at least 50 % of a contiguous area, with the exception of Zone V, Transition Marsh. Plant species which were commonly found in the area were also listed as associated plant species, related to the dominant plant species that characterized a particular zone.

In addition to the use of 1973 aerial photographs, multiple ground truthing field visits were conducted to substantiate interpretations made from aerial photos (See Daiber et al. 1976 for more detailed descriptions of the wetland classification zones, and for maps corresponding to Refuge wetlands). In the documentation of the 1976 state wetland assessment studies, all of the refuge marsh habitats were categorized as "natural," i.e., none of the refuge wetland areas were impounded at that time. This mapping effort illustrated that the wetlands of the Refuge area were primarily salt marsh, with pockets of freshwater marsh, but also areas of degraded hydrology where *Phragmites* had flourished.
Both of the 1951 and 1976 state wetland inventory and assessment efforts and subsequent state wetland delineation maps produced in the 1970s by DNREC have represented the historic wetland communities on the Refuge as naturally occurring tidal salt marsh environments. Units I, II, and IV were historically tidal salt marsh, with *Phragmites* encroachment along areas of human activities of barrow-ditching and flattening dunes to build beach houses along barrier beach island areas. By1970, more extensive Broadkill Beach home development along the eastern boundary of Unit III had eliminated most tidal salt water influences and flow. However, the peripheral edges still retained some salt marsh vegetation which persists to this day (mostly *Spartina patens*). Yet the middle core of Unit III contained transitional marsh

vegetation indicative of brackish and fresher water regimes, especially in areas immediately adjacent to and influenced by the fresher waterbody of Prime Hook Creek.

Prior to Impoundment Establishment

In 1963, the Service proposed a water management plan to the public, which outlined marsh management needs for the entire refuge, including Unit II. The plan was designed to impound refuge marshes without backing water against upland areas. Local residents expressed strong opposition to the proposal and the state Drainage Engineer felt that it had the potential to flood or waterlog contiguous agricultural lands which occurred at Bombay Hook NWR. A revised plan with inland canals to provide drainage of uplands was also strongly opposed. Subsequently, a "No Management" policy was adopted which enhanced the expansion of *Phragmites* on the Refuge's Prime Hook's Unit II and Unit III wetland complex from the early 1960s to 1980 (Fig. 1; USFWS 1982).

Figure 1. Condition of Refuge marsh near Fowler Beach in 1978, showing dense stand of *Phragmites*

Thus, Unit II had no water level management capabilities from the establishment of the refuge in 1963 to 1986. As a result of the altered hydrology in Unit II, only a narrow band of tidal marsh along the edge of the canal and around Oak Island remained. The dredging of Slaughter canal also contributed to *Phragmites* colonization, and by the 1980s, Unit II had reverted to a *Phragmites* jungle with dense stands covering 1,000 acres (Prime Hook's EA for Chemical Control of *Phragmites* and Proposed Marsh Rehabilitation 1983). This unit was essentially a tidal brackish wetland, although degraded and with restricted tidal flow, until the mid-1980s.

Similarly, *Phragmites* was first observed along Prime Hook Road in Unit III in the early 1950s and by 1965 it had spread south throughout the unit. Encouraged by drier conditions from mosquito ditching, draining, and excessive soil deposition, red maples were now growing along Prime Hook Creek, which was once a tidal emergent marsh. Just prior to Service acquisition, portions of the Unit III Prime Hook marshes were also managed by a system of water control structures and a pumping station in Unit III, which was owned by Island Farm Corporation and King Cole and designed by the Soil Conservation Service to provide water for cattle (USFWS 1982).

