Beneficial Use of Dredge Material
Section 1122 of the Water Resources Development Act of 2016
Pilot Project Proposal Form

## Title:

Grays Harbor South Jetty Sand Placement Pilot Project

## Applicant

Submitted by the Washington State Coastal Zone Management Program
Washington State Department of Ecology – DUNS: 7813478280000

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## Project Partners

City of Westport
U.S. Army Corps of Engineers
Washington State Parks and Recreation Commission
Washington State Department of Fish and Wildlife
Washington State Department of Natural Resources

This project proposes to restore the eroded beach profile and primary dune along the shoreline south of the Grays Harbor South Jetty spanning the jurisdiction of two State Parks and the City of Westport. This project is critical to supporting the needs of the local government and public interests in addressing chronic coastal erosion hazards that are affecting local, state, and federal infrastructure at the entrance to Grays Harbor, while protecting coastal ecosystem habitats. Furthermore, this pilot will provide an important learning opportunity to compare the benefits of frequent nearshore sediment placement methods verses a comparable scale onshore placement of dredge material.

## Background

Grays Harbor is located on the Southwest Washington coast, about 45 miles north of the Columbia River and 110 miles south of the entrance to the Strait of Juan de Fuca. Grays Harbor is 15 miles long and 11 miles wide. The harbor broadens gradually from the Chehalis River at the City of Aberdeen to a large, pear-shaped, shallow estuary encompassing North and South Bays. On the ocean side, two long spits enclose the estuary, Point Brown on the north and Point Chehalis on the south. Two federally maintained rubble mound jetties, extend seaward from the sand spits at Point Chehalis and Point Brown, respectively. A federally maintained deep-draft navigation channel extends 27.5 miles from the Bar, through the Grays Harbor estuary, and terminating on the Chehalis River in Cosmopolis, WA (Figure 1). Each year the U.S. Army Corps of Engineers (USACE) dredges approximately 2.5 million cubic yards (CY) of dredged material from the federal channel to provide safe and reliable navigation to Grays Harbor.

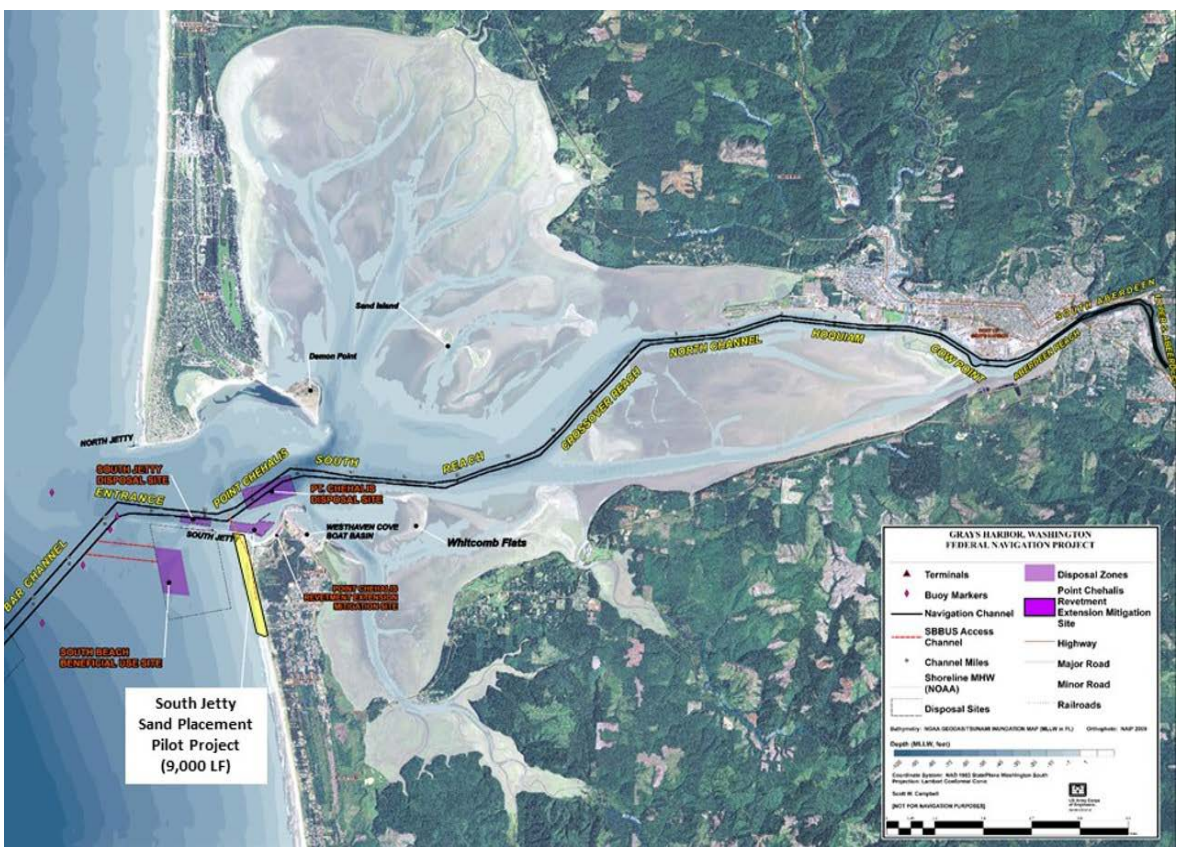


*Figure 1: Grays Harbor Channel and Proposed Grays Harbor South Jetty Sand Placement Pilot Project Area*

Grays Harbor is located within the Columbia River littoral cell which extends over 100 miles of shoreline between two rock headlands: Tillamook Head in Northwest Oregon and Point Grenville in Southwest Washington. The majority of sediments within the littoral cell derive from the Columbia River. The net direction of longshore (littoral) transport in the cell is from south to north. Construction of the jetties at the Mouth of the Columbia River and at Grays Harbor near the turn of the 20th century significantly changed littoral transport patterns within the Columbia River littoral cell. At Grays Harbor, jetty construction resulted in inlet narrowing and deepening to sustain safe and reliable navigation into the harbor. As the inlet was constricted, sediments from the mouth of the inlet were scoured and transported offshore, resulting in an offshore migration of the ebb tidal delta and massive accretion of the shorelines flanking the jetties. Subsequently, the physical barrier of the South Jetty and the migration of the ebb tidal delta offshore, disconnected the shoal on the updrift (southern) side of the inlet to the ebb tidal delta and altered the process which historically bypassed sediment across the inlet. As a result, the sediment exchange across adjacent shorelines within the littoral cell diminished (Kaminsky et al., 2010). Construction of the north and south jetties from 1898 to 1916 resulted in over 30 feet (~10 m) of scour in portions of the entrance channel between the jetties (erosion denoted by hot colors) as the entrance was confined (Figure 2). From 1954 to 1999 the prior accretion to the South Beach nearshore began to chronically erode[1].

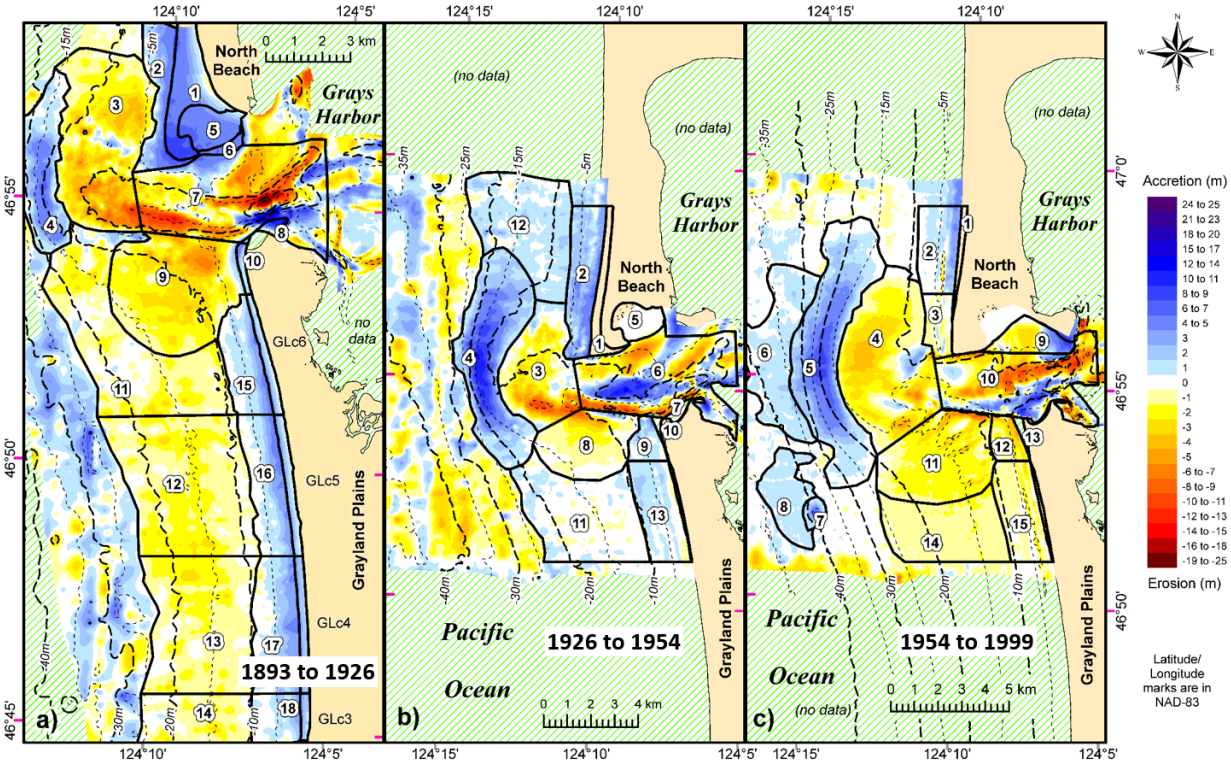


*Figure 2: Grays Harbor bathymetric changes from 1893 to 1999 (from Kaminsky et al., 2010)*

Associated with the nearshore erosion, the shoreline within about 1.5 miles of the Grays Harbor South Jetty has been chronically eroding in recent decades, in part associated with jetty deterioration (Buijsman et al., 2003). Shoreline erosion along both Half Moon Bay and South Beach narrowed the neck of land remaining connected to the South Jetty. To help mitigate the erosion, the USACE placed

[1] A more in-depth historical chronology of coastal construction, erosion, and mitigation along the Grays Harbor County shoreline is provided in Attachment A.

200,000 CY of dredged sand in the form of a submerged nearshore berm in Half Moon Bay in May 1992 and 373,000 CY of dredged sand in the South Beach nearshore in the fall of 1993 (Osborne et al., 2003). This was the beginning of a long term commitment to the beneficial use of dredged material at Gray Harbor (Table 1).

*Table 1. History of Beach and Nearshore Nourishment in Grays Harbor County*

| Year | Nearshore Sites | | Beach Sites | | | | Description of beach nourishment |
|---|---|---|---|---|---|---|---|
| | South Beach (cy) | Half Moon Bay (cy) | Breach Fill (cy) | Half Moon Bay (cy) | Westport (cy) | Ocean Shores (cy) | |
| 1992 | | 200,000 | | | | | |
| 1993 | 373,000 | | | | | | |
| 1994 | 265,000 | 146,000 | 600,000 | | | | 600,000 cy sand to fill the breach |
| 1995 | | | | 300,295 | 82,000 | | 300,295 cy sand south of revetment; 82,000 cy sand at City outfall |
| 1996 | | 274,780 | | | | | |
| 1997 | | 308,604 | | 5,000 | | | 5,000 cy sand at HMB shoreline berm south of revetment |
| 1998 | | 421,468 | | | | | |
| 1999 | 76,187 | 228,470 | | 228,963 | | | 228,963 cy sand at revetment extension beach fill |
| 2000 | | | 11,600 | | | | 11, 600 cy of 12" minus cobble and gravel along HMB Breach Fill |
| 2001 | | | 16,100 | | | | 16,100 cy of 12" minus cobble and gravel along HMB Breach Fill |
| 2002 | 75,219 | 378,441 | 135,000 | | | | 135,000 cy sand at HMB |
| 2003 | 125,388 | 329,106 | | | 1,700 | | 1,700 cy sand at HMB beach along dune trail |
| 2004 | 262,176 | 289,652 | 29,553 | | | | 29,553 cy sand at HMB Breach Fill |
| 2005 | 217,909 | 102,184 | 22,779 | | | | 22,779 cy sand at SB at Breach Fill |
| 2006 | 55,170 | 126,892 | | | | | |
| 2007 | | 140,406 | | | | | |
| 2008 | | 171,353 | | | | | |
| 2009 | 214,502 | 144,975 | | | | | |
| 2010 | 118,182 | 91,720 | 30,000 | | | | 10,000 cy sand at HMB Breach Fill; 20,000 cy sand at SB Breach Fill |
| 2011 | 298,251 | 177,150 | | | | | |
| 2012 | 142,313 | 111,205 | 30,000 | | | | 30,000 cy sand from upland source to Breach Fill |
| 2013 | 477,637 | 86,147 | | | | | |
| 2014 | 498,440 | | | | | | |
| 2015 | 506,330 | | | | | 3,350 | 1,600 cy of sand + 1,750 cy of sand placed in front of geotubes |
| 2016 | 544,980 | | | | 1,000 | | 1,000 cy of sand placed on South Beach dune by WBTS HOA |
| 2017 | 499,001 | 101,019 | | | 650 | | 650 cy of sand placed on South Beach dune by WBTS HOA |
| **Sum** | **4,749,685** | **3,829,572** | **875,032** | **534,258** | **85,350** | **3,350** | |
| | **Total Nearshore** | | **Total Beach** | | | | **Total Nourishment** |
| | **8,579,257** | | **1,497,990** | | | | **10,077,247** |

In December 1993, a storm with only a 2-year return period initiated a breach along the south side of the South Jetty between the ocean and Half Moon Bay, which deepened and widened from only about 13 ft, initially, to about 650 ft in the subsequent months, eroding a portion of Westhaven State Park and posing a threat to City of Westport public facilities, including the municipal water well and wastewater treatment plant (Kaminsky et al., 1997; Arden, 2003; Buijsman et al., 2003; Kraus and Wamsley, 2003; Wamsley et al., 2006). In May 1994, the USACE nourished both the Half Moon Bay berm with an additional 146,000 CY of dredged sand and the South Beach nearshore with 265,000 CY of dredged sand before subsequently closing the breach in the fall of 1994 by filling it with 600,000 CY of sand dredged from the Federal navigation channel at a cost of $3,730,000 (approximately $6.22 per CY) (Arden, 2003; Kraus and Wamsley, 2003; Osborne et al., 2003) (Figure 3). Photo set of South Jetty breach area. The breach fill was renourished in 2002, 2004, 2005, 2010, and 2012 (Tables 1 and 2) to prevent breaching. Since, 1994 the Corps has utilized nearshore placement of dredged material and direct beach and dune

nourishment to mitigate the erosive trends and reduce the risk of long-term impacts to the navigation channel.

*Table 2. Grays Harbor South Jetty Reconstruction and South Beach Erosion and Mitigation 1993-2017*

| Period | Event |
|---|---|
| Dec 1993 | A breach occurred between the ocean and Half Moon Bay adjacent to the South Jetty, threatening Westport's municipal water well and wastewater treatment plant. |
| Fall 1994 | The USACE fills the South Jetty breach with 600,000 cy of sand dredged from the navigation channel, at a cost of approximately $8 million. |
| Jan 1995 | The City of Westport places 82,000 cy of sand and armor rock to protect the sewer outfall line. |
| Jul 1995 | The USACE relocates 150,000 cy of breach fill material from Half Moon Bay shoreline to South Beach. |
| Mar 1999 | A storm lowers a 200-ft. section of the South Jetty to about +9 ft. MLLW and damages the jetty where it intersects the shoreline. |
| Sep 1999-May 2002 | The USACE reconstructs a 3,500-ft. section of the South Jetty seaward of the high-water shoreline (Sta. 87+00 to 120+00) to an elevation of +23 ft. MLLW. |
| Dec 1999-Feb 2000 | The USACE constructs wave diffraction mound at landward end of south jetty to reduce wave-induced erosion of Half Moon Bay, and constructs a cobble transition beach with 11,600 cy (17,358 tons) of 12-inch minus cobble and gravel to slow Half Moon Bay beach erosion directly adjacent to the jetty. |
| Winter 2001-2002 | A series of storms erodes South Beach, overtops the breach fill and temporary truck haul road across the breach fill to the South Jetty, and damages the truck haul road across breach fill to the South Jetty. |
| Dec 2001-Jan 2002 | The USACE places an additional 16,100 cy of 12-inch minus cobble and gravel along the breach fill portion of the Half Moon Bay shoreline to slow the erosion. |
| Apr-May 2002 | The USACE excavates 135,000 cy of sand from Point Chehalis Revetment Extension Mitigation site and places it by truck haul over 8 acres at the breach fill in the form of a natural dune with a top elevation of +36 ft. MLLW at a cost of $519,750. USACE nourishes the South Beach nearshore with 75,219 cy of sand. |
| Nov 2002 | The USACE plants 50,000 sprigs of native American dune grass (Elymus mollis) on 3 acres of the breach fill to prevent wind and rain erosion of the restored area. |
| 2003 | The USACE nourishes the Half Moon Bay nearshore with 329,106 cy of sand and the South Beach nearshore with 125,388 cy of sand. |
| Feb 2004 | The USACE excavates 29,553 cy of sand from the revetment stockpile and places it at the breach fill. |
| 2004 | The USACE nourishes the South Beach nearshore with 262,176 cy of sand. |
| Dec 2004 | The USACE excavates 22,779 cy of sand from the revetment stockpile and places it at the breach fill. |
| 2005 | The USACE nourishes the South Beach nearshore with 217,909 cy of sand. |
| 2006 | The USACE nourishes the South Beach nearshore with 55,170 cy of sand. |
| 2009 | The USACE nourishes the South Beach nearshore with 214,502 cy of sand. |
| 2010 | The USACE nourishes the South Beach nearshore with 118,182 cy of sand. |
| Oct 2010 | The USACE places 20,000 cy sand on the South Beach shoreline and 10,000 cy sand on the Half Moon Bay shoreline as an interim measure to reduce the potential for a breach to occur. |
| 2011 | The USACE nourishes the South Beach nearshore with 298,251 cy of sand. |
| 2012 | The USACE places 30,000 cy of sand from an upland source to the breach fill. The USACE nourishes the South Beach nearshore with 142,313 cy of sand. |
| 2013 | The USACE nourishes the South Beach nearshore with 477,637 cy of sand. |
| 2014 | The USACE nourishes the South Beach nearshore with 498,440 cy of sand. |
| 2015 | The USACE nourishes the South Beach nearshore with 506,330 cy of sand. |
| Feb 2016 | The Westport by the Sea Homeowners Association (WBTS HOA) repairs the eroded dune with coir fabric, 1,000 cy of sand fill, and anchored logs in front of Building 8 condominium. |
| 2016 | The USACE nourishes the South Beach nearshore with 544,980 cy of sand. WBTS HOA adds 1,000 cy of sand on the eroded South Beach dune. |
| 2017 | The USACE nourishes the South Beach nearshore with 499,001 cy of sand. WBTS HOA adds a total of 650 cy of sand fill during two repairs of the eroded South Beach dune in March and November. |

The shoreline breach was a catalyst for focusing attention on the need for better information on regional coastal processes. In the fall of 1994, the Washington Department of Ecology convened a series of meetings with local, state, and federal agencies to determine how to develop this information; the meetings resulted in a cooperative study to investigate the natural hazards, coastal changes, and sediment dynamics along the southwest Washington coast (Kaminsky and Gelfenbaum, 1999).
Table 2. Grays Harbor South Jetty Reconstruction and South Beach Erosion and Mitigation 1993-2017

A beach monitoring program was initiated in 1996, and since that time through the present, beach profiles have been collected quarterly, beach surface maps have been collected twice per year (summer and winter) and nearshore bathymetry profiles have been collected every summer (Ruggiero et al., 2005). At the site of the proposed Grays Harbor South Jetty Sand Placement Pilot Project, there are two beach profiles, a surface map, and seventeen nearshore bathymetry profiles[2]. Additional beach and nearshore profiles and a surface map area are located to the south of the project site.

By the late 1990s, it was evident that the shoreline and nearshore area south of the South Jetty was undergoing chronic erosion and that any new breaching would likely be caused by erosion and dune recession from the ocean side (Hughes and Cohen, 2006). Between 1954 and 1999, the nearshore area within 3.7 miles south the South Jetty lost 70.5 million CY of sediment (1.57 million CY/yr) (Kaminsky et al., 2010). From 2002 onward, the USACE continued nearly annual nearshore nourishment of both South Beach and Half Moon Bay (Table 1). The 3,500-ft reconstruction of the South Jetty between 1999 and 2002 did not reduce the nearshore erosion or the rate of shoreline recession. Figure 3 illustrates the shoreline retreat near the South Jetty. From 2009 to 2012, the average annual nearshore nourishment to South Beach was about 193,000 CY/yr. This amount was substantially increased to an average of about 505,000 CY/yr between 2013 and 2017.

There have been a number of efforts to address coastal erosion in Grays Harbor since the December 1993 shoreline breach at the Grays Harbor South Jetty. During the strong El Niño during the winter of 2015-2016, the last remnant of the primary dune at the south end of Westport Light State Park, just north of the Westport by the Sea Condominiums was lost. The dune had been chronically eroding since 1997 at an average rate of 7.2 ft/yr as documented by quarterly beach surveys collected by the Washington Coastal Zone Management Program Coastal Monitoring & Analysis Program at nearby beach profile “Worm” (Figure 4). The erosion threatened the Westport by the Sea Condominiums and in February 2016, the Homeowners Association repaired the eroded dune with coir fabric, sand fill, and anchored logs. This site was repaired again in March 2017 and November 2017 with added sand and coir fabric.

[2] Starting in March 2016, three additional beach profiles were added, and in June 2016, this was increased to six additional beach profiles which are surveyed seasonally within the project site. In addition to the cross-shore profiles, the top and bottom of the erosion scarp are walked to capture its position in time and track its retreat.

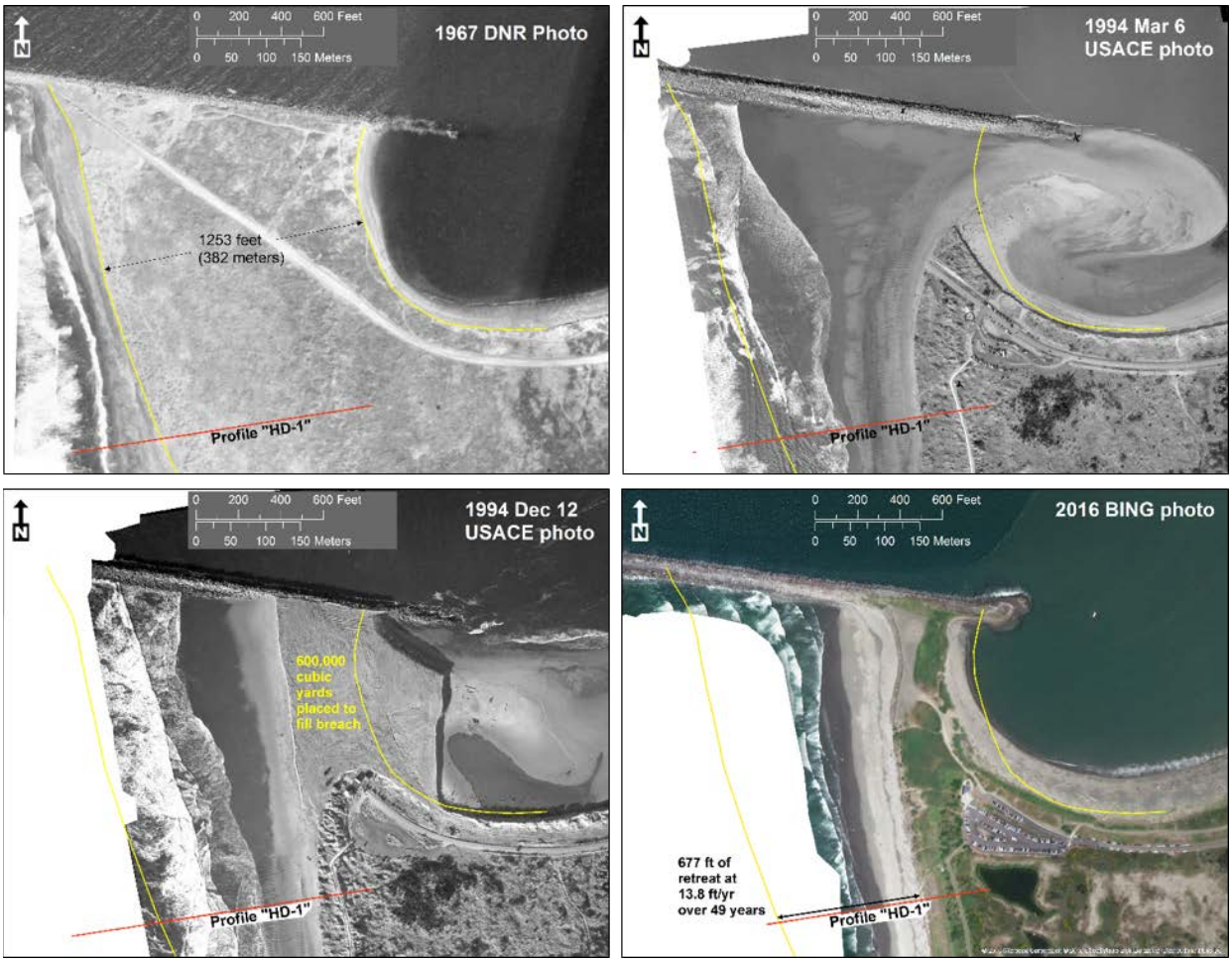


*Figure 3: Grays Harbor South Jetty Breach History and Shoreline Change*

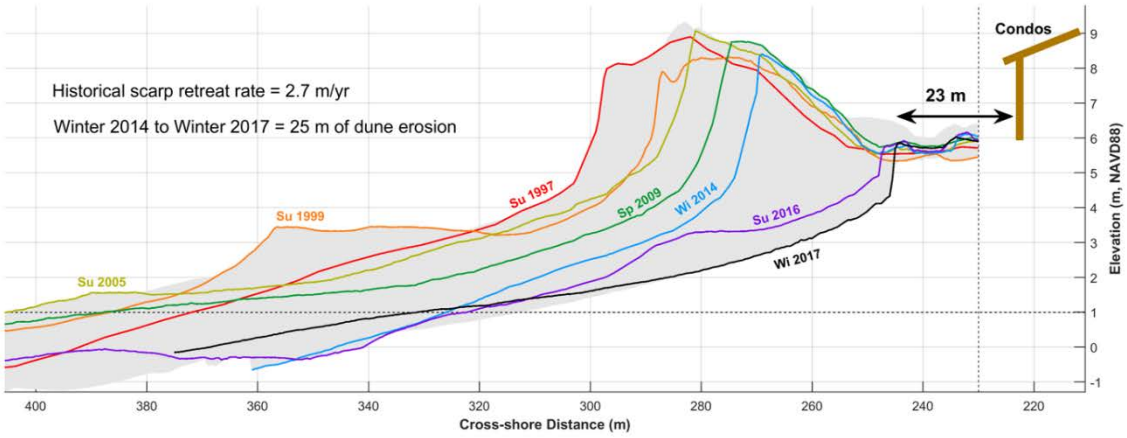


*Figure 4: Grays Harbor South Beach Change at Profile "Worm"*

In January 2016, an alliance of local, tribal, state and federal partners (including the USACE) formed the Grays Harbor Resilience Coalition (GHRC) to address both immediate and future natural hazards through collaborative research, planning, and investment in capital projects (Grays Harbor Resilience Coalition Project Report, 2017).[3] The effort was spearheaded by the Cities of Ocean Shores and Westport, with support from the Washington Coastal Zone Management Program and U.S. Rep. Derek Kilmer. The strong GHRC alliance created the potential for catalyzing meaningful action. Formed to help strengthen requests for assistance in Grays Harbor County by establishing a unified voice among several partners, the collation set the groundwork so separate jurisdictions could work together to establish county-wide priorities and support one another in legislative requests.

