MOUTH OF COLUMBIA RIVER REGIONAL SEDIMENT MANAGEMENT PLAN

2021 UPDATE

Prepared for Lower Columbia Solutions Group
By
Jim Owens Consulting Company

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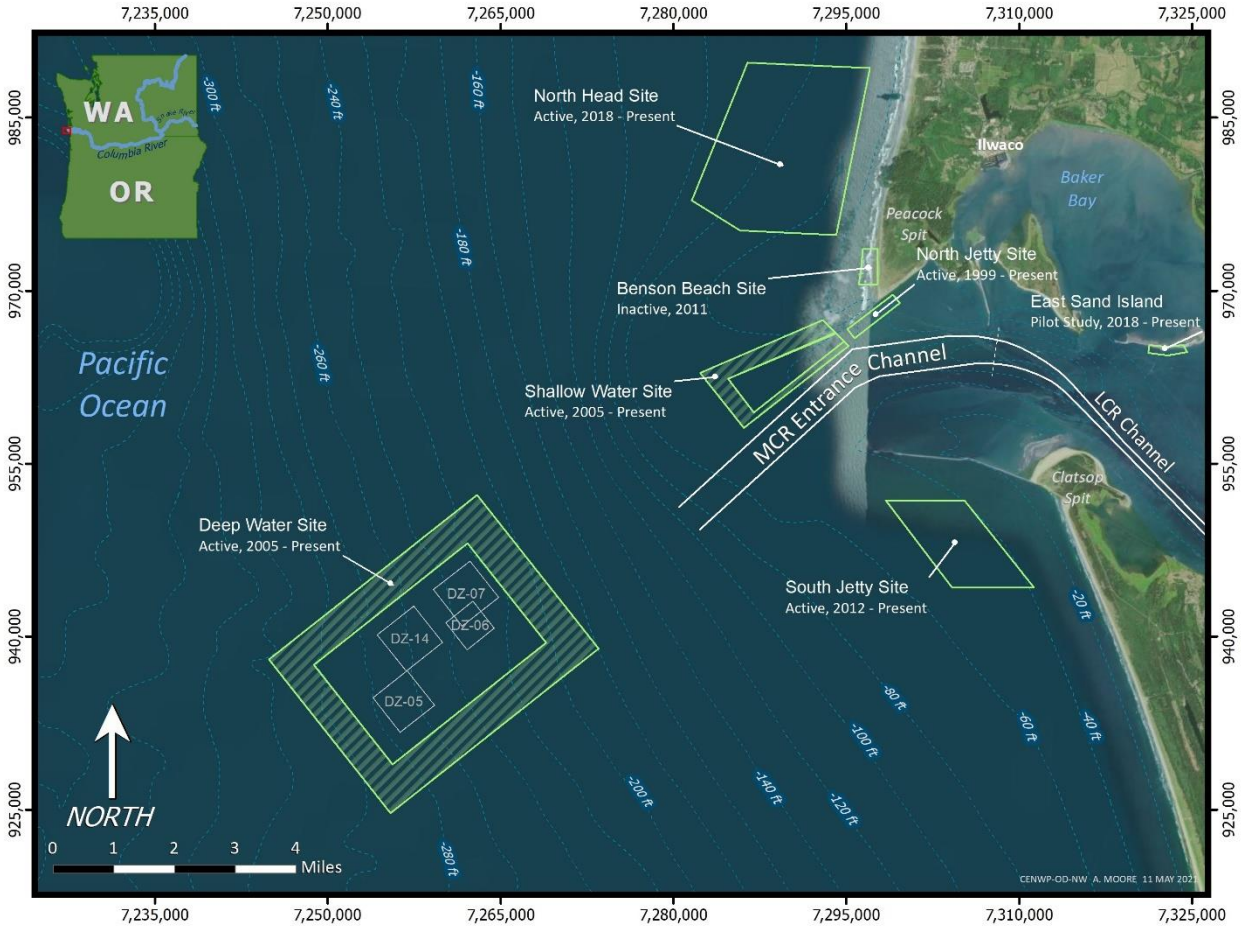

EXECUTIVE SUMMARY

For the past decade, a Regional Sediment Management Plan (RSMP) developed by the Lower Columbia Solutions Group (LCSG) has guided the beneficial use, monitoring and research of dredged material placement projects at the Mouth of the Columbia River (MCR). That 2011 RSMP is being updated by the LCSG to capture program accomplishments, scientific findings from research and monitoring, and the evolution of the program's direction. This 2021 Update also provides a vision and direction for an ongoing beneficial use program that builds on experiences and lessons learned through a series of demonstration placements of dredged materials from MCR. Specifically, this Update:

- Reaffirms the program goals and elements identified in the 2011 RSMP.
- Identifies current management direction and structure.
- Identifies the focus for program activities in the near-term and intermediate futures.
- Summarizes scientific findings from research and monitoring conducted to date.
- Updates the program's history and accomplishments.
- Reorganizes and expands the contents of the 2011 RSMP.

The need for the RSMP is driven by ongoing erosion of the beach and nearshore Columbia River bar system that threatens the viability of the Columbia River jetty system, the Long Beach Peninsula in Washington, and Clatsop Spit in Oregon. The loss of an estimated one million cubic yards of material each year from the littoral zone has been determined to be unsustainable and unacceptable. This RSMP is a multi-year, bi-state collaborative effort to manage dredged sediment placement at the MCR in a beneficial way to help protect entrance channel jetties, coastal beaches and nearshore habitats from erosion while avoiding and minimizing adverse environmental, resource and navigational safety effects. To accomplish this, the RSMP outlines a network of beneficial use placement sites along the Oregon and Washington coasts that are recommended by the LCSG through a program of annually-reviewed placement operations and prioritized research and monitoring. It is intended to serve as the basis for programmatic permitting of those sites, which include two nearshore sites – South Jetty Site (SJS) and North Head Site (NHS) – and two proposed onshore sites – Benson Beach and Clatsop Spit.

Prior to the initiation of the MCR RSMP planning process in the mid-2000's, dredged material from MCR was entirely disposed of by the U.S. Army Corps of Engineers (Corps), Portland District, at three in-water dredged material placement sites, two authorized by the U.S. Environmental Protection Agency (EPA) and a third through a State of Washington Clean Water Act (CWA) permit. Two of those sites are within the MCR's nearshore littoral area – a Shallow Water Ocean Placement Site (SWS) and a North Jetty Clean Water Act Site (NJS). A Deep Water Ocean Placement Site (DWS) is used when the other sites are at capacity for the season or when the weather is too treacherous to use the nearshore sites. Prior to the identification of additional beneficial use sites by the LCSG, approximately one-third of the sand dredged at MCR was taken to the DWS. Placement at the DWS removes a large portion of

this clean, uncontaminated resource from the nearshore zone, where it would be expected to help sustain jetties, beaches, and marine habitat.

Beginning in 2007, a series of demonstration placements and accompanying research and science/policy deliberations demonstrated that thin-layer placement at the RSMP's beneficial use sites increases the flexibility of the Corps' placement practices and addresses specific littoral sediment needs, while having limited risk of impact on navigational safety and biological resources. It is recognized, however, the beneficial use effects of adding sediment to the littoral system will not likely be measurable in the short term; it may be a decade or more before beneficial effects are observed.

Elements of the RSMP developed by the LCSG include: program goals and focus; key assumptions; a bi-state network of beneficial use disposal sites; guidelines for prioritizing disposal among the sites; a commitment to thin-layer placement and standards for avoiding effects on navigational safety from wave amplification; scheduling of placements to avoid impacts to ESA-listed species and to minimize conflicts with the crab fleet; baseline surveys and pre- and post-placement monitoring; adaptive management practices in which effects on physical and biological resources and on navigation safety are regularly monitored and use and management of sites adjusted as needed; and a program of ongoing research and monitoring, with a focus on navigation safety, Dungeness crabs, razor clams, and ESA-listed fish species.

Since program initiation, LCSG partners have assisted in design, management, and monitoring of 13 separate placements of dredged materials from MCR projects at the SJS and NHS nearshore sites. In addition, there have been three onshore placements at Benson Beach in Washington, either in conjunction with North Jetty repairs or as a one-time event intended to specifically address onshore erosion. As of 2021, over 2.8 million cy of material have been placed at the two nearshore sites and more than 530,000 cy at the Benson Beach onshore site. In addition to the placement of dredged materials in a beneficial manner, a variety of new or replacement navigation/weather buoys have been installed and cooperative research activities and studies undertaken.

Designed as an experiment to see if key groups involved with Lower Columbia River issues could tackle one or more short-term dredge material placement projects for beneficial uses, by all accounts, the MCR RSMP program has successfully met the goals and objectives set out in the 2011 RSMP. In recognition, the RSMP planning process has been identified by the National Policy Consensus Center and by the American Shore and Beach Preservation Association as a national model of collaborative science and decision-making.

Results of pilot projects at the SJS and NHS and accompanying monitoring and analysis have provided LCSG with the incentive and confidence to transition the beneficial use program from its pilot project phase to permanently designating beneficial use sites and codifying standard management practices for nearshore placements. Results from these nearshore placements include:

- Demonstration of the efficacy of thin-layer placement in a challenging ocean environment as a method of nearshore placement of dredged material that avoids significant impacts to navigation safety and biological resources.
- Successful thin-layer placement in nearshore waters via hopper dredge in a cost-effective manner.
- Protection of navigation safety by applying a maximum threshold to mounding of 10% in height over baseline condition.
- No observable short-term impacts on crab populations or other biological resources.
- Determination that the SJS and NHS are dispersive sites, confirming their viability and benefit as long-term dredged material placement sites.
- Evidence of some reduction of bottom scouring at the SJS.
- Establishment of a placement volume for these sites of 400,000 - 500,000 cy/year as within a threshold of concern.

Despite consensus in early science/policy workshops that onshore placement is the best way to meet RSMP goals, onshore placement has proven to be more logistically and fiscally difficult than nearshore placement. Funding considerations have limited onshore placement to one large placement in 2010. Maintenance dredging is subject to the Federal Standard, i.e. the least-cost, environmentally-acceptable and engineering-sound placement option. While cost per maintenance dredging cycle, or even placement event, may be higher in some cases, full life-cycle costs may result in a net cost savings to the government. The Corps' Portland District has recently received grant funding for analysis of a life-cycle analysis approach, using MCR as a case study, to fully account for costs and benefits from the beneficial use of dredged materials compared with placement alternatives across multiple maintenance dredging cycles. It is expected that such an analysis will reveal hidden costs and benefits at a programmatic level that may not be accounted for in a per-cycle analysis.

While onshore placement has been limited, it has had several key results, Including:

- Affirmation that on-shore placement at Benson Beach remains the best alternative to address coastal erosion north of the North Jetty and reduce the potential for scour along the toe of the Jetty.
- Determination that the present volume of new sediment transported north from the MCR is insufficient to offset erosion at Benson Beach.
- While nearshore placements at the NHS and SWS have been shown to enhance the sediment budget of Benson Beach, uncertainty about what volumes of placement in the nearshore are necessary to make a difference on the beach and whether such volumes are achievable without causing mounding and inducing wave amplification.

While not explicitly addressed, the program's objective to make sustainable, beneficial use of dredged sediment to help protect nearshore fishery habitats, coastal beaches and the jetties

from erosion can be expected to assist in indirectly responding to sea level rise. A defacto goal of the Plan is to maximize beneficial use of sediment in an environmentally responsible manner to respond to global climate change and protect and maintain critical community economic and environmental infrastructure.

Both the 2011 RSMP and this 2021 Update have been prepared by the LCSG, a diverse, bi-state collaboration of local, state and federal governmental and non-governmental stakeholders interested in and affected by dredge material placement activities at MCR and in the lower Columbia River. Stakeholders include representatives from local, state, and federal governments; ports; crabbing and fishing interests; coastal communities; conservation groups; and others. The LCSG is the author, organizer, and implementer of both a 2011 RSMP for the MCR and this 2021 Update. It is essentially the "keeper" of the RSMP.

The MCR beneficial use program represents almost 20 years of successful collaboration among LCSG partners. It has fostered state-of-the-art benthic invertebrate and sediment transport research and monitoring and a significantly improved understanding of sediment transport in the MCR area. A variety of new or modified video and acoustic telemetry techniques have been employed to demonstrate that there are no significant adverse effects from thin-layer placement at the SJS and NHS on Dungeness crab mortality and mobility, as well as on the overall benthic environment. The range of biological issues for which there are any significant concerns has been determined to be very narrow, with consensus that biological effects can be minimized through dispersed, thin-layer placement and rotation of placement among sites to reduce the potential for mounding. While data gaps continue to be filled, a considerable volume of scientific research has been conducted. Combined with the deliberations and consensus emanating from an ongoing series of LCSG science/policy workshops, this research makes the MCR area probably the most studied area on the north Oregon and southwest Washington coasts.

While noteworthy in its accomplishments, the beneficial use program has and continues to face a variety of challenges. A fundamental challenge has been adequate and sustainable funding. For the most part, beneficial use projects have been dependent upon research or operations/maintenance (O&M) funding secured by the Corps' Portland District. While the funding of placement and associated R&M at beneficial use sites is a District priority, the vagaries of the federal budget process prevent the Corps from committing to an ongoing annual funding contribution level. Obtaining adequate and consistent funding for program facilitation/coordination has been especially challenging. While the Corps has historically been the primary funder, more recently the LCSG has had to depend upon member contributions to secure these neutral facilitation services. As of Summer 2020, the Corps assumed financial support and contracting for ongoing facilitation support and contracted with the Columbia River Estuary Study Taskforce (CREST) for these services. The selection and funding of CREST as the group's facilitator for the next five years is expected to provide more stable and consistent facilitation and staffing support to the LCSG. There have also been repeated funding challenges for research and monitoring of placement at beneficial use sites, the most significant being the timeliness of the review, approval and payments processing between agencies, e.g. Corps and

NOAA Fisheries for crab research. As the pilot project phase shifts to permanent beneficial use placement sites, the focus of funding for research is also changing from biological resources to sediment transport.

The value of the beneficial use program is not in question, but questions of how beneficial it has been and can be in augmenting the nearshore sand budget and in addressing onshore erosion have yet to be answered. In particular, the value of nearshore placement to address onshore erosion simply cannot be determined. It is not known what volumes are needed at nearshore sites to measure any difference on shoreline erosion and are these volumes achievable without causing mound induced wave amplification.

Opening Statement from Jim Owens with Jim Owens Consulting Company, the primary author of this revised RSMP.

As facilitator and coordinator for the Mouth of Columbia River Regional Sediment Management Plan (RSMP) for the Lower Columbia Solutions Group (LCSG) for over twelve years, I want to acknowledge the contributions and commitment of all LCSG members to the collaborative process to develop and implement an ongoing program for the beneficial use of dredged materials from the mouth of the Columbia River. More specifically, I acknowledge Jim Neva, an early LCSG convener and strong supporter of the collaborative process who passed away several years ago; Dale Beasley, who consistently and forcefully reminded us to not forget the "users" of MCR waters; Brian Lynn and Patty Snow, who for some years now have been the steady and trusted "co-captains" of the ship; Rod Moritz, who brings an infectious spirit and curiosity to the process; Curtis Roegner, who made the science of Dungeness crabs both fun and exceptionally informative; and Steve Greenwood, who provided me the chance and the trust to facilitate this collaborative process.

Of note, the LCSG's program for the beneficial use of dredged materials at MCR was recognized as the 2020 Robert L. Wiegel Coastal Project of the Year by the American Shore and Beach Preservation Association. This national award goes to coastal projects that demonstrate a sustainable and positive environmental, social, or recreational benefit. The award states that the LCSG is recognized for: "achievements (that) are the result of strong relationship building, shared trust, and collective determination to sustain an important adaptive management process. The LCSG's success in reimagining the planning process for the Mouth of the Columbia River is being recognized as a model of collaborative science and decision-making." More about the award can be found at:
https://ecology.wa.gov/Blog/Posts/November-2020/Washington-Coastal-Zone-Management-Program-Receive

Jim Owens
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ACRONYMS

AMP	Adaptive Management Program
AUP	Annual Use Plan
cfs	cubic feet per second
cm	centimeter
Corps	U.S. Army Corps of Engineers
CREST	Columbia River Estuary Research Group
CRCFA	Columbia River Crab Fishermen's Association
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
cy	cubic yard
DLCD	Oregon Department of Land Conservation and Development
DNR	Washington Department of Natural Resources
DOGAMI	Oregon Department of Geology and Mineral Industries
DSL	Oregon Department of State Lands
DWS	Deep Water Site
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
LCSG	Lower Columbia Solutions Group
MCR	Mouth of Columbia River
m	Meter
MPRSA	Marine Protection, Research and Sanctuaries Act
NEPA	National Environmental Policy Act
NHS	North Head Site
NJS	North Jetty Site
NMFS	National Marine Fisheries Service
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OPRD	Oregon Parks and Recreation Department
ODSL	Oregon Department of State Lands
O&M	Operations and Maintenance
Plan/RSMP	Mouth of Columbia River Regional Sediment Management Plan
R&M	Research and Monitoring
ROV	Remotely Operated Vehicle
SEPA	Washington State Environmental Policy Act
SJS	South Jetty Site
SMMP	Site Management and Monitoring Plan
SWS	Shallow Water Site
USGS	U.S. Geological Survey
WDOE	Washington Department of Ecology
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WSPR	Washington State Parks & Recreation

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A. INTRODUCTION

A 2011 Regional Sediment Management Plan (RSMP) developed by the Lower Columbia Solutions Group (LCSG) has served as a blueprint to guide the beneficial use, monitoring and research of dredged material placement projects at the Mouth of the Columbia River (MCR) for over a decade. That RSMP is being updated by the LCSG to capture program accomplishments, scientific findings from research and monitoring, and the evolution of the program's direction. This 2021 Update also provides a vision and direction for an ongoing beneficial use program that builds on experiences and lessons learned over the past 15+ years of regional collaboration and research. Specifically, this Update:

- Reaffirms the program goals and elements identified in the 2011 RSMP.
- Identifies current management direction and structure as agreed to by LCSG members.
- Identifies the focus for program activities in the near-term and intermediate futures.
- Summarizes scientific findings from research and monitoring conducted to date.
- Updates the program's history and accomplishments.
- Reorganizes and expands the contents of the 2011 RSMP.

This RSMP is the outcome of a multi-year, bi-state collaborative effort to manage dredged sediment placement at the MCR in a beneficial way. The beneficial use of dredged sediment at MCR is intended to help protect entrance channel jetties, coastal beaches and nearshore habitats from erosion while avoiding and minimizing adverse environmental, resource and navigational safety effects. The purpose of the RSMP is to provide sustainable, beneficial alternatives to deep water placement of materials dredged annually from the MCR by the U.S. Army Corps of Engineers (Corps). To accomplish this, the RSMP identifies a network of beneficial use placement sites along the Oregon and Washington coasts that are adaptively managed by the LCSG through a program of annually-reviewed placement operations and prioritized research and monitoring. It is intended to serve as the basis for programmatic permitting of those sites, which include two nearshore sites – South Jetty Site (SJS) and North Head Site (NHS) – and two onshore sites – Benson Beach and Clatsop Spit.

LCSG and its partners have developed this RSMP in the belief that concerted action is needed to address ongoing erosion of the beach and nearshore Columbia River bar system that threatens the viability of the Columbia River jetty system, the Long Beach Peninsula in Washington and Clatsop Spit in Oregon. The loss of an estimated one million cubic yards of material each year from the littoral zone has been determined to be unsustainable and unacceptable. Construction of the MCR jetties has not only altered sediment transport processes but has also modified waves and seafloor topography in the area. The interaction of waves and seafloor topography affects nearshore circulation patterns and, thus, shoreline accretion and erosion

rates. As erosion patterns continue, a sediment-starved littoral cell will result in significant ecosystem and physical effects. A catastrophic jetty failure or breach at either the South or North jetties will create significant ecosystem changes and result in dramatic impacts to the navigation channel and estuary. Strategic placement of dredged material within beneficial use dredged material disposal sites is expected to bolster the littoral budget, including the offshore bar system along the Oregon and Washington shores adjacent to the MCR.

For the purposes of this Plan, the MCR region includes the Long Beach and Clatsop Plains sub-cells of the larger Columbia River littoral cell and the lower Columbia River estuary.