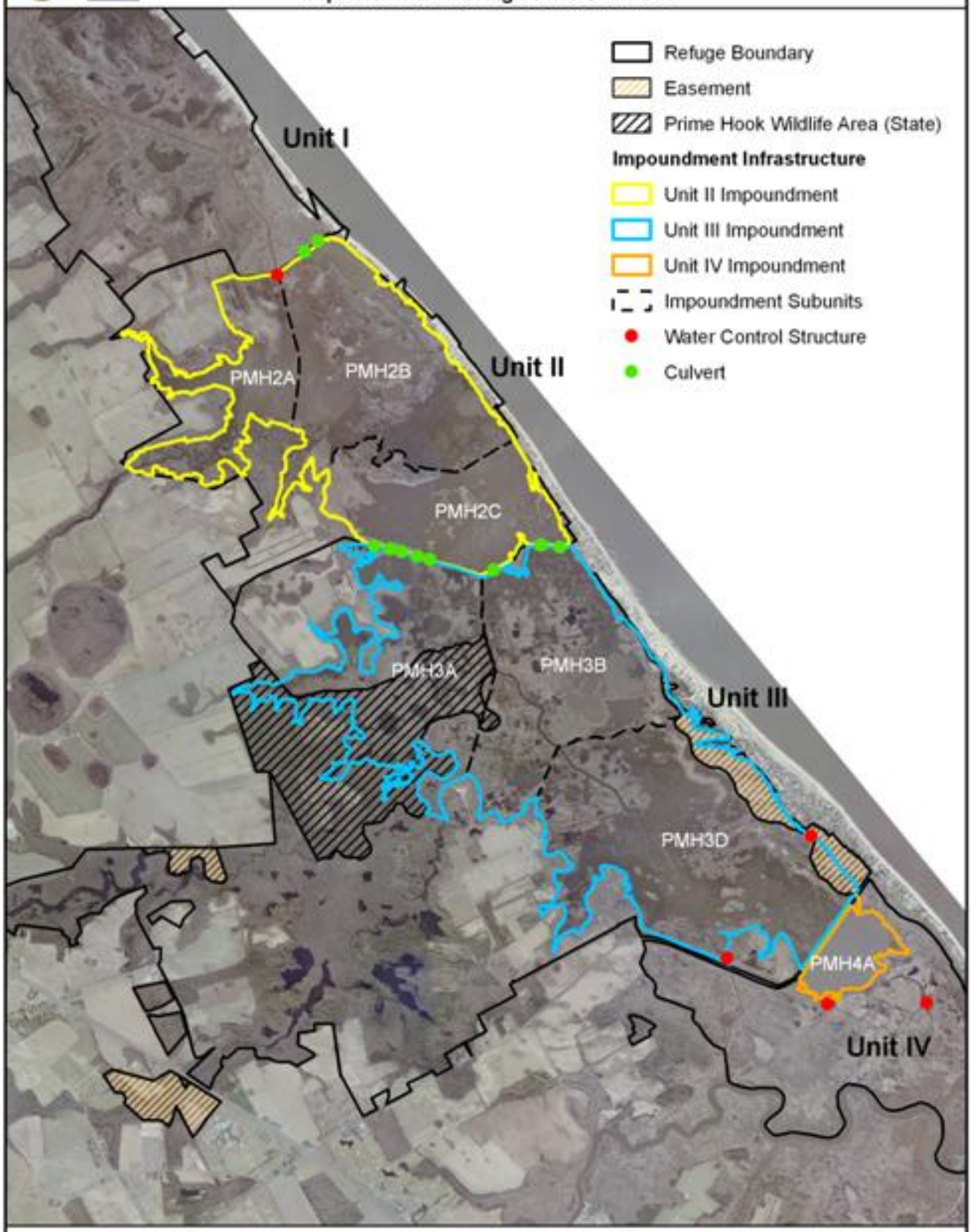
Between 1962 and 1968, all the outlets of Prime Hook Creek into the Delaware Bay were permanently blocked either by severe storms or by private landowner actions. In 1968, a developer of Broadkill Beach had the Broadkill Sound excavated 10.25 miles of ditches, located one mile south of the current Prime Hook Creek water control structure. This action increased the drainage of Unit III marshes, hastening their drying out and lowering of water tables. Severe droughts in 1977 and 1980 resulted in the complete desiccation of most potholes and water areas in the Unit III marsh. By 1984 much of Unit III reverted to a *Phragmites* jungle. In addition to the loss of high quality marsh habitats, extreme fire hazards created by dense stands of *Phragmites* threatened private property values adjacent to the refuge (USFWS 1982).