With the additional support of state Rep. Steve Tharinger, the Washington Legislature included $200,000 in the state's 2016-17 supplemental capital budget to support the GHRC effort. Ecology received an additional $25,000 from FEMA to support GHRC projects. The GHRC used the $225,000 to:

1. Collect data, create maps, and conduct an initial technical analysis of up to five potential project sites.
2. Convene the GHRC to develop, evaluate and prioritize a list of resilience projects and create a capital budget request for one or more projects for the state 2017-19 biennial budget.

[3] Grays Harbor Resilience Coalition Project Report. 2017. Washington State Department of Ecology, Publication Number 17-06-018: https://fortress.wa.gov/ecy/publications/SummaryPages/1706018.html

In response, the Washington Department of Ecology Coastal Monitoring & Analysis Program (CMAP) performed augmented monitoring at chronically eroding beaches at Westport beginning in March 2016. This enabled a more detailed analysis of the amount of sand being lost to the beaches and dunes. At Westport between the South Jetty and 2.1 miles south of the jetty at profile "Spice", the average loss of sand is 63,100 CY/yr. A dune erosion scarp extends to about 3.1 miles south of the South Jetty. The erosion threatens the loss of State Park property as well as houses and condominiums along the beach. Erosion may also impact habitat for Dungeness crab, razor clam, and surf smelt (Shipman et al., 2014).

The South Beach shoreline along Westport and Cohassett Beach are experiencing a sediment deficit that is not likely to be augmented by natural processes. The South Jetty induces offshore transport of sand that is carried northward by energetic winter waves approaching from the southwest, while blocking the southward onshore transport of sand by milder summer waves approaching from the northwest.

The beneficial use of dredged material to increase the supply of sand to the nearshore and beaches are imperative to reducing the rate of chronic coastal erosion, but even with current amount of investment in nearshore nourishment, the South Beach shoreline along Westport and Cohassett Beach continues to experience a sediment deficit. The loss of the primary dune fronting existing development on relatively low interdunal areas implies an urgency for large scale sand placement for dune restoration to retain sufficient buffer against large storms with elevated water levels. Without the augmentation of the sediment budget to this area, the shoreline is expected to continue to retreat in the future.

After careful analysis and collective deliberation, the GHRC agreed to: prioritize the rehabilitation of the Grays Harbor North Jetty in the City of Ocean Shores; and pursue cost sharing for a Grays Harbor South Jetty sand placement pilot project in partnership with USACE. These projects were identified as essential components toward a long-term solution to the chronic coastal erosion hazards, designed to address the root causes of the respective problems – providing long-term protection with minimal negative impacts. Both projects were submitted for the Washington State Capital Budget, but neither received funding in the 2017-2019 biennial budget.

## Project Description

Every year, approximately 2.5 million CY of sand is dredged from Grays Harbor to keep the federal navigation channel open. Large investments have been made in this area to make beneficial use of dredged sand. Approximately half of that sand is placed in estuarine dispersive disposal sites. The remaining half is disposed in two shallower beneficial use sites, allowing some (though not all) of the sand to stay in the nearshore system.

This project proposes to place 250,000 CY of dredged material obtained from the Grays Harbor Federal Navigation Channel to restore the eroded beach profile and primary dune along the shoreline south of the Grays Harbor South Jetty. The project will span the jurisdiction of two State Parks and the City of Westport - 9,000 LF southward from the South Jetty (Figure 1 and 5). This region is most immediately and critically threatened by erosion (see Figures 8-2 and 8-3 in Attachment A). The volume is based on 80-feet average width restoration and a minimum of 25 CY per square width. The restored dune crest elevation would be between 22-24 feet in elevation. Much of the adjacent land is within the jurisdiction of Washington State Parks and Recreation Commission, with a southern portion within the City of Westport's corporate limits. The beach is designated as a state highway patrolled by state park rangers.

*Figure 5: Proposed Grays Harbor South Jetty Sand Placement Pilot Project Area, with the location of two long-term beach profile locations shown for reference*

The sand will be pumped directly south of the Grays Harbor South Jetty at Westhaven and Westport Light State Parks using a hydraulic dredge (hopper or cutterhead) and a pipeline onto the eroded beach-berm areas to be restored. The dredge will be stationed in the federal navigation channel north of South Jetty. A slurry of dredged material and water will be pumped up to 1.7 miles through the pipeline onto the beach. The Washing Coastal Zone Management Program will conduct physical and biological monitoring during and after the project to fully determine beneficial sand placement according to approved plans and restoration plantings.

## Purpose & Benefits

The proposed project is a result of a 2-year collaborative planning process and supports the needs of the local government and public interests[4]. The purpose of this restoration project is reduce impacts of chronic coastal erosion to Federal, State, and local infrastructure and enhance public beach access, recreation, safety; while protecting, restoring, and creating aquatic ecosystem habitats.

In addition to the many local benefits (detailed in sections below), this project is a perfect pilot opportunity because of amount of technical work that has already been conducted in this area. The many efforts USACE and State provide an essential baseline of information to:

- Compare the effectiveness of frequent nearshore sediment placement methods verses a comparable scale direct onshore placement of dredge material;
- Develop a better understanding of the true costs beach nourishment practices; and
- Build on the understanding of coastal processes and the sediment budget, and better estimate the long-term maintenance requirements and coastal management options associated with the sediment deficit.

Furthermore, the Washington Coastal Zone Management Program is a valuable partner for this USACE pilot program because of our established partnerships with local communities and the federal government. This unique role allows us to be effective in the transfer of knowledge to ongoing beneficial use projects (i.e., Mouth of the Columbia River) and helping to guide other communities across the state who are interested in pursuing similar efforts. Leveraging our national partnerships, we can also present project results at interagency workgroups, and other forums (e.g., national and regional NOAA Coastal Zone Management Program Managers meetings, Coastal State Organization meetings, etc.)

***Reducing storm damage to property and infrastructure***

The probability for frequent impact from coastal erosion in the identified coastal erosion areas (Figures 8-2 and 8-3 in Attachment A) areas is highly likely, whereas less frequent and higher intensity events may impact a larger geographic extent. This erosion hazard area has had significant incidents that required emergency measures and resources to be taken by the local government and USACE to protect property and public infrastructure.

Along the erosion scarp in the City of Westport, a sanitary sewer pump station is currently under threat of inundation if erosion continues unabated. Damage to the pump station would affect $50 million of assessed value within the city– about 25 percent of Westport's assessed value and 20 percent of the city's water and sewer utilities' revenue. The West-by-the-Sea Condominiums represent a total

[4]Grays Harbor Resilience Coalition Project Report: https://fortress.wa.gov/ecy/publications/SummaryPages/1706018.html

assessed value of $30,000,000 – approximately $540,000 tax revenues to the City and County for schools, hospitals, and other public benefits.

Additionally, access to major roads is crucial to life-safety after a disaster event and to response and recovery operations, though smaller erosion events can cause disruption as well. Erosion debris can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems and delays for public and private transportation. This can result in economic losses for businesses.

The nourishment material would augment the historic breach area adjacent to the South Jetty and reduce O&M costs associated with beach and dune erosion. The USACE has performed dune nourishment to the breach fill area in 2002, 2004, 2005, 2010, and 2012 to reduce the risk of second breach from forming and impacting the reliability of the navigation channel.

When constructed, Westport By-the-Sea condominiums were beyond 200 ft. landward of Ordinary High Water Mark, but the erosion is now within 30 ft. of their doorstep. Flooding, storm surge, and large debris continue to threaten this community. Condo owners have pursued efforts to protect their homes with soft approaches that promote public access, recreation, and tourism. A series of three projects to date have cost over $96,000 for short-term protection and public access restoration using sand placement, dune plantings, anchored logs, and sand fencing, but only have a life of 1-2 years. The owners do not have the funds to continue this approach and are left with limited remaining options.

***Promoting public safety***

Despite significant nearshore nourishment of sand from the USACE, every year more than 63,000 CY of sediment erodes from Westport beaches and dunes, threatening loss of State Park property as well as houses and condominiums along the beach. Certain areas in the erosion hazard area have retreated to within 30 ft. of community assets. A large scale project to restore the eroded coastal beach berm along the proposed stretch of shoreline is essential to protecting public safety. While erosion is generally a slow moving, chronic stressor on a community, during storm events, high rates of shoreline retreat can occur, also causing damage from associated flooding and the transport of drift logs and other debris. Wave overtopping of coastal structures, dune blowouts, and infragravity “sneaker” waves can cause can cause high velocity flows over inland areas thought to be safe by unsuspecting observers. The wave climate of the Pacific Northwest is one of the most severe in the world and the mobility of the fine Columbia River sand that make up the beaches of southwest Washington result in relatively large seasonal morphology changes and long-term regional changes from sediment imbalances that may not be realized until the shoreline is within close proximity to human use areas that have been commonly viewed as stable and secure from the coastal hazards.

***Protecting, restoring, and creating aquatic ecosystem habitats***

The restoration of the eroded beach and dune will provide critically needed sand important to the benthic habitat of Dungeness crab, razor clam, and forage fish. During winter conditions, patches of gravel often appear across the lower beach face as a result of the winnowing of sand and the exposure of coarser lag material (Figure 5). This is indicative of the erosion of a relatively thin veneer of Columbia River sand above relict gravels and coarse sediment that originated from the Chehalis River Basin at the upper Grays Harbor Estuary. Ruggiero et al. (2005) shows that the beach near the Grays Harbor South Jetty is composed of the coarsest sediment on any of the beaches in the Columbia River littoral cell.

While the mid-beach sediments throughout the littoral cell show a mean grain size of 0.18 mm, the mean grain size of the along South Beach ranges from 0.60 and 0.71 mm. The coarse sand, granules, and gravel that contribute to this relatively coarse sandy beach have been transported onshore from the mid- to lower shoreface.

Side-scan sonar data, multibeam backscatter data and surface sediment samples on the northern Grayland Plains (South Beach) mid-shoreface reveal gravel patches and rippled scour depressions (Twichell and Cross, 2001; Ferrini and Flood, 2005). Sediment grain-size analysis indicates the gravel patches contain well-rounded pebbles of mostly 2–20 mm in diameter, and bottom photographs show that they are mostly free of shell debris (Twichell et al., 2000). Most of the gravel patches have abrupt boundaries with veneers of rippled fine sand, indicated by areas of low backscatter on the side-scan sonar imagery. The rippled scour depressions contain coarse, poorly sorted sands and gravels (Gelfenbaum et al., 2000) and are generally viewed as migratory. The chronic erosion of the South Beach nearshore exposes relict gravel across the shoreface profile and reworks this material onshore.

The beach nourishment will also enhance shorebird habitat, including listed species such as Western Snowy Plover, which has critical habitat located at Midway Beach just south of placement area.

In addition, this project will avoid the need for alternative protective measures that are currently being developed by private land owners. Certain types of response to shoreline erosion (i.e., hard armoring) could have adverse consequence and lasting impacts on the coast, including:

- Extending erosion to properties further along the shoreline and blocking onshore sources of sediment necessary for resupplying and maintaining a useable beach.
- Obstructing public access to and along the shoreline, which is to result in tourism losses, critical to our coastal economies.
- Degrading habitat and harming plant and animal species listed under the Endangered Species Act (ESA) as well as reducing natural on-shore vegetation and increasing nearshore wave energy.

*Figure 5. Photo showing gravel on lower beach face fronting eroded dune along South Beach.*

***Stabilizing coastal systems and enhancing shorelines for recreation***
This project provides a demonstration of the value of using soft engineering techniques to: counter chronic erosion; protect public resources; reduce the imminent threat to infrastructure and private property; alleviate the need for shoreline armoring; and enhance public access, recreation and safety for visitors and residents. Currently the public beach and primary dune along the State Parks are degraded, with limited access in some areas because of steep vertical erosion scarp. South Beach is among the most popular surfing beaches in Washington State with Westhaven State Park being the primary access point. Makeshift trails cut through the dune along the breach fill and at the southern end of Westport Light State Park, which leads to a weakened dune face and accelerated gullying and blowouts that threaten the breach fill, maintained public access points, the lighthouse trail, and the neighboring Westport-by-the Sea Condominiums. In addition, the steep and high erosion scarp along the State Parks is a public safety hazard: pedestrians can fall on their way down to the beach and can also have trouble escaping from infragravity "sneaker" waves once they are on the beach. The nourishment will recreate a more dynamically stable environment that can be managed in a way that is preserves the natural character of the southwest Washington coast and enhances the public benefit and economic wellbeing of Westport and the Cohassett Beach community.

***Supporting risk management adaptation strategies***
As mentioned above, this project was identified and scoped as part of the Grays Harbor Resilience Coalition (GHRC) to address both immediate and future natural hazards through collaborative research, planning, and investment in capital projects. [5] This project would directly contribute to risk reduction measures identified in the Governor's Resilient Washington Subcabinet[6] and the newly updated State Enhanced Hazard Mitigation Plan (FEMA approval anticipated June 2018).[7]

## Leveraging Opportunities

There is an opportunity to leverage upcoming regional hopper dredging contracts to reduce coastal storm damage risk to the City of Westport's coast as well as along the Southwest Washington Coast. During the past 20 years, hydraulic dredges have been utilized to pump sand onto the beach in Ilwaco, Tokeland and Westport by the USACE. The Benson Beach demonstration project, completed in 2010, serves as an example of a State and Federal partnership to beneficially utilize operations and maintenance dredge material in the nearshore. Potential upcoming federal beach nourishment projects include re-nourishment of the Shoalwater sand dune project in Willapa Bay in June 2018 and the Grays Harbor South Jetty Breach Fill area as early as April 2020. The regional hopper dredging contract shares dredging capacity between Seattle, Portland, and San Francisco Districts in order to minimize mobilization/demobilization costs to a single project. Projects on the Lower Columbia River, The Mouth of the Columbia River, and San Francisco Bay have been identified as other projects with a need for direct hopper placement in 2019/2020.

Existing nearshore beneficial use sites have been used to place sand dredged from the federal navigation channel in since 1992. The South Beach Beneficial Use Site is adjacent to the recent within one-half nautical mile of Westport Light State Park. This site has been effective at supplying sediment to the nearshore region but has limited effect of supplying sediment directly to the beach where public

[5] Grays Harbor Resilience Coalition Project Report. 2017. Washington State Department of Ecology, Publication Number 17-06-018: https://fortress.wa.gov/ecy/publications/SummaryPages/1706018.html
[6] Resilient Washington Subcabinet Report: Finds and Recommendations. 2017. Washington State Emergency Management Division: https://www.mil.wa.gov/emergency-management-division/resilient-washington-subcabinet
[7] Washington State Enhanced Mitigation Plan. 2014. Washington State Emergency Management Division: https://mil.wa.gov/other-links/enhanced-hazard-mitigation-plan

infrastructure is located. Supplementing this area with direct beach nourishment would have immediate effect for reducing coastal storm damage to the State Parks and the local community.

## Compliance with Appropriate Environment and Regulatory Requirements

In addition, we conducted an initial feasibility discussion on compliance with appropriate federal, state, and local environmental and regulatory requirements. The area habitat biologist from Washington Department of Fish and Wildlife and the Planner for the City of Westport indicate that the project is consistent with State and Local regulations, specifically the Washington State Hydraulic Code RCW 77.55 and the City of Westport Shoreline Master Program, and could obtain permits pursuant to those regulations. The project would likely receive Washington Department of Ecology (Ecology) Section 401 Water Quality Certification. Ecology supports the beneficial use of dredged material and has certified similar actions at the North Jetty of the Columbia River (Cape Disappointment State Park) and at Graveyard Spit (Willapa Bay). The Corps has already conducted similar actions (mentioned above) and NEPA consistency was established therein.

## Project Costs & Proposed Funding Strategy

Mobilizing a hopper dredge with pump ashore capability on the West Coast has proven to be costly as most private contract dredges are staged on the Atlantic our Gulf Coasts. Therefore, it has become impossible to justify project costs for a single beach nourishment project. Thus the pilot project in Westport must leverage other coastal storm damage reduction and navigation O&M dredging contracts to be cost-effective. The Grays Harbor, Columbia River, Mouth of the Columbia River, and San Francisco Bay, and Humboldt Bay federal O&M projects are proposed to be included as an option within the FY20 Regional Hopper Contract. The Federal O&M Navigation project at Grays Harbor is planning to place material at the Half Moon Bay upland placement site in FY20. All NEPA work associated with this project has been completed. Assuming three projects can share mobilization cost, only the incremental cost associated with additional pipeline and possibly a booster pump would be required for the proposed pilot project. A preliminary cost breakout above the federal standard for the pilot project is included in Table 3.

*Table 3. Grays Harbor South Jetty Reconstruction and South Beach Erosion and Mitigation 1993-2017*

| | **Unit Price ($/CY)** | **Lump Sum ($)** | **Quantity (CY)** | **Cost ($)** |
|---|---|---|---|---|
| 1. Federal Standard Dredging Mob/Demob (FY19/FY20 Regional Hopper split between 3 projects at Seattle, Portland, San Francisco Districts) | | 2,253,333 | - | $2,253,333 |
| 2. Federal Standard Dredging & Upland Placement (FY19/20 Regional Hopper) | 16.00 | | 200,000 | $3,200,000 |
| 3. Incremental mob/demob cost for pump ashore (additonal pipeline/booster pumps) | | 1,040,000 | - | $1,040,000 |
| 4. Incremental cost to pump ashore (assumes additional 1 mile of pipeline and booster pump) | 10.00 | | 250,000 | $2,500,000 |
| Total | | | | $8,993,333 |
| Total O&M dredging portion | | | | $5,453,333 |
| **Total Incremental portion for Pilot Project** | | | | **$3,540,000** |

Notes:

1. Pump ashore costs for federal standard estimated from FY18 Shoalwater Dune nourishment project
2. Assumes 2% inflation per year to construction date of 2020

## Statement of Non-Federal Interest Financial Ability to Provide a Share of the Project Costs

The local community intends to contribute resources to shaping a protective dune where critically needed, and the State intends to contribute to monitoring of the restoration project. Contributions by City of Westport and the Washington State Parks and Recreation Commission would also include maintaining signs for traffic and pedestrian control to and from beach access points, supporting security of the restored dune, monitoring security fence placement, and coordinating sand placement in concert with USACE contractors and personnel as needed. A photo record of sand placement would be provided to the USACE and others for their records and public relations news releases. After the beneficial placement of sand, the City of Westport would plant dune grass and other coastal vegetation and provide vistas to enhance the public's recreational use of the restored dune.

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# City of Westport

**604 N Montesano St.**
**P O Box 505**
**Westport, WA 98595**
**Phone: 360-268-0131 Fax: 360-268-0921**


March 9, 2018

Headquarters, U.S. Army Corps of Engineers
Directorate of Civil Works, ATTN: CECW-CO-OD
Operations and Regulatory Community of Practice
441 G. Street NW
Washington D.C. 20314

Subject: Sec. 1122- Beneficial Use of Dredged Material- Water Resources Development Act of 2016
City of Westport Letter of Support- Washington Coastal Zone Management Program
Grays Harbor South Jetty Sand Placement Pilot Project

Commanding Officer:

The City of Westport, Washington, located on the Pacific Ocean Coast of the State of Washington, is writing to express our strong support for the Washington State Coastal Zone Management Program ***Grays Harbor South Jetty Sand Placement Pilot* Project** submitted under Sec. 1122 of WRDA of 2106.

This project is critical to supporting the needs of our local government and the public interest in addressing chronic coastal erosion hazards that are affecting local, State and Federal infrastructure near the entrance to Grays Harbor and the Corp's projects for Grays Harbor Navigation Channel, jetties, and the Westport Harbor that is within the city boundary. This pilot project would protect coastal ecosystems habitats while providing an important learning opportunity to compare the benefits of current frequent nearshore sediment placement methods verses this pilot project for comparable scale on-shore placement of dredged material.

Our coastal community area has increased coastal berm erosion of the Corp's South Jetty that includes lands of Washington State Park's Westport Light State Park south of the south jetty, extensive coastal erosion impacting $40 million dollars of structures that utilize our City utilities, and continues southerly along Westport's corporate coastal limits. Loss of city utility revenue due to erosion damage of those structures would reduce the city utility revenue by 20%.

The City of Westport supports the Washington State Coastal Zone Management Program submitted project ***Grays Harbor South Jetty Sand Placement Pilot Project***. This project would have multiple inter related purposes that provide a high level of tangible economic and environmental benefits as well as intangible values when the dredged sand is placed upland as a beneficial use in concert with or separately from open water dredged sand disposal. We believe this pilot project can be implemented in compliance with known environmental regulations and would support the local sponsoring agency in project implementation.

**We believe that the many benefits of the upland sand disposal pilot project include:**

1. Reducing storm damage to property and city of Westport infrastructure by restoration of eroded land by placing dredged sand water ward from the beach berm to regain the berm grass environment and to regain and enhance the dune land buffer between public use areas and normal and expected wave overtopping the dune.
2. Promote Public Safety by placing sand upland that restores the previous wider buffer between the wave action at the dune face and the human use of the back shore area. It also allows for designated pedestrian beach access area(s) with safer walk locations.
3. Protecting, restoring, and creating aquatic ecosystem habitats with placed dredged sand that regains habitat eroded and that would be restored and enhanced to create an aquatic ecosystem based on designed contours that foster aquatic environments for both flora and fona.
4. Stabilizing coastal systems and enhancing shorelines with rebuilding dune heights to minimize expected higher waves overtopping that cause subsequent berm erosion. Reduced wave overtopping of dunes helps stabilize the shoreline by reducing erosion and that allows aquatic ecosystems habitat to mature.
5. Promoting recreation by protecting existing State Park lands and by restoring those coastal berm lands lost to wave erosion which provides for easier access to coastal beach. It also provides for coastal view vistas as part of the recreation function of the park.
6. Supporting risk management adaptation strategies such as providing for safe ingress and egress to park land and coastal park area beaches. Beneficial use of dredged sand placed on the coastal berm areas also restores the primary dune face buffer between coastal primary frontal dune and back shore infrastructure with developments to maintain FEMA Flood Zone of Zone X such they are not in a Special Flood Hazard Area (SFHA) mandating FEMA flood insurance.
7. Reducing the costs of dredging and dredged material placement or disposal, such as projects that use dredged material for:
    (A) Construction or fill material – dredged sand would be used as fill material to restore eroded Shoreline dunes by placing dredged sand generally water ward from the eroded primary Frontal dune a variable width averaging 50 -75 feet along the coastal length several thousands of feet within the city boundary.
    (B) Civic improvement objectives include an enhanced park land environment for human use as well as wildlife such as deer, sea gulls, song birds, when supplemented with a variety of grasses and shore vegetation. ADA and handicap viewing locations that provide beach-water views are anticipated as items that could be incorporated.
    (C) Other innovative uses and placement alternatives that produce public economic or environmental benefits include the evaluation process and expected cost reduction when comparing beneficial use of sand placed for upland disposal verses off shore open water disposal.