Prior to the initiation of the MCR RSMP planning process in the mid-2000's, dredged material from MCR was entirely disposed of at three in-water dredged material placement sites, two authorized by the U.S. Environmental Protection Agency (EPA) and a third through a Washington Clean Water Act (CWA) permit. Two of those sites are within the nearshore littoral area – a Shallow Water Ocean Placement Site (SWS) and a North Jetty Clean Water Act Site (NJS). A Deep Water Ocean Placement Site (DWS) is used when the other sites are at capacity for the season or when the weather is too treacherous to use the nearshore sites. Historically, approximately one-third of the sand dredged at MCR was taken to the DWS. Placement at the DWS removes a large portion of this clean, uncontaminated resource from the nearshore zone, where it would be expected to help sustain jetties, beaches, and marine habitat. The network of beneficial use sites identified in the 2011 RSMP and reaffirmed in this Update expands the network of previously "authorized" sites by adding both nearshore and onshore placement locations to the system.

Based upon Goals and Defining Principles first identified in the 2011 RSMP and reaffirmed in this Update, management considerations (regulatory, operational, navigation, and resource) are identified for identifying and managing beneficial use sites. These also include guidelines for prioritizing dredged material placement among beneficial use sites, navigation safety standards, and a commitment to adaptive management based on research and monitoring (R&M). A history of dredged material placement at the four sites currently authorized by the Plan and a summary of what's been learned are provided. Program accomplishments, benefits and challenges are also identified.

Both the 2011 RSMP and this 2021 Update have been prepared by the LCSG, a diverse, bi-state collaboration of local, state and federal governmental and non-governmental stakeholders interested in and affected by dredge material placement activities at MCR and in the lower Columbia River. Following controversy in the 1990's associated with deepening of the navigation channel in the Columbia River from its mouth to Vancouver, Washington, the governors of Oregon and Washington, in concert with the Council on Environmental Quality and the U.S. Institute for Environmental Conflict Resolution, convened the LCSG in July 2002 to provide a regional, rather than a state-by-state, approach to sediment management planning for the Lower Columbia River. Stakeholders include representatives from local, state and federal governments; ports; crabbing and fishing interests; coastal communities; conservation groups; and others. In 2012, a Declaration of Cooperation was signed by 16 federal and state

agencies, local governments and the Columbia River Crab Fishermen's Association (CRCFA) to support and collaboratively implement the 2011 MCR RSMP. The history of the LCSG, its structure, functioning, accomplishments and challenges are detailed in Appendix A. (Click here to read the full 2011 MCR Regional Sediment Management Plan and 2012 Declaration of Cooperation.)

B. RSMP GOALS AND FOCUS

This RSMP Update consolidates and organizes regional sediment management planning work completed over the last 15+ years by LCSG and its partners into a long-term strategy to guide MCR sediment management practices, serve as the basis for permitting continued use of beneficial use sites, and facilitate the securing of federal and state appropriations to fund ongoing research, monitoring and project management. It is based primarily on the research conducted for a series of pilot beneficial use disposal projects and the outcomes of multi-stakeholder workshops conducted on almost an annual basis since 2005.

In developing this program of beneficial use placement of dredged materials, the LCSG has identified "do no harm" by avoiding and minimizing adverse effects to the aquatic ecosystem and attendant human uses (CWA Section 404(b) as the RSMP's underlying guiding principle. This RSMP provides sustainable, long-term alternatives to deep water sediment placement through the beneficial use of dredged sediment at both nearshore and onshore sites along the Oregon and Washington coasts immediately south and north of MCR. ***It reflects the LCSG's goal to transition from the program's pilot project phase, establishing permanently designated beneficial use sites and standard management practices as Plan elements.*** (These are detailed in Section C.)

Objectives identified in the 2011 RSMP have been added to and reframed in the intervening interval. This 2021 RSMP reaffirms and restates those objectives as the program's goals. They include:

- Use dredged material in a sustainable and beneficial fashion that will help protect nearshore fishery habitats, coastal beaches and the jetties from erosion while avoiding and minimizing adverse environmental, resource and navigational safety effects.
- Replenish sand in the nearshore and onshore to increase stability of the sand shoals that the North and South jetties are built upon, thus reducing wave damage to the jetties and erosion and associated property loss along the northern Oregon and southern Washington coasts.
- Continually improve the understanding of sediment transport within the Columbia River littoral cell.
- Minimize "wasting" clean sand placement in deep water through identification and management of a suite of placement areas for dredged sediment that can be sustainably and adaptively managed, retain clean sand in the littoral system, and benefit

biological resources and navigation safety.

- Design placement practices to avoid unacceptable adverse effects on navigational safety through dispersed, thin-layer placement and rotation of placement among a network of sites.
- Through an ongoing research and monitoring program, adaptively manage placement activities to measure effectiveness of beneficial use and avoid or minimize adverse effects. Focus scientific research and monitoring efforts on species that may be most vulnerable to effects from dredged material placement, including Endangered Species Act (ESA)-listed species and commercial and recreational fisheries (i.e. crabs and razor clams).
- Address loss of biological habitat from ongoing erosion and sediment transport in the littoral zone, e.g. seabed scouring in the area directly south of the South Jetty.
- Create a management plan that is financially, ecologically, and socially sustainable.
- Provide a regional rather than a state-by-state approach to sediment management at MCR and maintain collaborative partnerships among federal and state agencies, local governments, fishing community, and other interests.
- Facilitate the securing of federal and state appropriations to fund ongoing research and monitoring at MCR.
- Serve as the basis for programmatic permitting of a network of beneficial use placement sites.

The LCSG has also identified as a key short-term program goal the design of an ongoing monitoring program that measures economic, social and ecosystem benefits and that ensures RSMP objectives are met. Additionally, the group has prioritized the development of strategies for onshore placement at Benson Beach and, as needed, at Clatsop Spit.

The RSMP focuses on the near term, serving as a two-year guide and leaving further planning for a five or 10-year management plan. Its scope is intentionally broad enough to accommodate suggestions of expanding the network of beneficial use sites, the geographic scope of the RSMP, and the integration of related sediment management activities in the Lower Columbia River. As a programmatic management plan, it does not qualify as federal or state-required environmental analysis, e.g. environmental assessment under the National Environmental Protection Act (NEPA) or the Washington Environmental Protection Act (SEPA). However, it recognizes that planning for and management of a network of sites reduces the costs and complexity of permitting individual sites and facilitates proactively responding to future funding opportunities. Its scientific focus is also at a programmatic level and while it provides links to scientific studies conducted as part of Plan implementation, it intentionally does not provide scientific references. A limited bibliography of scientific papers relied upon in developing the 2011 RSMP and this Update is provided as Appendix B. Links to scientific studies and presentations conducted in conjunction with beneficial use projects carried out under this

Plan are provided in summaries of LCSG meetings, posted at https://lowercolumbiasolutions.org.

At a January 2020 Science/policy workshop, the LCSG identified the current focus for the MCR RSMP to be:

- Seek a secure and durable source of funding from the Corps' national RSM program to help support the operations and implementation of the LCSG's collaborative, bi-state process promoting beneficial use of dredged materials. Also, develop a plan to be ready with an application if another Water Resources Development Act (WRDA) Section 1135 or other funding method becomes available.
- Through onshore beneficial use projects, address increasing erosion at Benson Beach that threatens the root of the North Jetty, a Corps wetlands mitigation site, and Cape Disappointment State Park campground sites and other park facilities. Support continuing inclusion of a pump ashore project in the Corps' budget in case funding becomes available. Support sand fencing projects in the interim to help reduce the rate of shoreline retreat.
- Monitor the impacts and results of the recently completed North Head Site pilot project to determine the viability of the area as a long-term beneficial use placement site.
- Monitor and analyze trends of sediment input on razor clam recruitment to help determine if nearshore placement has beneficial effects on the species.
- Develop a program for routine South Jetty monitoring, frequent enough to ensure mound induced amplification does not occur. Include measures of placement benefits, with adaptive management of placement as needed to avoid or minimize adverse effects.
- Assess cost savings to the Corps associated with beneficial use of dredged material. Establish measures to determine the long-term dynamic capacity of the SJS and NHS nearshore sites.
- Retain a long-term facilitator for general management of the LCSG process, with overall direction provided by the Washington and Oregon coastal management agencies.

C. RSMP ASSUMPTIONS AND ELEMENTS

1. PLAN ASSUMPTIONS

The regional network of authorized placement sites for material dredged annually from MCR includes sites managed independently of this RSMP and sites identified by and managed pursuant to this Plan. As described in the Introduction, three placement sites (SWS, NJS, and DWS) were authorized by the U.S. Environmental Protection Agency (EPA) and/or State of Washington prior to the development of the 2011 MCR RSMP. Except where their management may directly affect placement at beneficial use sites identified by the LCSG in the

2011 RSMP and reaffirmed in this Update, the management of those sites is not addressed herein.

A series of demonstration placements beginning in 2007 and accompanying research and science/policy deliberations indicate that thin-layer placement at the RSMP's beneficial use sites increases the flexibility of placement practices and addresses specific littoral sediment needs, while having limited risk of impact on navigational safety and biological resources. While data gaps continue to be filled, there is a considerable amount known about the area and a valid basis for expectations about the levels of potential risks to the physical and biological environments.

Other assumptions and conditions upon which this RSMP is predicated include:

- The sediment that is annually dredged from MCR is classified as fine-medium sand (mean grain size = 0.22 mm). It is considered "clean" sand. There is noticeable color variation in the sand moving out of MCR, indicating a high degree of sand grain sorting from south to north, with heavier minerals (iron) near Benson Beach and adjacent to North Head. In summer, this sand generally moves to the south in response to ocean currents flowing to the south, and in winter major storms move the sand dramatically to the north.
- Placement at the DWS in effect removes sand from the nearshore system. A basic RSMP tenet is that dispersing material in deep water should only be employed when weather or other factors eliminate nearshore or onshore options.
- To demonstrably help sustain jetties, beaches, and marine habitat, a minimal amount of sand dredged from MCR needs to be committed annually for placement within the littoral zone.
- There is a point at which a dredged material placement site is too deep and too far from the shore to contribute sand to the littoral process. As a general rule, dredged material placed inland of 65 feet (20 meters) has been determined to effectively contribute sand to the littoral systems north and south of MCR.
- Placement at beneficial use sites identified in this Plan is limited to MCR sediment and placement by the Corps; placement by other authorized parties at the EPA-designated DWS is not precluded by this Plan.
- Beneficial use effects of adding sediment to the littoral system will not likely be measurable in the short term; it may be a decade or more before any beneficial effects are observed.
- While the focus is on beneficial placement at specific sites identified in this Plan, nothing precludes the identification of additional sites as potential placement locations.
- Placement of dredged material is an exercise in risk management that necessitates an adaptive management approach.
- Current placement practices and erosion patterns may have their own sets of effects on environmental resources and navigation safety. Thus, a key determinant in assessing

the viability and use of beneficial use sites should be comparing potential impacts of placement at those sites to those associated with current placement practices.

2. KEY PLAN ELEMENTS

Since MCR RSMP planning began 15+ years ago, there has been agreement among LCSG members on the key elements that guide the beneficial use, monitoring and adaptive management of dredged materials from MCR. These include the following, each further described below:

- Bi-state network of beneficial use placement sites.
- Guidelines for prioritizing placement among the beneficial use sites.
- Thin-layer placement of dredged materials.
- Standards for avoiding effects on navigational safety from wave amplification:
- Scheduling placements to avoid impacts to ESA-listed species and to minimize conflicts with the crab fleet, i.e. scheduling placements following the end of the Oregon and Washington crab seasons.
- Baseline surveys and pre- and post-placement monitoring.
- Adaptive management practices in which effects on physical and biological resources and on navigation safety are regularly monitored and use and management of sites adjusted as needed.
- Program of ongoing research and monitoring, with a focus on navigation safety, Dungeness crabs, razor clams, and ESA-listed fish species.

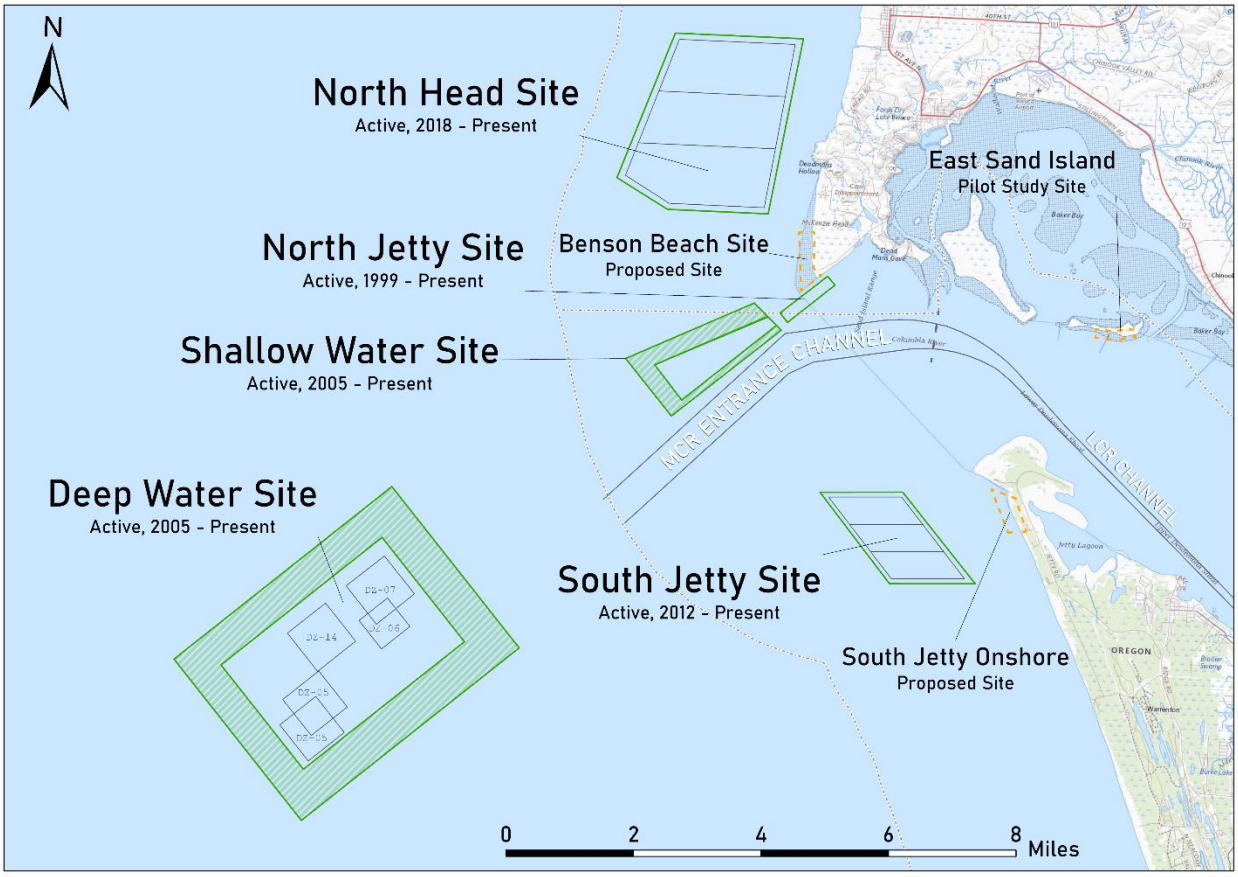
In addition to these beneficial use program elements, the LCSG has consistently supported navigational aid projects at MCR, including enhancements to ARGUS beach monitoring, installation of a CDIP wave-ride buoy, and most recently an ocean measurement buoy.

a. Bi-state Network of Beneficial Use Placement Sites

To provide the MCR dredging program maximum flexibility, this RSMP recognizes a network of seven placement sites for material dredged from MCR.

- Three EPA or state authorized in-water placement sites, separately authorized prior to this RSMP-- Shallow Water Site (SWS), North Jetty Site (NJS), and Deep Water Ocean Placement Site (DWS).
- Four beneficial use sites, including two within the nearshore (subtidal) zone -- South Jetty Site (SJS) and North Head Site (NHS) -- and two onshore (intertidal) sites at Benson Beach and Clatsop Spit.

The following figure illustrates this bi-state network of placement sites. Summary descriptions of the three previously authorized sites follow, with more detail provided in Appendix B and at: https://www.epa.gov/sites/production/files/2015-10/documents/r10-_mcr_smmp_2005.pdf Summary descriptions of the MCR RSMP beneficial use sites also follow. The history of site use, results and observations from placements to date, and current management direction are detailed for each site in Appendix B.



MCR Network of Dredged Material Placement Sites

The four sites identified in the 2011 Mouth of Columbia River RSMP are reaffirmed in this 2021 Plan as the most appropriate beneficial use locations going forward. These sites are intended to provide both nearshore (subtidal) and onshore (intertidal) opportunities for beneficial use of the uncontaminated sand dredged each year at MCR. Their selection is reaffirmed based on scientific research conducted over the past 15 years, the results of multiple demonstration projects at the two nearshore sites, their potential to positively contribute to retaining sand within the littoral zone, and the determination that they do not have significantly greater value as habitat than other nearby areas within the littoral zone. ***Nothing in this RSMP precludes the identification of additional sites as potential dredged material placement locations.***

While the Corps' previously authorized sites continue to be used on a regular basis, the establishment of this network of additional beneficial use sites enables the Corps to shift a large portion of the material dredged at MCR to these nearshore and onshore areas. These beneficial use sites give the Corps more flexibility in where it can dispose of dredged materials, given that no one of the authorized sites has the capacity to take all of the dredged material available annually. They also provide an opportunity to address significant erosion issues, obtain needed information on nearshore processes, and divert a sand resource that is otherwise "lost" if it goes to deep water placement.

(1) EPA or State Authorized In-Water Placement Sites

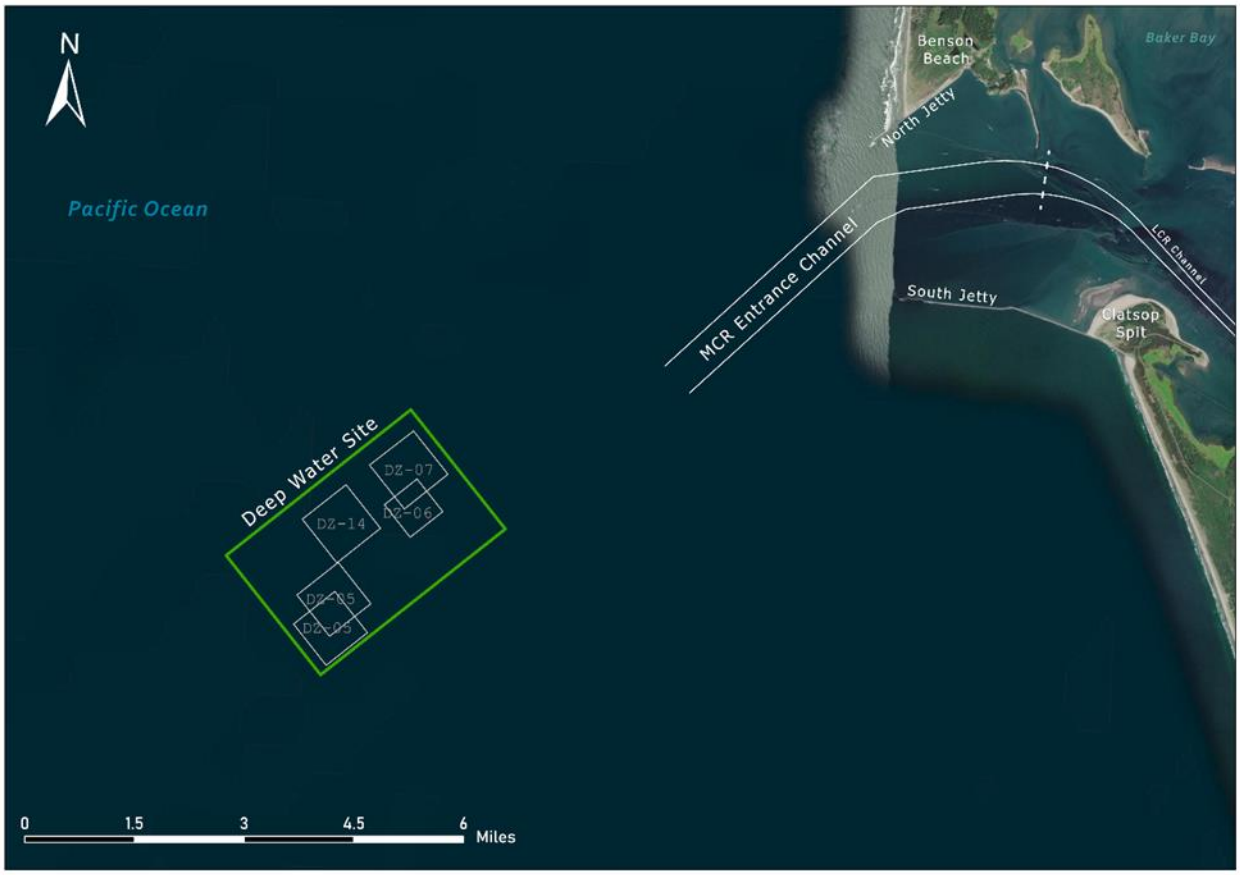
(a) Shallow Water Site (SWS)

Designated by EPA in 2005 under Section 102 of Marine Protection, Research and Sanctuaries Act (MPRSA), the SWS lies two miles offshore from MCR in water depth of 45 - 75 feet. The SWS is designated for the placement of material dredged from either the MCR or the Lower Columbia River. Assessments of sediment transport indicate it is a dispersive site with clearly defined but gradual sediment transport to the north and west away from SWS onto Benson Beach and beaches to the north. The Corps has identified placement at the SWS as critically important to sustaining Peacock Spit with sand, maintaining the littoral sediment budget north of MCR, protecting the North Jetty from scour and wave attack, and stabilizing the MCR inlet. Increasing the volume of placement at the SWS at the end of the jetty to help reduce erosion at Benson Beach has been suggested at recent science/policy workshops. Because of its dispersiveness, site capacity over the long-term is unlimited. On an annual basis, capacity is estimated to be between 4.5-6 million cy.