Freshwater Impoundment Management

In the 1980s, the Service impounded 200 acres of salt marsh in Unit IV (1981), and converted approximately 1,500 acres of salt marsh in Unit II (1986) and about 2,500 acres of salt marsh and transition marsh vegetation in Unit III (1984) into brackish and freshwater wetland plant communities (Map 3-1). At the time, the Service believed these impoundments were a cost-effective opportunity to provide a rare and biologically productive coastal wetland type, which was important to migratory waterbirds, by using natural topography and an existing road infrastructure to impound fresh water.

PRIME HOOK NATIONAL WILDLIFE REFUGE
Comprehensive Conservation Plan
Impoundment Management Overview

Map 3-1



Produced by Coastal Delaware NWR Complex, Milton, DE
Base Map: USGS 2007 Digital Orthophotography
Refuge Boundary & Data: USFWS
Map Projection: NAD_1983_UTM_Zone_18N
Map Date: 5/20/2011

Miles: 0, 0.5, 1, 2
Kilometers: 0, 0.5, 1, 2

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The key engineering features (e.g. roads and artificial drainage ditches) were already in place, although they had not been engineered explicitly for water management. Man-made ditches of Slaughter Canal and Petersfield Ditch served as the locations for two large water control structures, while Fowler Beach Road, Prime Hook Beach Road, and Broadkill Road formed functional dikes running from the mainland and across the salt marsh to what was, at the time, a single, continuous barrier island. Additional structures were constructed to establish the necessary water control in each unit.

In Unit IV, two concrete control structures with logs on the impoundment side and flap gates on the tidal side were installed in 1982 to impound this area known as. These structures were replaced in 2005 in order to maintain water level management capability in this unit. Since this retro-fitting of with individual stop-log flap gates, we have experienced many problems with this design and since 2006 have lost much of our capability to conduct the water level management manipulations of prior years.

In 1987, a large concrete water control structure was put into place on Slaughter Canal to establish water level management in Unit II. This water control structure is a concrete multi-bay water control structure with 11 separate bays. It spans 46 feet across the Slaughter Canal, and serves to impound 1,500 acres within Unit II with water management capability. Unit II restoration of water level management in 1988 significantly raised the water table of these marshes. Salt water intrusion from Unit I into Unit II was held in check by this structure and Fowler Beach Road. Prime Hook Road serves as a southern barrier. After water level management capability was established, salinities within this impoundment have ranged from zero to eight ppt year round, up until 2005. Coastline changes that began in 2006 in Unit I, and developed in 2008 and 2009 in Unit II, allowed more salt water to begin entering Unit II (see below).

An EA for the Rehabilitation Management and Maintenance of wetlands in Unit III was written in 1982 and by 1984, the management infrastructure to restore water level manipulation capability was installed by the Service. This infrastructure included a one mile dike east and west of the water control structure on Broadkill Beach Rd, which tied the uplands areas to the structure. The infrastructure also included the two large concrete structures; one spanning Petersfield Ditch (35 feet long with 8 bays) and the second spanning Prime Hook Creek (20 feet long with 5 bays). Salt water intrusion is held in check by two road barriers: Prime Hook Rd on the northern boundary of the unit and Broadkill Beach Rd on the southern boundary. From the 1990s to 2005, after impoundment infrastructure was established, salinities within this impoundment range from zero to five ppt. Since 2006, salinity values in the impoundment have ranged from 2 to 25 ppt. Unit II and Unit III are connected via culverts in Prime Hook Rd.

It is also interesting to note that from perspective of state wetland regulations, the Refuge's impounded marshes are still considered to be tidal salt marsh habitats by DNREC due to their historic development and origins, despite the fact that Prime Hook NWR's impoundments have been in place for over twenty-five years. It is DNREC's wetland policy that the refuge's impounded marshes will continue to be considered as tidal marshes for at least the next 100 years, regardless of current and future management.

Storm & Overwash Formation History

Notable storm-induced overwashes occurred on the refuge in 1982, 1988, and 1999. The dunes were artificially rebuilt in 1999. In 2006, Hurricane Ernesto caused a beach overwash just north of Fowler Beach Road in Unit I. On May 12, 2008, a Nor'easter brought flooding that overtopped or completely removed portions of the beach dunes extending from the Slaughter Beach Community to the Prime Hook Beach community. The overwash north of Fowler Beach Road has experienced overwash events in the past. For example, an overwash in nearly the exact same location was present in the 1930's (Fig. 2).