The Grays Harbor South Jetty Project was identified as a priority project through the Grays Harbor Resilience Coalition (GHRC) planning process. Coalition members include City of Westport, Washington State Department of Ecology (Ecology Shorelands Program), Port of Grays Harbor, Grays Harbor Emergency Management, Corps of Engineers, FEMA and others.

USACOE
3/9/18

We fully support this proposed pilot beneficial use of dredged sand project as submitted by the Washington State Department of Ecology's Coastal Zone Management Program.

Please call me at my city office (360) 268-0131 if you desire further support information.

Sincerely,

Robin Bearden

Robin Bearden, Mayor
City of Westport, Washington

Don Hoch
Director

STATE OF WASHINGTON
WASHINGTON STATE PARKS AND RECREATION COMMISSION
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March 9th, 2018

Department of Defense
Department of the Army, U.S. Army Corps of Engineers
Thomas P. Smith
Chief Operations and Regulatory Division

Dear Mr. Smith:

I am writing to express my strong support for the Washington State Coastal Zone Management Program *Grays Harbor South Jetty Sand Placement Pilot Project*. This project is critical to supporting the needs of the local government and public interests in addressing chronic coastal erosion hazards that are affecting local, state, and federal infrastructure at the entrance to Grays Harbor, while protecting coastal ecosystem habitats.

The pilot project will also provide an opportunity to learn about the effectiveness of on-shore placement of dredged material in addressing chronic erosion hazards in the area. Washington State Parks is very concerned about the recent, and apparently unpermitted, placement of riprap on the beach near Ocean Shores and in the North Cove area. In both cases, public access to the beach has been completely eliminated during parts of the tidal cycle. Riprap has also been stockpiled in the dunes just west of the Westport by the Sea condominiums, in apparent preparation for future placement if necessary. The pilot project will help us better understand alternatives to shoreline armoring and reduce the likelihood of additional material being placed on the beach that would result in further impacts to public beach access throughout the area.

Thank you for considering this important project.

Sincerely,

Matt Niles
SW Region Manager

cc Lisa Lantz, Stewardship Manager

HILARY S. FRANZ
COMMISSIONER OF PUBLIC LANDS

DEPARTMENT OF
NATURAL RESOURCES

AQUATIC RESOURCES DIVISION
1111 WASHINGTON ST SE
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March 8, 2018

Department of Defense
Department of the Army, U.S. Army Corps of Engineers
Thomas P. Smith
Chief Operations and Regulatory Division

Subject: Grays Harbor South Jetty Sand Placement Pilot Project

Mr. Smith:

I am writing to express my support for the Washington State Coastal Zone Management Program *Grays Harbor South Jetty Sand Placement Pilot Project*. This project will support the needs of the local government and public interests in addressing chronic coastal erosion hazards that are affecting local, state, and federal infrastructure at the entrance to Grays Harbor, while protecting coastal ecosystem habitats. Furthermore, this pilot will provide a learning opportunity to compare the benefits of frequent nearshore sediment placement methods versus a comparable scale on shore placement of dredge material. The benefits of this project include: promoting public safety; protecting, restoring, and creating aquatic ecosystem habitats; and promoting public access.

Thank you for considering this important project.

Sincerely,

Rick Schwartz

Rick Schwartz
Aquatic Land Manager
Rick.Schwartz@dnr.wa.gov
(360) 740-6813

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# ATTACHMENT A

## Chapter 8 of Grays Harbor Draft Hazard Mitigation Plan

# COASTAL EROSION

Coastal erosion is defined as the wearing away of coastal land by natural forces, such as by water waves, wind, and tidal currents. Beach sediments are routinely mobilized by these forces, which can change the shape and size of a beach over a range of time scales from hours to years. These changes are often only recognized as erosion when there is a significant net loss of material that causes an impact or instability to the adjacent upland. Coastal erosion can occur during an episodic event, such as a large storm, or as a chronic condition with the gradual loss of the beach or coastal land.

Washington's Pacific Ocean coastline is subject to high energy waves that can cause rapid coastal erosion during typical winter storms that coincide with high tides and elevated water levels. The Grays Harbor shoreline south of Point Grenville is composed of fine sand derived from the Columbia River that is readily mobilized by wind and wave action. Seasonal fluctuations in waves and water levels typically cause beach erosion in the winter and beach accretion (or build up) in the summer. Where the beaches are backed by bluffs composed of older sedimentary deposits, bluff erosion constitutes a permanent loss of the upland.

Localized coastal erosion such as adjacent to shoreline armoring or along a river mouth can result from the interactions of forces that locally change the transport and distribution of sediments. Large-scale coastal erosion can occur during the infrequent, yet periodic, Cascadia subduction zone earthquakes, associated with coastal subsidence and large tsunamis.

## 8.1 GENERAL BACKGROUND

Coastal erosion is a natural process that is common along the shoreline interface of a water body and the land. Along sedimentary coasts, a beach is commonly found at this interface, with sediments moving and changing the shape of the beach in response to hydrodynamic forcing. As such, the beach typically serves as a buffer zone between the water's edge and the more stable back beach dune or upland margin. While a net loss of sediment from a beach may be noticeable and affect human uses and the environment, often much greater concern and impact occurs when there is dune or upland erosion, particularly where this land has been considered to be stable and suitable for development.

Along the southwest Washington coast, the introduction of exotic dune grasses and other vegetation during the 1930s have resulted in a sharper distinction between the beach and the barrier-dune upland. The introduced vegetation increased the accumulation and stability of barrier dunes that were previously more prone to wind drift, erosion, and constant change. As the dunes became densely colonized and stabilized by vegetation, they were developed and perceived as land not subject to further loss. Moreover, what was once a wide dune and buffer zone between the beach and the older barrier formation that was sustained during the 1700 Cascadia subduction zone earthquake became an abrupt vegetation line that separated the beach from the upland. While this vegetation line may mark the upland boundary of typically inundated land on an annual scale, it does not mean the land is not subject to erosion hazards. In fact, coastal erosion hazards associated with a co-seismic subsidence event with a return interval of about 500 years may extend a few hundred meters inland from the vegetation line. Such a hazard zone is comparable to a landslide hazard zone that is informed by the occurrence of a slide within the last 10,000 years. For context, the entirety of the coastal barriers along the southwest Washington coast are only a few thousand years old and record several events of massive erosion from co-seismic subsidence events since their formation.

Coastal erosion generally occurs as a result of physical forcing or an imbalance in the sediment budget. For example, the construction of jetties at the mouth of Grays Harbor in the early 1900s caused a large change in the way sediment is shared between the adjacent coasts along Westport and Ocean Shores. The jetties

have enabled more sediments to accumulate north of Grays Harbor than to the south along the Grayland Plains. The sediment imbalance initiated a century ago by the construction of the jetties still contributes to the net erosion of sediment from the Westport area. Along Ocean Shores, coastal erosion is more recently exacerbated by the deterioration of the Grays Harbor North Jetty. Absent of reconstruction, the capacity of the jetty to sustain the beach in its present location diminishes over time, contributing to the net loss of sediment along the beach north of the jetty.

North of Point Grenville, coastal sediments are derived locally from the nearshore, streams, rivers, and bluffs. Here, local geology can determine how much erosion occurs independent of hydrodynamic forcing. Where sediments are limited, the erodibility of the coastal substrate and bluffs depends on the relative hardness and mechanical strength of the material. Headlands and outcrops are composed of highly erosion-resistant rock. In general, rocky coasts erode through hydraulic action of waves and abrasion action of debris, progressively splintering and removing pieces of rock. Rock fragments then undergo a process of attrition, becoming smaller and rounder particles as they collide with each other.

In addition to rock composition, the geology may control the elevation and slope of the nearshore area, which in turn can determine how wave energy is dissipated before reaching the shoreline. A shallow and mild-sloped shoreface will cause waves to break offshore and greatly reduce their ability to erode coastal uplands. In contrast, a deep and steep shoreface will enable high waves to break directly onto the beach and dissipate as run-up onto the upper beach or bluff. In general, a deep and steep shoreface will manifest as a steep and rocky beach composed of larger particles, such as cobbles or boulders, because smaller particles, such as sand and gravel, are readily transported away and deposited in areas having a lower energy regime.

On a seasonal scale, coastal erosion typically occurs during the winter, when distant and local storms produce large waves, high winds, and elevated water levels. Winter storms typically approach the shoreline from the southwest, resulting in northerly and offshore sediment transport that erodes beaches, whereas as fair-weather summer conditions generally produce smaller waves approaching from the northwest that result in southerly and onshore sediment transport that builds up the beaches. During strong El Niño events, sustained elevated water levels can accentuate seasonal coastal erosion, such as during the 1997/98 winter, when monthly averaged water levels were as much as 1.3 ft higher than normal (Kaminsky et al., 1998).

In summary, coastal erosion is dependent on a combination of site-specific conditions and influencing factors. Most commonly, the factors that contribute to erosion fall into three broad categories:

- Hydraulic energy regime (waves, water levels, currents, winds, storm climatology)
- Geomorphic setting (sediment supply and grain size, geologically inherited substrate, landform and composition, e.g., coastal barrier, bluff, geology, vegetation, streams, rivers).
- Human activity (e.g. dams, jetties, coastal structures that affect sediment transport and sediment budget).

## 8.2 HAZARD PROFILE

### 8.2.1 Extent and Location

The best predictor of where coastal erosion might occur is along shorelines that have eroded in the past. A range of geological, historical, and contemporary approaches can be used to identify coastal erosion hazard areas and their associated time and space scales. One way to reveal if either chronic or episodic erosion has occurred is through the mapping of historical shorelines. Coastal erosion can also be recognized in surface topography by steep scarps and slumps along dunes and bluffs that are generally unstable and unvegetated. Eroded beaches are typically narrower, steeper, and composed of coarser sediment than adjacent stable beaches. Sandy beaches may have higher concentrations of heavy minerals and surface lag

deposits that are more resistant to transport relative to other local sediments. Past erosion events may also be detected by ground-penetrating radar and recorded as subsurface lag deposits that were subsequently buried during an accretion phase.

Scientific research studies such as the Southwest Washington Coastal Erosion Study (Gelfenbaum and Kaminsky, 2010) have provided a strong foundation for understanding and anticipating coastal changes from a multi-disciplinary perspective. For the purposes of this hazard mitigation plan, coastal erosion hazard areas are identified through the analyses of changes in shorelines derived from aerial photographs and quarterly beach profile surveys that have been performed by the Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) along the southwest Washington coast since 1996.

Erosion hazard areas are mapped only where these existing data indicate a chronic erosion trend over the past 10 years or more, and where, without mitigation, future erosion impacts can be anticipated over the next 10 years (Figure 8-1). The erosion hazard areas are based on existing data and knowledge that is focused on the outer coast south of Point Grenville, and are not necessarily inclusive of coastal erosion areas for the entirety of Grays Harbor County. Erosion hazard areas are mapped for Westport (Figure 8-2), Cohassett Beach (Figure 8-3), the shoreline near the Grays Harbor North Jetty (Figure 8-4), the Ocean Shores Oyhut Wildlife Recreation Area (Figure 8-5), Damon Point (Figure 8-6), Whitcomb Flats in Grays Harbor (Figure 8-7), and along the mouths of Connor Creek and the Copalis River (Figure 8-8).

The erosion hazard areas indicated do not account for various interventions that could reduce or prevent coastal erosion, other conditions such as jetty deterioration that might lead to accelerated erosion, nor the fact that other areas could be affected by coastal storms and erosion. For example, wave breaking over the Grays Harbor North Jetty may scour sand and damage East Ocean Shores Boulevard, yet this is not indicated on the maps since there is no chronic erosion of the shoreline along the North Jetty. Similarly, episodic erosion driven by a large storm could also occur outside of the mapped erosion hazard areas. The erosion hazard maps only indicate areas with a documented erosion trend that has occurred over the past decade or longer. Each erosion hazard area map shows the erosion trend in feet per year along the shoreline. Table 8-1 provides a summary of the number of affected structures, parcels, shoreline length, and acres.

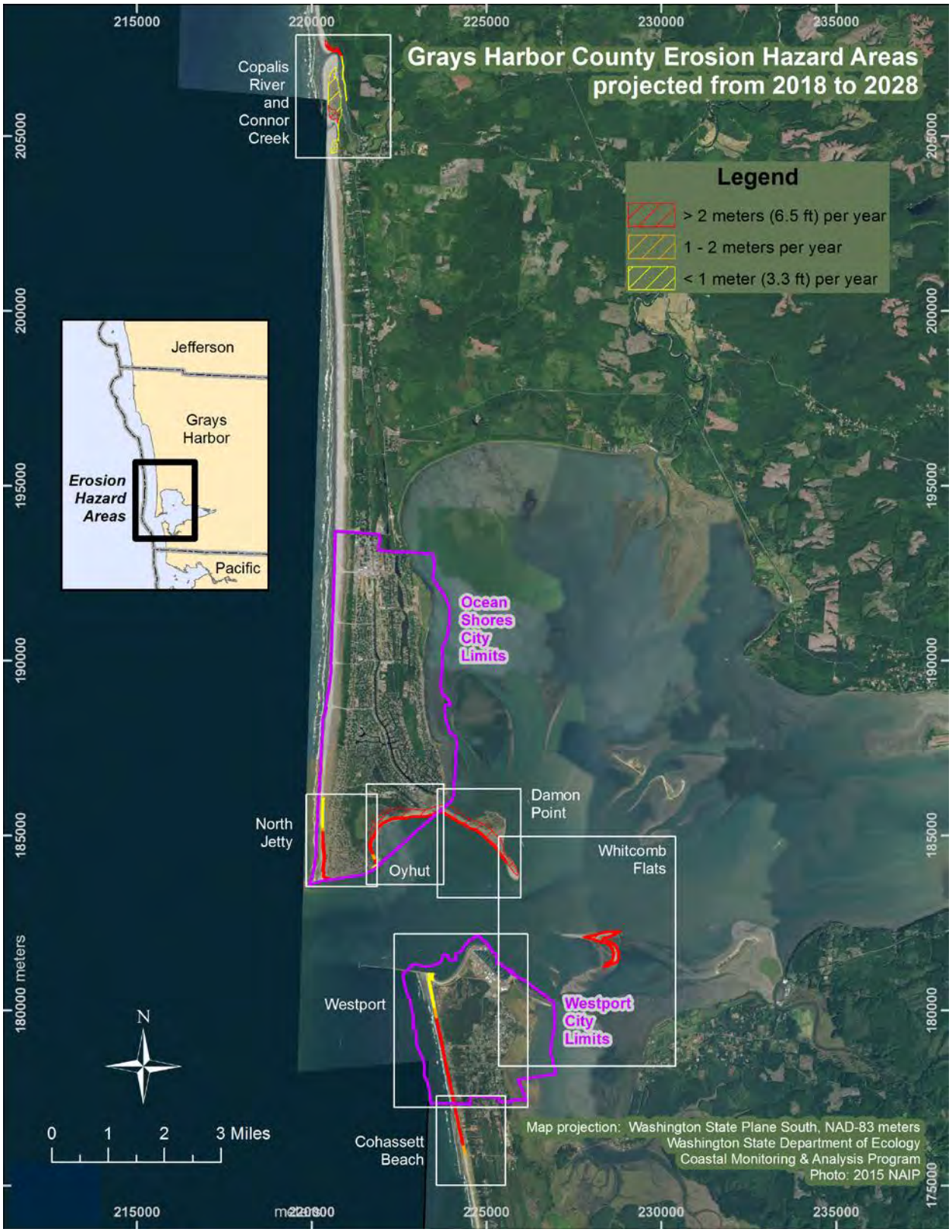


*Figure 8-1. Overview of erosion hazard areas*

*Figure 8-2. Westport erosion hazard areas*

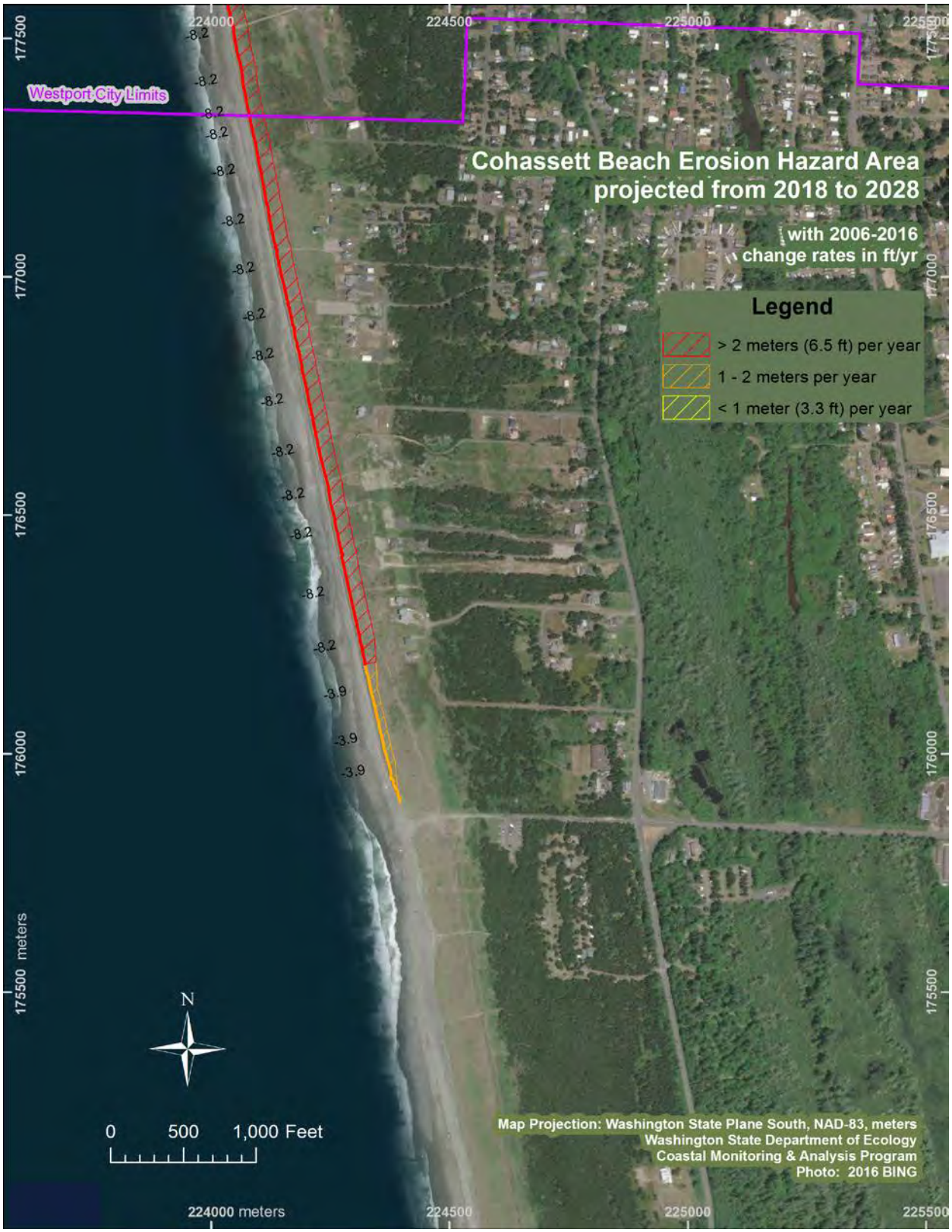


*Figure 8-3. Cohassett Beach erosion hazard areas*

*Figure 8-4. Ocean Shores North Jetty erosion hazard areas*

*Figure 8-5. Oyhut erosion hazard areas*

*Figure 8-6. Damon Point erosion hazard area*

*Figure 8-7. Whitcomb Flats erosion hazard area*

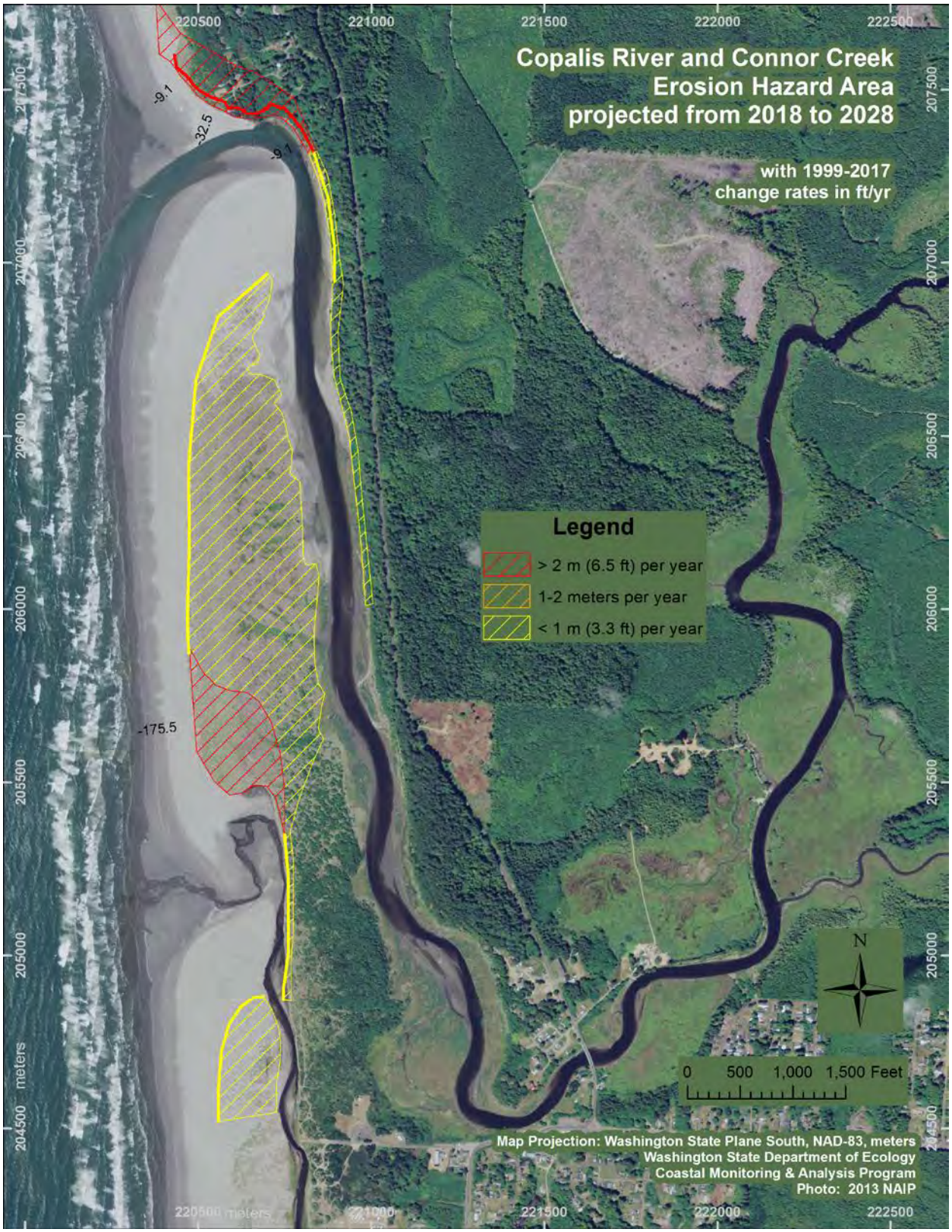


*Figure 8-8. Copalis River and Connor Creek erosion hazard areas*

**Table 8-1**
**Summary Inventory of Grays Harbor Erosion Hazard Areas**

| Jurisdiction & Name of Area | Num. of Struct-ures | Num. of Parcels | Length of Shoreline (km) | Length of Shoreline (miles) | Num. of Acres | Other |
|---|---|---|---|---|---|---|
| ***City of Ocean Shores*** | | | | | | |
| North Jetty area | 13 | 31 | 2.53 | 1.57 | 16.9 | |
| Oyhut Wildlife Recreation Area | 20 | 30 | 3.28 | 2.04 | 139.9 | Also Sewage Treatment Plant, Marine View Dr |
| ***Subtotal*** | **33** | **61** | **5.81** | **3.61** | **156.8** | |
| ***City of Westport*** | | | | | | |
| *Westport* | 9 | 49 | 4.00 | 2.49 | 25.6 | 4 State Parks & 2 City of Westport parcels are excluded |
| ***Subtotal*** | **9** | **49** | **4.00** | **2.49** | **25.6** | |
| ***Grays Harbor County*** | | | | | | |
| Copalis River & Connor Creek | 3 | 24 | 3.73 | 2.32 | 141.7 | |
| Cohassett Beach | 0 | 1 | 1.49 | 0.93 | 9.6 | |
| Whitcomb Flats | 0 | 0 | 4.39 | 2.73 | 63.5 | |
| Damon Point | 0 | 0 | 2.49 | 1.55 | 150.2 | Affects access to a recreation area |
| ***Subtotal*** | **3** | **25** | **12.10** | **7.52** | **365.0** | |
| **Total** | **45** | **135** | **21.91** | **13.62** | **547.4** | |

## 8.2.2 Previous Occurrences

The barrier beaches along the southwest Washington coast have a relatively short geological history. Grayland Plains, the barrier beach between Grays Harbor and Willapa Bay began to sustain seaward growth from the back edge only about 2,800 years ago, while the oldest portions of the North Beach Peninsula north of Grays Harbor have built seaward from the bay side only for the last 2,500 years (Peterson et al., 2010b). These coastal barriers are built from the accumulation of sand supplied by the Columbia River and shaped by tectonic processes of the Cascadia Subduction Zone that produces great earthquakes (magnitude ≥ 8) with a recurrence interval that averages about 500 years (Atwater and Hemphill-Haley, 1997; Atwater et al., 2004).