(b) North Jetty Site (NJS)

This site was established in 1999 under Section 404 of the Clean Water Act (CWA) for the purpose of placing dredged material along the North Jetty to help reduce undermining of the jetty by wave and current scour. The NJS is approximately 200 feet south of the North Jetty, covering approximately 115 acres in water 40 -70 feet deep. Placement is limited to MCR dredged material. The capacity of the site to handle larger volumes of dredged material is limited and uncertain. In recent years, the site has received approximately 300,000 cubic yards annually. Much of the dredged material placed at the site has abated a potentially destabilizing scour along the southern toe of the North Jetty, which was the primary purpose its creation.

(c) Deep Water Site (DWS)



Designated by EPA in 2005 as a Water Ocean Placement Site under the MPRSA, the DWS lies six miles from MCR in water depths of 190 - 300 feet. A 11,000 x 17,000-foot placement area is defined within the DWS boundaries, with specific "drop zones" for the placement of dredged material. The DWS is designated for the placement of material dredged from either the MCR or the Lower Columbia River. It is non-dispersive with material placed at the site expected to remain on-site. Annual placement capacity is not limited. The Corps uses the DWS when other sites, including both authorized and beneficial use sites, have been used to the maximum extent practicable or when weather conditions or operational constraints preclude use of those other sites. This RSMP specifically discourages use of the DWS except when weather or other factors preclude use of existing and new nearshore or onshore sites.

Between 2004-2018, an average of 1.3 million cy of material was placed annually at the DWS. In 2018, 1.02 million cy was placed. In line with the RSMP's goal to discourage deep water placement, placement was greatly reduced to 427,000 cy in 2019 and to 358,000 cy in 2020. The Corps indicates that the intent is to continue to minimize placement there.

(2) RSMP Beneficial Use Sites

(a) South Jetty Nearshore Site (SJS)

The SJS is located in Oregon in the nearshore littoral zone south of the South Jetty in waters 40-60 feet deep. Dredged material at this location is intended to provide sand needed to mitigate erosion and supplement the sediment budget in the nearshore area adjacent to the South Jetty. The site is approximately 9,500 feet long by 7,000 feet wide.

In LCSG science/policy workshops beginning in the mid-2000's, this site was identified as the area in the greatest need of dredged material, with significant scouring of the seabed expected to accelerate without the input of sand into the littoral zone. It is also identified as a geographically centric site in terms of the littoral zone south of the South Jetty and the most proximate area to disperse sand to help stabilize the jetty. It is expected to be the least productive area within the South Jetty vicinity in terms of benthic invertebrate abundance. Modelling indicates that much of the material added to the area would be expected to stay in place.

As further described in Appendix B, the MCR RSMP program of placement of dredged materials at beneficial use sites began with the initiation of the Oregon Nearshore Beneficial Use Project in 2004 to collaboratively address the depletion of sand in the nearshore environment south of the South Jetty. To address scientific information needs and share this information with decision-makers, LCSG and the Oregon State University Institute for Natural Resources commissioned a series of scientific white papers and convened joint workshops. Among the conclusions were that a limited demonstration project should be conducted at the SJS to

determine the feasibility of "thin layer" disposal in the nearshore environment. This led to a series of demonstration (or pilot) projects, beginning in 2007 and continuing in most years until the recognition of the SJS as a permanent placement site by the LCSG in 2018. These demonstration projects were intended to test:

- The feasibility of "thin-layer" placement by a hopper dredge in the nearshore environment.
- The amount of material required to create a "trackable" feature on the seabed, i.e. berm, which could be monitored to determine the rate and direction of sediment transport.
- Potential impacts to navigation safety and to biological resources, specifically Dungeness crabs and benthic invertebrates.
- Tracking of deposited sediment movement over time to determine the extent to which it remains in the littoral zone.

Varying amounts of material have been placed over the last 13 years, increasing to a high of approximately 400,000 cy in 2018 and 2020. The Corps has recently proposed increasing the amount to 500,000 cy, an amount authorized under the current CWA Section 401 water quality certification.

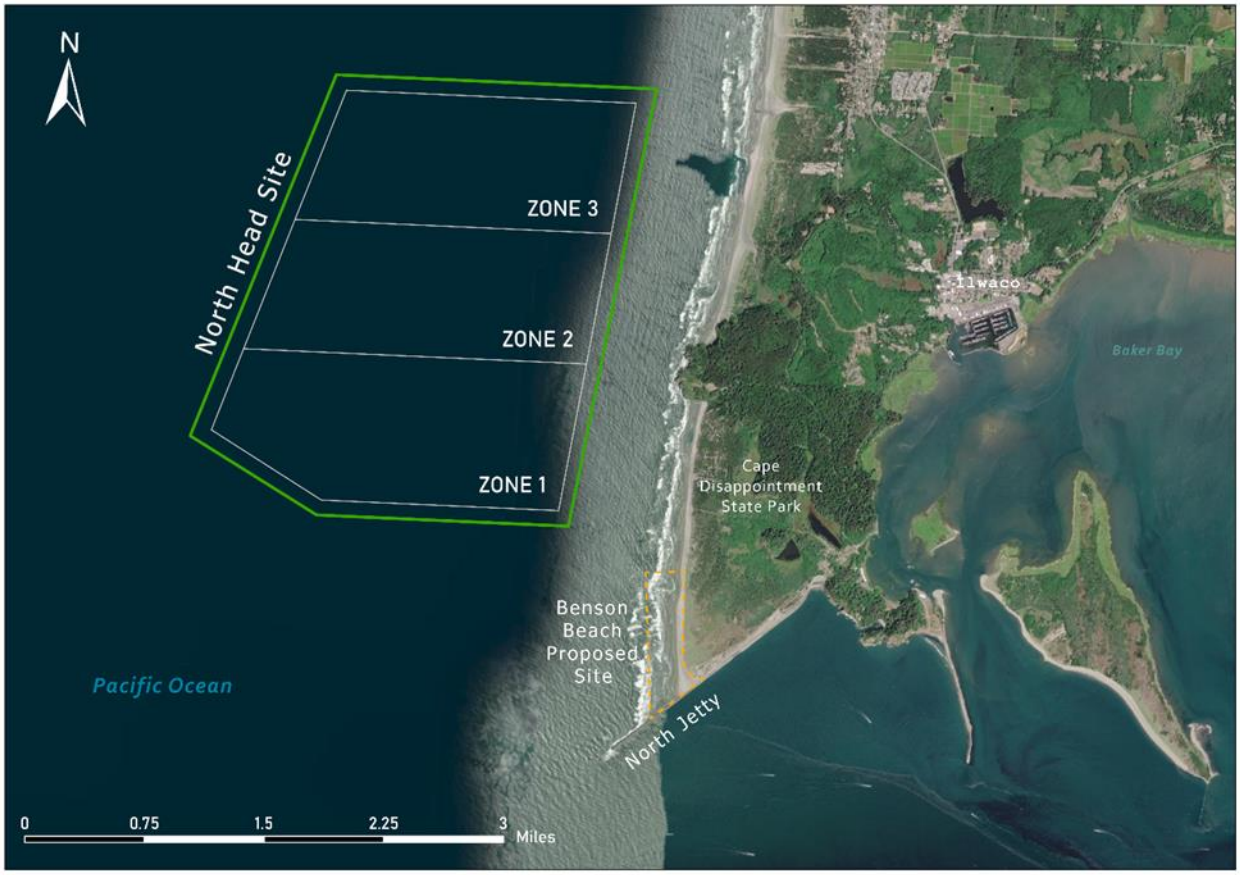
The SJS has proven to be a viable placement site both in terms of dispersiveness of material into the nearshore and from an operational perspective. In general, it appears that some of the material placed there is retained within the proximity of the South Jetty and leads to deposition both along the jetty and the Clatsop Plains shoreline. It also appears that it is helping to reduce the bottom scouring that was a key factor in its selection as a placement site.

SJS demonstration placements have also fostered an experimental approach to investigate effects of sediment deposition events on benthic communities. Essentially, a state of the art crab/benthic invertebrate monitoring program has evolved over the past 15+ years, entailing a variety of new or modified video and acoustic telemetry techniques including: "campods" (benthic video landers) to measure acute effects of placement including sediment depth and impact on fauna; acoustic telemetry to measure acute and cumulative impacts on crabs by using tags and monitoring movement/behavior; and benthic video sleds to compare invertebrate and fish abundances in different habitats. Monitoring of crabs indicates no evidence of increased mortality and no long-term effects. At placement, crabs move out quickly, the majority to the north; they return to the dump site within an hour or two after placement. Unknown are cumulative effects and the extent of northward migration.

Monitoring and analysis in conjunction with pilot projects at SJS over the past 15+ years have demonstrated the efficacy of thin-layer placement as a method of nearshore placement of dredged material that avoids significant impacts to navigation safety and biological resources. Based upon this conclusion, the LCSG has transitioned the SJS from being an experimental or demonstration site to being a permanent, long-term placement site for materials dredged from the MCR.

The LCSG intends to use the site's CWA Section 401 water quality recertification process scheduled for 2022 as the vehicle for assessing the potential to increase the site's footprint to facilitate placing a greater amount of material without creating mounding impacts and to increase the maximum volume of material placed at the site from its currently authorized 500,000 cy to 600,000 cy. Given limited funding and based upon results to date, annual research and monitoring of dredging impacts have been determined by the LCSG to not be a priority at this site. Rather, the LCSG intends to establish an ongoing program to monitor key indicators that could act as triggers to identify unintended affects and the need for adaptive management. There is also a need for additional monitoring and modeling of sediment transport at the SJS and close monitoring of potential impacts to the South Jetty and the Clatsop Spit. Periodic evaluation of infauna impacts and fish utilization has also been identified as needed.

(b) North Head Nearshore Site (NHS)



As with the South Jetty Site, this placement location was identified through early science/policy workshops and confirmed in the 2011 RSMP as the priority nearshore area north of MCR to explore for beneficial use feasibility and, specifically, for dispersion of materials along Benson Beach and Peacock Spit in Washington. The NHS is located approximately 2.5 miles north of the

North Jetty and directly offshore from North Head Point, with water depths ranging from 20 – 60 feet. It is intentionally a large placement site (approximately 7,400 feet long by 3,000 feet wide on the beach side and 4,400 feet long by 5,600 feet long by 4,500 feet wide on its ocean side), as there are significant differences between the north and south portions of the area in terms of current circulation patterns and benthic fauna density and diversity. The NHS essentially acts as a nearshore partner or surrogate for onshore placement at Benson Beach, with placement at this site intended to disperse sand to and thus reduce erosion at Peacock Spit and Benson Beach.

The identification of NHS as a potential beneficial use site occurred in 2009 under the auspices of the Southwest Washington Littoral Drift Restoration Project (see Appendix B for project details). However, placement of dredged materials did not occur at the NHS until 2018. In the intervening period, the Littoral Drift Project prioritized onshore placement at Benson Beach, while the LCSG focused on a series of demonstration projects at the SJS, intended in part to better inform a placement program at the NHS. Discussion of how to move forward with placement at the NHS was reinitiated at a 2016 science/policy workshop, with a comparatively large study area identified, the intent being to reflect the variable various ocean conditions and provide flexibility for placement within the area. The hope was that some sediment might feed Benson Beach and the shoreline to the north. Unlike at the SJS where no mounding was the goal, the concept for placement at the NHS included constructing a two-foot high berm of dredged material in 35-50 feet of water to measure dispersion and the site's viability as a placement site.

A five-year CWA certification was issued by the State of Washington in 2018 for a pilot project, the goal being to define the best location(s) within the study area for a permanent placement site(s) and an appropriate site capacity. In the first phase of the pilot project, approximately 51,000 cy were placed to create a two- foot high detectable feature (berm) approximately 5,000 feet in length to observe sediment dispersion. A second phase of the pilot project in 2019 entailed placement of 100,00 cy and sediment transport modeling to identify transport pathways and the most beneficial locations for dredged material placement. A third phase of the pilot project in 2020 placed approximately 283,000 cy, with sediment transport modeling used as a surrogate for a sand tracer study.

The three phases of the pilot project demonstrated that the NHS is a dispersive site, with sediment transported vigorously regardless of "mound" orientation. Monitoring of the mound placed in an east-southeast direction in the third phase indicated that sand is being transported as desired toward Benson Beach. It appears that the NHS is less dispersive than the SWS, however. Other conclusions included:

- There was no wave height amplification associated with a 2-2.3 foot berm in 35-50 feet of water depth.
- Given good weather conditions, a hopper dredge can operationally place sediment alongshore and cross-shore at the NHS.

- The larger the site, the greater the opportunity to dispose of large volumes of material via thin-layer placement. A placement volume of 400,000-500,000 cy/year appears to be below a threshold of concern, with placement at the southern end of the NHS appearing to have the greatest potential benefit to Benson Beach. Current plans for placement at NHS are not expected to significantly reduce erosion at Benson Beach, however. To reduce erosion at Benson Beach, more sediment needs to be placed and placed more efficiently.
- Sediment transport modeling suggests that transport pathways are highly sensitive to wave height and direction. The highest sediment mobility is found on Peacock Spit and nearshore north of the MCR.

Based upon recent discussions, the LCSG's intent is to transition the NHS from being a demonstration site to being a permanent, long-term placement site, using sub-areas of the site on a rotational (annual) basis at 300,000-500,000 cy/year, maintaining a berm of no greater than two feet in height, and placing materials in other than a straight line. To minimize overuse of the site and reduce conflicts with the fishing fleet, no more than one-third of the site would be used in any given year. At the same time, the southern subarea will be a priority, as it has the greatest potential for transport of sand to Benson Beach. Longer-term goals are to assess the viability of expanding the study area to the south closer to the North Jetty and increasing the volume of material placed above 500,000 cy/year, with different volumes of material placed within different portions of the site, e.g. 500,000 cy/year in the southern third of the site and less in the northern third.

(c) Benson Beach Onshore Site

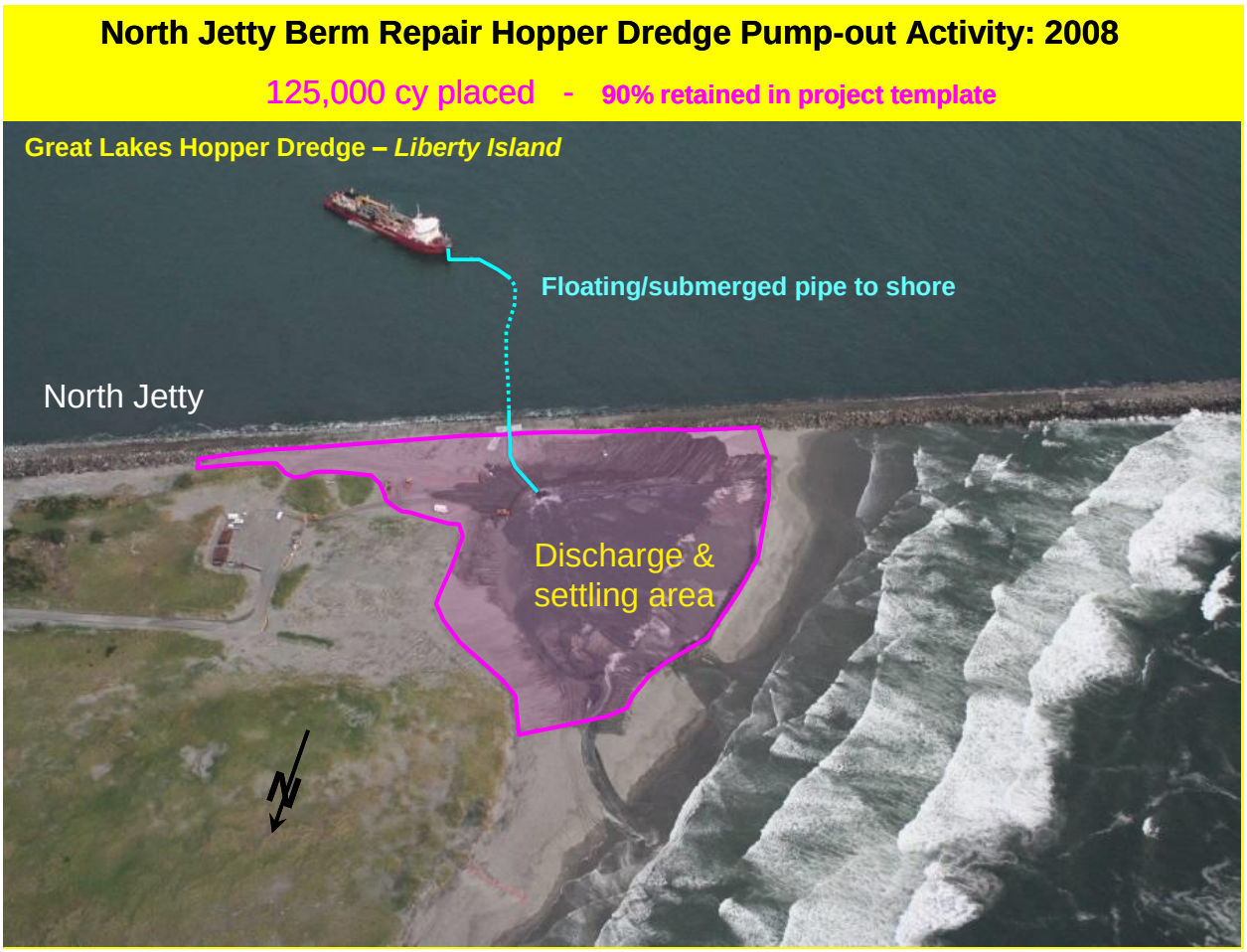
The Benson Beach intertidal or onshore site is directly north of and adjacent to the North Jetty in Washington. Benson Beach was naturally created by the construction of the North Jetty. Because of a reduction of sediment input into its littoral cell, Benson Beach has significantly eroded. Construction of the North Jetty has changed the Peacock Spit, with waves / currents beating it down and diffusing it out. The Corps has been monitoring Peacock Spit since 1958 and has observed that its underwater shelf is shifting, contributing to Benson Beach erosion. The accreted sand that makes up Benson Beach appears to be migrating north within the northern Long Beach littoral zone. The present volume of new sediment transported north from the MCR is insufficient to offset the erosion at Benson Beach. Without stabilization of Benson Beach, more rapid scouring is expected to occur along the toe of the North Jetty, with greater potential for breaching in storm events.