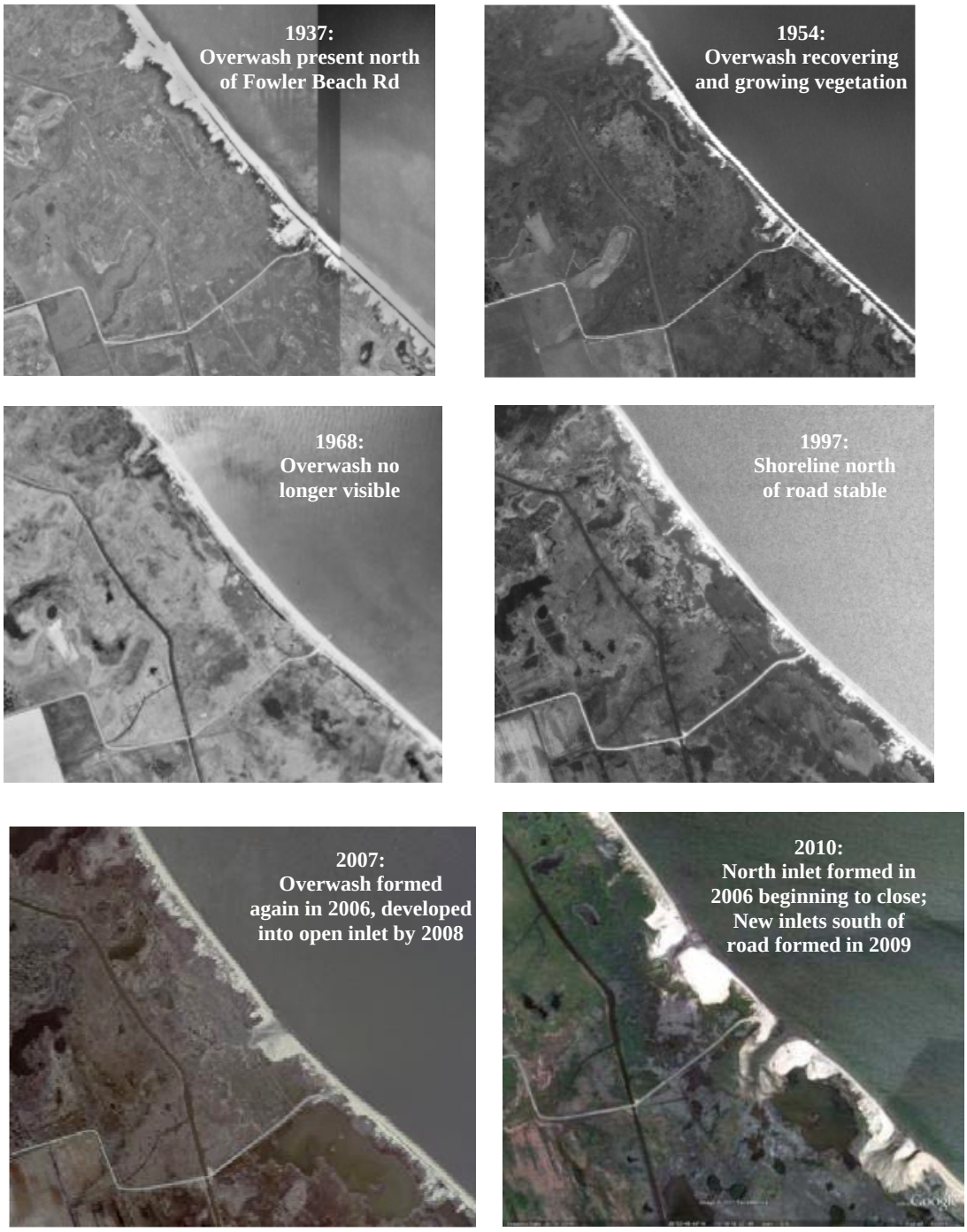
The beach immediately south of Fowler Beach Road has formed inlets during the past few years, as well. The impacted area south of Fowler Beach Road (Unit II) covers approximately 4,000 linear feet of beach, with 95% of the breaches on private lands or a mix of private and Refuge-owned lands. These inlets flood the managed freshwater impoundment in Unit II with saline bay water. The State DNREC enhanced the dunes in this area when the Unit II impoundment was established in 1988, and DNREC and/or FWS have reconstructed them on several occasions between 1988 and 2008, to prevent high tides from entering the freshwater impoundment from the Bay.