Each great subduction zone earthquake is accompanied by coseismic subsidence of 0.5 to 2.5 m (Atwater, 1996, Atwater and Yamaguchi, 1991; Atwater and Hemphill-Haley, 1997), and corresponding shoreline retreat on the order of a few hundred meters (Doyle, 1996; Peterson et al., 1999, 2000). These large-scale, episodic coastal erosion events are recorded by a sequence of scarp formations that have been mapped with ground penetrating radar in the subsurface of the coastal barriers (Meyers et al., 1996; Jol et al., 1996; Smith et al., 1999: Peterson et al., 2010b). The buried erosion scarps manifest as heavy mineral layers that are preserved by interseismic rebound, beach recovery, and continued accumulation of sediment between events that results in shoreline advance at long-term average rates of approximately 0.5 m/yr (Meyers et al., 1996; Woxell, 1998; Peterson et al., 1999). Meyers et al. (1996), Woxell (1998), and Phipps et al. (2001) correlate the most seaward and recent paleoscarp to the A.D. 1700 Cascadia earthquake subsidence event on January 26, 1700 (Satake et al., 1996; Atwater et al., 2005).

Cascadia Subduction Zone earthquakes affect the coast not only through abrupt subsidence, but also through the generation of large tsunamis (e.g., Atwater, 1987; Darienzo and Peterson, 1990; Clague et al., 2000; Kelsey et al., 2002, 2005; Peters et al., 2003; Witter et al., 2003; Atwater et al., 2005; Nelson et al., 2006). While dramatic shoreline retreat occurs due to subsidence, tsunamis erode beach sediments and transport them landward in high-velocity flows (Dawson, 1994; Dawson and Stewart, 2007) to form deposits that normally extend 0.5 to 1.5 km inland from the open coast (Peters et al., 2003; Schlichting and Peterson, 2006; Jol and Peterson, 2006).

The shape and location of the shoreline have undergone substantial change since 1700, particularly over the past century following construction of jetties at the mouth of Grays Harbor (Kaminsky et al., 2010). The Grays Harbor South Jetty was constructed between 1898 and 1902 to a length of 2.6 miles, and the Grays Harbor North Jetty was built to a length of 3.2 miles between 1908 and 1916. Within the first several decades following jetty construction, shoreline changes are closely correlated with changes in jetty condition (Buijsman et al., 2003). Over time, the net result has been significantly more seaward growth of the North Beach Peninsula, accumulating roughly 8 to 10 times more sand than Grayland Plains, resulting in an imbalance in the sharing of sediment between the adjacent coasts and accentuated erosion in the Westport area (Kaminsky et al., 2010). Coastal erosion has been shown to be an issue in Westport since the construction of the Grays Harbor South Jetty in the early 1900s and since the shoreline accretion began to slow along the Ocean Shores Peninsula during the 1950s (Buijsman et al., 2003). There have been numerous reports documenting challenges, costs, and impacts of coastal erosion over the past few decades. Table 8-2 provides a historical chronology of coastal construction, erosion, and mitigation along the Grays Harbor County shoreline. Table 8-3 identifies the locations and volumes of sand placed to nourish eroding areas to mitigate the impacts of coastal erosion. A brief summary of historical shoreline changes and events are discussed below.

| Table 8-2<br>Grays Harbor Coastal Construction, Erosion, and Mitigation History | |
|---|---|
| **Period** | **Event** |
| Jan 1700 | Cascadia earthquake causes coast-wide erosion. |
| May 1792 | Captain Robert Gray surveys Grays Harbor. |
| Aug 1841 | Wilkes Expedition surveys Grays Harbor. |
| Apr 1854 | Chehalis County is formed, later to become Grays Harbor County. |
| 1856 | Pioneers settle at Chehalis Point (Westport). |
| 1860-1862 | U.S. Coast Survey surveys Grays Harbor and publishes Hydrographic Survey. |
| 1862 | George Davidson of the U.S. Coast Survey publishes Directory of the Pacific Coast, or Coast Pilot of California, Oregon, and Washington (first edition). |
| 1881 | The USACE conducts study of Grays Harbor. |
| 1886-1887 | U.S. Coast Survey surveys Grays Harbor and adjacent shorelines and publishes Topographic Sheet. |
| 1889 | George Davidson of the U.S. Coast Survey publishes Coast Pilot of California, Oregon, and Washington (completely rewritten third edition). |
| 1894 | The USACE conducts a field survey of the Grays Harbor entrance. |
| 1897 | Grays Harbor Coast Guard Station is established. |
| May 1898-Sep 1902 | The USACE constructs the Grays Harbor South Jetty to an elevation of +8 ft MLLW and a total length of 13,734 ft, of which 11,950 ft extended seaward of the high-water line in 1902. During construction, the channel adjacent to the jetty undermined the structure causing material overruns that depleted project funds before the design length of 18,154 ft could be reached. A groin (spur) pointing into the channel is constructed 11,952 ft from the high-water line in 1902. |
| Jun 1898 | Gray Harbor light is commissioned. |
| Sep 1902 | Moclips is platted. |
| Apr 1904 | Pacific Beach is platted. |
| 1904-1906 | By 1904, the depth over the Grays Harbor ebb-shoal increases from -12 to -22 ft MLLW as a result of jetty construction, meeting the stated purpose of the project. In addition, the beach south of the jetty accretes, creating a 3,000-ft seaward progradation of the high-water shoreline. However, deterioration of the jetty began around 1904. By 1906, the South Jetty had settled due to scour, and the bar channel began to widen and shoal. This unfavorable shoaling led to construction of the North Jetty. |
| 1907-1910 | The USACE constructs 10,000 ft of the Grays Harbor North Jetty to an elevation of +5 ft MLLW. |
| 1910-1913 | The USACE completes the North Jetty to a project length of 16,000 ft and an elevation of +5 ft MLLW. |
| Feb 1911 | Moclips Beach Hotel and other buildings on Moclips beach destroyed by coastal storm. |
| 1913-1916 | The USACE reconstructs the North Jetty is to +8 ft MLLW and extended it to a length of 17,204 ft. |
| 1916 | As jetties continued to deteriorate and were inadequate to maintain project dimensions in the bar channel, dredging commenced (57,000 cy) and continued at regular intervals until 1926 (except for 1918 and 1919). |
| Dec 1920 | A small tsunami washes 12 Sunset Beach Cottages in Moclips from their foundations. |
| 1925 | Ocean City is platted. |

| Table 8-2 *(cont.)* Grays Harbor Coastal Construction, Erosion, and Mitigation History | |
|---|---|
| **Period** | **Event** |
| 1926-1942 | The bar channel required almost continuous dredging between 1926 and 1942. The total quantity dredged from the entrance between 1916 and 1942 is approximately 22 x 106 cy (USACE 1967). |
| 1933 | By 1933, the South Jetty had subsided to an average depth of 5 to 10 ft below MLLW (+6 ft MLLW at the high-water shoreline and -10 ft MLLW at the outer end). |
| 1934 | The outer 8,000 ft of the North Jetty, between the high water shoreline and the tip of the jetty, subsides to approximately -1.5 ft MLLW. |
| 1935-1939 | The USACE reconstructs a 12,656-ft section of the South Jetty (about Sta. 80+00 to 220+00) to an elevation of +20 ft MLLW. Jetty reconstruction blocked the supply of sand to Point Chehalis, causing serious erosion of Point Chehalis. A 32-ft section of the jetty is removed to try to restore the supply of sand, but it is quickly blocked by accretion south of the jetty. |
| 1939-1946 | The outer 900 ft of the South Jetty is destroyed, and crest rock is displaced to +2 ft MLLW over the next 2,656 ft. |
| 1940 | The inner 7,300 ft of the North Jetty, shoreward of the high-water shoreline, is impounded with sand. |
| Feb 1941-May 1942 | The USACE reconstructs the North Jetty to an elevation of +20 ft MLLW for 7,700 ft seaward of the high-water shoreline, then to +30 ft MLLW for an additional 528 ft. A 412-ft segment seaward of the reconstructed section is at MLLW and is not restored. The structure landward of the high-water shoreline is not rebuilt. |
| 1942 | Maintenance dredging of the bar and entrance channels is no longer required due to scouring effects of the jetties. |
| 1942-1949 | The outer 325 ft of the North Jetty is leveled, and about 400 ft of the reconstructed section is lowered 4 ft below grade. |
| 1946-1951 | An additional 900 ft of the South Jetty is destroyed, and the next 4,100 ft subsided to 0 to +10. |
| 1946 | Half Moon Bay begins to form east of the South Jetty root. |
| 1950-1957 | The USACE constructs the Point Chehalis Revetment (2,880 ft) and 7 groins, and 3 timber pile breakwaters to serve as shore protection for marina at Westport due to erosion associated with South Jetty reconstruction. |
| 1949-1953 | An additional 325 ft of outer end of the North Jetty is leveled, and more than 1,000 ft of the remaining section subsided to +10 ft MLLW. |
| 1951-1953 | An additional 900 ft of the outer South Jetty is destroyed, and the next 4,500 ft subsided to 0 to +2 ft MLLW. The next 2,400 ft subsided to +4 ft MLLW. |
| 1952-1954 | More than 300 ft of the South Jetty (between Sta. 70+00 and 80+00) is dismantled, and the rock used for construction of the Point Chehalis revetment. |
| 1956 | Joe Creek threatens Pacific Beach as the mouth erodes through dunes. |
| 1961 | Only 2,100 ft of the reconstructed portion of the North Jetty remained at or near grade (+20 ft MLLW). |

| Table 8-2 *(cont.)* Grays Harbor Coastal Construction, Erosion, and Mitigation History | |
|---|---|
| **Period** | **Event** |
| 1962 | By April 1962, average elevation of the South Jetty between Sta. 135+00 and 198+00 (6,300 ft) is about MLLW; seaward of this point from Sta. 198+00 to 220+00 (2,200 ft), crest elevation ranged from -6 ft MLLW to -48 ft MLLW. The landward section from about Sta. 88+00 (high-water shoreline) to 135+00 (4,700 ft) is near grade. |
| Mar 1964 | Alaskan tsunami causes damages beach front houses and bulkheads at Moclips, buildings and State Highway 109 log bridge over Joe Creek at Pacific Beach, State Highway 109 at Iron Springs Resort at Boone Creek, and buildings, mobile homes, and State Highway 109 bridge at Copalis River. |
| 1966 | The USACE reconstructs a 4,000-ft section of the South Jetty (from Sta. 110+00 to 150+00) to +20 ft MLLW, leaving the outer 7,000 ft in a degraded condition (-10 ft MLLW or deeper). |
| 1970 | City of Ocean Shores is incorporated. |
| 1970-1973 | The USACE performs extensive groin replacement, revetment repair, and timber breakwater construction along Point Chehalis (including timber pile closure of Westport Marina entrance between breakwaters A and B). |
| 1974 | A section of the North Jetty, about 1,300 ft seaward of the high-water shoreline, ranged from +3 to +14 ft MLLW. The jetty seaward of this point is below MLLW. |
| Winter 1974-1975 | The North Jetty is severely damaged in a major storm and portions of the adjacent beach and primary dune are washed away, with debris scattered several hundred ft inland. |
| 1975-1976 | The USACE reconstructs a 6,000-ft section of the North Jetty, from the high-water shoreline seaward to an elevation of +20 MLLW. |
| 1976 -1977 | Ocean Shores Critical Area Dune Stabilization. The City of Ocean Shores and the Grays Harbor Conservation District repair and stabilize the primary dune area adjacent to the North Jetty that was washed away in the Winter of 1974- 1975. Fertilizer is spread over 55 acres, extending approximately 1.5 miles long by 300 ft wide to enhance plant growth along the primary dune north of the North Jetty. European beachgrass is planted to stabilize the 9-acre denuded area, and two 500-ft long, 3-ft high picket fences are installed 35 ft apart, starting 100-ft landward of the high water mark, to enhance sand deposition and rebuild the primary dune. The first fence failed in November 1976, and a second sand fence was installed farther inland from the first fence, and this second fence was partially destroyed in March 1977 by high tides accompanied by storm conditions. |
| Winter 1982-1983 | Strong El Niño causes greater than normal winter beach erosion. |
| 1988 | The northward migration of the mouth of Connor Creek appears to accelerate to as much as 1,000 ft/yr, driven by winter storms and wave overwash of barrier into the channel. |
| 1990 | The USACE constructs outer harbor navigation channel improvements including deepening of bar and outer entrance channel to 46 ft MLLW, widening of bar channel to 1000 ft, and entrance channel to 600 ft. The USACE deepens the inner harbor reaches and turning basins from -30 ft MLLW to -36 ft MLLW. |
| 1991 | The USACE reactivates maintenance dredging of the bar and entrance channel. |

| Table 8-2 *(cont.)* Grays Harbor Coastal Construction, Erosion, and Mitigation History | |
|---|---|
| **Period** | **Event** |
| 1986-1992 | The Half Moon Bay shoreline receded at a rate of more than 10 ft/yr, destroying several US Coast Guard structures, and endangering the City of Westport's sewer outfall. |
| 1992 | The USACE places 200,000 cy of sand in the form of a submerged nearshore berm in Half Moon Bay to mitigate erosion. |
| Fall 1993 | The USACE rehabilitates the southern 800 ft of the Point Chehalis revetment, and places 373,000 cy of sand in the nearshore of South Beach to nourish the eroding shoreface. |
| Dec 1993 | A breach occurred between the ocean and Half Moon Bay adjacent to the South Jetty, threatening Westport's municipal water well and wastewater treatment plant. |
| May 1994 | The USACE nourishes the Half Moon Bay nearshore with 146,000 cy of sand and the South Beach nearshore with 265,000 cy of sand. |
| Fall 1994 | The USACE fills the South Jetty breach with 600,000 cy of sand dredged from the navigation channel, at a cost of approximately $8 million. |
| Dec 1994 | The City of Westport declares state of emergency over coastal erosion in Half Moon Bay that caused four sections of sewer outfall pipe (40 ft) to break apart. |
| Jan 1995 | The City of Westport places 82,000 cy of sand and armor rock to protect the sewer outfall line. |
| Jul 1995 | The USACE relocates 150,000 cy of breach fill material from western Half Moon Bay shoreline to South Beach. |
| 1995 | Whitcomb Flats loses its remnant dune and vegetation to wave overwash. |
| Dec 1995 | The USACE places 300,295 cy of sand along Half Moon Bay extending 800 ft south from the Point Chehalis revetment due to erosion threatening Westport's wastewater treatment plant, north well, and business district. |
| 1996 | The USACE nourishes the Half Moon Bay berm with 274,780 cy of sand. |
| Oct 1996 | A two-tiered rock revetment, 850-ft long named "wave bumpers" are constructed at Ocean Shores at a cost of approximately $600,000. |
| Feb 1997 | Governor Locke allocates $50,000 from emergency funds for an Ocean Shores study of coastal erosion. The USACE places 5,000 cy of sand on the Moon Bay shoreline berm adjacent to the Point Chehalis revetment to reinforce the revetment terminus and reduce the potential for storm induced wave overtopping of the backshore berm and associated flooding of the City of Westport business district. |
| Jul 1997 | Congress appropriates $6 million to study a long-term solution to coastal erosion at the Grays Harbor South Jetty. The Washington State Legislature appropriates $1 million to the Southwest Washington Coastal Erosion Study, and $70,000 emergency funds to study Ocean Shores coastal erosion, while Governor Locke provides an additional $30,000 for the Ocean Shores study. |
| Dec 1997 | Damon Point State Park access road washes out during a coastal storm. |
| 1998 | The USACE nourishes the Half Moon Bay nearshore with 421,468 cy of sand. |
| Aug 1998 | Governor Locke's Coastal Erosion Task Force begins to develop policy recommendations. |

| Table 8-2 *(cont.)* Grays Harbor Coastal Construction, Erosion, and Mitigation History | |
|---|---|
| **Period** | **Event** |
| Dec 1998 | Ocean Shores installs geotubes north of the wave bumpers to protect an additional 540 ft of dune from erosion at a cost of approximately $200,000. |
| Dec 1998 | Damon Point State Park access road washes out approximately 1300 ft east of the 1997 washout. |
| Dec 1998-Mar 1999 | Point Chehalis Revetment Extension Project. The USACE extends the Point Chehalis Revetment 1,900 ft south along Half Moon Bay at a cost of $2.6 million. |
| Jan 1999 | By the beginning of 1999, Connor Creek had migrated north of Heath Road, cutting off beach access. |
| Feb 1999 | Waves overtop the North Jetty and damage East Ocean Shores Boulevard. |
| Mar 1999 | A storm lowers a 200-ft section of the South Jetty to about +9 ft MLLW and damages the jetty where it intersects the shoreline. A storm removes the Ocean Shores restroom facility adjacent to North Jetty. Ocean Shores incurs over $1 million in damages but is not eligible for federal disaster assistance. East Ocean Shores Boulevard is further damaged by wave overtopping the North Jetty. |
| Apr-May 1999 | The USACE places 228,963 cy of dredged sand on top of and seaward of the revetment extension at a cost of approximately $1 million. |
| 1999 | The USACE nourishes the Half Moon Bay nearshore with 228,470 cy of sand and the South Beach nearshore with 76,187 cy of sand. |
| Sep 1999-May 2002 | The USACE reconstructs a 3,500-ft section of the South Jetty seaward of the high-water shoreline (Sta. 87+00 to 120+00) to an elevation of +23 ft MLLW. |
| Dec 1999-Feb 2000 | The USACE constructs a wave diffraction mound at landward end of south jetty to reduce wave-induced erosion of Half Moon Bay, and constructs a cobble transition beach with 11,600 cy (17,358 tons) of 12-inch minus cobble and gravel designed to slow Half Moon Bay beach erosion directly adjacent to the jetty. |
| 2000-Nov 2001 | The USACE reconstructs the North Jetty from Sta. 95+00 to 145+00, to a top elevation of +23 ft MLLW at a cost of approximately $3 million. |
| Feb 2000 | A section of the Damon Point access road, paved in 1999, is washed out. |
| Mar 2000 | Connor Creek erodes beach access road at Griffiths-Priday State Park. |
| Nov 2000 | High wind and waves destroy several pedestrian bridges over Connor Creek. |
| Winter 2001-2002 | A series of storms erodes South Beach and overtops the breach fill and temporary truck haul road across the breach fill to the South Jetty and damages the temporary truck haul road across the breach fill to the South Jetty. |
| Dec 2001-Jan 2002 | The USACE places an additional 16,100 cy of 12-inch minus cobble and gravel along the breach fill portion of the Half Moon Bay shoreline to slow the erosion. |
| Apr-May 2002 | The USACE excavates 135,000 cy of sand from the Point Chehalis Revetment Extension Mitigation site and places it by truck haul over 8 acres at the breach fill in the form of a natural dune with a top elevation of +36 ft MLLW at a cost of $519,750. The USACE also nourishes the Half Moon Bay nearshore with 378,441 cy of sand and the South Beach nearshore with 75,219 cy of sand. |
| Jun 2002 | The USACE restores upland revetment stockpile with 135,706 cy of dredged sand. |
| Nov 2002 | The USACE plants 50,000 sprigs of native American dune grass (Elymus mollis) on 3 acres of the breach fill to prevent wind and rain erosion of the restored area. |

| Table 8-2 *(cont.)* Grays Harbor Coastal Construction, Erosion, and Mitigation History | |
|---|---|
| **Period** | **Event** |
| 2003 | The USACE nourishes the Half Moon Bay nearshore with 329,106 cy of sand and the South Beach nearshore with 125,388 cy of sand. |
| Oct 2003 | Approximately 70 ft of concrete walking trail (Lighthouse Dune trail extension) along Half Moon Bay is undermined by erosion extending over 350 ft along the shoreline. The City of Westport makes an emergency declaration to place ecology blocks and 1,700 cy of sand at an estimated cost of $53,000. |
| Feb 2004 | The USACE excavates 29,553 cy of sand from the revetment stockpile and places it at the breach fill. |
| 2004 | The USACE nourishes the Half Moon Bay nearshore with 289,652 cy of sand and the South Beach nearshore with 262,176 cy of sand. |
| Dec 2004 | The USACE excavates 22,779 cy of sand from the revetment stockpile and places it at the breach fill. |
| 2005 | The USACE nourishes the Half Moon Bay nearshore with 102,184 cy of sand and the South Beach nearshore with 217,909 cy of sand. |
| Jan 2006 | A landslide occurs along approximately 80 ft of Roosevelt Beach bluffs, spreading bluff material about 300 ft across the beach. |
| Feb 2006 | Erosion of Damon Point exposes about 100 ft of the Catala shipwreck. |
| 2006 | The USACE nourishes the Half Moon Bay nearshore with 126,892 cy of sand and the South Beach nearshore with 55,170 cy of sand. |
| 2007 | The USACE nourishes the Half Moon Bay nearshore with 140,406 cy of sand. |
| Nov 2007 | Connor Creek bridge at the end of Heath Road opens to allow pedestrian access to the beach at a cost of $334,000. |
| Dec 2007 | The narrowest section of Damon Point was washes out again, resulting in the closure of the Damon Point access road. |
| 2008 | The USACE nourishes the Half Moon Bay nearshore with 171,353 cy of sand. |
| 2009 | The USACE nourishes the Half Moon Bay nearshore with 144,975 cy of sand and the South Beach nearshore with 214,502 cy of sand. |
| 2010 | The USACE nourishes the Half Moon Bay nearshore with 91,720 cy of sand and the South Beach nearshore with 118,182 cy of sand. |
| Oct 2010 | The USACE places 20,000 cy sand on the South Beach shoreline and 10,000 cy sand on the Half Moon Bay shoreline as an interim measure to reduce the potential for a breach to occur. |
| Oct-Nov 2010 | The USACE repairs 300 ft of the Point Chehalis revetment in two locations damaged by wave overtopping. 1,120 tons of 2-4 ton rock is placed to repair 100 ft of revetment between Groin C and D during an emergency repair during a storm on October 23, 2010. 200 ft of revetment west of Groin A is repaired in Nov. 2010 with 2,800 tons of 9-17 ton rock. |
| 2011 | The USACE nourishes the Half Moon Bay nearshore with 177,150 cy of sand and the South Beach nearshore with 298,251 cy of sand. |
| Jan 2012 | The Quinault Marina RV park loses five sites to coastal erosion. |
| 2012 | The USACE places 30,000 cy of sand from an upland source to the breach fill. The USACE nourishes the Half Moon Bay nearshore with 111,205 cy of sand and the South Beach nearshore with 142,313 cy of sand. |

| Table 8-2 *(cont.)* Grays Harbor Coastal Construction, Erosion, and Mitigation History | |
|---|---|
| **Period** | **Event** |
| 2013 | The USACE nourishes the Half Moon Bay nearshore with 86,147 cy of sand and the South Beach nearshore with 477,637 cy of sand. |
| Nov 2013 | The USACE repairs another 300 ft section of the Point Chehalis Revetment damaged by wave overtopping at a cost of $500,600. |
| Jan 2014 | The USACE adds rock to shoreline revetment at Taholah. |
| Apr 2014 | The USACE places 4,500 tons of rock to repair a breach in the shoreline revetment at Taholah at a cost of $300,000. |
| 2014 | The USACE nourishes the South Beach nearshore with 498,440 cy of sand. |
| 2015 | The USACE nourishes the South Beach nearshore with 506,330 cy of sand. |
| Oct 2015 | The City of Ocean Shores replaces failing geotubes with geobag structure in same footprint as failed geotubes at a cost of $100,000. |
| Nov 2015 | The USACE places 1,600 cy of sand at the toe of the geobags. |
| Dec 2015 | The City of Ocean Shores declares emergency after geotubes become severely damaged and places 1,750 cy of additional sand at the toe of the geotubes. A bluff landslide occurs at Seabrook, Pacific Beach. |
| Jan 2016 | The USACE proposes to install a dynamic cobble revetment fronting the Ocean Shores geotubes, but when that material is unavailable, they install a revetment using approximately 3,850 cy (5,000 tons) of 24" angular rock. |
| Feb 2016 | The Westport by the Sea Homeowners Association repairs the eroded dune with coir fabric, sand fill, and anchored logs in front of Building 8 condominium. |
| Mar 2016 | Taholah shoreline revetment is damaged and breached. |
| 2016 | The USACE nourishes the South Beach nearshore with 544,980 cy of sand. |
| Jul-Oct 2016 | The City of Ocean Shores installs and removes seasonal sand fence to help build up sand accumulation at the toe of the primary dune. |
| 2017 | The USACE nourishes the Half Moon Bay nearshore with 101,019 cy of sand and the South Beach nearshore with 499,001 cy of sand. |
| Oct 2016-Feb 2017 | The USACE repairs up to 500 ft of the Point Chehalis revetment with approximately 640 tons of underlayer filter stone (quarry spall), 640 tons core stone (3-7 ton), and 6,400 tons of armor stone (9-13 ton). The work is the same as in 2013, but at three different segments. |
| May-Oct 2017 | The City of Ocean Shores installs and removes seasonal sand fence to help build up sand accumulation at the toe of the primary dune. |