Despite placement of approximately one million cy of sediment in the SWS annually between 2014 and 2019, Benson Beach continued to erode during this period at approximately 420,000 cy/yr. While Benson Beach accumulated approximately 900,000 cy of sediment in 2020, it is not known if this is only a temporary reversal in the erosion trend and whether it is due to dredge material placement at SWS or NHS or to changes in environmental conditions. This recent gain, however, is not sufficient to reverse effects of steady erosion over the past few

years. The dunes along Benson Beach are 0.5-1 meter lower than they were 6-7 years ago, making them more at risk for overtopping and associated erosion and flooding. Washington State Parks and Recreation representatives indicate that multiple oceanfront camping sites at Cape Disappointment State Park have been lost over the past several years, resulting in closing camping at oceanfront camp sites at the park between November – April.

It was initially concluded in a 2007 science/policy workshop and reaffirmed in 2009 workshops that onshore placement at Benson Beach is the best alternative to address coastal erosion north of the North Jetty and the best use of dredged materials from MCR. Benson Beach is identified as the location in the littoral zone north of the North Jetty that would be expected to have the greatest benefit in terms of beach and drift restoration and the least effect on habitat impacts, as well as the most appropriate location for a demonstration onshore placement project.

There have been three placements of dredged material on Benson Beach, either in conjunction with North Jetty repairs or as a one-time event intended to specifically address onshore erosion. In 2004 and 2008 events, dredged material was placed via pump-ashore discharge from a dredge vessel to the shoreline. In the 2008 placement, approximately 125,000 cy was dredged from the MCR navigation channel and pumped ashore to repair the foredune, which had been protecting the North Jetty root from wave surge action. The destruction of the foredune along the North Jetty was providing storm waters with a direct path to the unrepaired part of the jetty. During ocean storms, water was reaching the lagoon area and raising the existing water level, causing water to flow through the jetty. The 2008 placement was characterized by rapid loss of the sand placed due to a major storm event.



The 2010 onshore placement of 367,000 cy grew out of the Southwest Washington Littoral Drift Restoration Project, an effort by the Coastal Communities of Southwest Washington to develop a long-term strategy for placement of dredged material in the littoral zone north of the North Jetty. This $3.5 million pump-ashore demonstration project entailed placement of material in an area approximately 1,000 feet north of the North Jetty along Benson Beach in Cape Disappointment State Park. The project was subject to the Corps's "least-cost" placement policy. Under this policy, any sand placement project that costs more than the least-cost option (disposal at DWS, in this case) requires a non-federal cost-share. In response, the State of Washington contributed $1.69 million in incremental funding for the project, which was added to $1.8 million in Corps maintenance funding. Monitoring activities were funded under the Corps' Regional Sediment Management program. Project goals included restoring the littoral drift, rebuilding onshore sands, tracking sediment movement over time, and determining whether replenishing the littoral zone helps protect the North Jetty. Monitoring over 15 months showed that material placed against the toe of the foredune remained the longest. There was some measurable decrease in localized erosion during the first winter season, with a "healthier" beach the following spring and summer. After that time, the material placed had almost completely washed away. Additional project details can be found at: https://lowercolumbiasolutions.org/projects/sw-washington-littoral-drift-benson-beach/

Sand fencing has also been used at Benson Beach as a barrier to slow down sand being carried away by the wind. In conjunction with the 2008 berm repair project, 2,300 feet of sand fencing was installed. While a severe winter storm caused significant damage, the sand fence performed beyond expectation. By allowing sand accretion and dune creation before the storm occurred, the sand fence minimized negative impacts of the storm. The newly constructed dunes acted as protective barriers to the North Jetty and uplands. During Summer 2009, an additional 3,000 feet of fencing was placed to help increase the sand accumulation. Based upon project results, it has been recommended that future sand fencing projects include continual monitoring of fence performance, installation of additional fence, and planting of native dune vegetation. Additional fencing is expected to help to break the wind flow over the top of the North Jetty berm and greatly help to minimize the effects of storm surge and over-wash of the berm during winter storms. Another sand fencing project at Benson Beach in 2021/2022 is currently being scoped.

There is broad support for onshore beach nourishment along Benson Beach north of the North Jetty intended to minimize erosion at Benson Beach and Peacock Spit and allow for beach accretion. Onshore placement has consistently been identified as the most effective method for reducing erosion at Benson Beach and the question remains of whether nearshore placement will have little, if any, impact on that erosion. While nearshore placements at the NHS and SWS have been shown to enhance the sediment budget of Benson Beach, it has not been determined what volumes of placement in the nearshore are necessary to make a difference on the beach and whether such volumes are achievable without causing mounding and inducing wave amplification.

In recent discussions, the LCSG has indicated that a program of ongoing onshore placement is needed to address safety and economic concerns, including loss of camping/other park infrastructure, loss of State Park revenues, safety to the public, etc. Past one-time onshore placements have had only short-term benefits. The LCSG has also indicated that onshore placement needs to be coupled with strategies such as sand fencing to keep the sand in place. According to the Corps, given operational and funding efficiencies, onshore placement at Benson Beach may best be undertaken in conjunction with nearshore placement at NHS.

A priority strategy identified at the LCSG's January 2020 science/policy workshop is to compete for available federal funding for an onshore placement project. At this time, pump ashore with a hopper seems to be the best technology. Its high cost ($1.9 - $2.6 million) is made especially challenging by the Corps' incremental cost policy. The Portland District includes a Benson Beach onshore placement project in its budget request every year but it is not funded apparently because it is not directly tied to navigation needs. The squeaky wheel approach and unified messaging have been identified as needed to successfully compete for funding. Corps staff indicates that a best case scenario for funding is 2022, with 2023 more likely. An updated CWA certification will be needed and cost sharing with Washington will likely be required unless the case can be made that placement is directly related to protecting the North Jetty.

(d) Clatsop Spit Onshore Site

This onshore beach nourishment site is located south of the South Jetty along Clatsop Spit in Oregon. Material deposited onshore in this beneficial use site is intended to build up the immediate shoreline to address concerns that a breach of Clatsop Spit could be caused by significant storm events and attendant wave action. Presently, new sediment flushed from the MCR is blocked by the South Jetty from reaching the Clatsop Spit shoreline. As a result, this shoreline is receding without the input of sediment into the littoral zone. The protective system of bars parallel to the shoreline is diminishing in size, reducing their wave breaking effects and posing an erosion risk to the spit and the South Jetty.

Portion of South Jetty and Northern End of Clatsop Spit

While information specific to placement at this site is more limited than for the other beneficial use sites, it is assumed that placement would occur in an area(s) proximate to the South Jetty that is especially vulnerable to potential breaching. To protect and stabilize the north end of the Clatsop Spit foredune adjacent to the South Jetty, the Corps constructed a "dynamic revetment" or berm in 2013. This area was identified in a 2016 science/policy workshop as the most vulnerable portion of the shoreline south of the South Jetty to potential breaching of Clatsop Spit's foredunes with a series of severe storms. More than 30,000 cy of gravel and cobble stones were deposited in a cul-de-sac-shaped berm arcing 1,100 feet along the coastline. The berm is intended to emulate a natural, gravelly beach. The larger rocks in the berm move onshore in the face of waves and high tides, as opposed to sand being pulled offshore. A 2018 monitoring study indicated that the berm is functioning well in helping to stabilize the area. While the berm eroded more than 60 feet inland near the jetty, in a sacrificial

area on the northern end, the structure has withstood multiple storm events. The project has an expected life cycle of 30-50 years, but will need more material added every 10-15 years, depending on the severity of future storms.

Dynamic Revetment Project, Base of South Jetty

While no additional projects are proposed at this time, this RSMP retains the Clatsop Spit onshore site as a potential beneficial use site within the Plan's network of sites. It is recommended that concept planning for future onshore placement activities be initiated as part of the renewal of Oregon's water quality certification process in 2022.

b. Site Prioritization Guidelines

Interim guidelines for prioritizing placement of dredged materials among beneficial use sites were identified in the 2011 RSMP. Those guidelines were based on the following principles, which are reaffirmed in this 2021 Update:

- No single site has the capacity to take all the dredged material available annually.
- The opportunity to utilize multiple sites on a rotating basis is expected to reduce the potential for mounding impacts and minimize effects on biological species of concern.
- The DWS will be used only on a contingency basis when funding, equipment, environmental, safety or other issues preclude use of other sites.
- Determinations on the nature of placement at beneficial use sites are made by the Corps in its Annual Use Plan after consultation with the LCSG. Placement programs at the other authorized sites are at the Corps' sole discretion.

The guidelines for prioritization established in the 2011 Plan ranked placement at the beneficial use sites as follows, assuming availability of funding and equipment:

(1) SJS nearshore site would be a first priority, as this area has been identified as having the greatest need of dredged material, with scouring of the seabed expected to accelerate without the input of sediment into the littoral zone.

(2) The next priority would be onshore beach nourishment along Benson Beach north of the North Jetty. Material deposited in this area would be primarily intended to minimize erosion at Benson Beach and Peacock Spit and allow for beach accretion.

(3) If onshore placement at Benson Beach is not practical, the North Head NHS) nearshore site would then be a priority.

(4) Onshore placement along Clatsop Spit south of the South Jetty is a lower priority at this time due to the high priority for placement within the nearshore area to address degrading bathymetric conditions and to shore up the South Jetty. However, if equipment improvements provide for pump-ashore capabilities, simultaneous nearshore and onshore placement should be explored.

While this ranking still makes some sense, the beneficial use program has progressed to a point where ***the goal is to simultaneously place dredged material at as many of the four sites as feasible in a season,*** in part to diminish the need to use the DWS, with the following caveats:

- SJS is the only site that has moved from pilot project to routine status and the only site permitted for ongoing placement. Renewal/revision of the authorizing Clean Water Act (CWA) 401 water quality certification and Coastal Zone Management Act (CZMA) consistency determination will be needed to continue placement there after 2022.
- A new or amended CWA 401 water quality certification will be needed before routine placement can occur at NHS.
- Permitting will need to be secured before placement at Benson Beach can occur; cost sharing by Washington may also be required if least cost requirements remain applicable.
- No planning, permitting nor pilot projects have been initiated at the Clatsop Spit site.

To illustrate potential distribution of dredged materials among the seven sites comprising the current MCR dredged placement site program, Corps staff recently offered the following suggestion for distribution of dredged material, based on an average of approximately 3.5 - 4 million cy of material dredged annually.

Potential Distribution of Sediment to MCR Placement Sites

Site	Annual Volume (cy) (Recent Trend)	Potential Annual Volume (cy)
Separately Authorized Sites		
NJS	200,000	200,000
SWS	1.4 million	1.8 - 2 million
DWS	800,000	<200,000
Subtotal	2.4 million	2.2 – 2.4 million
Beneficial Use Sites		
SJS		400 – 500,000
NHS		300 -- 500,000
Benson Beach		200 - 400,000 every 3-6 years
Clatsop Spit		NA
Subtotal	1.0 – 1.4 million	1 – 1.4 million

As noted under Plan Assumptions, this RSMP does not preclude the identification of additional sites as potential placement locations. For example, the LCSG agreed at its January 2021 meeting to consider a proposal by the Corps to add three sites (east side of Jetty A, West Sand Island, and East Sand Island) into the Plan, based upon technical and policy analysis of how they fit into the RSMP's scope and any potential impacts to continued use of the currently authorized beneficial use sites.

c. Navigational Safety Standards

A fundamental RSMP goal is to ensure that placement practices avoid unacceptable adverse effects on navigational safety. A variety of navigation safety standards were incorporated into the 2011 RSMP and are reaffirmed in this Update. They are edited/modified as follows:

- Avoid mounding which could have a measurable effect on navigation safety at the ocean surface through adherence to a maximum threshold of 10% over baseline conditions.
- Limit dredged material placement at beneficial use sites to dispersed, thin-layer placement.
- To reduce the potential for mounding impacts, rotate placement among sites and within portions of sites where feasible.
- To the extent feasible, obtain prediction and real-time information on waves and wind in critical navigation areas and where wave model discrepancies are large. Use this information in wave model calibration and ground-truthing of wave models and share with the commercial and recreational boating communities.
- Incorporate a common bathymetric grid in modeling.
- In monitoring for navigational safety:

- Employ bathymetric monitoring, including a pre-placement bathymetric survey of the site's contours to determine capacity and as a baseline for management within the dredging season. Use the pre-placement surveys to determine a placement strategy for the season that minimizes mounding and any resultant wave amplification. Following the season, conduct a similar post-placement survey of the site's contours, the primary focus being to determine whether mound induced wave amplification has exceeded a maximum threshold of 10% over baseline conditions. Use the post-placement surveys to adaptively develop a placement strategy for the next season.
- Monitor shoaling within the MCR navigation channel associated with migration of placement sediment from beneficial use sites.

Placement at the SJS and NHS nearshore sites following the end of the crab season has served to avoid conflicts with the crab fishing fleet and the need to designate transit lanes to and from the nearshore sites. To help minimize conflicts in the future, the Columbia River Crab Fishermen's Association (CRCFA) has identified the need to establish direct communication with the fleet as a standard operating procedure for the placement of dredged material. The crab fleet is transitioning to real-time electronic monitoring which promises to be a critical tool in ensuring timely communication.

d. Adaptive Management Based Upon Research and Monitoring

As noted under Plan Assumptions, placement of dredged materials is an exercise in risk management that necessitates an adaptive management approach. Thus, ***a fundamental concept of this Plan is an adaptive management approach to placement that is informed by an ongoing program of research and monitoring*** and that is responsive to both the Plan's goals and to operational, regulatory, navigation safety, biological resource, and funding considerations. Fundamental precepts of this adaptive management approach include:

- Regularly monitor effects on physical and biological resources and navigation safety and adjust placement practices and management of placement sites as needed.
- Regularly review past, current, and proposed placement programs and overall RSMP implementation through periodic (generally annually) LCSG-sponsored science/policy workshops and technical team meetings.
- Schedule program reviews to be able to determine iteratively whether any adaptive measures need to be taken mid-season or during the next dredging season.

Monitoring of material placement includes daily tracking of the placement of material within each disposal site and frequent bathymetry surveys at the disposal sites during the dredging season. Minimum site monitoring requirements for each active disposal site at MCR are a pre-placement bathymetry survey (beginning of season) and a post-placement survey (end of season). Special studies are also conducted as needed to assess the potential effects of dredged material placement within specific placement sites.

The goal of these R&M efforts is two-fold: (1) provide information to inform planning and design of future beneficial use site placements; and (2) determine iteratively whether adaptive measures need to be taken to adjust placement programs currently in process or planned for the upcoming season. The existing base of knowledge provided through pilot (demonstration) beneficial use placement projects, sand tracer studies, other research, and science/policy workshops is utilized to guide the design of pre-dispersal and post-dispersal data collection and monitoring of biological and physical impacts of dredge placement. The annual assessment by the LCSG of the results of the prior season's monitoring helps inform decisions about research and monitoring needs for the upcoming season. Agreed-to research and monitoring is then included in and funded as part of the Corps' AUP.

This monitoring and evaluation are essential to achieve the desired outcomes of beneficial dredged material placement while still minimizing the risk of unwanted consequences, i.e. detrimental impacts to marine life and navigational safety. Conversely, it can also be used to identify certain positive outcomes such as improving habitat, reducing beach erosion, or protection of the jetties. The focus of these efforts is summarized below; what's been learned to date from these efforts is summarized in Section E.

- *Sediment Transport:* Sand tracer studies are key to understanding where dredged materials go after placement. Because of the high cost of such studies, a U.S. Geological Survey (USGS) sediment transport model is currently being used as a surrogate for a sand tracer study at the NHS.
- *Beneficial Effects*: Continuous monitoring is conducted to determine beneficial effects of adding sediment to the littoral zones north and south of MCR and of keeping sand in the system. Stabilizing or reducing erosion rates are difficult to measure in the short term. Beach profile transects monitored by the Oregon Department of Geology and Mineral Industries (DOGAMI) and core samples are key indicators.
- *Navigation Safety:* Effects of mounding on navigation safety are monitored with each placement.
- *Biological Sciences:* Biological information for the beneficial use sites is not as well developed as the physical information. Spending years studying the biological activity at these sites, however, would result in considerable amounts of sediment continuing to leave the littoral system. The Plan's R&M program instead relies upon a combination of initial baseline studies coupled with monitoring of particular populations over time, with Dungeness crab as the priority species monitored and razor clams and fish species in a less critical category.

Current monitoring at MCR is being conducted through a cooperative agreement between the Corps and Washington Department of Ecology (WDOE), in collaboration with U.S. Geologic Survey (USGS) and other entities, and includes annual beach and nearshore environmental monitoring. Monitoring of the shoreface of Peacock Spit in Washington and at Clatsop Spit in Oregon is assessing long-term morphology changes at MCR. Beach topography data is collected at bathymetric transects along the shoreface of Benson Beach to the area one mile north of

North Head, and adjacent to the South Jetty and the area one mile south along Clatsop Spit. Cross-shore beach profiles are also being collected within 1,000 meters of the North Jetty from dunes/inland vegetation to low water. These profiles document the present condition of the North Jetty berm by extending beach profiles over the berm and into the dunes/upland where possible. South of the South Jetty, cross-shore beach profiles are being collected coincident with nearshore bathymetric profiles. Survey data is being collected using the Coastal Profiling System (high-speed maneuverable water-craft equipped with an echosounder and Global Positioning System), an all-terrain survey vehicle, and GPS backpacks to assess nearshore morphological change. These data serve to calibrate and augment the North Head Argus Beach Monitoring System, allowing the system to quantify nearshore changes throughout the high-energy winter months. These data are also linked to the annual bathymetric condition surveys conducted by the Corps.

The data collected from this annual beach and nearshore monitoring is being compared and contrasted with data collected in previous years at the same locations by the 1998 Southwest Washington Coastal Erosion Study: https://apps.ecology.wa.gov/publications/documents/98105.pdf Goals include identifying areas of bathymetric/topographic change and pathways of sediment transport.

At its January 2020 science/policy workshop, the LCSG identified the need to begin the conversation about what a long-term research and monitoring plan for dredged material placement should entail, including a schedule for long-term monitoring on a recurring basis, e.g. every three-five years. Part of the goal for this long-term plan will be to determine what the group wants to know in the longer term about this beneficial use placement program that can be informed by consistent and routine monitoring and what is extrapolatable to other coastal situations.

D. MANAGEMENT CONTEXT AND CONSIDERATIONS

A variety of factors have been considered (and will continue to be) by the LCSG in developing this RSMP and in managing and monitoring its implementation. These considerations provide the context for the RSMP's Goals and Plan Elements defined in Section D.

1. PHYSICAL SETTING AND CONSIDERATIONS

The lower Columbia River is a complex waterway of vital importance to the economy and ecology of the Pacific Northwest. For endangered salmon and other species, it is a crucial link between the ocean and inland watersheds. Its mouth is home to one of the largest Dungeness crab fisheries on the West Coast. Economically, the lower Columbia is a critical transportation corridor for the United States, transporting over 50 billion tons of cargo each year, valued at over $20 billion. The Columbia-Snake River System is the nation's largest wheat export gateway and second for soy. When combined with corn and other grains, it is the third largest grain export gateway in the world. It is number one on the West Coast for forest products, mineral bulk exports, and auto exports.

The Columbia River bar is reputed to be the second most treacherous in the world and the most treacherous in the United States. Approximately 2,000 vessels and 700 people have been lost in this area. In 2009, *Smithsonian* magazine published an article entitled "Crossing the Bar" which colorfully summarizes the challenges of navigating the MCR.

> The bar, where the river's mighty current collides with ocean swells, is one of the most treacherous harbor entrances on the planet. Winter storms whip the sea into a ship-hungry maelstrom that long ago earned this patch of water the nickname 'Graveyard of the Pacific.' Pilots guide ships at every major harbor around the world, but the bar pilots here have distinguished themselves by working a potent brand of maritime mojo in the face of what a 19th century naval officer called 'the terrors of the bar'."(*Smithsonian*, February 2009).