Large overwashes and inlets formed along the coast of Unit II in the fall of 2009. Unlike previous overwash events, these would require more substantial dune work to repair. In order to slow the sudden and rapid return of salt water into the Unit II impoundment and permit time for more careful restoration planning, the Service prepared an Environmental

Assessment in order to permit DNREC to repair the dune breaches one more time using on-site material. The EA was challenged by litigation (outside groups that wanted no action to take place), causing a further delay. The Service's position was upheld by the judge, and the work was permitted to proceed. However, in the intervening time, Hurricane Irene had removed a large amount of the on-site sand from the area. The work was conducted by DNREC with the remaining on-site material, but re-opened within several days.

Unit III has also been managed as a freshwater impoundment for the benefit of waterfowl. Although not directly impacted by overwashes and inlets as Unit II is, the two units share water exchange through culverts under Prime Hook Road. Increased salinity in Unit II will influence the salinity in Unit III, even as freshwater inputs reduce the salinity in at least the central portion of Unit III. Conditions in Unit III may lend themselves to the proliferation of *Phragmites*.

Figure 2. Historic Overwash Activity near Fowler Beach, showing portions of Units I and II. [Imagery from DNREC (1937, 1954, 1997), USGS (2007), USDA (2009), and Google Earth (2010)]



Management Challenges

The following physical, biological, and social factors complicate our understanding and response to the wetland management challenges precipitated by recent storm events. These factors will be presented and discussed in more detail during the meeting:

- Based on radiometric core analysis, accretion over the last ~50 years in the Unit II and Unit III impoundment has been the lowest in the state, estimated to have been about half the current rate of sea level rise.
- Current elevations within the impoundment are 7 or more inches below the preferred growth elevation range of *Spartina alterniflora.*
- In some places, the roads that serve as dike infrastructure for impoundment management are over a foot below MHHW in elevation, exacerbating flooding.
- The water control structures installed over 20 years ago for impoundment management are situated at a lower elevation than was prescribed during engineering, believed to be the result of a benchmark error (possibly some subsidence as well).
- Anecdotal observations of the wetland condition over recent months have noted some areas of salt marsh vegetation establishment, primarily *Spartina patens*, but also *S. alterniflora*, in scattered areas throughout Unit II where previously there was little or no *Spartina*.
- However, large areas throughout the impoundment that were vegetated wetland just last summer, and in some cases as recently as a couple months ago, have converted to open water.
- Prime Hook Road, which divides Units II (where two of the breaches are) and Unit III, serves as the only public access to and from a small beach community; Flooding over the road is more frequent than before the breaches, and residents feel strongly that it poses a danger to the community.
- Flooding at very high tides or during storms more frequently reaches the yards and into the homes of neighboring landowners; Similarly, adjacent farm land is flooded along its margins more frequently.
- Unit III experiences exchange of water with Unit II, through culverts in Prime Hook Rd, but is tidally-restricted and also experiences freshwater inputs. These conditions may create a *Phragmites* problem. In recent months, dramatic additional vegetation loss in Unit III has been observed.
- The refuge faces ecological uncertainty regarding how the impounded wetlands in Unit II will continue to respond to substantial daily tidal flow, given its physical condition after decades of salt water exclusion and poor accretion.
- A Refuge Comprehensive Conservation Plan (CCP), drafted as an Environmental Impact Statement (EIS), has been developed and is nearly ready for public release and comment; This CCP outlines options for future habitat management, including a return to impoundment management, active restoration of salt marsh, or passively permitting the system to respond in whatever manner is natural.
- Within the draft CCP, the Refuge proposes salt/brackish marsh restoration as its preferred alternative, recognizing that this will be a challenging task; Both small-scale and large-scale restoration strategies are considered, to be pursued as further evaluations determine to be appropriate and/or as necessary resources become available.
- Substantial additional modeling and planning would be required in order for any restoration to be successful. The funding for such planning would be substantial and is not yet secured. Discussions with a private firm capable of such modeling have been initiated, and a draft scope of work prepared for consideration.