**Table 8-3**
**History of Beach and Nearshore Nourishment in Grays Harbor County**

| Year | Nearshore Sites | | Beach Sites | | | | Description |
|---|---|---|---|---|---|---|---|
| | South Beach (cy) | Half Moon Bay (cy) | Breach Fill (cy) | Half Moon Bay (cy) | Westport (cy) | Ocean Shores (cy) | |
| 1992 | | 200,000 | | | | | |
| 1993 | 373,000 | | | | | | |
| 1994 | 265,000 | 146,000 | 600,000 | | | | 600,000 cy sand to fill the breach |
| 1995 | | | | 300,295 | 82,000 | | 300,295 cy sand south of revetment; 82,000 cy sand at City outfall |
| 1996 | | 274,780 | | | | | |
| 1997 | | 308,604 | | 5,000 | | | 5,000 cy sand at HMB shoreline berm south of revetment |
| 1998 | | 421,468 | | | | | |
| 1999 | 76,187 | 228,470 | | 228,963 | | | 228,963 cy sand at revetment extension beach fill |
| 2000 | | | 11,600 | | | | 11, 600 cy of 12" minus cobble and gravel along HMB Breach Fill |
| 2001 | | | 16,100 | | | | 16,100 cy of 12" minus cobble and gravel along HMB Breach Fill |
| 2002 | 75,219 | 378,441 | 135,000 | | | | 135,000 cy sand at HMB |
| 2003 | 125,388 | 329,106 | | | 1,700 | | 1,700 cy sand at HMB beach along dune trail |
| 2004 | 262,176 | 289,652 | 29,553 | | | | 29,553 cy sand at HMB Breach Fill |
| 2005 | 217,909 | 102,184 | 22,779 | | | | 22,779 cy sand at SB at Breach Fill |
| 2006 | 55,170 | 126,892 | | | | | |
| 2007 | | 140,406 | | | | | |
| 2008 | | 171,353 | | | | | |
| 2009 | 214,502 | 144,975 | | | | | |
| 2010 | 118,182 | 91,720 | 30,000 | | | | 10,000 cy sand at HMB Breach Fill; 20,000 cy sand at SB Breach Fill |
| 2011 | 298,251 | 177,150 | | | | | |
| 2012 | 142,313 | 111,205 | 30,000 | | | | 30,000 cy sand from upland source to Breach Fill |
| 2013 | 477,637 | 86,147 | | | | | |
| 2014 | 498,440 | | | | | | |
| 2015 | 506,330 | | | | | 3,350 | 1,600 cy of sand + 1,750 cy of sand placed in front of geotubes |
| 2016 | 544,980 | | | | | | |
| 2017 | 499,001 | 101,019 | | | | | |
| **Sum** | **4,749,685** | **3,829,572** | **875,032** | **534,258** | **83,700** | **3,350** | |
| | **Total Nearshore 8,579,257** | | **Total Beach 1,496,340** | | | | **Total Nourishment 10,075,597** |

### *Westport and Cohassett Beach*

During and immediately after construction of the South Jetty, the adjacent shoreline advanced seaward by 2,077 ft, before retreating by 846 ft between 1909 and 1926 (Kaminsky et al., 2010). As the South Jetty deteriorated, sand from the ocean shoreline passed over the jetty to nourish the shoreline on the harbor side until the jetty was rehabilitated between 1935 and 1940. The jetty repairs resulted in further build out of the shoreline to the south until about 1960 (Buijsman et al., 2003), while shoreline erosion commenced and began to form Half Moon Bay by 1946, which necessitated construction of a 2,880-ft long revetment, seven groins, and three timber pile breakwaters to stabilize the Point Chehalis shoreline between 1950 and 1957 (Osborne et al., 2003). Over time, the Half Moon Bay shoreline between the revetment and the south jetty continued to recede, destroying several U.S. Coast Guard structures and continuing to endanger city infrastructure (USACE, 1997).

Portions of the Point Chehalis revetment have been rebuilt several times since 1960, with a major reconstruction of the revetment and groins between 1972 and 1973 (USACE, 1973). A 4,000-ft landward section of the South Jetty was rebuilt in 1966, but the shoreline within 1.5 miles of the jetty continued to erode and, after 1987, began to accelerate as the more landward portion of the jetty was exposed by the retreating shoreline and continued to deteriorate (Buijsman et al., 2003). Shoreline erosion along both Half Moon Bay and South Beach narrowed the neck of land remaining connected to the South Jetty. To help mitigate the erosion, the U.S. Army Corps of Engineers placed 200,000 cy of dredged sand in the form of a submerged nearshore berm in Half Moon Bay in May 1992 and 373,000 cy of dredged sand in the South Beach nearshore in the fall of 1993 (Osborne et al., 2003).

In December 1993, a storm with only a 2-year return period initiated a breach along the south side of the South Jetty between the ocean and Half Moon Bay, which deepened and widened from only about 13 ft, initially, to about 650 ft in the subsequent months, eroding a portion of Westhaven State Park and posing a threat to City of Westport public facilities, including the municipal water well and wastewater treatment plant (Kaminsky et al., 1997; Arden, 2003; Buijsman et al., 2003; Kraus and Wamsley, 2003; Wamsley et al., 2006). The magnitude of the erosion and its implications caught coastal communities and governmental agencies by surprise, and there was much debate and controversy over the appropriate response (Kaminsky et al., 1997). In May 1994, the U.S. Army Corps Seattle District nourished both the Half Moon Bay berm with an additional 146,000 cy of dredged sand and the South Beach nearshore with 265,000 cy of dredged sand before subsequently closing the breach in the fall of 1994 by filling it with 600,000 cy of sand dredged from the navigation channel at a cost of $3,730,000 (approximately $6.22 per cubic yard) (Arden, 2003; Kraus and Wamsley, 2003; Osborne et al., 2003) (Figure 8-9).

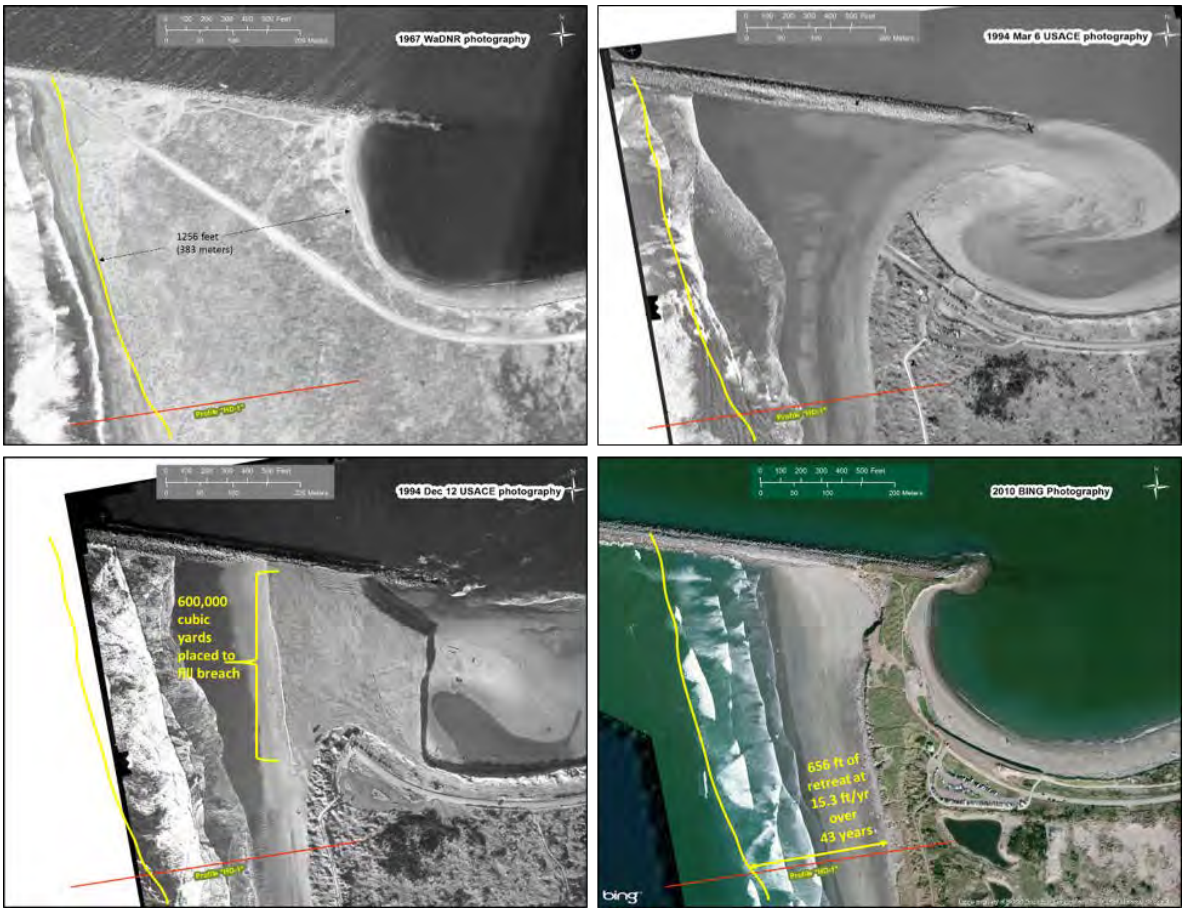


*Figure 8-9. Photo set of South Jetty breach area*

The shoreline breach was a catalyst for focusing attention on the need for better information on regional coastal processes. In the fall of 1994, the Washington Department of Ecology convened a series of meetings with local, state, and federal agencies to determine how to develop this information; the meetings resulted in a cooperative interagency proposal to investigate the natural hazards, coastal changes, and sediment dynamics along the southwest Washington coast (Kaminsky and Gelfenbaum, 1999).

Despite the closure of the breach and nearshore placement of additional sand in Half Moon Bay in the fall of 1994, coastal erosion continued to impact development along Half Moon Bay. In January 1995, the City of Westport declared a state of emergency when four sections of sewer outfall pipe broke apart due to erosion. The City carried out emergency repairs and placed 82,000 cubic yards of sand on the Half Moon Bay shoreline to protect their sewer outfall line from additional damage. Nearly all of this material eroded by the end of winter, and in the fall of 1995, the U.S. Army Corps of Engineers placed 300,295 cubic yards of dredged sand directly onshore south of the Point Chehalis revetment (Osborne et al., 2003).

By this time, it became clear that ongoing nourishment of sand to Half Moon Bay would be needed to maintain a stable beach profile and shoreline position. Between 1996 and 1999, the U.S. Army Corps of Engineers increased the sand supply to Half Moon Bay, placing more than 300,000 cy/yr, on average. In 1999, the U.S. Army Corps of Engineers also resumed substantial beach nourishment and further protection of upland facilities by extending the Point Chehalis revetment by 1,900 ft and placing 228,963 cy of sand on top of and seaward of the revetment extension. The revetment extension was designed and constructed as a buried revetment behind the primary dune along the shoreline, and as part of an interagency mitigation agreement, periodic nourishment of the beach along the revetment is required to ensure the armor stone toe

of the revetment is not exposed (Arden, 2003; USACE, 2014). As such, the sand fronting the buried revetment could also be used, as needed and available, as an upland stockpile of sand suitable for rehandling to nourish adjacent eroding beaches, particularly the breach fill, as was done in 2002, 2004, 2005, and 2010 (Table 8-2) to prevent breaching.

During the winter of 1999-2000, the U.S. Army Corps of Engineers installed a wave diffraction mound at the landward end of the south jetty to reduce wave-induced erosion of Half Moon Bay. While the stated purpose was to reduce the potential for another breach by distributing the wave energy more evenly throughout the bay, the net effect near the breach fill was to increase the wave energy, and 11,600 cy of cobble and gravel fill was placed on the beach along the breach fill to counter these effects. The wave diffraction mound effectively changed the hard point that determines the equilibrium shape of the crenulate bay. As a result, the western end of Half Moon Bay experienced erosion between 1999 and 2004, as the bay adapted to the changed anchor point (Hughes and Cohen, 2006). This adjustment toward a new shoreline planform made it imperative to continue the placement of dredged material in Half Moon Bay until a dynamic equilibrium was reached. Hughes and Cohen (2006) acknowledge, however, that while the nearshore bathymetry and shoreline will change over time in response to storms and longer periods of milder waves, any loss of dunes along the bay would not be replaced by these natural forces. In October 2003, erosion of the southwest Half Moon Bay shoreline undermined a concrete pedestrian walkway and the City of Westport installed ecology blocks and 1,700 cubic yards of sand to prevent collapse of the walkway as an emergency action (Figure 8-10).

*Figure 8-10. Emergency dune protection constructed at Half Moon Bay, Westport, in October 2003*

By this time, it was also evident that the shoreline and nearshore area south of the South Jetty was undergoing chronic erosion and that any new breaching would likely be caused by erosion and dune recession from the ocean side (Hughes and Cohen, 2006). Between 1954 and 1999, the nearshore area within 3.7 miles south the South Jetty lost 70.5 million cy of sediment (1.57 million cy/yr) (Kaminsky et

al., 2010). From 2002 onward, the U.S. Army Corps of Engineers continued nearly annual nearshore nourishment of both South Beach and Half Moon Bay (Table 8-3). The 3,500-ft reconstruction of the South Jetty between 1999 and 2002 did not reduce the nearshore erosion or the rate of shoreline recession. Figure 8-9 illustrates the shoreline retreat near the South Jetty. From 2009 to 20012, the average annual nearshore nourishment to South Beach was about 193,000 cy/yr. This amount was substantially increased to an average of about 505,000 cy/yr between 2013 and 2017.

During the strong El Niño during the winter of 2015-2016, the last remnant of the primary dune in the vicinity of the Westport by the Sea Condominiums was lost. The dune had been chronically eroding since 1997 at an average rate of 7.2 ft/yr as documented by quarterly beach surveys collected by the Washington Department of Ecology Coastal Monitoring & Analysis Program at nearby beach profile "Worm" (Table 8-4; Figure 8-11). The erosion threatened the Westport by the Sea Condominiums and in February 2016, the Homeowners Association repaired the eroded dune with coir fabric, sand fill, and anchored logs in front of Building 8.

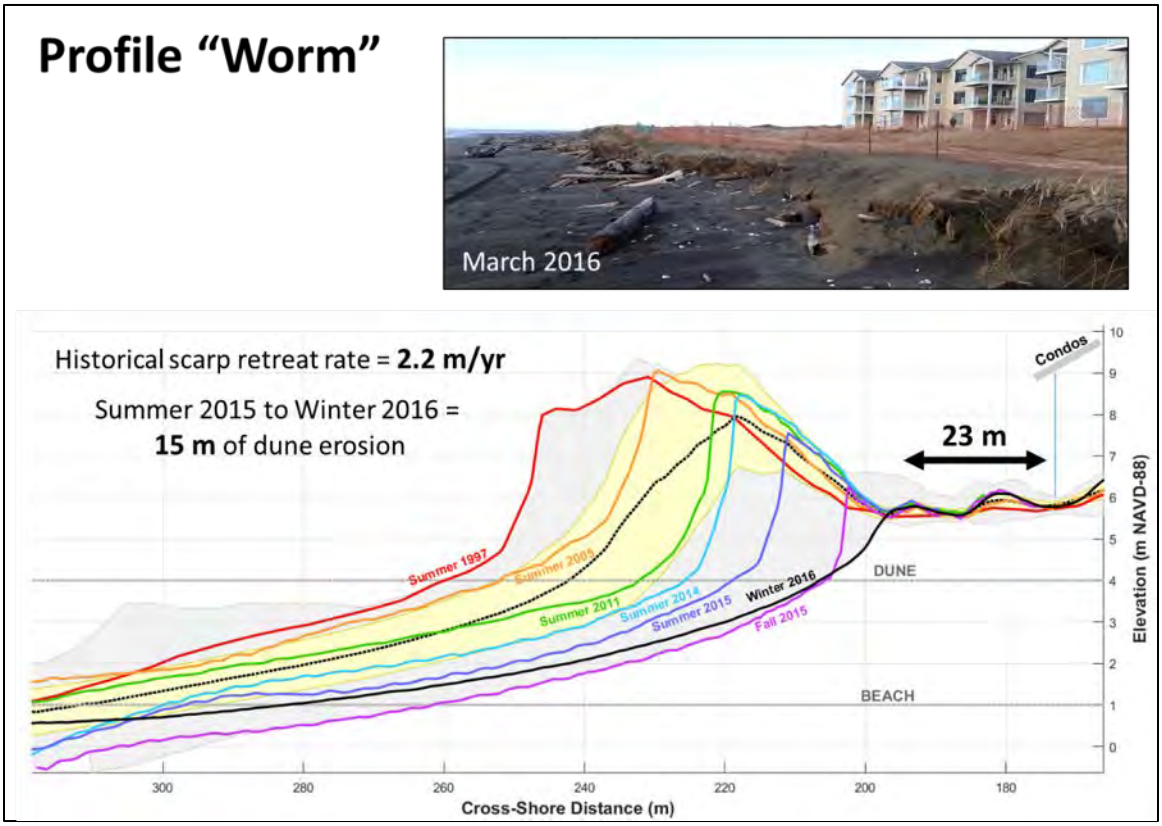


*Figure 8-11. Cross-shore beach profile data collected by the Washington Department of Ecology at Westport between summer 1997 and winter 2016*

With $200,000 support from the legislature for the Grays Harbor Coastal Resilience Coalition, the Washington Department of Ecology Coastal Monitoring & Analysis Program performed augmented monitoring at chronically eroding beaches at both Westport and Ocean Shores beginning in 2015. This enabled a more detailed analysis of the amount of sand being lost to the beaches and dunes. At Westport between the South Jetty and 2.1 miles south of the jetty at profile "Spice", the average loss of sand is 63,100 cy/yr (Table 8-4). This quantity represents a feasible amount of sand that could be potentially added to the coast if cost-shared with the U.S. Army Corps of Engineers. Without additional augmentation of the sediment budget to this area, the shoreline is expected to continue to retreat in the future.

*Table 8-4. Beach and dune volume change trends for Washington Department of Ecology beach profiles; the columns on the far right show total erosion and net loss or gain for the North Beach and Grayland Plains subcells.*

| | | | | | Volume Change Trends (m^3/yr/m) | | | Total Volume (cubic yards per year) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Description* | **Profile Name** | **Approx Northing** | Length of shoreline represented (m) | **DUNE** | **BEACH** | **DUNE + BEACH** | **DUNE** | **BEACH** | **DUNE + BEACH** | **Erosion only** | **Net loss or gain** |
| | | **Diana** | 199545 | **3900** | 9.8 | 10.2 | 20.0 | **49,700** | **52,100** | **101,900** | | |
| | *the casino* | **Casino** | 196555 | **2902** | 3.5 | 14.4 | 17.9 | **13,100** | **54,800** | **68,000** | | |
| | | **Damons** | 193740 | **2778** | 10.5 | 21.2 | 31.7 | **38,100** | **77,000** | **115,100** | | |
| | | **ET** | 191000 | **3068** | 12.9 | 17.8 | 30.6 | **51,600** | **71,400** | **123,000** | | |
| ***North Beach*** | | **Butter** | 187605 | **1800** | 15.0 | 13.7 | 28.7 | **35,300** | **32,200** | **67,400** | | |
| | | **NB #19** | 187400 | **604** | 8.7 | 10.9 | 19.6 | **6,800** | **8,600** | **15,500** | | |
| | | **NB #14** | 186397 | **909** | 8.3 | 5.2 | 14.1 | **9,900** | **6,200** | **16,700** | | |
| | *scarp ends* | **NB #10** | 185582 | **499** | 6.2 | -2.8 | 4.1 | **4,000** | **-1,800** | **2,700** | **-25,800** | **487,300** |
| | | **NB #9** | 185398 | **195** | 1.8 | -2.4 | -0.6 | **500** | **-600** | **-100** | | |
| | | **NB #8** | 185192 | **203** | 6.1 | -5.2 | -2.6 | **1,600** | **-1,400** | **-700** | | |
| | | **NB #7** | 184992 | **196** | 0.7 | -6.6 | -6.3 | **200** | **-1,700** | **-1,600** | | |
| | | **NB #6** | 184799 | **196** | 2.7 | -9.8 | -12.0 | **700** | **-2,500** | **-3,100** | | |
| | | **NB #5** | 184601 | **198** | -2.0 | -15.4 | -16.1 | **-500** | **-4,000** | **-4,200** | | |
| | | **NB #4** | 184404 | **183** | -5.7 | -15.4 | -21.5 | **-1,400** | **-3,700** | **-5,200** | | |
| | *geobags* | **X1-North** | 184235 | **100** | -0.4 | -8.3 | -8.8 | **-100** | **-1,100** | **-1,200** | | |
| | | **NB #3** | 184204 | **115** | -3.8 | -11.6 | -17.5 | **-600** | **-1,700** | **-2,600** | | |
| | *wave* | **NB #2** | 184005 | **128** | -4.3 | -12.8 | -22.9 | **-700** | **-2,100** | **-3,800** | | |
| | *bumpers* | **X1-South** | 183948 | **102** | 0.0 | -7.1 | -7.6 | **0** | **-1,000** | **-1,000** | | |
| | *North Jetty* | **NB #1** | 183801 | **146** | 7.0 | -4.5 | 2.7 | **1,300** | **-900** | **500** | | |
| ***Grays Harbor*** | | | | | | | | | | | | |
| ***Grayland Plains*** | *South Jetty* | **HD-1** | 180642 | **1120** | 1.3 | -2.8 | -1.4 | **2,000** | **-4,100** | **-2,100** | | |
| | *Westport By* | **Worm** | 179078 | **877** | -7.2 | -7.8 | -15.0 | **-8,300** | **-8,900** | **-17,200** | | |
| | *the Sea* | **GP #85** | 178887 | **195** | -2.8 | -7.0 | -11.5 | **-700** | **-1,800** | **-2,900** | | |
| | | **GP #84** | 178687 | **188** | 0.2 | -7.4 | -9.5 | **0** | **-1,800** | **-2,300** | **-63,100** | **-26,900** |
| | | **GP #83** | 178512 | **149** | -0.7 | -6.3 | -4.5 | **-100** | **-1,200** | **-900** | | |
| | | **GP #82** | 178389 | **362** | NaN | -6.7 | NaN | **NaN** | **-3,200** | **NaN** | | |
| | | **Spice** | 177787 | **1776** | -4.9 | -7.1 | -12.0 | **-11,400** | **-16,400** | **-27,800** | | |
| | *scarp ends* | **Rdan** | 174837 | **2900** | 8.3 | -1.4 | 6.9 | **31,500** | **-5,200** | **26,300** | | |

Despite the placement of over 2.1 million cy of sand in the Half Moon Bay nearshore between 2002 and 2013, the Point Chehalis revetment has recently required routine repairs due to the increased wave energy associated with the continued deepening of the inlet. Typical winter storm waves now overtop the revetment that is not possible to eliminate under the constraints of the current project authorization (Michalsen and Brown, 2015). The overtopping causes flooding throughout the Westport business district and Marina area. Frequent wave overtopping removes armor stone and core material and erodes the sand foundation on the landward side which causes progressive damage, destabilization, and subsidence of the revetment. The U.S. Army Corps of Engineers performed structural repairs along different sections of the revetment in 2010, 2013, and 2015 (Table 8-2; Figure 8-12).

*Figure 8-12. Photo of Point Chehalis revetment repairs in 2013 from Michalsen and Brown (2015)*

### *Ocean Shores at North Jetty*

Following completion of the Grays Harbor North Jetty in 1916, the shoreline rapidly advanced seaward adjacent to the jetty. By 1927, the shoreline within 4 miles of the jetty advanced an average of 0.75 mile seaward from its pre-jetty position. The shoreline advanced progressively less seaward as far north as Copalis Beach, which changed the regional shoreline orientation to face more to the west-northwest (Kaminsky et al., 2010). Between 1927 and 1950, the regional shoreline continued rotate and build seaward, advancing at an average rate of 45 ft/yr near the jetty and progressively decreasing to a rate of about 5 ft/yr near Moclips. After 1967, the shoreline all the way to Point Grenville advanced seaward. Thus, the North Jetty effectively established a new seaward anchor point for the North Beach Peninsula that affects the shoreline position all the way to Point Grenville.

Closer to the jetty, and upon inspection of shorter intervals of time, the shoreline within about 2 miles north of the jetty is highly affected by the condition of the jetty. By 1934, the outer 1.5 miles of the North Jetty between the shoreline and its western end subsided to approximately -1.5 ft mean lower low water (MLLW). Consequently, the shoreline within 2 miles of the jetty began to retreat in 1923 until the jetty was reconstructed in 1942 to an elevation of +20 ft MLLW for 7,700 ft seaward of the shoreline and then to +30 ft MLLW for an additional 528 ft (Buijsman et al., 2003; Byrnes and Baker, 2003).