Like many rivers, the Columbia River is highly engineered. At the MCR, a deep draft navigation channel six miles long is maintained by the Corps and protected by three rubble-mound jetties: the North Jetty (2.5 miles long) on the Washington side; the South Jetty (6.6 miles long) on the Oregon side; and Jetty A (0.9 mile long) inland on the Washington side. These structures help maintain the depth and orientation of the navigation channel, they ensure safe passage for commercial and recreational vessels entering and exiting the estuary. At the same time, these jetties, combined with upriver dams and other structures, have altered the river's flow and reduced by nearly two-thirds the historic level of sediments moving through MCR, resulting in a continual decrease of sediment in the nearshore ocean environment. As a result, ocean beaches and the jetties on both sides of MCR are at increasing risk of erosion because offshore sand no longer buffers wave energy. Sandy bottom Dungeness crab habitat may also be in jeopardy as the nearshore ocean bottom erodes to mud in some areas. (For more detail on MCR jetty construction and its effects on shoreline morphology and sediment transport see the section of 2011 RSMP titled *Brief History of the Mouth of the Columbia River.*)

Mouth of the Columbia River

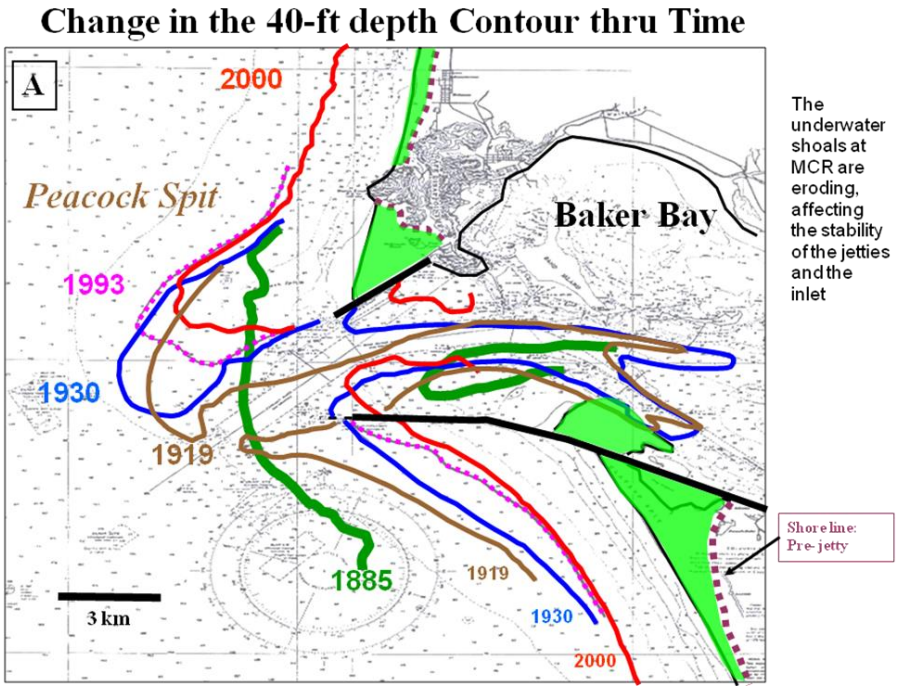
"CONSTRUCTED" 1885-1917

To keep the Columbia River shipping channels open, approximately three to five million cubic yards (cy) of sand are dredged annually from the MCR by the Corps' Portland District. The dredged material is primarily clean quartz sand. Dredging at MCR and placement of material into offshore waters along the Washington and Oregon coasts has occurred for more than a century. A history of dredging and ocean placement and summary of physical and biological studies sponsored by the Corps in the early 1970s through the mid-1970s is provided in a June 2007 *Summary of Physical and Biological Studies at the Mouth of the Columbia River Sponsored by the U.S. Army Corps of Engineers* prepared by the Corps' Portland District.

Currently, there is a very strong erosion trend on the north side of MCR between the North Jetty and North Head, while north of North Head there is an overall trend of accretion. Sand is not coming back into the area between the jetty and North Head after large storm events, creating a sediment-starved system that does not have the material it needs to recover. The erosion at Benson Beach is particularly noteworthy as it is close to the sediment source and it is the area most eroding. Washington State Parks & Recreation (WSP&R) representatives have indicated that oceanfront camping sites have been lost over the past several years at Cape Disappointment State Park, resulting in closing camping at oceanfront camp sites between November – April. Erosion moving north up the coast is also of concern. Of note, after several years of significant erosion, in 2020 Benson Beach accumulated approximately 900,000 cy of sediment. It is not known at this time whether that accumulation is due to dredge material placement at NHS, the rehabilitation of the North jetty completed in 2019, or to changes in environmental conditions, e.g. wave climate, fluvial supply or other conditions (see NHS description in Appendix B).

On MCR's south side, there has been a history of relatively positive accretion generally. However, a presentation at the LCSG's December 2020 meeting indicated that the South Jetty nearshore lost about 1.2 million cy of sediment between 2019-2020. This contrasts with a net gain of 670,000 cy between 2014-2020 (see South Jetty Site description in Appendix B). This change raises concerns about impacts to the South Jetty and about the potential for breaching of Clatsop Spit's foredunes with a series of severe storms. In conjunction with recent South Jetty repairs, cobble was placed in a small area of erosion at the root of the jetty. The cobble (dynamic revetment) helped build up the dunes adjacent to the South Jetty root.

According to the 2010 *Oregon Climate Change Adaptation Framework* Report, ongoing erosion is expected to continue or become more severe as climate change factors increase the frequency and duration of storm events. The impacts of long-term sea level rise and shorter-term changes in ocean conditions are expected to increase risks of catastrophic erosion events near MCR.



Multiple computer models of sediment transport processes indicate that the strategic placement of dredged material within beneficial use sites can bolster the littoral budget, including the offshore bar system adjacent to the MCR. (Gelfenbaum et al., 2005; Byrnes and Griffee, 2006; Ruggiero et al., 2006; Osborne et al., 2007).

It has been almost 25 years since the last updating of charts showing historical bathymetric differences that illustrate where sediment is accreting and decreasing over time. The Columbia River Crab Fishermen's Association has urged the LCSG to advocate for a NOAA offshore survey to update sediment movement since 1998 to help determine if beneficial use placements are meeting the overall goal of coastal erosion abatement.

2. REGULATORY CONSIDERATIONS

Placement of dredged material from the MCR is managed under numerous federal, state and local laws. Federal regulations include: the National Environmental Policy Act (NEPA); Clean Water Act (CWA); Marine Protection, Research and Sanctuaries Act (MPRSA); Endangered Species Act (ESA); Marine Mammal Protection Act (MMPA); Magnuson-Stevens Fishery Conservation and Management Act; Fish and Wildlife Coordination Act (FWCA); and Coastal Zone Management Act (CZMA). Under section 404 of the Clean Water Act (404), the Corps and U.S. Environmental Protection Agency (EPA) jointly regulate the discharge of dredged material into waters of the United States. Under section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA) the Corps and EPA jointly regulate the transport and placement of dredged material in ocean waters; EPA concurrence is required for ocean placement.

An Annual Use Plan (AUP) developed by the Corps and approved by EPA Region 10 as part of a 2005 Site Management and Monitoring Plan (SMMP) guides the Corps' year-to-year management of MCR dredged material placement sites. In addition to providing a framework for management of placement activities on a day-to-day basis, the AUP describes a program to collect information on those activities via monitoring or assessment of operational data.

The LCSG process and the beneficial use program identified in this RSMP are integrated by the Corps into development of its AUP. The RSMP serves as the basis for programmatic permitting of the beneficial use placement sites identified in the Plan. Following LCSG approval of the 2011 RSMP, the Corps formally expanded its dredged material placement network to include three of the four beneficial use sites identified by the RSMP -- SJS, NHS and Benson Beach Onshore Site. Through an Environmental Assessment and Finding of No Significant Impact prepared pursuant to NEPA, the sites were selected under CWA section 404. The potential use of a fourth site identified in the RSMP -- the South Jetty Onshore Site (Clatsop Spit) -- has not yet been assessed and thus not included in any permitting processes. While the LCSG is responsible for overseeing implementation of this RSMP and for periodic updates as needed, the actual placement of dredged material at any of this Plan's beneficial use sites is exclusively the responsibility of the Corps.

Under CWA section 401, the states of Washington and Oregon must also certify that aquatic discharges do not violate state and federal water quality standards. In Washington, upland placement of dredged material is regulated by WDOE under the CWA and the state's CZMA program and by the Department of Natural Resources (WDNR) under its Dredged Material Management Program. WDNR has indicated that no authorization or lease is required for nearshore or onshore placement of beneficial use materials. Also applicable is Pacific County's Shoreline Management Plan which includes a 10% limit on mound-induced wave amplification (Ocean Section 6)

Nearshore placement in Oregon is regulated by both the Oregon Department of Land Conservation and Development (DLCD) under the state's CZMA program and by the Oregon Department of Environmental Quality (ODEQ) for CWA compliance. For onshore placement in

Oregon, both Oregon Department of State Lands (ODSL) and Oregon Department of State Parks and Recreation (OPRD) may have jurisdiction under their responsibilities for submerged/submersible lands management and beach nourishment, respectively. An Ocean Shore Alternative Permit is required from OPRD to determine impacts to recreation, natural resources, and scenic and safety values.

Onshore placement also entails consistency with county land use plans and regulations in both Clatsop (OR) and Pacific (WA) counties.

As previously noted, beneficial use projects at MCR are subject to the Corps's "least-cost" placement policy. Under this policy, any sand placement project that costs more than the least-cost option requires a non-federal cost-share.

Nothing in this Plan is intended to change any existing authorization or regulatory conditions applicable to the management of sites previously authorized under federal and state regulations (SWS, NJS and DWS).

The RSMP is predicated on the premise that compliance with applicable laws and regulations is best accomplished through cooperative partnerships with the various regulatory agencies in order to align necessary regulatory requirements while considering equipment availability, in-water work and funding timeframes, and other operational constraints. The RSMP is intended to help minimize the time to meet regulatory requirements and obtain authorizations, while maximizing involvement and input from the regulatory agencies during the planning, implementation and monitoring phases.

3. OPERATIONAL CONSIDERATIONS

The MCR is considered one of the world's most dangerous coastal inlets. These dangerous conditions constrain the timing and method of dredge material placement in the area. In addition, MCR dredge material placement is subject to a variety of operational constraints such as in-water work windows; costs of conducting work; availability of dredges with the equipment and capability to perform required work; placement site use management and monitoring requirements imposed by EPA and the states; and coordination with local fishermen and mariners. The hopper dredges used at MCR also serve other West Coast locations and do not work continuously at the MCR.

Weather conditions and wave and current intensity at the MCR limit dredge operations primarily to the months of June – mid-October, with some work conducted into November as weather permits. The timing of placement is also limited by approved "work windows" for actions potentially affecting Endangered Species Act (ESA)-listed salmon species in the Lower Columbia River.

When planning the dredging season, a variety of conditions are analyzed and captured in the Corps' AUP including shoaling conditions and dredging requirements, capacity of placement sites, timing of site use, type and availability of dredges, and other factors.

From Corps of Engineers presentation, May 2018 Science/Policy Workshop

Two of the beneficial use sites identified in this Plan are located nearshore in waters ranging from 20 to 60 feet in depth, while the other two sites are located onshore. A hopper dredge used in nearshore areas must be capable of safely navigating and maneuvering in relatively shallow areas and disposing of material in a measured and relatively thin-layer, generally averaging less than 12 cm in depth. Another operational constraint is that, under most conditions, a loaded hopper dredge cannot safely move parallel to the waves or shoreline while disposing of material; it needs to start at the closest point to the shore and move out perpendicularly, heading directly into the waves. Improved capabilities for placement from retrofitted hopper dredges are expected in the near future, which may help facilitate both nearshore and onshore placement within the area.

There is general agreement that onshore placement is the best way to replenish eroding beaches, protect the bases of jetty structures, avoid mounding and associated wave amplification, and avoid the potential for material filling the navigation channel. However, onshore placement is more logistically and fiscally difficult and the rate of sediment dispersal is relatively low. Discharging dredged material at the two onshore sites would be more challenging than nearshore placement. At this time, a contract dredge would be required for these practices. In addition to equipment constraints, the short dredging season makes onshore placement challenging and limited because of the amount of material that must be dredged within the short dredging season. For example, 2008 North Jetty berm repairs were interrupted by an unusual August storm.

There is a limited pool of contractors and their dredges that can physically work at the MCR. The Jones (Merchant Marine) Act requires that only U.S.-flagged, built, and crewed vessels can be utilized to conduct work in the United States. Most of the dredges are located on the East

Coast and require a trip through the Panama Canal to arrive on the Pacific Coast. Typically, MCR dredging is accomplished with two hopper dredges. Use of a third dredge is constrained by high mobilization cost and limited availability, given demands in other parts of the country.

Pursuit of a dedicated "West Coast" hopper and/or pump ashore dredge has been identified in LCSG discussions as a desired strategy for the group. There would be opportunities to use a dedicated pump ashore dredge not only at Benson Beach but at Grey's Harbor in Washington, Beverly Beach in southern Oregon, and in San Francisco where there are erosion issues. Corps staff estimates the cost of a dedicated dredge at about $50 million.

4. NAVIGATION SAFETY CONSIDERATIONS

Since program inception, navigation safety has been identified as a primary consideration in the identification, management and monitoring of beneficial use placement sites. The Columbia River Crab Fishermen's Association, an instigator in establishment of the LCSG and continuing participant, has repeatedly stated its concern that placement in the nearshore can potentially cause navigational hazards if too much sand is mounded in one area and that mound-induced wave amplification is a life-safety issue.

Wave amplification at historical dredged sediment placement sites led to agreement at early science/policy workshops on a variety of navigation safety considerations to be addressed in management direction for placement at beneficial use sites. That management direction, along with accompanying monitoring measures, is incorporated as a key element of this Plan (Section C.c).

- Navigation safety in areas of dredged material placement can best be enhanced by avoiding mounding which could have a measurable effect on navigation safety at the ocean surface. A maximum threshold of 10% over baseline conditions should be adhered to.

- Mounding should be routinely monitored so that any induced wave amplification does not exceed a maximum threshold over baseline conditions.

- To avoid the potential for adverse navigational safety and biological effects associated with mounding of sediment, placement of dredged materials should be via dispersed, thin-layer placement.

- Prediction and real-time information on waves and wind is essential in critical navigation areas and where wave model discrepancies are large. Directional wave measurements are desirable for both wave model calibration and ground-truthing of wave models, and for boater safety and safe-transit planning.

- Modeling should incorporate a common bathymetric grid and should include criteria for shoaling, refraction, diffraction, non-linearity, wind effects, and reflection.

To help in implementing these and other management considerations, new buoys were installed at MCR in 2018 to provide additional data collection and wind monitoring has been

expanded on North Head and integrated with wind measurements from the Clatsop Spit area. In addition, various cooperative research activities and studies have been undertaken, including enhancements to the existing ARGUS beach monitoring system at North Head, initiation of a detailed wave analysis for the area south of the South Jetty and north of the North Jetty, evaluation of nearshore circulation south of the South Jetty using remote sensing data, deployment of a CDIP wave-ride buoy at the approaches to MCR, and a sediment tracer study for the area south of the South Jetty.

5. RESOURCE CONSIDERATIONS

Extensive scientific research and monitoring (R&M) in both physical and biological sciences has accompanied each of the pilot beneficial use projects conducted to date, the scope of which has been determined through science/policy workshops, funding constraints, and logistical factors. To advise on science issues associated with this Plan, in 2007 the LCSG, through contract with Oregon State University's Institute of Natural Resources, convened a team of scientific experts in both physical and biological sciences, all of whom are familiar with the unique physical and biological processes that occur at the MCR. This group was charged with prioritizing the knowledge gaps in scientific understanding about the MCR system, and to provide scientifically-based R&M recommendations. Based upon advice from these experts and results of the many studies that have been conducted subsequently, it has been concluded that, with thin-layer placement, minimal biological impacts would be expected. In addition, the late summer timing of placement reduces concerns about impacts on some species. The use of "clean" sediments is also expected to minimize biological questions/concerns. These considerations have been "drivers" in designing and implementing beneficial use placement. Additional considerations related to biological species known to be present at beneficial use sites are summarized below.

(1) Dungeness Crab

From both biological science and economic perspectives, the primary species of concern associated with placement of dredged materials at beneficial use sites is Dungeness crabs (*Cancer magister*). Dungeness crabs utilize the MCR area as a primary habitat that is especially important for mating and egg development (McCabe et al., 1985). The MCR area is a major Dungeness crab fishing location, with most crab fishing occurring north of the North Jetty and south of the South Jetty to Cannon Beach in water depths of generally less than 150 feet.

Newly Recruited Crab Juveniles

Conclusions from early science/policy workshops noted that there is incomplete scientific information quantifying impacts to crab from past dredge placement at MCR, including the lack of analysis of crab mortality from placement or analysis of ecosystem function or crab food web requirements. Other conclusions included:

- There has also been limited analysis of juvenile crab refuge requirements and the importance of bottom debris to survival.
- Concerns identified about impacts to crab from placement include direct burial, loss of refuge for immature crab, loss of stable mature food supply for 'Harvest Ready' crab, fragmentation of fishing grounds, and any large reductions in production over time.
- From an effects perspective, the life history stages and uses of most concern are the commercial fishery and breeding adults. 0+ and 1 + juveniles at placement sites would be expected to be a very small fraction of coastal production. Monitoring should focus on sub-adult and legal males and breeding adults.
- To mitigate potential adverse effects, migration routes and placement during spikes in abundance should be avoided so as to not unreasonably degrade the marine environment.
- To best assess and monitor potential impacts to this species, it will be critical to determine whether the proposed placement areas are crab aggregation areas, recognizing that abundance in any given area at any particular time does not necessarily reflect future numbers.
- Monitoring should occur over a long enough time span to assess repetition (minimum of three years).
- The best timeframe for monitoring would be late summer/fall.

Beginning with an initial demonstration project at the South Jetty Site in 2005 and continuing through Phase 2 of the North Head pilot project in 2019, extensive monitoring of crab abundance, movement and impacts of placement events has been conducted by NOAA Fisheries using a variety of monitoring techniques assessing various factors, including crab pots (abundance), video sled (densities in control and impact zones), video lander (impact dynamics

and crab abundances before and after placement events), and acoustic tags (acute and long-term movements in response to placement events). Results and conclusions from this monitoring are summarized in the descriptions of the SJS and NHS pilot projects in Section E.2 and detailed in Appendix B.

(2) Other Benthic Invertebrates

The conclusion of early (2005 and 2009) science/policy workshops was that distribution of benthic species is inherently patchy and variable and effects on benthic invertebrates would be inconsequential as long as the sediment being dispersed is similar in size to the native sediments.

While the MCR is a major Pacific razor clam (*Siliqua patula*) harvesting location, the specific intertidal zones addressed by this Plan are not understood to carry significant populations of razor clams. Most of the harvested razor clams occur along the Benson Beach area when the beach is exposed during low tides. This benthic community is characterized by species that have adapted to a high energy environment, including waves, sediment movement, storms, freshwater, and strong tides. The members of this community are highly mobile and rapid burrowers, quick tube builders, or rapid colonizers.

Razor clams found in subtidal waters deeper than 30 feet (9 meters) may serve as the broodstock for the intertidal populations and are, therefore, of commercial interest although they also might be from another stock entirely. These subtidal razor clams could be impacted during the discharge of dredged material due to their limited ability to move horizontally (Lassuy and Simons, 1989). However, based on laboratory experiments (Vavrinec et al, 2007), those impacts should be considerably reduced by the use of thin-layer dispersal methods.

A 2009 science/policy workshop concluded that the additional sand provided by onshore placement could benefit intertidal razor clam stocks along beaches affected by erosion. Some effect to the community would be expected following placement, but this would not necessarily have a long-term negative impact. The time frame for recovery would be variable depending on project-specific details such as thickness of material disposed, timing, etc. LCSG's Technical Team recommended in July 2019 that monitoring of trends of sediment input on razor clam populations at Benson Beach be conducted to determine whether nearshore placement has positive impacts such as increased razor clam recruitment.

A poorly known clam species (*Tresuspajaroana,* a species of horse or gaper clam) could also potentially (though unlikely) be within nearshore placement areas.

(3) Marine Birds

Multiple marine bird species breed over winter and migrate along the coast. However, abundance relative to other parts of the coast is low for some species such as the marbled murrelet, a federally- and state-listed species. Bird community composition is different during

spring and fall migration relative to summer. Bird counts indicate the important of the edge of the Columbia River plume for supporting resident (particularly common murres, cormorants, pelicans, and gulls) and migrating marine bird species (grebes, scoters and winter gulls).

Impacts on abundance and distribution of marine birds would be very localized and not expected to be a significant issue. In terms of potential effects, loss of food for foraging species is the primary concern. ESA-listed marbled murrelets may be affected only if the project has a substantial negative effect on their benthic prey. The impact of decelerating erosion could be potentially positive in the long term for dune-dependent species such as snowy plovers and streaked-horned larks, both listed species. Science/policy workshop deliberations recommended that localized abundance and distribution be monitored, as well as changes in foraging behavior (specifically, foraging success and diet).

(4) Marine Fish

Given the location of beneficial use sites and the lack of fine sediments in disposed materials, migratory fish, such as juvenile salmonids and green sturgeon, are unlikely to be adversely affected by placement at the MCR. It is assumed that those species, for the most part, can simply move out of impacted areas. Acoustically tagged sturgeon and adult salmon detected on acoustic receiver arrays in the MCR impact zones do not indicate altered trajectories from controls. The timing of placement operations in autumn also precludes significant impact on juvenile salmon, as most species have migrated prior to placement. Video sled surveys indicate no significant difference to flatfish abundances before and after placements. Even though the natural background of turbidity in the MCR vicinity can be quite high, video observations and instrument measurements of suspended sediments during thin-layer placement of marine sands is very short term in nature (minutes). These data suggest turbidity is will not significantly impact fish species at MCR. One unknown is whether bringing in an external food source with the dredge materials is a positive or negative impact for fish and benthic invertebrate species. Future monitoring for juvenile fish is probably best conducted in conjunction with Dungeness crab studies.

(5) Marine Mammals

Marine mammals are commonly observed in the MCR area. Pinnipeds observed in the area include harbor seals, California sea lions, Steller sea lions. Cetaceans observed in the vicinity include humpback whales, fin whales, gray whales, harbor porpoises, and less commonly blue whales and killer whales. The likelihood of impact from placement activities is expected to be low, as marine mammals in the area already are exposed to commercial and recreational vehicle traffic through and in the vicinity of the MCR navigation channel. Placement operations should be timed to avoid timing conflicts with gray whale migration. Surveys for abundance of marine mammals in the area could be conducted in conjunction with any bird surveys to achieve greater efficiency of survey funds. Surveys for marine mammals before, during, and after dredge material placement would provide data on presence/absence but would be difficult to correlate with any dredge placement activities because of the wide ranging nature of these animals.

E. PROGRAM ACCOMPLISHMENTS, BENEFITS, AND CHALLENGES

1. PROGRAM ACCOMPLISHMENTS

It has been almost 20 years since the initial convening of the LCSG and the initiation of collaborative, bi-state planning for the beneficial use of materials dredged from MCR. By all accounts, the program has successfully met the goals and objectives set out in the 2011 RSMP. In recognition, the RSMP planning process has been identified by the National Policy Consensus Center and by the American Shore and Beach Preservation Association as a national model of collaborative science and decision-making. (The LCSG collaborative process is described in Appendix A.)

Since program initiation, LCSG partners have designed, managed, and monitored 13 separate placements of dredged materials from MCR projects at two nearshore sites, the SJS in Oregon and the NHS in Washington. In addition, there have been three onshore placements at Benson Beach in Washington, either in conjunction with North Jetty repairs or as a one-time event intended to specifically address onshore erosion. In total, over 2.8 million cy of material have been placed at the two nearshore sites and more than 530,000 cy at the Benson Beach onshore site. Each of these placements has been accompanied by research and monitoring of sediment transport and effects on navigation safety, Dungeness crab, and benthic invertebrates. Each placement has informed the design of subsequent placement operations and R&M programs, based upon annual assessment by the LCSG of results and application of adaptive management as needed.

In addition to the placement of dredged materials in a beneficial manner, a variety of new or replacement navigation/weather buoys have been installed and cooperative research activities and studies undertaken since initiation of the program (see Section D.4).

Results of pilot projects at the SJS and NHS and accompanying monitoring and analysis have provided LCSG with the incentive and confidence to transition the beneficial use program from its pilot project phase to permanently designating beneficial use sites and codifying standard management practices for nearshore placements. Results from these nearshore placements include:

- Demonstration of the efficacy of thin-layer placement in a challenging ocean environment as a method of nearshore placement of dredged material that avoids significant impacts to navigation safety and biological resources.
- Successful thin-layer placement in nearshore waters via hopper dredge in a cost-effective manner. Given good weather conditions, a hopper dredge can operationally place sediment in a variety of configurations to enhance sediment transport within the nearshore littoral zone.

- Protection of navigation safety by applying a maximum threshold to mounding of 10% in height over baseline condition. According to the Columbia River Crab Fishermen's Association, adherence to this mounding standard "is the significant difference maker in reduction of small vessel casualties at the MCR".
- No observable short-term impacts on crab populations or other biological resources. This is in line with the conclusion of scientific experts in both physical and biological sciences convened by the LCSG that, with thin-layer placement, minimal biological impacts would be expected.
- Determination that the SJS and NHS are dispersive sites, confirming their viability and benefit as long-term dredged material placement sites.
- Evidence of some reduction of bottom scouring at the SJS.
- Establishment of a placement volume for these sites of 400,000 - 500,000 cy/year as within a threshold of concern.

Despite consensus in early science/policy workshops that onshore placement is the best way to replenish eroding beaches, protect the bases of jetty structures, avoid mounding and associated wave amplification, and avoid the potential for material filling the navigation channel, onshore placement has proven to be more logistically and fiscally difficult than nearshore placement. In addition to equipment constraints, the short dredging season makes onshore placement challenging and limited, because of the amount of material that must be dredged within the short dredging season. Perhaps the greatest impediment, however, has been the Corps' least cost policy and its requirement for cost-sharing. While onshore placement has been limited, it has had several key results, especially when combined with results from the NHS pilot project:

- Affirmation that on-shore placement at Benson Beach remains the best alternative to address coastal erosion north of the North Jetty and reduce the potential for scour along the toe of the Jetty.
- Determination that the present volume of new sediment transported north from the MCR is insufficient to offset erosion at Benson Beach.
- While nearshore placements at the NHS and SWS have been shown to enhance the sediment budget of Benson Beach, uncertainty about what volumes of placement in the nearshore are necessary to make a difference on the beach and whether such volumes are achievable without causing mounding and inducing wave amplification.

Other accomplishments of the beneficial use program Include:

- Almost 20 years of successful collaboration among disparate parties, with the key entities remaining fully engaged.
- Significant and continuing reduction in the amount of dredged material going to the DWS.
- State-of-art benthic invertebrate and sediment transport research and monitoring.

- Adaptive management of placement projects informed by research and monitoring and regular science/policy workshops.
- Improved understanding of sediment transport in the MCR area.

Additional accomplishments related to the LCSC collaborative process are described in Appendix A.

2. PROGRAM BENEFITS

The beneficial use projects implemented through the LCSG process serve as models of reliance upon and responsiveness to state-of-the-art science and adaptive management. These projects provide the dual benefits of avoiding the "wasting" of a clean sand resource to deep water placement while using the dredged materials for beneficial purposes. Examples of these and other noteworthy program benefits are summarized below, followed by identification of several key challenges facing the LCSG beneficial use program.

- **The inclusiveness and broad representation of the LCSG benefit many interests.**

The LCSG's MCR planning process has been cited by the National Policy Consensus Center as one of its best examples nationally of bringing together disparate interests for a common purpose and, in doing so, breaking down institutional barriers. The two original purposes of the LCSG were to rebuild relationships among the parties that had been polarized during the Columbia River Cannel deepening debate, and to provide a neutral forum for working collaboratively on sediment management practices in the Lower Columbia. In and of itself, the group's longevity speaks to its success and effectiveness in meeting those goals. The following is a sampling of the accomplishments and benefits of this collaboration:

- Strong, enabling partnerships have been forged among federal, state, and local agencies; port districts; non-governmental stakeholder groups, including crab fishing and environmental interests; and academic institutions. These relationships carry over to other forums and issues besides the MCR.
- The collaborative governance structure creates a forum for solving complex issues of dredging, sediment management, infrastructure development, and ecosystem restoration. Working together as a group for close to 20 years has reduced historic antagonisms (including legal challenges); fostered the coordination of policies; led to creative solutions; and resulted in more positive, timely outcomes.
- The process serves as a model for multi-party collaborative decision-making for other parts of the Oregon and Washington coasts (as well as the larger West Coast) that are also addressing issues associated with dredged materials.
- LCSG is identified as the regional "go to" entity on beneficial use of dredged materials and serves as a clearing house to coordinate policy, projects and research related to dredge material placement and sediment management.

- Despite the range of types and interests of its members, the LCSG has successfully advocated for the group's collective interests with Congressional and legislative representatives.
- The value of collaboration in planning for the MCR is evidenced by the number of projects originating in science/policy workshops that have been implemented, including dredged material placement pilot projects and various navigational aid projects.

- **State-of-the-art science informs placement programs and demonstrates that thin-layer placement has no significant effects to physical and biological resources or navigation safety.**

While data gaps continue to be filled, a considerable volume of scientific research has been conducted over several decades for the MCR and adjacent nearshore areas. Combined with the deliberations and consensus emanating from the continuing series of science/policy workshops, this research makes the MCR area probably the most studied area on the north Oregon and southwest Washington coasts.

The understanding of the area's physical and biological resources has been significantly expanded through the program's state-of-the-art scientific research program, which has and continues to focus on sediment transport and crab/benthic invertebrate research. A better understanding of the sediment transport system within the Columbia River littoral cell is being gained through ongoing Corps/USGS/WDOE research on sediment transport patterns.

Similarly, knowledge about potential effects of placement on Dungeness crabs, other benthic invertebrates, and ESA-listed fish species has benefited from state-of-the art monitoring by NOAA Fisheries, Point Adams Field Station. NOAA Fisheries has employed a variety of new or modified video and acoustic telemetry techniques over the past 15+ years to demonstrate that there are no significant adverse effects from thin-layer placement at the SJS and NHS on Dungeness crab mortality and mobility, as well as on the overall benthic environment. The Columbia River Crab Fishermen's Association has confirmed that harvest levels and navigation safety have not been affected.

The extensive and comprehensive research and monitoring that has accompanied the series of nearshore pilot projects has considerably improved the understanding of the MCR area and provides a valid basis for expectations about the levels of potential risks to the physical and biological environments. The range of biological issues for which there are any significant concerns has been determined to be very narrow, with consensus that biological effects can be minimized through dispersed, thin-layer placement and rotation of placement among sites to reduce the potential for mounding.

Potential benefits to razor clams have recently emerged as an issue to research, specifically assessment of whether nearshore placement has positive impacts to razor clam recruitment. If it is determined that there is a correlation between increased nearshore placement, reduced

erosion, and razor clam recruitment, then the program would be able to claim a benefit to recreation uses in the MCR area.

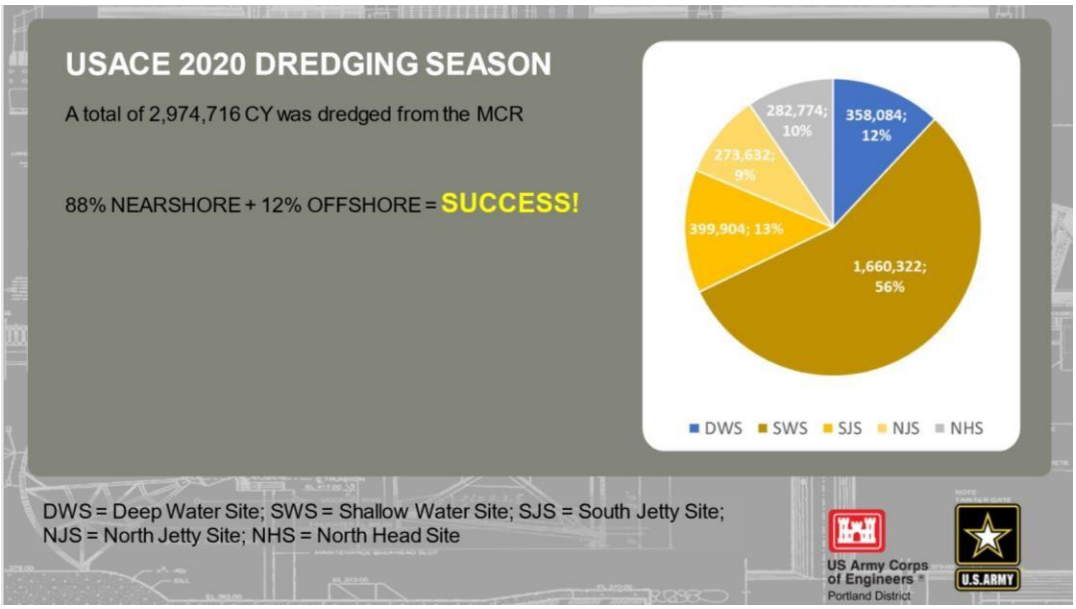
- **The design, permitting, and management of beneficial use placement projects benefit from an adaptive management approach informed by a program of ongoing research and monitoring.**

The LCSG is committed to an adaptive management approach to dredged material placement that is informed by ongoing research and monitoring focused on biological resources of concern, navigation safety, and sediment transport. This approach has helped to ensure that beneficial use sites are located and managed to avoid or minimize adverse effects on key species of concern, as well as their critical habitat. Similarly, it has been critical in avoiding mounding of sediment that could create navigation hazards due to wave amplification. The evolving shift in the program's historic focus on biological resource R&M to better understanding sediment transport is an example of adaptively managing limited resources to determine the most beneficial locations and amounts of dredged material placement.

The adaptive management model has, in turn, benefitted from exceptional cooperation among LCSG members in the development of R&M programs and participation in regular science/policy workshops to assess monitoring results and plan future placements. These cooperative partnerships with the various regulatory agencies also help minimize the time to meet regulatory requirements and attain authorizations.

- **Dredged material management at MCR benefits from the addition of beneficial use sites to the network of available placement location and from successful experimentation with placement techniques.**

The network of beneficial use sites provides an opportunity to address significant erosion issues on the northern Oregon and southern Washington coasts, obtain needed information on nearshore processes, and divert a sand resource that is otherwise "lost" if it goes to deep water placement rather than to beneficial use in the littoral zone. The establishment of new sites permitted and designed to receive dredged materials enables the Corps to shift a large portion of the material dredged at MCR from the DWS Site to nearshore and onshore areas. Of note, the Corps reports that in 2020 approximately 88% of the material dredged from MCR was placed at nearshore sites. These beneficial use sites also give the Corps more flexibility in where it can dispose of dredged materials given that no one of the authorized sites has the capacity to take all the dredged material available annually.



Thin-layer placement has increased the flexibility of placement practices and is helping to address specific littoral sediment needs, while having limited risk to navigational safety and biological resources. Multiple placements of various amounts of material over a 12-year period at the SJS have demonstrated the efficacy of thin-layer placement. Adherence to a maximum mounding height threshold has prevented excessive sand buildup that could affect navigation safety. Pilot projects at the SJS and NHS have given the Corps an opportunity to prove its ability to successfully place materials in challenging nearshore environments and in different configurations, including alongshore and cross-shore.

- **The use of dredged material beneficially offsets some of the negative impacts that the Columbia River jetties and maintenance dredging may have on natural coastal processes.**

While operations and maintenance dredging will continue at MCR, the beneficial use of dredged materials is intended to reduce the migration of littoral drift into the navigation channel and over the long term may reduce the volumes and frequency of dredging needed at the mouth. The addition of beneficial use placement sites may help rebalance the littoral budget on a broader geographic scale. The placement of dredged material into the nearshore environment is intended to mimic pre-jetty conditions of sediment movement along the northern Oregon and southwest Washington coasts by returning sand to the littoral drift.

- **The beneficial use program saves money.**

The system of beneficial use sites saves money for federal and state governments and local taxpayers in several key ways:

- Provides financially feasible placement alternatives which help protect jetties and indirectly the viability of the Columbia River navigation channel. Keeping sand onshore or in the nearshore helps protect the North and South jetties and the investments the Corps has made in restoring them. For the North Jetty, this includes reestablishment of adjacent wetlands.
- Helps reduce erosion affecting other infrastructure in the area, e.g. roads and campsites at Cape Disappointment State Park.
- Placement of dredged material at nearshore beneficial use sites is less expensive than "wasting" it at the DWS.
- Planning for and management of a network of sites reduces the costs and complexity of permitting individual sites. It also avoids each regulatory agency having to conduct its own planning, permitting, etc.
- Lessons from placement of dredged material and results of research and monitoring at MCR can be extrapolated to other coastal areas in Oregon and Washington, reducing the need for and cost of projects in those areas.

- **The placement of dredged materials at beneficial use sites likely helps to incrementally address anticipated effects of global climate change.**

While not explicitly addressed, the program's objective to make sustainable, beneficial use of dredged sediment to help protect nearshore fishery habitats, coastal beaches and the jetties from erosion can be expected to assist in indirectly responding to sea level rise. A defacto goal of the Plan is to maximize beneficial use of sediment in an environmentally responsible manner to respond to global climate change and protect and maintain critical community economic and environmental infrastructure.

3. PROGRAM CHALLENGES

While noteworthy in its accomplishments, the beneficial use program has and continues to face a variety of challenges. Because the functioning and success of the program and that of the LCSG are interdependent, this summary of key challenges addresses both program and process.

- **Achieving Financial Stability**

A fundamental challenge for the program has been adequate and sustainable funding. Funding for LCSG operations and beneficial use initiatives has never been consistent nor firmly established, with considerable variation in the availability and the amount of funds over the years. Participation on the LCSG is voluntary and no dues are assessed. At several points in its history, contributions from members have been solicited to help fund program management (contracted coordination/facilitation) or for specific aspects of research for pilot projects. However, for the most part, beneficial use projects have been dependent upon research or

operations/maintenance (O&M) funding secured by the Corps' Portland District. While the funding of placement and associated R&M at beneficial use sites is a District priority, the vagaries of the federal budget process prevent the Corps from committing to an ongoing annual funding contribution level. Another key funding consideration is moving from pilot projects to beneficial use sites being designated as permanent placement sites. Corps staff advises that once a beneficial use site is permitted for placement, it is no longer considered research or exploratory and funding is tied to the District's O&M funding for dredging and channel maintenance.

Obtaining adequate and consistent funding for program facilitation/coordination has been especially challenging. Since LCSG inception, a neutral facilitator has been contracted through the National Policy Center's Oregon Solutions program for assistance with program management, including organization and facilitation of science/policy workshops and Management and Technical team meetings. While the Corps has historically been the primary funder, more recently the LCSG has had to depend upon member contributions to secure these neutral facilitation services. In 2019, WDOE developed a cooperative agreement approach wherein LCSG members would contribute to an agreed-upon scope of work for the facilitation services for the coming year, then go out to bid for a contractor to provide those services. Legal and timing challenges in obtaining the necessary interagency agreements and in accepting non-agency contributions complicated this approach and the LCSG returned to reliance the National Policy Consensus Center to obtain services in 2019-20. As of Summer 2020, the Corps assumed financial support and contracting for ongoing facilitation support and contracted with the Columbia River Estuary Study Taskforce (CREST) for these services. CREST is a bi-state council of governments that represents the counties, cities and ports of the lower Columbia region and the North Oregon coast. CREST's mission is to provide locally-based, high quality environmental planning, habitat restoration and research services to the Columbia-Pacific Region. The selection and funding of CREST as the group's facilitator for the next five years is expected to provide more stable and consistent facilitation and staffing support to the LCSG.

In addition to inconsistent availability of funding, the level of facilitation/coordination funding has been sufficient only to cover basic meeting organization and convening services. Needed coordination functions for which there has been insufficient funding include periodic briefings to Congressional and state legislative staffs, outreach to ports and parties who could be potential LCSG members, and media outreach.