Following jetty reconstruction, the shoreline adjacent to the jetty began to advance again until about 1950 when the shoreline within about 1.5 miles north of the jetty stabilized as the outer end of the North Jetty subsided. By 1974, the North Jetty seaward of the shoreline had subsided to an elevation ranging from +3 to +14 ft MLLW for 1,300 ft (1/4 mile) after which the remaining jetty farther to the west was below MLLW. The North Jetty was again reconstructed in 1976, returning a 6,000-ft section of the jetty seaward of the shoreline to +20 ft MLLW. This jetty reconstruction did not significantly affect the local shoreline, as the shoreline remained relatively stable within about 1.5 miles north of the jetty. Figure 8-13 illustrates relatively little change in the shoreline position within about a mile of the jetty since 1951.

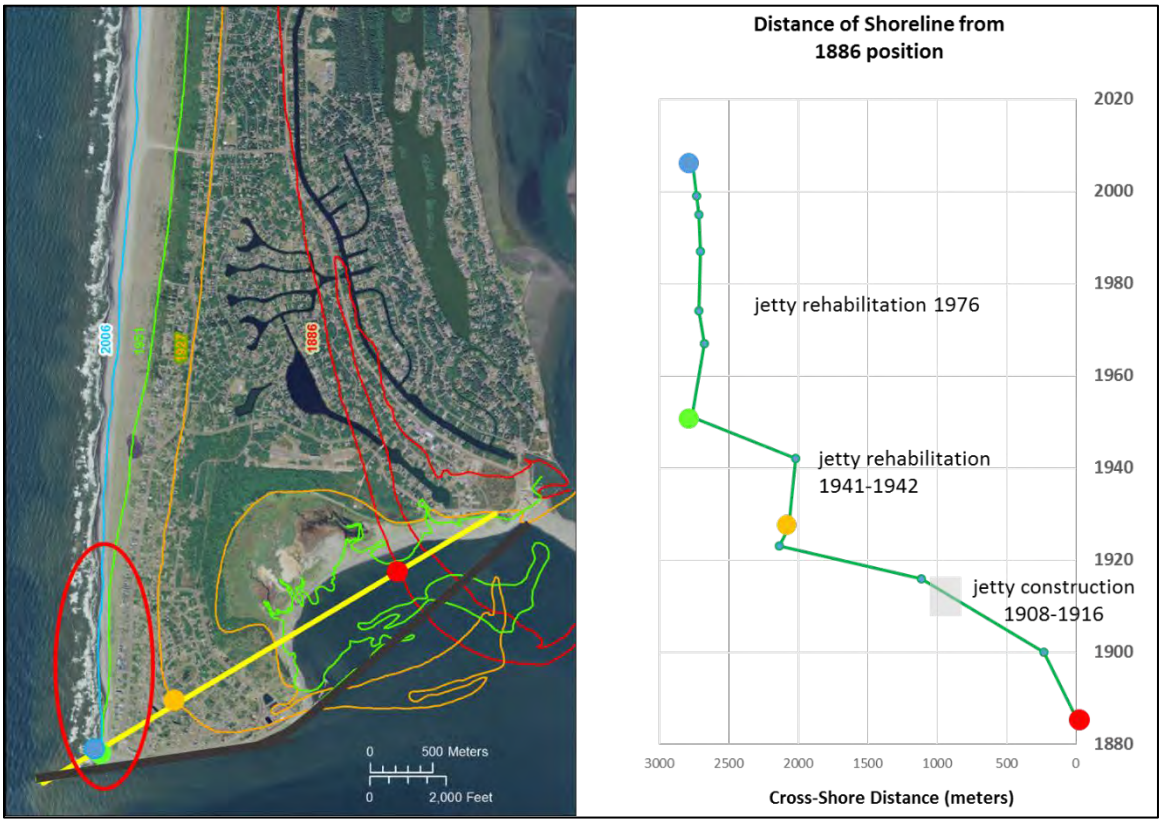


*Figure 8-13. Change in shoreline position near the Ocean Shores North Jetty; shoreline positions through time are taken along the yellow line in the image on the left as a cross-shore distance from the 1886 shoreline (red); the green dots in the plot on the right denote additional shoreline positions not shown on the map on the left*

Following reconstruction of the jetty, in 1976 and 1977, the City of Ocean Shores and the Grays Harbor Conservation District sought to assist in the repair and stabilization of the primary dune that had been severely damaged during the winter of 1974-1975, just prior to the jetty repair. A major storm had completely washed away the dune next to the jetty and had blown-out the dune in several locations within 1.5 miles north of the North Jetty (Grays Harbor Conservation District, 1975). Fertilizer was spread over 55 acres, extending over a swath about 1.5 miles long by 300 ft wide to enhance plant growth along the primary dune north of the North Jetty. European beachgrass was planted to stabilize a 9-acre denuded area

near the jetty that had been washed out during the storm. The project also installed two 500-ft long, 3-ft high picket fences along the previous dune line that were spaced 35 ft apart to enhance sand deposition and rebuild the primary dune. The first fence failed in November 1976, and a second sand fence was installed farther inland from the first fence, and this second fence was partially destroyed during a March 1977 storm (Grays Harbor Conservation District, 1977).

While the shoreline position near the jetty did not significantly change since 1951, nor advance seaward following substantial jetty reconstruction in 1976, development along the primary dune continued to occur, allowing little buffer to account for future shoreline retreat commensurate with jetty degradation over time. Homes and condominiums near the jetty started to be built in the 1980s, and during the winter of 1995-1996, up to 40 ft of the primary dune eroded, placing five developed properties at imminent risk (Figure 8-14). In October 1996, an 850-ft long terraced revetment structure, referred to as the "wave bumpers," was built to provide temporary protection. In January 1998, after a major storm event and high tide, flanking erosion on both ends of the wave bumpers concerned the City and private property owners, and they proposed the installation of geotubes to prevent additional retreat of the primary dune along the north end of the wave bumpers (City of Ocean Shores, 1999). Following a lengthy permit process, 540 ft of geotubes were installed in December 1998, and as part of permit conditions, the City agreed to develop an Environmental Impact Statement associated with a long-term strategy for coastal erosion management.

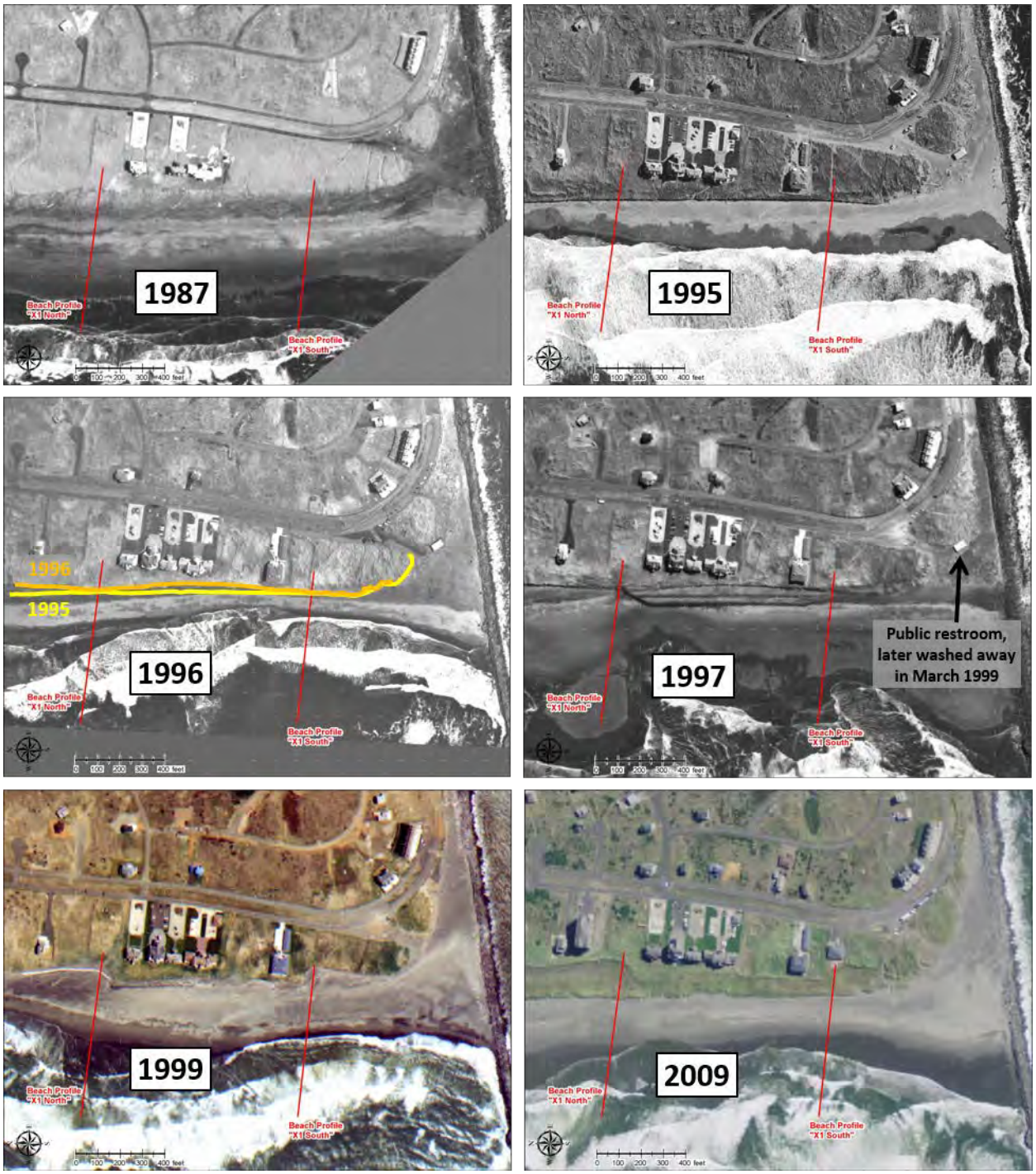


*Figure 8-14. Historical aerial photos of the beach north of the Ocean Shores North Jetty; the 1996 photo shows the position of the vegetation line in 1995 (yellow) and 1996 (orange)*

During a March 1999 storm, waves overtopping the jetty brought over five feet of water to an area 0.75 miles inland of the jetty, damaging East Ocean Shores Boulevard, washing away a public restroom, and causing over $1 million in damages to public and private property (Figure 8-15). While part of the overtopping was due to the degradation of the jetty, it can also be attributed to the erosion of the ebb delta and overall deepening of the inlet that exposes the jetty to larger and more frequent ocean waves approaching from the southwest (USACE, 2000). The more frequent overtopping caused more frequent

and extensive flooding of southern Ocean Shores, erosion of two of the four lanes of Ocean Shores Boulevard along the jetty, as well as erosion along the landward side of the jetty and the formation of swash channels at both ends of the structure (along the Ocean shoreline and along the Oyhut shoreline next to the wastewater treatment plant) (USACE, 2000).

*Figure 8-15. Flooding and erosion of the Ocean Shores public restroom during a storm in March 1999*

In May 1999, the City of Ocean Shores released a Draft Environmental Impact Statement on their long term coastal erosion management strategy (City of Ocean Shores, 1999) which identified several alternatives including: (1) no action, (2) retreat and retreat with dune construction, (3) onshore and/or offshore beach nourishment, and (4) construction of structural features, including seaward extension of the jetty that was not reconstructed in 1976.

During 2000 to 2001, the U.S. Army Corps of Engineers reconstructed a 5,000-ft section of the North Jetty landward of the ocean shoreline to the wastewater treatment plant to +23 ft MLLW; the section seaward of the shoreline was not reconstructed.

Beach monitoring data by the Washington Department of Ecology Coastal Monitoring & Analysis Program showed that following the La Niña winter of 1998-1999 through 2006, the shoreline and dune recovered from it erosive state and built seaward, resulting in most of the wave bumpers and geotubes to become buried in sand. The beach then began to lose volume while the dune continued to build until the fall of 2011. Both the dune and beach retreated sharply during the winter of 2010-2011 and continued on an erosional trend through the winter of 2015 (Figure 8-16 and Figure 8-17).

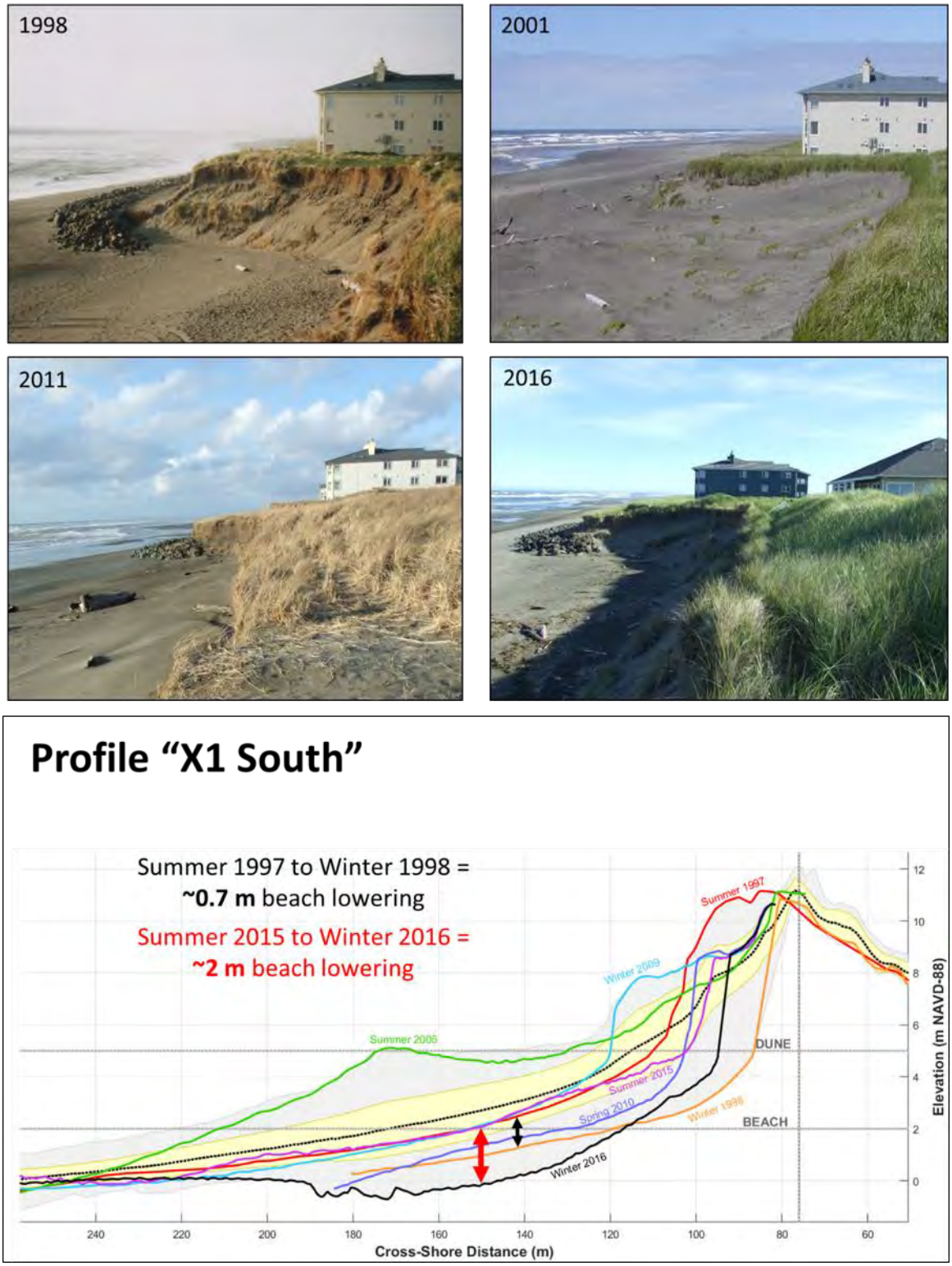


*Figure 8-16. Cross-shore beach profile data collected by the Washington Department of Ecology north of the Ocean Shores North Jetty between summer 1997 and winter 2016*

*Figure 8-17. Photos of Washington Department of Ecology beach profile "South," taken in July 2008 (top) and November 2015 (bottom), illustrating significant dune erosion*

In October 2015, a section of the geotubes immediately north of the wave bumpers was undermined, resulting in a failure at the base. The City of Ocean Shores responded quickly and replaced the failed section with a geobag block structure. By early November 2015, storms threatened to undermine the geobags and the U.S. Army Corps of Engineers provided emergency assistance by placing 1,600 cy of sand at the toe of the geobags (Figure 8-18). A December 2015 storm further exposed and damaged the remaining geotubes to the north, and the City of Ocean Shores placed an additional 1,750 cy of sand at the toe of the geotubes. By January 2016, those sand supplies were lost to erosion and under a declaration of emergency, the U.S. Army Corps installed a rock revetment fronting the full length of the geobags and geotubes (Figure 8-19). This resulted in substantial flanking erosion of the dune to the north of the revetment (Figure 8-20). During the summers of 2016 and 2017, the City of Ocean Shores installed sand fences to the south and north of the revetment structures at the base of the eroded dune to enhance the accumulation of sand during the summer recovery periods (Figure 8-21).

*Figure 8-18. Photos showing geobags and dune nourishment at Ocean Shores in November 2015*

*Figure 8-19. Photos showing Ocean Shores geobags in November 2015 and rock revetment installed in front of geobags during winter 2016*

*Figure 8-20. Photo showing end scour north of the Ocean Shores rock revetment*

*Figure 8-21. Photos showing sand fences installed north of the Ocean Shores rock revetment in 2016*

With augmented beach profile monitoring by the Washington Department of Ecology Coastal Monitoring & Analysis Program (CMAP) since 2015, a persistent erosion scarp of the dune up to about 1.2 mile north of the North Jetty has been mapped. Analyses of the beach profile data has shown that the erosion trend between 2010 and 2015 resulted in the average loss of 25,800 cy of sand from the beach and dune within about 1.2 mile of the North Jetty (Table 8-4). CMAP concluded that without rehabilitation of the North

Jetty seaward of the shoreline, nourishment of sand to the beach and dune would only offer a temporary solution to the erosion.

In 2003, the U.S. Army Corps published a study that evaluated feasible methods for reducing annual maintenance dredging by modification of the North Jetty (Kraus and Arden, 2003). This study further established the relationship between the jetty condition and its seaward extent to the position of the shoreline. The study predicted that each structural alternative considered would result in beach accretion adjacent to the jetty relative to the existing conditions ("Alternative 1"). The larger structures created the greatest change, with maximum advance in shoreline position of approximately 250 ft.

Two of the more feasible scenarios involved jetty extensions westward from the existing end: Alternative 3A involved a 500-ft extension and Alternative 3B involved a 1,200-ft extension. For the 5-yr ("short-term") model simulations, Alternative 3A advanced the shoreline up to 140 ft next to the jetty, and Alternative 3B produced a shoreline as much as 250 ft seaward. Shoreline advance was predicted to be greatest at the jetty and rapidly reduce to no change within 0.5 miles to the north. Between about 0.5 and 2.5 miles north of the jetty, the shoreline was projected to retreat up to a maximum of 30 ft for Alternative 3A and 55 ft for Alternative 3B, with the erosion maximums occurring about 0.75 miles north of the jetty for both alternatives (Figure 8-22). The predicted shoreline erosion relative to the existing condition is associated with a northward shift of a gyre and rip current due to the jetty extension. Existing conditions show a rip current embayment that tends to migrate between about 600 and 1,000 ft north of the jetty; this embayment is predicted to shift northward with the extension of the jetty and contribute to localized net shoreline retreat.

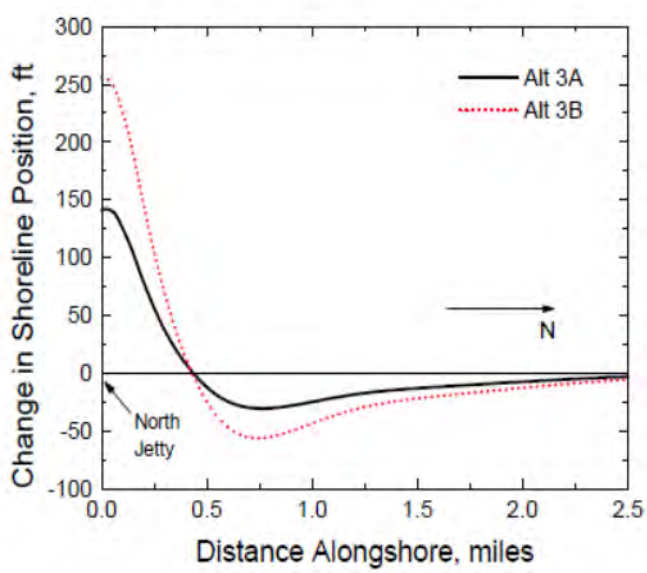


*Figure 8-22. Short-term change in shoreline position relative to alternative 1 (excerpted from Kraus and Arden, 2003)*

For long-term model simulations of 30 years, the maximum shoreline advance distances are similar, but the maximum shoreline retreat to the north is reduced compared to the 5-year projection (Figure 8-23).

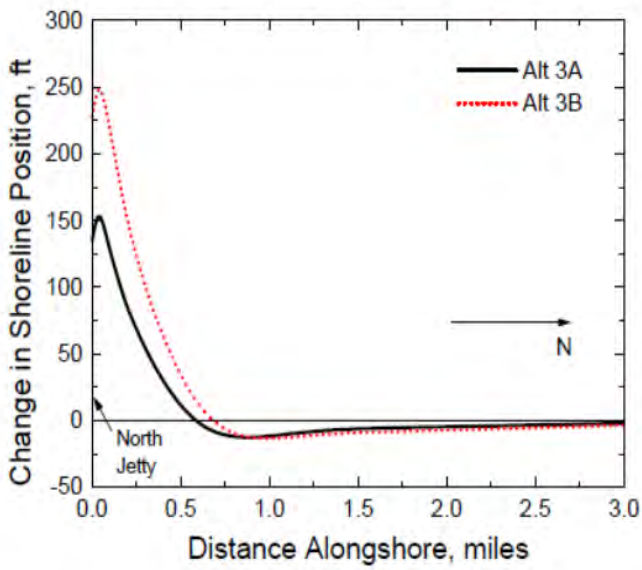


*Figure 8-23. Long-term change in shoreline position relative to existing conditions (excerpted from Kraus and Arden, 2003)*

While these study results are favorable to the City of Ocean Shores, these alternatives would only be expected to reduce southward bypassing of sand into the inlet by 16,000 to 80,000 cy/yr. These reductions are small compared to the estimated 400,000 cy/yr of sand bypassing southward from the North Jetty under the existing conditions. This situation does not result in a sufficient benefit/cost ratio to enable the U.S. Army Corps of Engineers to construct the jetty extensions.

A comparative analysis was more recently performed by Coast & Harbor Engineering on behalf of the City of Ocean Shores (Coast and Harbor, 2016). This study developed a qualitative empirical relationship between the stability of the shoreline and the effective length of the North Jetty and estimated that approximately 1,000 ft of jetty repairs to the existing jetty are required to stabilize the shoreline (i.e., prevent chronic landward retreat). As a result, the City of Ocean Shores has made a request to the State Legislature to provide $4 million to implement at least a partial jetty repair.

### *Oyhut Wildlife Recreation Area and Damon Point*

Surveys prior to the construction of the North Jetty consistently show an outer spit or elongated island extending from the North Beach peninsula into the mouth of Grays Harbor. In the 1841 and 1860 surveys, this feature is identified as Eld Island (for illustrations, see Figures 10 and 11 in Kaminsky et al., 2010). Following construction of the North Jetty in 1916, a new outer spit rapidly grew seaward and southward toward the jetty. By 1921, the spit reached the jetty to form an intertidal embayment on the leeward side. (Figure 8-24). With the deterioration of the jetty over time, the spit grew into the entrance to Grays Harbor, and by 1927 extended eastward approximately 5,000 ft from its westward connection to the jetty. The shallow embayment to the north developed as a salt marsh and became known as the Oyhut tidal flats.

The elongated spit continued to grow until the North Jetty was reconstructed in 1942. As a result of the elimination of sand supply from north to south over the jetty, the spit quickly eroded and became an island by 1943 (Figure 8-25). As the jetty landward of the reconstructed section deteriorated, a spit reformed along the axis of the jetty to the east and, by 1948, reconnected to the remnant island that had migrated eastward to the south of the jetty. This spit was the beginning of what later evolved into Damon Point.

By 1975 when the North Jetty to the west was again reconstructed, two spits extended toward the southeast from the eastern portion of the original jetty. Following completion of jetty reconstruction in 1976, the westward lesser spit deteriorated, likely from the reduction of sediment supply entering the inlet from the north. By 1981, the basal end of the spit along the axis of the North Jetty was breached, allowing for greater tidal flow into the Oyhut embayment (Figure 8-26). By 1985, the two spits to the east merged at the basal end of Damon Point.

With continued deterioration and subsidence of the original jetty section to the west of Damon Point, an elongated spit developed from the southwest portion of the Oyhut tidal flats by 1990. To the north and east of the distal end of this spit was another sand barrier that extended to Damon Point by a narrow neck of land just west of the submerged jetty. At this time the main tidal outflow from the tidal flats was directed toward Damon Point. Kaminsky et al. (1999) suggest that the discharge of sediment through the drainage channel oriented toward Damon Point may be responsible for the nearly stable Damon Point shoreline position between 1990 and 1997.

By 1997, the southwestern area of the Oyhut tidal flats had become more exposed, with deeper water penetrating farther northward, inside the area bounded by the submerged jetty. The elongated spit that extended to the northeast in 1990 ceased to exist. Kaminsky et al. (1999) note that 1998 photography reveals sedimentation near the outflow of the main drainage outflow area at the southwestern portion of the Oyhut tidal flats. It is likely that little of this sediment flows toward Damon Point and, as a result, most of the western end of the Damon Point began to rapidly retreat at rates greater than 98 ft/yr. This is similar to the period between 1985 and 1990 that followed the period when the Oyhut drainage outflow in the southwestern portion of the tidal flats became more dominant. The high rates of shoreline retreat along Damon Point between 1997 and 1998 may have been partially due to higher wave and water levels associated with the El Niño event. The basal end of Damon Point has narrowed over time and the access road washed out during storms in December 1997, December 1998, February 2000, and December 2007, after which no further attempt was made to keep it open to vehicles.

From 1999 to present, the Oyhut shoreline continued to retreat landward and become more of a barrier beach with a gradual infilling of the salt marsh with sand (Figure 8-27). The development and expansion of Oyhut Bay between the remaining hard points at the eastward end of the reconstructed North Jetty near the wastewater treatment plant and the Ocean Shores Marina at the west end of the Bay will control the future evolution of this crenulate bay. The remnant deteriorating section of North Jetty between the Wastewater Treatment Plant and the Marina offers little protection from large waves entering the bay and transforming its shoreline. As Damon Point continues to retreat toward the northwest, the marina breakwater and the Quinault RV Park has become increasingly exposed. Five RV sites were lost to coastal erosion in 2012.

As Damon Point has retreated to the northwest along the basal end, the distal end has continued to grow toward the southeast. This growth has forced the southward migration of the channel thalweg and has altered the transmission of ocean waves into the inner harbor (USACE, 2014).

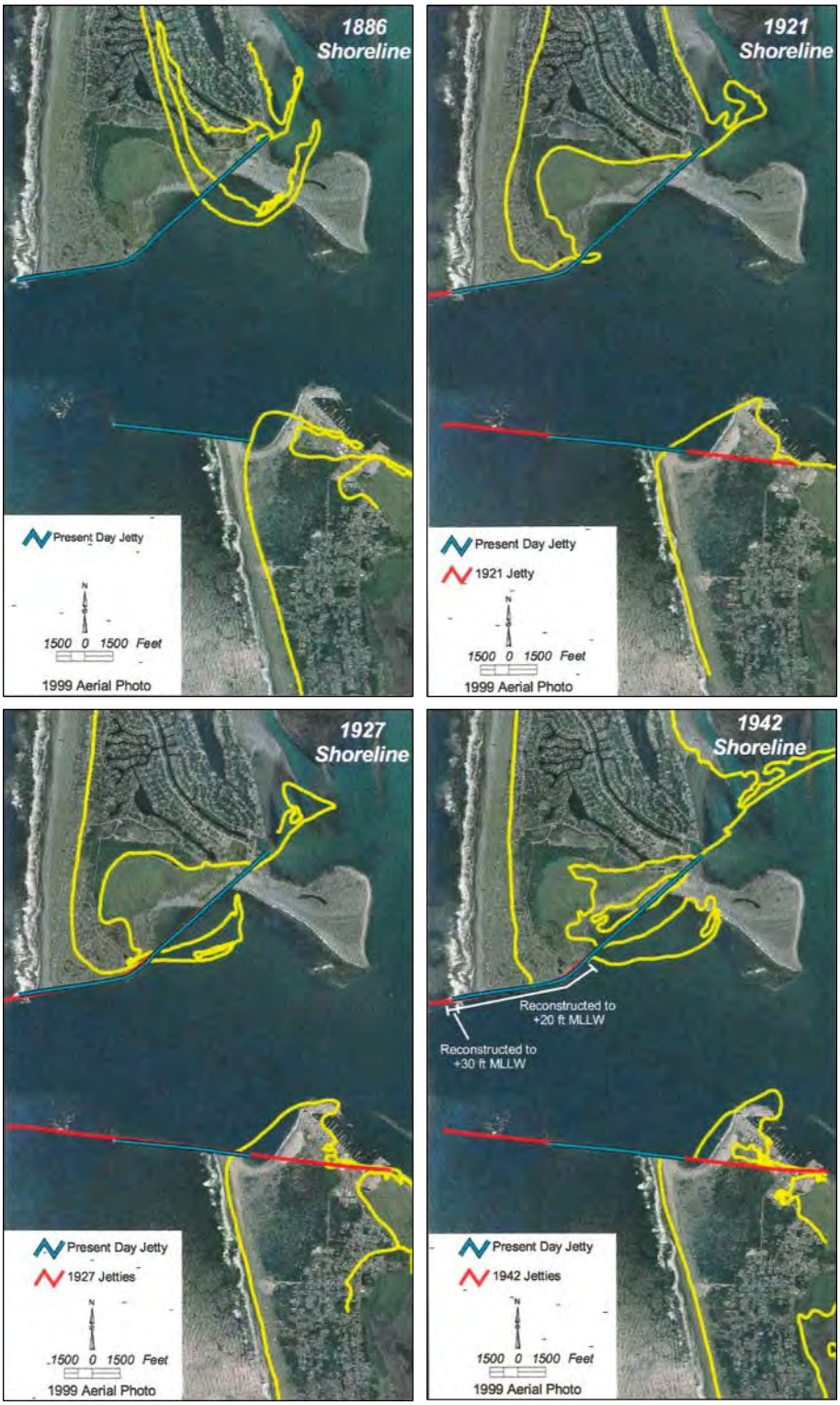


*Figure 8-24. Historical shoreline change at the mouth of Grays Harbor from 1886 to 1942 (from Baker and Byrnes, 2004)*

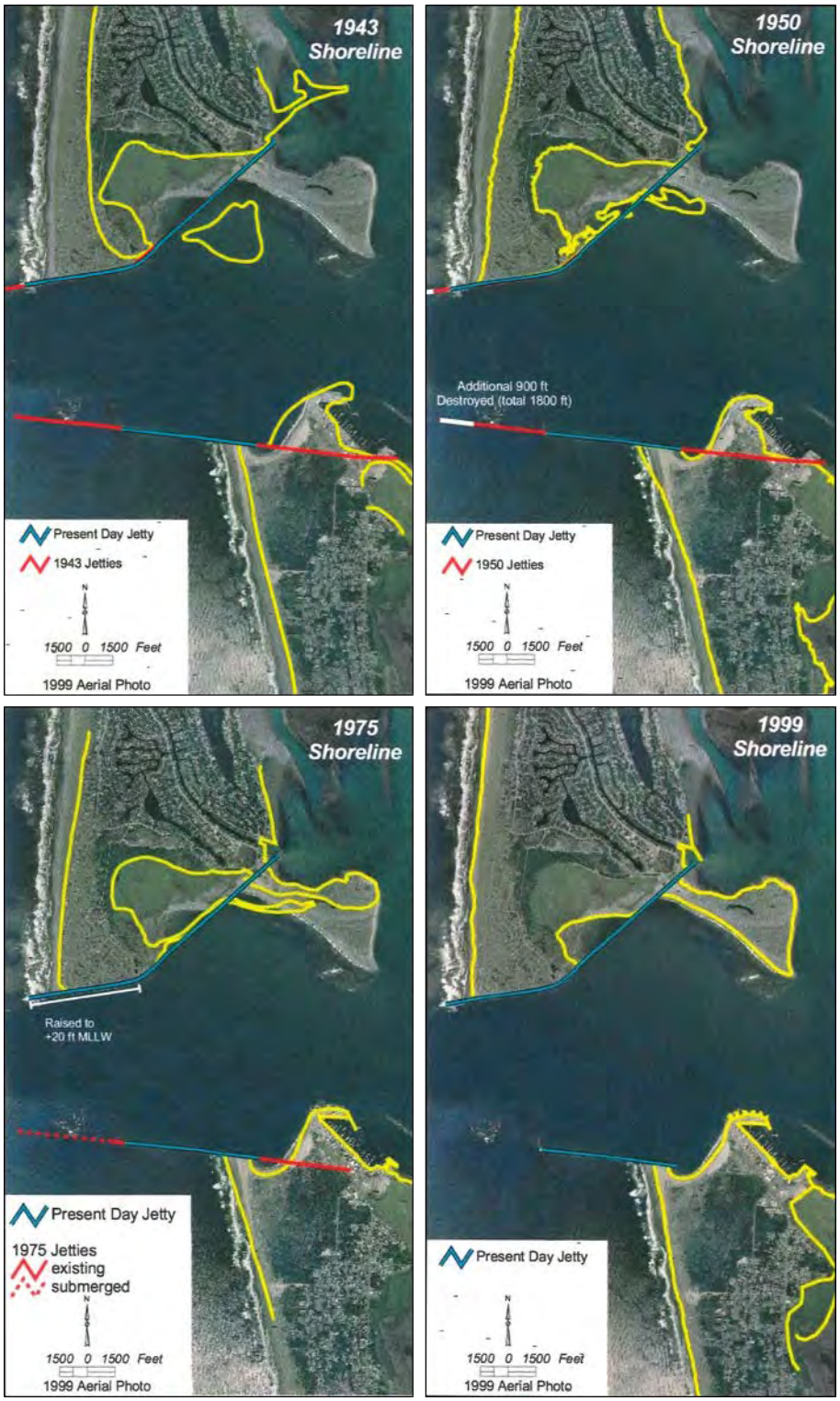


*Figure 8-25. Historical shoreline change at the mouth of Grays Harbor from 1943 to 1999 (from Baker and Byrnes, 2004)*

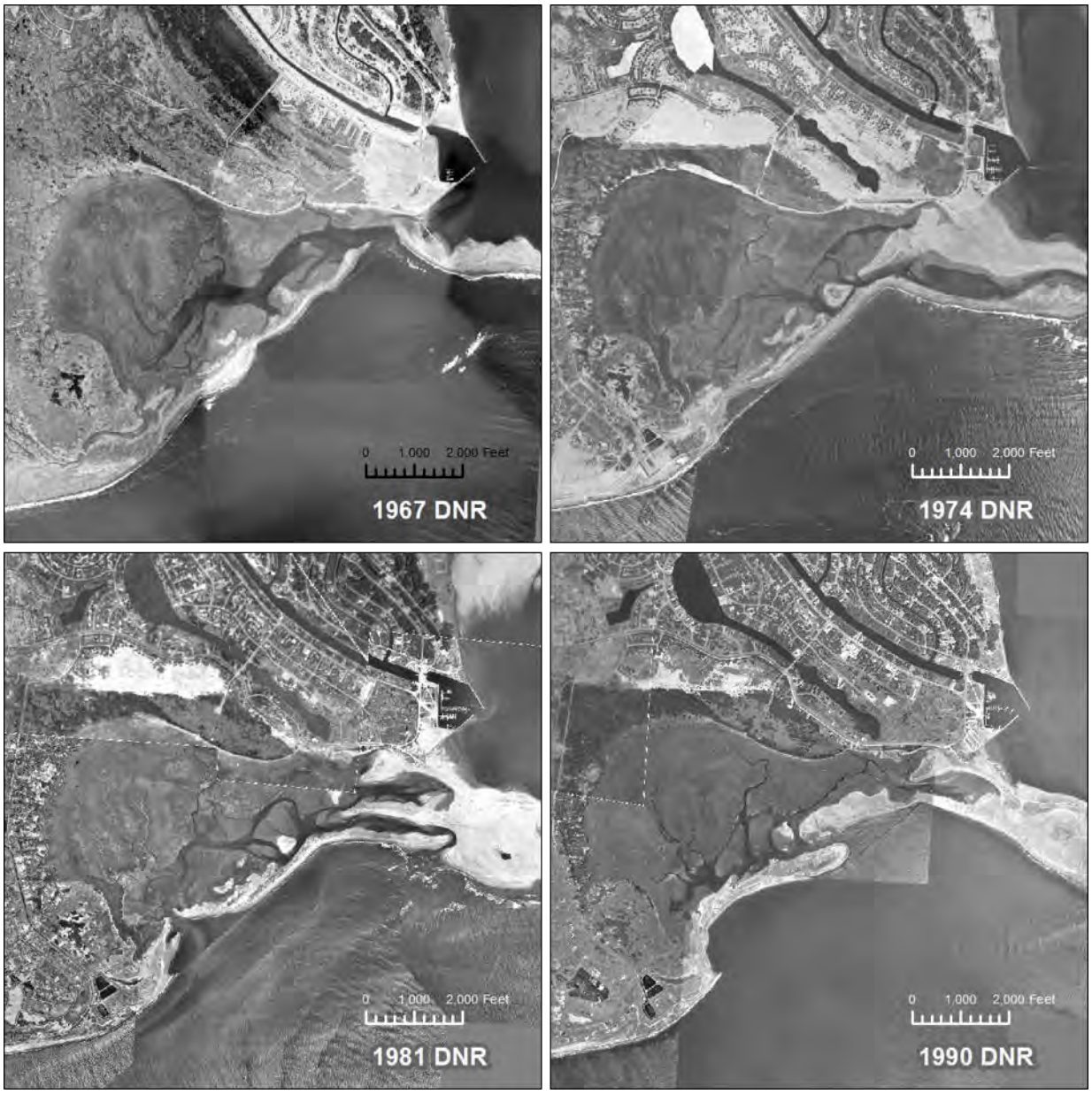


*Figure 8-26. Historical shoreline photos from the Oyhut Wildlife Recreation Area from 1967 to 1990*

*Figure 8-27. Historical shoreline photos from the Oyhut Wildlife Recreation Area from 1999 to 2015*

### *Whitcomb Flats*[1]

Whitcomb Flats is a flood tidal shoal complex located approximately 1 mile east of Point Chehalis (Figure 8-1). Its sediments are composed of sand derived of marine origins which were deposited by tidal flood currents and wave-induced transport. The flood shoal has been a long standing land feature within Grays Harbor which predates the navigation project; Whitcomb Flats was mapped in the 1890 condition survey prior to jetty construction in 1898. Osborne (2003) conducted a geomorphology study on the evolution of Whitcomb Flats using georectified aerial photographs from 1962 to 2001. Figure 8-28 shows Whitcomb

[1] This section is primarily modified after USACE, 2014

Flats has experienced a net eastward migration over this time period. This migration is tied closely with the morphology of the inlet throat.

As discussed in the previous section, the deteriorated condition of the North Jetty resulted in significant sediment transport from North Beach over and through the North Jetty. This caused the distal end of Damon Point to grow toward the southeast, which is a trend that has continued up until present time. This has, in turn, constricted the throat of the inlet between Damon Point and Point Chehalis and resulted in net erosion of 40 million cubic yards of sediment from the seabed since 1954. The pathways of sediment scoured from the inlet throat have primarily been directed offshore due to the strength of the ebb currents on an outgoing tide and has resulted in a diminished sediment supply to Whitcomb Flats over time. Additionally, as Damon Point continued to grow southeast, this forced the southward migration of the channel. As the thalweg migrated south, the wave transmission into the inner harbor was also altered. Deepwater wave energy transmitted into the harbor through the inlet throat refracts into the shallows near Whitcomb Flats. Geomorphology analysis suggests these waves can overwash the low-relief sand flat and cause the eastward migration of Whitcomb Flats.

Osborne (2003) concludes that the eastward migration of Whitcomb Flats appears to be caused by a combination of factors that may include: wave-induced overwash processes and erosion by storm waves; tidal transport; a reduction in sediment supply caused by armoring of the shoreline on the south side of the inlet at Point Chehalis in the 1950s; and, perhaps to a lesser extent, aeolian transport by prevailing westerly winds. Relocation of the navigation channel from Sand Island Reach to South Reach in the late 1970s, maintenance dredging at South Reach, and the widening and deepening project in the 1990s have also contributed to the overall increase in depth locally that has allowed larger waves to reach Whitcomb Flats.

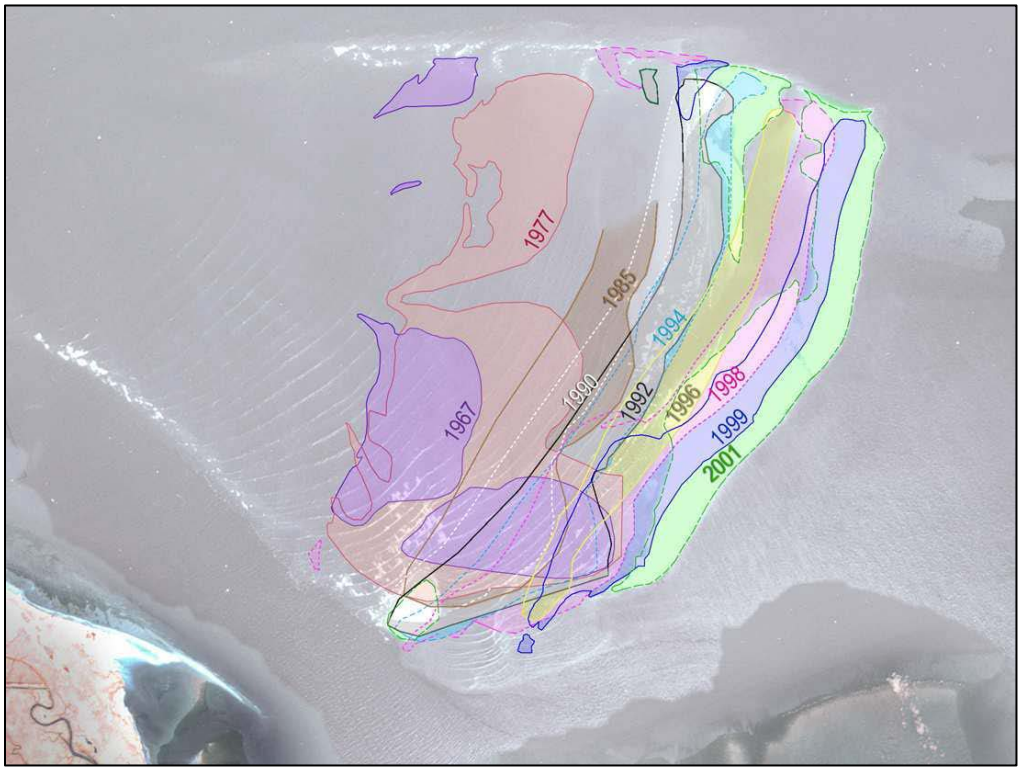


*Figure 8-28. Eastward migration of Whitcomb Flats from 1967 to 2001 (from Osborne, 2003)*

### *Copalis River and Connor Creek*

As described in the Ocean Shores section, the construction of the North Jetty in 1916 enabled the rapid accumulation of sediment to advance the shoreline seaward as far north as Copalis Beach by 1927 and as far north as Moclips by 1950. This northward pulse of beach accretion over time likely induced the net northward migration of river and stream mouths along North Beach. The historical shorelines mapped by the U.S. Coast Survey in 1868 and 1927 show the Copalis River mouth located near the center of Griffiths-Priday State Park. The 1950 shoreline mapped by the U.S. Coast Survey shows the Copalis River mouth migrated northward, and it has continued that trend to the present, though at an increasingly slower rate (Figure 8-29).

Connor Creek, located farther to the south, migrated an even greater distance over time. In 1887, the mouth of Connor Creek was in the vicinity of its crossing under State Highway 109 immediately north of Dunes Lane, which is about 0.8 miles north of the intersection of State Highway 109 and State Highway 115 (Figure 8-29). By 1927, the creek mouth migrated approximately 1.5 miles north and, by 1950, it migrated an additional 0.8 miles north.

Historically, during the 1950s to 1970s, many efforts were undertaken to hold the mouth of Connor Creek between Surfcrest Condominiums to the south and Sea View Estates to the north. The northward migration of the creek mouth appeared to accelerate northward around 1988 at a rate as high as 1,000 ft/yr, affecting a number of properties, including Beachwood Resort, Dunes Beach Resort, Griffiths-Priday State Park, Rod's RV Park, Sea View Estates, Sunrise Resorts, Tidelands Campgrounds, and numerous private residences. The northward migration is likely caused by the predominance of northward sediment transport that lengthens the barrier spit between the ocean and the creek channel. The deposition of sand along the tip of the spit encroaches on the channel and forces the mouth northward. In addition, during winter storms, wave overwash of the barrier can significantly enhance the outflow at the creek mouth, causing erosion along the northern bank.

From 1987 to 2007, the migration of Connor Creek mouth impacted septic systems, cut off vehicular and pedestrian beach access, increased flooding, and decreased tourism. The Heath Road beach access was lost to erosion in January 1999 and the Griffiths-Priday beach access at Benner Road was cut off in March 2000. In November 2007, the Connor Creek pedestrian bridge was opened at the Heath Road beach approach to provide public and emergency vehicle access to the beach. From 1987 to 2016, the mouth of Connor Creek migrated northward by about 2.3 miles (Figure 8-30 and Figure 8-29).

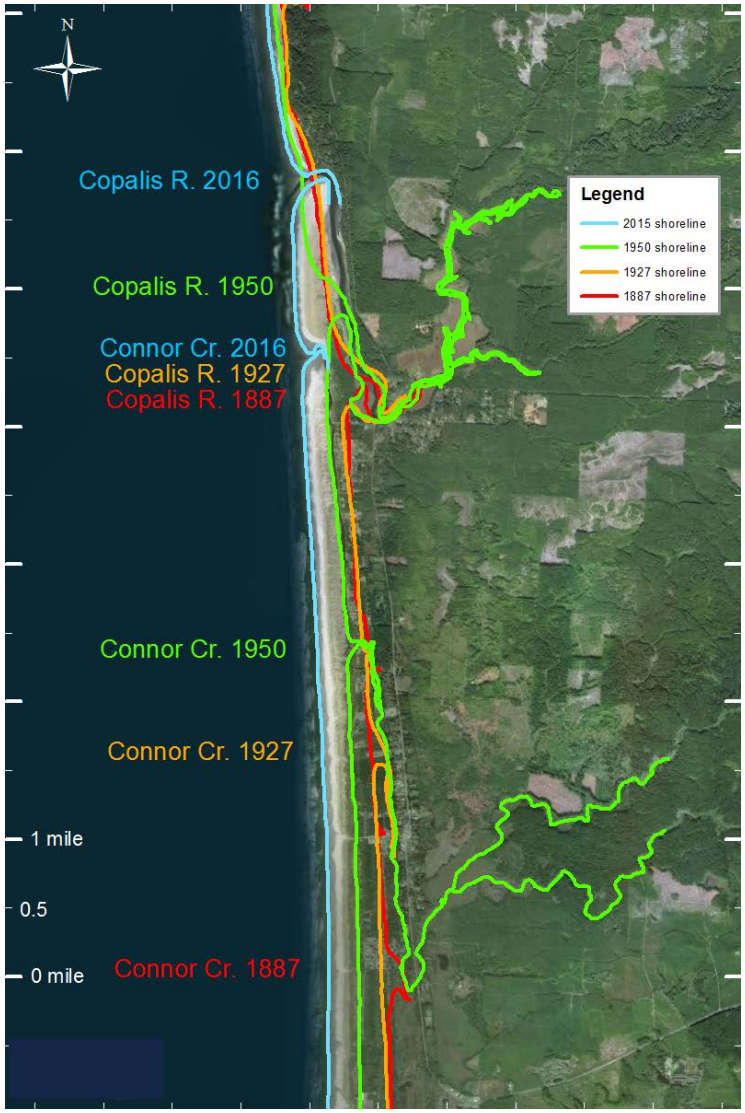


*Figure 8-29. Historical shorelines extending from Connor Creek to the Copalis River illustrating the northward channel mouth migration and seaward shoreline growth over time*

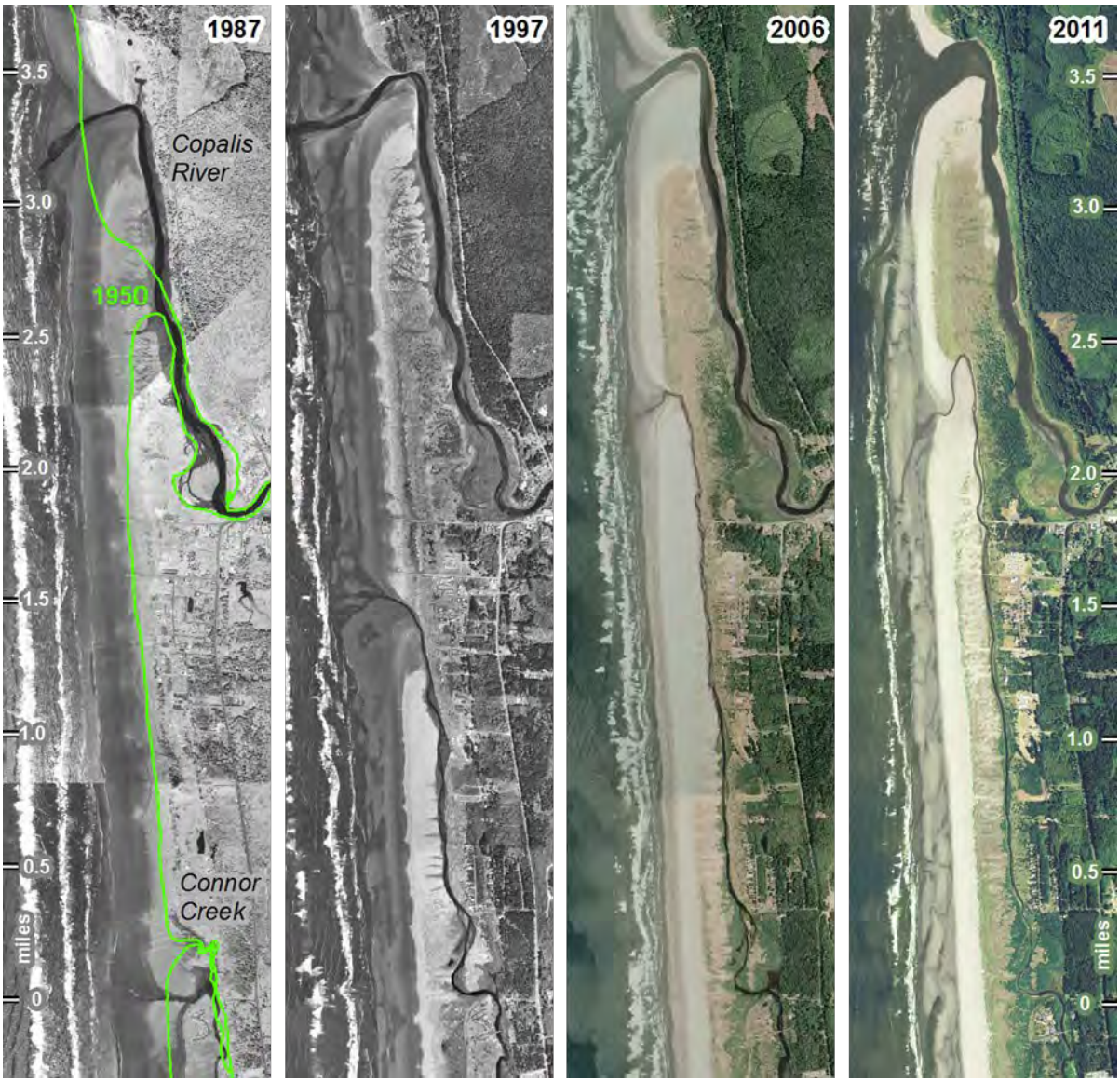


*Figure 8-30. Historical migration of Copalis River mouth and Connor Creek mouth; the 1950 shoreline is overlain on the 1987 photo*

## 8.3 VULNERABILITY ASSESSMENT

### 8.3.1 Overview

The probability for frequent impact from coastal erosion in the identified coastal erosion areas (Figures 8-1 to 8-8) areas is highly likely, whereas less frequent and higher intensity events may impact a larger geographic extent. Coastal erosion does not physically impact the entire county, except in the case of a Cascadia subduction-zone earthquake and/or large tsunami that would likely induce large county-wide coastal erosion. Ocean Shores and Westport have had significant incidents that required emergency measures to be taken by the local government and U.S. Army Corps of Engineers to protect property and public infrastructure.