There have also been repeated funding challenges for research and monitoring of placement at beneficial use sites, the most significant being the timeliness of the review, approval and payments processing between agencies, e.g. Corps and NOAA Fisheries for crab research. As the pilot project phase shifts to permanent beneficial use placement sites, the focus of funding for research is also changing from biological resources to sediment transport.

Brainstorming strategies for securing sustainable funding is a standard feature of LCSG meetings. The following were identified at a January 2020 science/policy workshop:

- Fund R&M over a longer term, rather than annually. Annual contracts are challenging and time consuming. There is a desire to move more toward a package of services that can be outlined in the RSMP to authorize work over a longer timeframe. A 3-5 year plan with objectives to reach in that timeframe would be much more efficient and cost-effective. Because the Corps budges on an annual basis, funding a multi-year program may be challenging. However, incremental components of a five-year program could be contracted / budgeted for annually.
- Investigate the regulations and policies associated with incremental costs. Calculate how costs for a permanent pump ashore program at Benson Beach would compare to the annual cost of transporting materials to the DWS or other sites.
- Seek national RSM program funding to help fund the production and distribution of informational materials, e.g. brochures, slideshows, etc. The Portland District/LCSG should put in a proposal for outreach materials, as well as for staffing support for this collaborative effort.
- Investigate similar regional placement programs around the country to see how they are funded.
- Encourage regular communication from Corps staff on the federal budget process and timelines for applying for funding.

- **Operational Considerations**

As more fully described in Section D.3, MCR dredged material placement is subject to a variety of operational constraints such as weather conditions and wave and current intensity: in-water "work windows"; costs of conducting work; availability of dredges with the equipment and capability to perform required work; placement site use management and monitoring requirements imposed by EPA and the states; and coordination with local fishermen and mariners.

Pursuit of a dedicated "West Coast" hopper and/or pump ashore dredge has been identified in LCSG discussions as a desired strategy for the group. There would be opportunities to use a dedicated pump ashore dredge not only at Benson Beach but at Grey's Harbor in Washington, Beverly Beach in southern Oregon, and in San Francisco where there are erosion issues. Corps staff estimates the cost of a dedicated dredge at about $50 million.

Additionally, LCSG members have suggested that more timely sharing of the Corps' AUP would facilitate the group's deliberations on proposed placement actions for the coming season and facilitate any permitting needs and the design and funding of desired research and monitoring.

- **Resolving the incremental cost hurdle**

Despite consensus in early science/policy workshops that onshore placement at Benson Beach would be expected to have the greatest benefit in terms of addressing shoreline erosion north of the North Jetty, funding considerations have limited onshore placement in the area to one large placement in 2010. This $3.5 million project required a $1.7 million "match" in funding

from the State of Washington for the incremental cost to the Corps (additional cost associated with not disposing the dredged materials at other approved sites). Maintenance dredging is subject to the Federal Standard, i.e. the least-cost, environmentally-acceptable and engineering-sound placement option. The placement of dredged material at the MCR beneficial use sites has been assumed to cost more than conventional placement at other EPA and Corps-designated in-water sites. Obtaining state funding for additional onshore placements at Benson Beach has been labeled as "more than unlikely" due to state fiscal constraints, meaning that a specific Congressional appropriation would need to be obtained. (Additional detail on the issues associated with onshore placement at Benson Beach are provided in Section E.2.)

While cost per maintenance dredging cycle, or even placement event, may be higher in some cases, full life-cycle costs may result in a net cost savings to the government. The Corps' Portland District has recently received grant funding for analysis of a life-cycle analysis approach, using MCR as a case study, to fully account for costs and benefits from the beneficial use of dredged materials compared with placement alternatives across multiple maintenance dredging cycles. It is expected that such an analysis will reveal hidden costs and benefits at a programmatic level that may not be accounted for in a per-cycle analysis. Benefits from beneficial use site placement may not be realized unless analyzed at a system scale over multiple maintenance dredging cycles. The District's grant application notes:

> "While cost data are documented, a full analysis of the cost-benefit of RSM strategies utilizing a life cycle approach has not been implemented. … Since RSM seeks to provide value across business lines, benefits from all mission areas will be considered so true value to the nation from the application of RSM principles can be examined. … Demonstration of systemic benefits from routine utilization of RSM strategies will provide the evidence base necessary for RSM strategies to be adopted as the default operational option within the navigation business line. Portland District has been utilizing RSM principles for decades and is an example of using innovative approaches to gain multiple benefits. Analyzing these individual efforts together using a life-cycle of a system of RSM strategies will provide a basis for more widespread adoption of RSM principles in the region as well as across the nation."

- **Determining how beneficial**

The value of the beneficial use program is not in question, but questions of how beneficial it has been and can be in augmenting the nearshore sand budget and in addressing onshore erosion have yet to be answered. Beneficial use effects of adding sediment to the littoral system will not likely be measurable in the short term; it may be another decade or more before any effects are observable. In particular, the value of nearshore placement to address onshore erosion simply cannot be determined. It is not known what volumes are needed at nearshore sites to measure any difference on shoreline erosion and are these volumes achievable without causing mound induced wave amplification. This is particularly true for Benson Beach where it was recently suggested (January 2020 science/policy workshop) that 100% of the material dredged at MCR may be needed just to keep the beach in equilibrium.

- **Getting the Word Out**

Recent science/policy workshop discussions about how best to move the beneficial use program forward suggest that, outside of immediate program participants, there is "next to zero awareness" about the program. It is noted that there is an important story about the MCR program purpose, history, benefits, and accomplishments that needs to be shared with a much broader audience. Among the suggestions for broadening program awareness:

- A catchy story is needed for the media. Findings of the research on Dungeness crabs are particularly compelling.
- It is critical to expand into social media.
- A priority should be to share what has been learned at MCR with other coastal communities. The video, *The Story of the Lower Columbia Solutions Group*, is identified as an important tool for approaching other entities and for reengaging the Ports in the LCSG's efforts. The history of the jetties and subsequent changes to landforms and sediment movement could be part of that story.
- In terms of a public message, keep it simple and pointed: crabs, clams, camping, Columbia (River).
    - Focus on what the navigation channel means to the region's economy and how the Columbia River is the source of sediments for 100 miles north and south, sustaining beaches and coastal communities.
    - Explain how dredged sand is being used for beneficial purposes versus being "wasted", with the goal to avoid huge public costs associated with jetty failure and erosion of beaches.
    - Stress the bi-state collaboration theme.
- Avenues for telling the MCR story:
    - Reports/articles suitable for publication in public policy journals or similar professional publications, including a summary of this report.
    - Story map that could be presented to groups, local governments, and other organizations in the region; also, a story board or similar interpretative media suitable for display at public venues such as Cape Disappointment State Park.
    - Hosted site tours.

- **Sustaining Momentum/ Capturing the Institutional Memory**

Having a facilitator to work with the co-conveners to organize and convene regular meetings, collect and distribute information, and serve as a go-between among participants has been and continues to be essential to sustaining the group's momentum. Without periodic convenings, considerable time and energy is required to bring the group up to speed and to avoid recreating the wheel in terms of direction previously established. Similarly, the value in having consistent, long-term conveners cannot be over-stated. Of concern is that, after more than a decade of participation, a number of the group's leaders are or will soon be transitioning to other positions or to retirement, taking with them their institutional memory. Programs of mentoring capturing institutional memory and of mentoring new leaders should be considered.

APPENDICES

APPENDIX A
LOWER COLUMBIA SOLUTIONS GROUP

1. BACKGROUND

The Mouth of Columbia River (MCR) Regional Sediment Management Plan (RSMP) is a regional initiative led by the Lower Columbia Solutions Group (LCSG) that serves as the basis for establishing and managing a network of beneficial use placement sites that augments existing dredged material placement sites operated by the Corps of Engineers (Corps), Portland District. It is intended to guide management of sediment placement at this network of sites through development of annual dredged material placement programs, baseline studies, and ongoing research and monitoring (R&M). The LCSG is the author, organizer and implementer of both a 2011 RSMP for the MCR and this 2021 Update. It is essentially the "keeper" of the RSMP.

The LCSG is a diverse, bi-state collaboration of local, state and federal governmental and non-governmental stakeholders interested in and affected by dredge material placement activities at the mouth of the Columbia River (MCR) and in the lower Columbia River. It was convened by the governors of Oregon and Washington in July 2002 to provide a regional, rather than a state-by-state approach to sediment management planning. Stakeholders include representatives from local, state and federal governments; ports; crabbing and fishing interests; coastal communities; conservation groups; and others (see Section 2 below).

The group was originally created as an experiment to see if key groups involved with Lower Columbia River issues could tackle one or more short-term dredged material placement projects for beneficial uses. Initially convened by designees of the two Governors' offices in concert with the Council on Environmental Quality and the U.S. Institute for Environmental Conflict Resolution, management and convening of the LCSG was transferred in November 2014 to the Washington and Oregon Coastal Zone Management Programs – Washington Department of Ecology's (WDOE) Shorelands and Environmental Assistance Program and the Oregon Department of Land Conservation and Development's (ODLCD) Coastal Management Program.

In December 2002, original participants signed an Agreement Document to guide the group's work and, in June 2003, undertook a strategic planning project to explore the group's future. A Charter was agreed to in February 2005 and updated in May 2008. In January 2008, the Oregon and Washington Governors' offices and LCSG members signed a Declaration of Cooperation for Regional Sediment Management Planning, committing to collaboratively develop a regional sediment management plan. The LCSG currently operates under a 2012 Declaration of Cooperation which commits signatories to cooperatively implement the resulting 2011 Mouth of Columbia River RSMP. Click here to read the full MCR Regional Sediment Management Plan, the 2008 and 2012 Declarations of Cooperation, and associated documents.

Additional information on the history and functioning of the LCSG is provided in the video, *The Story of the Lower Columbia Solutions Group,* which can be viewed at: https://lowercolumbiasolutions.org/. This video was produced by the National Policy Consensus Center (part of the Hatfield School of Government at Portland State University to tell the story of how this diverse group of stakeholders came to be a model of productive collaboration.

2. STRUCTURE AND FUNCTIONING

The LCSG operates on a facilitated, informal team consensus approach in which coming to agreement means a proposed action is acceptable enough that all members participating can support it, with no member firmly opposing it. This approach is informal in the sense that formal voting is invoked only as a last resort; rather the facilitator and/or conveners solicit input from the group before framing and seeking accord with "the sense of the group".

Born out of controversy and mistrust among stakeholders in the 1990's associated with deepening of the navigation channel in the Columbia River, the success of the LCSG derives from its ability to build trust among its members. Continuity in terms of conveners, facilitators and key members having the experience of working together over the years and in having joint ownership of the process and its outcomes has helped a significant role in buildig that trust.

> *"The LCSG has been a benefit to all participants and its major accomplishment has been a building of TRUST between participants to allow them to work together in a manner that has done its intended purpose to graduate MCR management out of the court room and into the discussion room. … This is the most important aspect of the LCSG over the years – TRUST – exactly what the … group was designed to achieve."*
>
> Dale Beasley, Columbia Crab Fishermen's Association, May 2021

As noted under Acknowledgements and in Section E.2, the LCSG planning process has been identified by the National Policy Consensus Center and by the American Shore and Beach Preservation Association as a national model of collaborative science and decision-making. In awarding it the 2020 Robert L. Wiegel Coastal Project of the Year, the American Shore and Beach Preservation Association noted that the program's "achievements are the result of

strong relationship building, shared trust, and collective determination to sustain an important adaptive management process. The LCSG's success in reimagining the planning process for the mouth of the Columbia River is being recognized as a model of collaborative science and decision-making." Additional information about this award can be found at: https://ecology.wa.gov/Blog/Posts/November-2020/Washington-Coastal-Zone-Management-Program-Receive

Corp Staff Accepting the 2020 Coastal Project of the Year Award on Behalf of LCSG

LCSG members have expressed that another key factor in the group's success has been neutral, third-party facility and staffing support. From program inception until recently, that support was provided through contract with the National Policy Consensus Center's Oregon Solutions Program at Portland State University. Services provided included group facilitation and program management, including organization and facilitation of science/policy workshops and Management and Technical team meetings. Steve Greenwood with Oregon Solutions Program served as facilitator for the program's first few years, followed by Jim Owens of Jim Owens Consulting Company (previously with Cogan Owens Greene) for the next twelve years.

As of Summer 2020, the Corps assumed responsibility for funding and contracting for ongoing LCSG support, with the Columbia River Estuary Research Group (CREST) selected as facilitator. CREST is a bi-state council of governments that represents the counties, cities and ports of the lower Columbia region and the North Oregon coast. CREST's mission is to provide locally-based, high quality environmental planning, habitat restoration and research services to the Columbia-Pacific Region. The selection and funding of CREST as the group's facilitator for the next five years is expected to provide more stable and consistent facilitation and staffing support to the LCSG.

Just as adaptive management is a fundamental element of the Plan's program for the beneficial use of dredged materials from MCR, so too is adaptive management an underpinning of the LCSG process. The LCSG process is intentionally designed to collaboratively consider where and how best to target LCSG member resources, based upon changing needs, new opportunities, and available resources.

Participation on the LCSG is voluntary; active participants and their levels of participation have changed over time. Among those entities most consistently participating are:

Primary Participants -- Lower Columbia Solutions Group	
State of Washington	
Department of Ecology	Department of Fish & Wildlife
Department of Natural Resources	Washington Sea Grant Program
Washington State Parks	
State of Oregon	
Department of Land Conservation & Development	Department of State Lands
Department of Fish and Wildlife	Department of Geology and Mineral Industries
Department of Environmental Quality	Oregon Sea Grant Program
Regional Solutions Program, Oregon Governor's Office	Oregon Solutions Program, National Policy Consensus Center
Federal Agencies	
U.S. Army Corps of Engineers, Portland District	U.S. Environmental Protection Agency
NOAA Fisheries	U.S. Fish and Wildlife Service
U.S. Geological Survey	
Local Governments	
Port of Ilwaco	Port of Astoria
Port of Portland	Port of Vancouver
Pacific County, WA	Clatsop County, OR
City of Astoria	
U.S. Congressional Representatives	
Staff from various offices representing SW Washington and NW Oregon	
Stakeholder Groups	
Columbia River Crab Fishermen's Association	Columbia River Bar Pilots
Columbia River Estuary Study Team (CREST)	Lower Columbia River Estuary Partnership
Salmon For All	Pacific Northwest Waterway Association

The LCSG is led and convened by the managers of the Washington and Oregon Coastal Zone Management (CZM) Programs who have been tasked, with the assistance of a facilitator, with scheduling and organizing meetings and managing group business in-between meetings. Having a facilitator to work with the co-conveners to organize and convene regular meetings,

collect and distribute information, and serve as a go-between among participants has been essential to maintaining the group's momentum.

For at least the last seven to eight years, the LCSG has been operating with a Management Team and a Technical Team structure. The Management Team's role includes:

- Monitor overall program implementation.
- Develop recommendations for updating/revising the MCR RSMP as needed.
- Identify funds and/or other commitments from federal, state and local agencies and interest groups to help implement proposed R&M priorities.
- Request information from and resolve issues at the Technical Team level.
- Routinely report to the LCSG on the process for and progress of Plan implementation.
- Develop and oversee implementation of advocacy, communication and public education strategies and broader network engagement.

The Technical Team makes recommendations on program design and operations to the Management Team and LCSG. Its specific duties include:

- Review environmental and resource management surveys and studies (including pre- and post-placement surveys proposed to implement Plan direction), the Corps' Annual Use Plan (AUP), monitoring reports and other available documentation and recommend modifications to the upcoming year's beneficial use placement program to address any unanticipated adverse effects on species of concern or their habitat, or to navigational safety.
- Recommend baseline studies to provide sufficient scientific knowledge to inform a set of reasonable effects of placement at each beneficial use site, recognizing that the scope of such studies will need to be responsive to available funding.
- Recommend protocols for measuring resources to determine if beneficial or adverse effects have been realized, and design and evaluate options for how to proceed if adverse effects occur. This may include "triggers" or levels of impacts that, if exceeded, suggest that placement practices need to be modified or discontinued in order to avoid unacceptable adverse effects or mitigation measures need to be instituted.
- Identify minimum thresholds for the amounts of sand disposed of at each site that would provide for the efficacy of monitoring of the effects of placement at that site.
- Review and make recommendations for a detailed R&M program, including priorities responsive to available funding.
- Recommend any changes for placement locations or methods based upon analysis of available sediment, optimal placement based on tracer studies and sediment transport modeling, monitoring of mounding, and other factors.
- Report annually findings and recommendations to the LCSG.

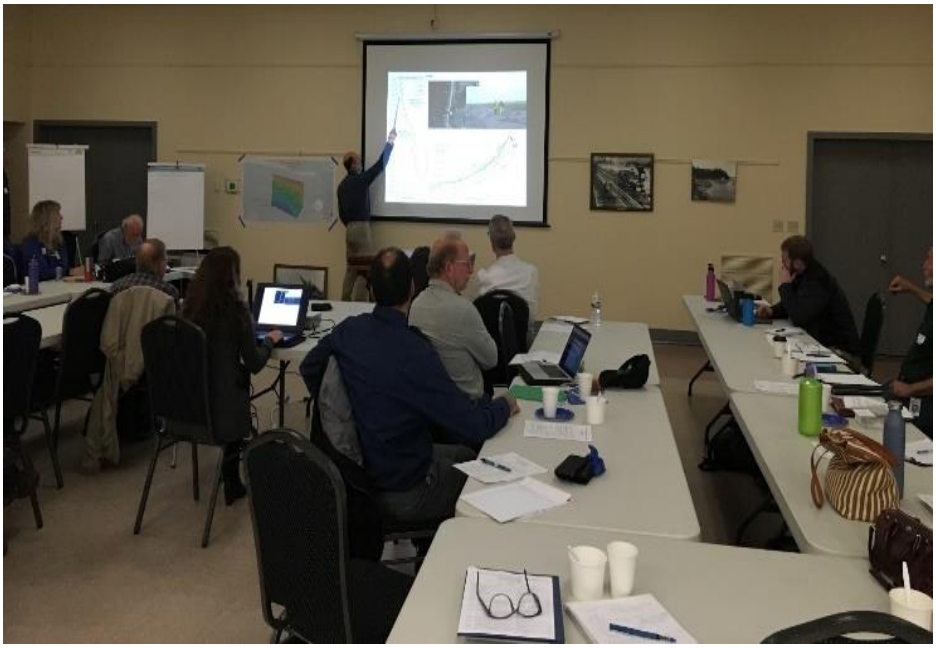
The Management Team meets at its discretion or at the request of LCSG and/or its facilitator. The Technical Team typically meets following the completion of the placement season to evaluate the results of that year's placement operations and associated R&M, the goal being to advise on modifications to be incorporated into the coming year's placement program. In addition, the Technical Team meets on an ad-hoc basis when significant unanticipated events and conditions suggest that program planning needs to be revisited. Staffing of both groups is provided by the LCSG.

Programs for placement of dredged material at MCR beneficial use sites are developed by the LCSG through periodic technical working group sessions and (typically) annual science/policy workshops. LCSG members have found value and benefit of having at least one in-person science-policy workshop annually. The science/policy workshops are an opportunity to assess the results of the preceding year's placements and monitoring, plan the current and/or coming year's projects, and address other management issues related to program implementation. Late November or early December timing for these workshops is critical to provide adequate time for the researchers to analyze and present data after the field season, as well as to complete the actions necessary in response to decisions made and ensure an effective program for the following season. Technical team meetings are utilized to develop specific placement program proposals and to identify any policy issues related to proposed placement programs for consideration by the LCSG at its science/policy workshops.