Coastal areas in Grays Harbor do experience some level of significant erosion activities annually primarily along the ocean coast within about 2 miles of the Grays Harbor jetties and along the shorelines along the Grays Harbor entrance.

The environmental impact from erosion is highly significant, with historic data demonstrating significant changes to sub-tidal, inter-tidal, and sub-aerial coastal environments. Erosion of low-lying entrance spits have resulted in a decline in snowy plover habitat and massive loss of Oyhut salt marsh, and deeper entrance conditions have enabled larger waves to enter Grays Harbor to cause the decline of Whitcomb Flats and loss of productive oyster beds. In addition, some erosion responses have been to protect public and private investments with shoreline armoring, which can also have detrimental impacts on natural processes that support ecosystem functions and exacerbate the geographic extent of the problem.

New construction in critical areas, which includes geologically sensitive areas, is regulated. However, erosion-related impacts to existing commercial and residential structures and associated infrastructure (utilities, roadways, etc.), when coupled with the economic impact to tourism and potential negative impact on real estate taxes, have the potential to harm the entire region.

### 8.3.2 Impact on Life, Health, and Safety

Erosion is generally a slow moving, chronic stressor on a community. However, during storm events, high rates of shoreline retreat can occur, also causing damage from associated flooding and the transport of drift logs and other debris. Wave overtopping of coastal structures, dune blowouts, and infragravity “sneaker” waves can cause can cause high velocity flows over inland areas thought to be safe by unsuspecting observers. The wave climate of the Pacific Northwest is one of the most severe in the world and the mobility of the fine Columbia River sand that make up the beaches of southwest Washington result in relatively large seasonal morphology changes and long-term regional changes from sediment imbalances that may not be realized until the shoreline is within close proximity to human use areas that have been commonly viewed as stable and secure from the coastal hazards. While both chronic and episodic erosion have severe consequences associated to loss of private assets and critical public infrastructure, the direct impacts on life, health and safety is typically low compared to other shoreline natural hazards. Erosion from co-seismic subsidence and large tsunamis can have a high impact on life, health, and safety, but the frequency of these events are relatively low.

### 8.3.3 Impact on Property

Coastal erosion impacts both private and public assets alike, including homes, businesses, public beach and public infrastructure such as roads and utilities. Land use along Grays Harbor County coastal areas varies from private single family homes, public beach, to commercial and industrial uses. A report produced by the Grays Harbor Resilience Coalition (2017) found that coastal erosion and flooding risks have historically caused severe problems for the county and these factors continue to be significant concerns.

Areas of Grays Harbor County that experience the highest risk of shoreline erosion are influenced by the condition of the north and south jetties at the mouth of Grays Harbor. When installed by the U.S. Army Corps of Engineers (USACE), these jetties created artificially stable shoreline conditions, and the surrounding coastal communities continue to develop nearby with the expectation these structures will provide continual protection from erosion. However, coastal processes change as jetties degrade over time, which lead to unintended and significant impacts to adjacent shorelines.

It is estimated that coastal erosion threatens more than $275 million worth of residential structures and community assets in Grays Harbor County. In the City of Ocean Shores erosion scarp runs for two miles, starting at the south end of the city’s North Jetty and toward the city center. The scarp is now a third of the

overall length of Ocean Shores itself and has increased every year since 2009. Twenty percent of Ocean Shores' property value is in jeopardy due to this scarp – $200 million of the city's $1 billion valuation. In the City of Westport, a dune erosion scarp extends more than 1,500 ft south along the shoreline from the South Jetty. Despite significant nearshore nourishment of sand from the U.S. Army Corps of Engineers, every year more than 63,000 cy of sediment erodes from Westport beaches and dunes, threatening loss of State Park property as well as houses and condominiums along the beach.

### 8.3.4 Impact on Critical Facilities and Infrastructure

Critical facilities and infrastructure at risk from erosion along the coastal zone of Grays Harbor County depends on the location of the facility or infrastructure relative to an erosion hazard area. Several types of infrastructure may be exposed to erosion hazards and associated flooding, especially along coastal roads and transportation infrastructure. Significant infrastructure along the coast exposed to erosion hazard includes the following:

- **Roads**—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations, though smaller erosion events can cause disruption as well. Erosion debris can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems and delays for public and private transportation. This can result in economic losses for businesses.
- **Marinas**—The Westport Marina is protected by the Point Chehalis revetment but the structure is not designed for the increasing wave climate that causes frequent overtopping and structural degradation. The Ocean Shores/Quinault Marina and RV Park is increasingly at risk of erosion as well as sedimentation within the marina.
- **Bridges**—Loss of pedestrian and vehicle access across Connor Creek due to erosion has been a recent historical problem, particularly for emergency services.
- Wastewater treatment plants—while the Westport plant is protected from erosion by the Point Chehalis revetment, beach erosion has damaged its outfall pipe in the past. The Ocean Shores wastewater treatment plant is not in immediate risk of erosion, but the formation a runnel along the landward side of the North Jetty and retreat of the Oyhut shoreline portend to increasing risk for the future.

In the City of Ocean Shores, municipal infrastructure including sewer, water, roads and the city's $24.8 million wastewater plant are all vulnerable to inundation due wave overtopping of the North Jetty and the potential for a breach of the primary dune within two miles of the North Jetty. The elevation of the land and infrastructure behind the primary dune, and inadequate drainage create the potential for extensive damages as has been observed in the past prior to jetty reconstruction. Along an erosion scarp in the City of Westport, a sanitary sewer pump station is currently under threat of inundation if erosion continues unabated. Damage to the pump station would affect $50 million of assessed value within the city– about 25 percent of Westport's assessed value and 20 percent of the city's water and sewer utilities' revenue.

### 8.3.5 Impact on Economy

Erosion events shutting down major transportation routes along the Grays Harbor County coast would not only limit the resources available for citizens' use, but also would cause economic impact on businesses in the area. Highway 101 serves as a primary transportation route along the county coast, running very near shore in some areas. Impacts to this highway could also significantly reduce the tourism industry along the coastal sections of the county, especially summer months. Beach access becoming limited may reduce local tourism, impacting the local community and economy, as has been experience in the past along Connor Creek. Washington beaches are accessible by common law to the public in both wet and dry areas, though this does not guarantee access. While this gives more access to public beach than in some other states

where the public domain on beaches differs, erosion of beaches may still have an impact on recreational tourism as accessible areas experience erosion. High and steep erosion scarps along Ocean Shores and Westport can limit public beach access. Reduced access to Damon Point due to erosion of the road and a decline in navigable access to the Quinault Marina and RV Park facilities due to erosion reduces economic opportunities. For example, the seasonal passenger ferry that once operated between Westport and Ocean Shores is no longer in service.

Loss of access to businesses and beaches may result in decreased tax revenues to coastal municipalities, school districts, and the County overall. While these impacts will be temporary, more severe and chronic erosion may result in loss of private property, causing permanent decreases in property tax revenue.

### 8.3.6 Impact on Environment

Erosion has the potential to impact coastal environments in nearshore areas and tidal marshes, beaches, and upland dune areas. Erosion and increased sediment input from shore areas may impact habitat for Dungeness crab, razor clam, and surf smelt (Shipman, MacLennan, and Johannessen, 2014). Grays Harbor is the second largest estuary in Washington State, with the Grays Harbor National Wildlife Refuge located on the north side of the bay comprising 1500 acres of salt marsh, intertidal mud flats, and upland habitat (https://www.fws.gov/refuge/Grays_Harbor/about.html). The harbor area may be of concern with regards to possible climate change impacts on increased erosion rates, as the delta may experience increased erosion at a greater rate than it is able to accrete sediment into the marsh and tidal areas and compensate for rises in sea level (Mauger et al., 2015). Grays Harbor estuary is also part of the Western Hemisphere Shorebird Reserve Network, it being a crucial habitat area for roughly 500,000 shorebirds of 24 different species during migration periods (https://www.whsrn.org/grays-harbor-estuary).

At the south end of the Ocean Shores Peninsula, Oyhut Wildlife Recreation Area encompasses 683 acres. Maintained as waterfowl habitat and recreation area, the Grays Harbor Estuary Management Plan (1986) considers this area a high priority area for active wildlife management, with significant riparian vegetation and saltwater marsh habitat. Except by natural processes, minimal alteration of this valuable habitat area should be allowed. That is, any future development adjacent to Oyhut should avoid negatively impacting the marsh and riparian areas, even those actions deemed erosion mitigation measures. Loss of back bay marsh in Oyhut due to the erosion of waterward spits and conversion of the tidal flats to barrier beach has likely contributed to significant and rapid loss of valuable marsh habitat. With continuing expansion and formation of Oyhut Bay, little marshland may be remaining in the coming decades.

The deepening of the entrance and the transmission of increasing larger waves into the inner harbor has contributed to the chronic erosion of Whitcomb Flats and loss of productive oyster beds.

Certain types of response to shoreline erosion (i.e., hard armoring) could have adverse consequence and lasting impacts on the coast, including:

- Extending erosion to properties further along the shoreline and blocking onshore sources of sediment necessary for resupplying and maintaining a useable beach.
- Obstructing public access to and along the shoreline, which is to result in tourism losses, critical to our coastal economies.

Harming plant and animal species listed under the Endangered Species Act (ESA) as well as reducing natural on-shore vegetation and increasing nearshore wave energy. GHRC partners agree that harder shoreline armoring is not the desired result; however, it is difficult to prevent private projects without other feasible options for landowners and the cities to protect their investments.

## 8.4 FUTURE DEVELOPMENT TRENDS

Under the Growth Management Act, the County is required to address geologic hazards within its Critical Areas Ordinance, which it does in Section 18.06. Continued application of land use and zoning regulations, as well as implementation of the International Building Codes, will assist in reducing the risk of impact from coastal erosion hazards.

While the population of Grays Harbor County shrunk between 2014 and 2016, from 73,300 to 72,820, projections by the Washington State Office of Financial Management have the county experiencing an increase in population to roughly 75,500 in 2030. Thought this is a modest increase development along the shoreline areas are in high demand. Large investments are made because of the views, access to the beach, and other ocean interests. These areas of the County and cities, however, are also some of the most vulnerable to erosion. Once development occurs, it is extremely difficult to adapt to the dynamics of Pacific Northwest coastal processes, placing increased pressure to protect when erosion occurs.

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could further raise sea levels, increasing beach erosion along the County's coastline. While total sea-level rise projections are uncertain, storm-induced increased water levels are likely. Higher water levels and increased wave action may overtop dunes and coastal structures and breach other coastal barriers and erosion mitigation measures, making the susceptibility of these areas to damaging erosion a greater threat.

## 8.5 ISSUES

Coastal erosion is both a chronic and episodic problem that affects coastal communities. The severity of coastal erosion changes seasonally, interannually, and over decadal time scales in response to climate variability, sediment budgets, and human activities such as dredged material management, jetty maintenance, and erosion mitigation methods that can either compound or reduce the impact. Previous studies and ongoing coastal change monitoring provide a solid scientific baseline for anticipating future erosion hazards. However, coastal conditions are changing over time, sea level and wave heights are increasing, strong El Niño events are predicted to increase, and the probability of a Cascadia subduction zone earthquake and tsunami increase with time since the previous event.

Important issues associated with coastal erosion in Grays Harbor County include the following:

- The South Beach shoreline along Westport and Cohassett Beach are experiencing a sediment deficit that is not likely to be augmented by natural processes. The South Jetty induces offshore transport of sand that is carried northward by energetic winter waves approaching from the southwest, while blocking the southward onshore transport of sand by milder summer waves approaching from the northwest. The beneficial use of dredged material to increase the supply of sand to the nearshore and beaches are imperative to reducing the rate of chronic coastal erosion. Beach monitoring indicates an average erosion of 63,100 cy/yr of sand from the beach and dunes along the length of the winter dune erosion scarp about 3.1 miles south of the South Jetty. The loss of the primary dune fronting existing development on relatively low interdunal areas implies an urgency for dune restoration to retain sufficient buffer against large storms with elevated water levels.
- The maintenance of the Half Moon Bay shoreline is relatively intense, consisting of routine nourishment of the nearshore area, periodic beach and breach fill nourishment, and relatively routine repair of the Point Chehalis revetment. With expected continual deepening of the inlet, the level of maintenance is likely to remain high. Any loss of dunes along the Half Moon Bay shoreline are not likely to be substantially recovered by natural processes, and dune retreat may

be largely influenced by the occurrence and duration of elevated water levels in addition to wave action. Strong El Niño conditions can sustain higher than normal water levels.

- The Grays Harbor North Jetty has reached its sand holding capacity and is deteriorating over time. Its condition affects shoreline stability not just locally, but northward to at least Copalis Beach. The large historical accretion of the North Beach shoreline is a result of the North Jetty providing a seaward anchor point. The Grays Harbor jetties are built and maintained to provide safe navigation through the mouth of Grays Harbor; they are not maintained to prevent shoreline erosion. The Ocean Shores shoreline within about 2 miles of the North Jetty is subject to interannual variability. The existing development of the primary dune encroaches on the natural variability of the shoreline and provides little buffer against shoreline retreat commensurate with jetty deterioration or fluctuations in the position and intensity of a persistent rip current embayment. Jetty reconstruction and maintenance to authorized dimensions for at least a few hundred feet seaward of the existing shoreline is imperative for adaptive management of erosion hazards and prevention of chronic shoreline and dune retreat. Beach monitoring indicates an average erosion of 25,800 cy/yr of sand from the beach and dunes along the length of the winter dune erosion scarp about 1.2 miles north of the North Jetty. Beach and dune nourishment offers only a temporary solution due to the limited holding capacity of the jetty. However, the use of sand fences during the spring to fall may be a cost effective means of accumulating sand that may be otherwise lost to transport into the harbor and providing a greater buffer against storm conditions. The lack of a suitable transition between the end of existing rock revetment structures and adjacent dunes is contributing to flanking erosion of the dunes. A dune breach represents the highest risk to upland infrastructure as the elevation of the land behind the primary dune is relatively low.
- Rapid and chronic erosion of the Oyhut and Damon Point shoreline threatens to impact the Quinault Marina and RV Park. The basal end of Damon Point is becoming narrower, flatter, and increasingly susceptible to overwash and breaching and its continued migration contributes to sedimentation of the marina and navigation channel. The long term viability of the marina will require considerable engineering and maintenance dredging. The Marina breakwater and the eastward end of the maintained North Jetty near the wastewater treatment plant provide anchor points that control the equilibrium location of the Oyhut Bay shoreline. More study is needed to develop a long-term prediction of the Oyhut shoreline and the relative importance of the anchor point at the Quinault Marina. An environmental impact assessment of no action may be as important as an assessment of alternative actions.
- The beneficial use of dredged material is critical to reducing the effects of chronic erosion. However, the effectiveness of sediment management scenarios needs to be evaluated. There has been little monitoring of the fate of material placed for beneficial use to determine the relative benefits and cost of onshore vs. nearshore placement of sediment.
- Continued loss of Whitcomb Flats is anticipated. The consequences of the degradation are insufficiently known.
- The continued northward migration of Connor Creek and the Copalis River is anticipated but at lower rates and more variability than in the past due to lower stream gradients following historical migration.

## 8.6 RESULTS

Based on review and analysis of the data, the Planning Team has determined that the probability for impact from erosion throughout the coastal areas is highly likely, with variable levels of intensity from year to year. Chronic erosion areas have been identified and mitigation planning and projects are needed to reduce

the impacts. The scale of historical and recent ongoing mitigation activities is relatively high considering the relatively large amount of annual sediment nourishment and periodic maintenance performed by the U.S. Army Corps of Engineers. The costs of managing coastal erosion are also high and optimized solutions require technical evaluation, engineering design, and project performance monitoring and assessment. Coastal erosion management is of highest intensity along both ocean and harbor shorelines within a few miles of the Grays Harbor jetties. Most of the erosion conditions are associated with long term adjustments to jetty construction and reconstruction and the effect on coastal processes and sediment budgets that these structures impose on the surrounding environment.

The economic and environmental impact from erosion is highly significant. New construction in critical areas, which includes geologically sensitive areas, is regulated. However, erosion-related impacts to existing commercial and residential structures and associated infrastructure (utilities, roadways, etc.), when coupled with the economic impact to tourism and potential negative impact on real estate taxes, have the potential to harm the entire region. Based on the potential impact, the Planning Team determined the CPRI score to be ____, with overall vulnerability determined to be a _____ level at a county level.

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# Attachment B
# Erosion History of Westport-by-the-Sea

2010-Present

# Division of WBTS

Phase I / II  & Phase III

# Value of WBTS to the County and City of Westport

- WBTS represents a total assessed value of $30,000,000
- Tax revenues flowing from WBTS to the city and county: $540,000
  - Schools: $191,000
  - City of Westport: $116,000
  - Hospital: $23,000
- These revenues are increasingly at risk
- WBTS is struggling to hold the dune line against the sea
- WBTS will ultimately require state and federal help in order to prevail
- WBTS costs of repairs and reinforcements to date (in round figures):

Feb 2016 repairs: $38,600 [50,600]

March 2017 repairs: $29,000 [37,700]

November 2017 Reinforcement: $8,100

**Total to date: $75,600** [96,000]

# Progress of Dune Retreat

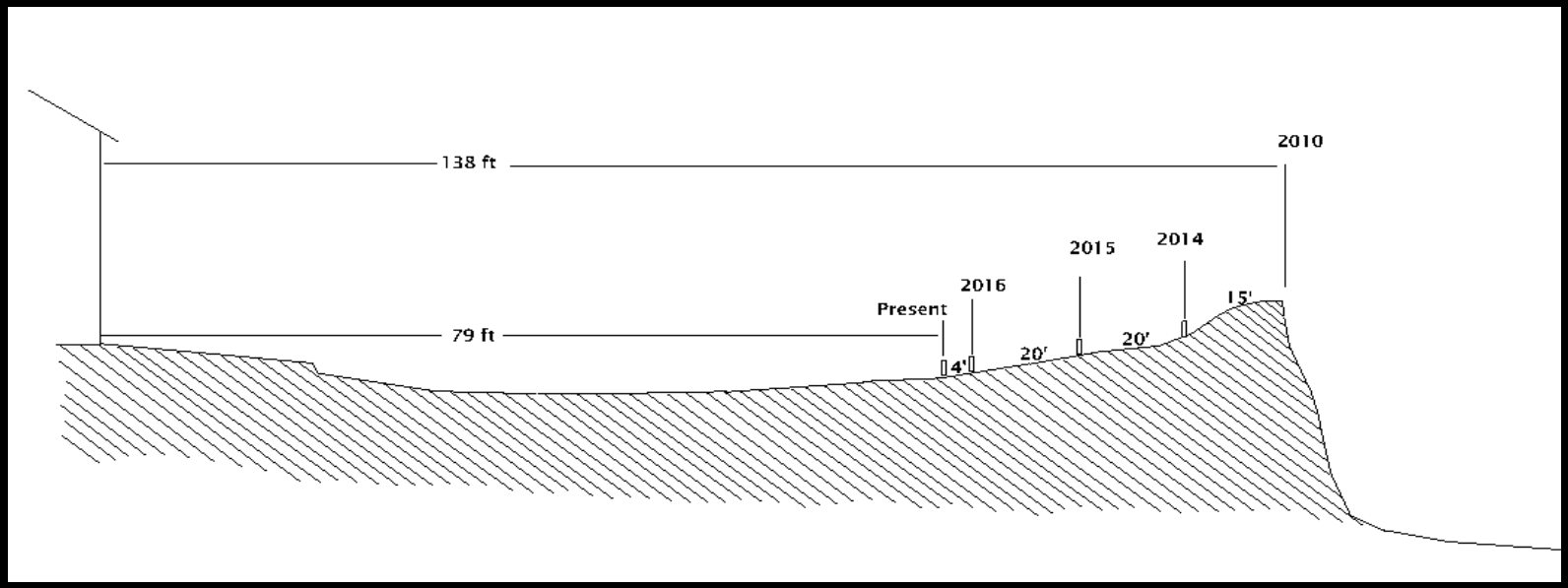
2010

2014

2015

2016

# Dune Retreat 2013-2016




- All distances were measured to dune crest which differed little from dune toe.
- In 2017, wave forces caused the crest to retreat substantially more than the toe, creating more inclined dune face.
- Toe remained generally static until Jan 2018 when strong storm scoured it out and drove dune face back 4 more feet.

# Historical Record of Dune Face Profile

March 24, 2016 | Dec 5, 2016 | May 25, 2017 | Feb 3, 2018

- Dune toe remained almost static but crest retreated due to erosion
- Dune toe suffered extensive scour-out In Jan 2018 making a new sheer face

# First Catastrophic Damage

March 2016

March 3, 2016

Nature's assist next day

# Repair Project

March 2016

Random logs were anchored in place

# Dune Reconstruction Elements

March 2016

Coir mat and sand laydown on top of straw bale reinforcement of dune face

# Finished Repair

March 2016

# Subsequent Storm Damage

March, 2016

Damage to straw bales and eroded dune fill

# Second New Washout

March 2016

April 2016

Aug 2016

Self initiated repairs by HOA

# Dune Drift Buildup

December 2016

Wind drifted sand buildup on top of coir mats

# Next Storm Damage

January 2017

Repeat washout despite HOA self repair action

# Additional Storm Damage

February 2017

Additional teardown of hay bale buttress and dune face washout

# Second Repair Project

February 2017

Major project repaired damages from successive Jan and Feb 2017 storms

# Reinforcement of Feb 2017 Repair

November 2017

Wind drifted overfill from previous month

Buildup and extension of dike

Completed dike

# Subsequent Destruction of Most of What had been Achieved in 2017

January 2018

This kind of event is happening during Jan-Feb King Tide period simultaneous with powerful storms. WBTS fears this is becoming a new norm. [photos by G. Blackmore unit 721]

# Most Recent Self Help

# Dune Condition North of WBTS

Lighthouse State Park – Jan 2018

Public trail washouts and dune bank undercuts

(Can this be used to persuade the Corps of Engineers, i.e., save a public facility?)

# Dune Condition South of WBTS

Jan 2018

Localized severe undercutting and dune face collapse

# Suggested Actions
(Time is of the essence)

- Redouble efforts to persuade the Corps of Engineers to apply harbor dredging spoils to dune replenishment from the south jetty southward
- Contact State Parks to propose it weigh in with the Corps on grounds of protecting Lighthouse State Park

# In the Near Term

- WBTS-3:
  - Has executed due diligence by attempting to implement soft solutions in keeping with ECY recommendations first offered in March 2015
  - Has concerns that while the soft solution has significantly retarded our dune erosion, it nevertheless exhibits important limitations
  - Worries that a better solution is needed because January-February King Tides coincident with one or more 35 foot sea-state storms must be considered a definite recurring phenomenon

# Summary

## The way we were and the way we are

Then Now