Summaries and presentation materials from management and technical team meetings and from science/policy workshops are circulated by the facilitator as drafts for member review, revised as needed, then disseminated vis email and posted on the LCSG website:

https://lowercolumbiasolutions.org/

Cape Disappointment site Visit, May 2018



Science-Policy Workshop May 2018

APPENDIX B
DESCRIPTIONS OF MCR BENEFICIAL USE SITES

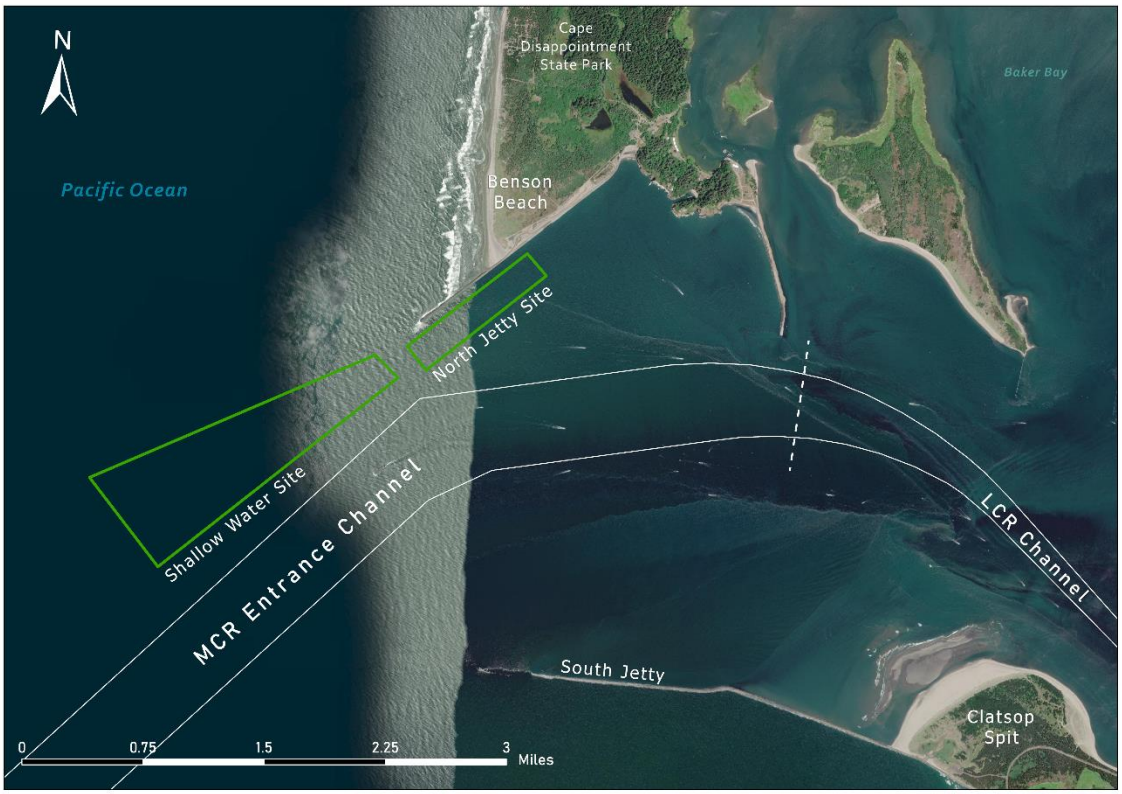
1. EPA OR STATE AUTHORIZED IN-WATER PLACEMENT SITES

a. SHALLOW WATER SITE (SWS)

Designated by EPA in 2005 under Section 102 of Marine Protection, Research and Sanctuaries Act (MPRSA), the SWS is a trapezoidal area of 3,100 - 5,600 feet (945 - 1,707 meters (m)) wide x 11,500 feet (3,505 m) long. It lies two miles (3.2 kilometers) offshore from MCR in water depth of 45 - 75 feet (14 – 23 m). The area used for placement (drop zone) is 1,054 feet to 3,600 feet (321 – 1,097 m) wide by 10,000 feet (3,048 m) long. The SWS is designated for the placement of material dredged from either the MCR or the Lower Columbia River.

The SWS is a dispersive site, transporting material primarily northward onto Peacock Spit. This was confirmed by a 2006 sediment tracer study, augmented with additional seabed sampling in spring/summer 2007. Part of the assessment was to investigate whether the dredged sediment placed at SWS augments the sediment in the nearshore and onshore areas north of the North Jetty, including Benson Beach. Results indicated a clearly defined but gradual movement of particles to the north and west away from SWS onto Benson Beach and beaches to the north. Increasing the volume of placement at the SWS at the end of the jetty to help reduce erosion at Benson Beach has been suggested at recent science/policy workshops.

The Corps has identified placement at the SWS as critically important to sustaining Peacock Spit with sand, maintaining the littoral sediment budget north of MCR, protecting the North Jetty from scour and wave attack, and stabilizing the MCR inlet. Because of its dispersiveness, site capacity over the long-term is unlimited. On an annual basis, capacity is estimated to be between 4.5-6 million cy; recent placements have not approached that estimated annual capacity. Approximately 33 million cy of dredged sand was placed there between 1997-2010. The Corps reports that 1,660,322 cy were placed at the site in 2020. The agency proposes placing up to 2.15 Mcy there in 2021.



a. North Jetty Site (NJS)

This site was established in 1999 under Section 404 of the Clean Water Act (CWA) for the purpose of placing dredged material along the North Jetty to help reduce undermining of the jetty by wave and current scour. The NJS is approximately 200 feet (61 m) south of the North Jetty and occupies an area of 1,000 feet x 5,000 feet (305 – 1,524 m). Average water depth is 35 - 55 feet (11 - 17 m). Placement is limited to MCR dredged material.

The site covers approximately 115 acres and is located in water 40 -70 feet deep. However, the capacity of the site is difficult to fully utilize due to the site's small size and shallowness, its proximity to the North Jetty, and the limited water depth on the site's east/south side. It is difficult to maneuver a ship the size of a medium-class hopper dredge through the entire site with safety. The capacity of the site to handle larger volumes of dredged material is limited and uncertain. Approximately 4.9 million cy of material was placed there between 1999-2010. In recent years, the site has received approximately 300,000 cubic yards annually. In 2020, less than 275,000 cy (273,632 cy) were placed; placement of approximately 200,000 cy is planned for 2021. Much of the dredged material placed at the site has abated a potentially destabilizing scour along the southern toe of the North Jetty, which was the primary purpose for creating the NJS.

b. Deep Water Site (DWS)

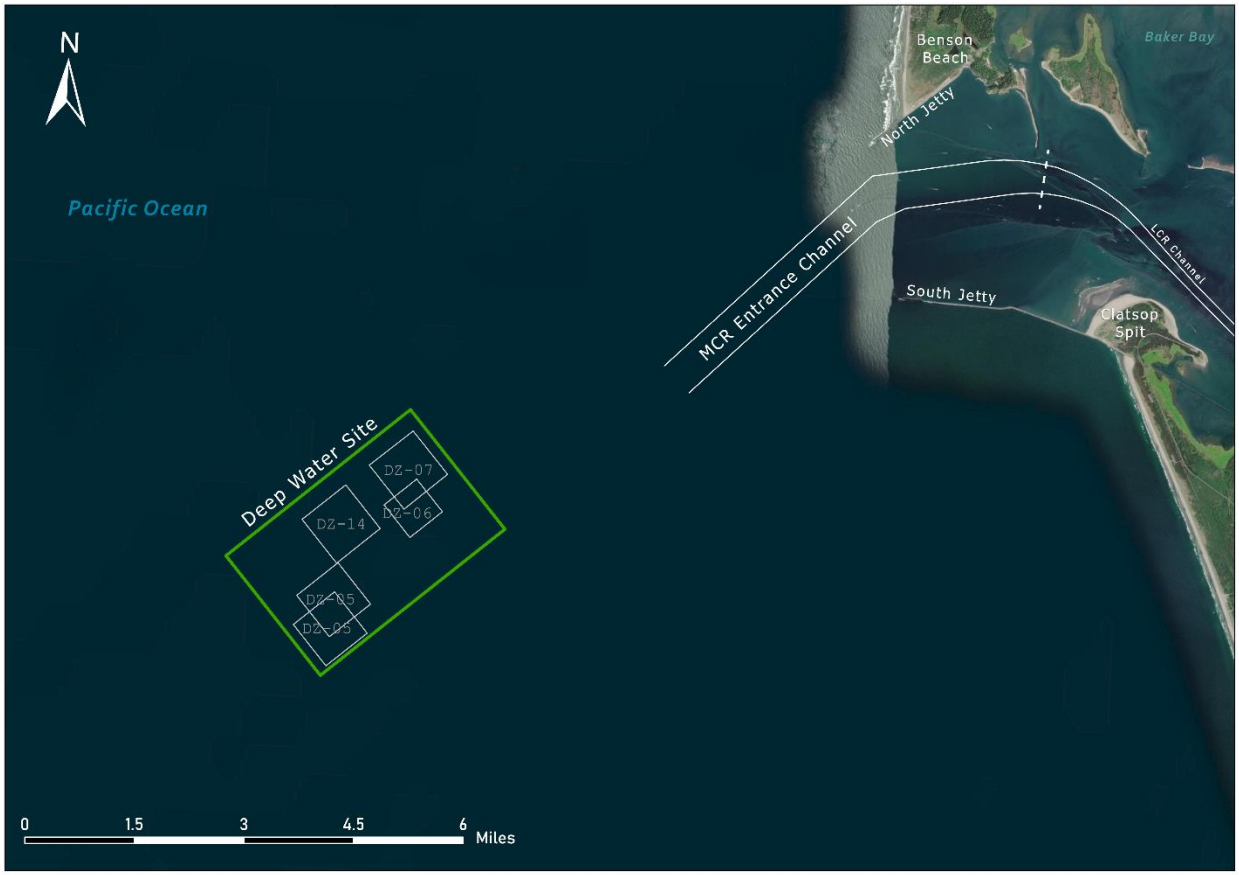
Designated by EPA in 2005 as a Water Ocean Placement Site under Section 102 of MPRSA, the DWS occupies an area of 17,000 x 23,000 feet (5,180 – 7,010 m) and lies six miles (9.7 kilometers) from MCR in water depths of 190 - 300 feet (58 - 90 m). A 11,000 x 17,000-foot (3,350 – 5,180 m) placement area is defined within the DWS boundaries, with specific "drop zones" for the placement of dredged material. The intent is to confine the dispersal of material within the drop zones to reduce the areal extent of dredged material deposition. The DWS is designated for the placement of material dredged from either the MCR or the Lower Columbia River.

The DWS is "non-dispersive" or "depositional'; material placed at the site is expected to remain on-site. Annual placement capacity is not limited. The Corps uses the DWS when other sites, including both authorized and beneficial use sites, have been used to the maximum extent practicable or when weather conditions or operational constraints preclude use of these other sites. This RSMP specifically discourages use of the DWS.

Between 2004-2018, an average of 1.3 Mcy of material was placed annually at the DWS. In 2018, 1.02 Mcy was placed. In line with the RSMP's goal to discourage deep water placement except when weather or other factors preclude use of beneficial use sites, placement was greatly reduced to 427,000 cy in 2019 and to 358,000 cy in 2020. The Corps indicates that the intent is to continue to minimize any placement there.

Although the DWS is authorized for placement of materials dredged from the Lower Columbia River up to River Mile 30, it has not yet been used for such. In lieu of using the DWS for this placement, the Corps has indicated its interest in exploring use of the nearshore beneficial use sites as an alternative with the LCSG.

Additional information about these three sites can be found at:
https://www.epa.gov/sites/production/files/2015-10/documents/r10-_mcr_smmp_2005.pdf



F. BENEFICIAL USE PLACEMENT SITES

To date, the beneficial use program has been focused on demonstration projects within both the Oregon and Washington nearshore areas, as well as a one-time onshore placement on Benson Beach within Cape Disappointment State Park intended to address increasing erosion within the area between the North Jetty and North Head.

The four sites identified in the 2011 Mouth of Columbia River RSMP are reaffirmed in this 2020 Plan as the most appropriate beneficial use locations going forward. These sites are intended to provide both nearshore (subtidal) and onshore (intertidal) opportunities for beneficial use of the uncontaminated sand dredged each year at MCR. Their selection is reaffirmed based on scientific research conducted over the past 15 years, the results of multiple demonstration projects at two nearshore sites, their potential to positively contribute to retaining sand in the littoral zone, and the determination that they do not have significantly greater value as habitat than other nearby areas within the littoral zone. Nothing in this Plan precludes the identification of additional sites as potential dredged material placement locations.

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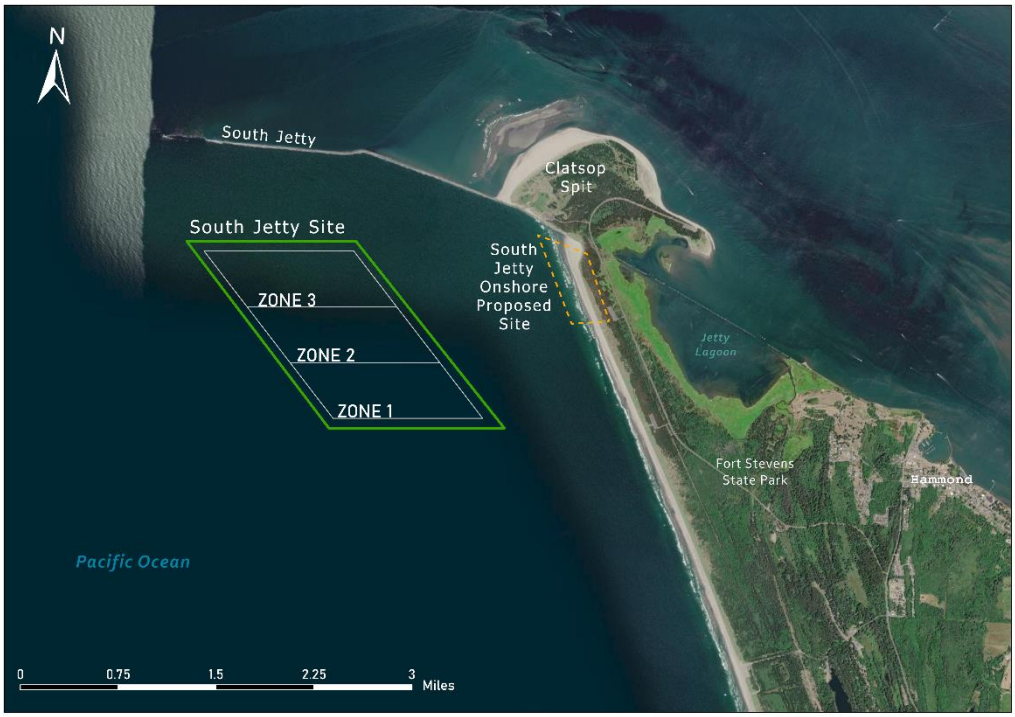
(1) South Jetty Site (SJS)

Description

The South Jetty Nearshore Site (SJS) is located in Oregon in the nearshore south of the South Jetty in waters 40-60 feet (12-18 m) deep. Dredged material at this location is intended to provide sand needed to mitigate erosion and supplement the sediment budget in the nearshore area adjacent to the South Jetty. The site is approximately 9,500 feet (2,895 m) long by 7,000 feet (2133 m) wide. (Corner coordinates can be found in a 2012 Environmental Assessment prepared by the Corps, Portland District). The site is projected to have an annual capacity of between 300,000 – 500,000 cy.



South Jetty Site, Oregon Nearshore

Based on bathymetric studies and other research, the area has a relatively small rate of erosion over the long term, losing between 88,000 – 270,00 cy per year. However, bottom scouring is occurring, exposing clay layers. In early science/policy workshops, this site was identified as the area in the greatest need of dredged material, with scouring of the seabed expected to accelerate without the input of sand into the littoral zone. It has also been identified as a geographically centric site in terms of the littoral zone south of the South Jetty and the most proximate area to disperse sand to help stabilize the jetty. It is expected to be the least productive area within the South Jetty vicinity in terms of benthic invertebrate abundance. Modelling indicates that much of the material added to the area would be expected to stay in place.

History of Use

It is fair to say that MCR beneficial use program began in 2004 with design of the Oregon Nearshore Beneficial Use Project. This demonstration project was an experiment by the LCSG to test new methods of sand placement in shallow nearshore waters to replenish the eroded

littoral zone and rebuild nearshore sands to better protect the South Jetty from waves. It was also intended to track deposited sediment movement over time and to determine the extent to which it remains in the littoral zone and helps protect the South Jetty. Project details can be found at:

https://lowercolumbiasolutions.org/projects/columbia-nearshore-south-jetty/

To address scientific information needs and share this information with decision-makers, LCSG and the Oregon State University Institute for Natural Resources commissioned a series of scientific white papers and convened joint workshops. Among the conclusions were that a limited demonstration project should be conducted to determine the feasibility of "thin layer" disposal in the nearshore environment. This led to a Phase I demonstration project in 2005 to test the viability of the enhanced dumping method in the nearshore area off the South Jetty. This test was intended to measure per-run ocean bottom accumulations to verify projected results and help determine the viability of this method. In this demonstration project, 34,000 cy of dredged material was released, creating a layer no deeper than four inches to protect crabs and clams. It is unknown if the material eventually settled onshore, traveled up the Columbia River, or was pulled out to deeper waters.

Based upon the results of the Phase I demonstration project, LCSG members proposed a Phase II Demonstration Project that would involve the targeted placement of approximately 150,000-300,000 cy of dredged material within the South Jetty site, for the purpose of building a discrete feature on the seabed (berm) which could be monitored to determine the rate and direction of sediment transport. The goal of the Phase II project, as originally conceived, was to apply enough material to determine where it goes.

Instead of proceeding with this larger placement project, the LCSG supported a sand tracer study being conducted in summer 2008. Although one of the original purposes of a Phase II demonstration project was to evaluate alternative dispersal methods and sites, it was determined that it was most critical to determine where the nearshore sediment goes, especially since the Phase I monitoring demonstrated that a berm would not protect the jetty. Initiated in August 2008, that study indicated dispersal toward the north and the South Jetty, with some dispersal to the west and significantly more to the east and then south along Clatsop Plains and the beach. The pattern of deposition to the north suggested transport from the end of the South Jetty in a west-northwest direction across the channel to the north and around the ebb shoal to the north as far as the south end of Long Beach, WA. In general, it appears that dredged sand deposited in the nearshore area south of the South Jetty disperses widely; it is expected that some of the material that moves north and west toward the navigation channel is retained within the proximity of the South Jetty and leads to deposition both along the jetty and the Clatsop Plains shoreline.

To address scientific information needs before proceeding with further SJS placements, the LCSG and Oregon State University's Institute for Natural Resources commissioned a series of scientific white papers and convened joint workshops. Among the studies conducted were assessment of the area's bathymetry, potential wave effects, sediment transport and

morphology change, razor clam effects, and other factors affecting/affecting by sediment placement. It was concluded that a limited demonstration project should be conducted to determine the feasibility of "thin-layer" placement in the nearshore environment.

Based upon the identification of the SJS as the area within the nearshore south of the South Jetty with the best potential to meet the project goals, in 2012 the LCSG and Port of Astoria obtained a Coastal Zone Management Plan consistency determination from the State of Oregon and an Ocean Research Permit from EPA Region 10 for a Phase 2 beneficial use project. One of the project's goals was to transition from demonstration projects to operational projects at the SJS.

In 2012, approximately 15,000 cy of evenly dispersed materials were placed in the nearshore area south of the South Jetty as a "practice placement" to hone skills at placing materials evenly in a thin layer. Based upon the knowledge accumulated from this demonstration project, it was proposed that placement transition from a one-time dump to using SJS as an operational site by distributing material evenly over a dredging season. Among the project findings were that at least 50,000 cy of material is required to create a "trackable" feature of 18-24 inches (46-61 cm), material can be placed with less than four inches of deposition using a conventional 6,000 cy hopper dredge, and accumulation can be maintained at less than one inch with multiple dumps.

Varying amounts of material have been placed over the last 13 years, increasing to a high of approximately 400,000 cy in 2018 and 2020.

History of South Jetty Site Placements

Year	Approximate Placement Volume (cy)
2007	34,000 cy -- Phase 1 demonstration project to test viability of enhanced placement
2012	15,000 cy – "Practice placement" as part of dredged material deposition study
2013	63,000 cy - plans for a 300k cy placement scaled back due to damage to dredge *Essayons*
2014	287,000
2015	285,000
2016	300,500
2017	300,500
2018	400,000
2019	285,000
2020	400,000

At a December 2020 LCSG meeting, the Corps proposed an increase in the amount of material placed at SJS in 2021 to 500,000 cy.

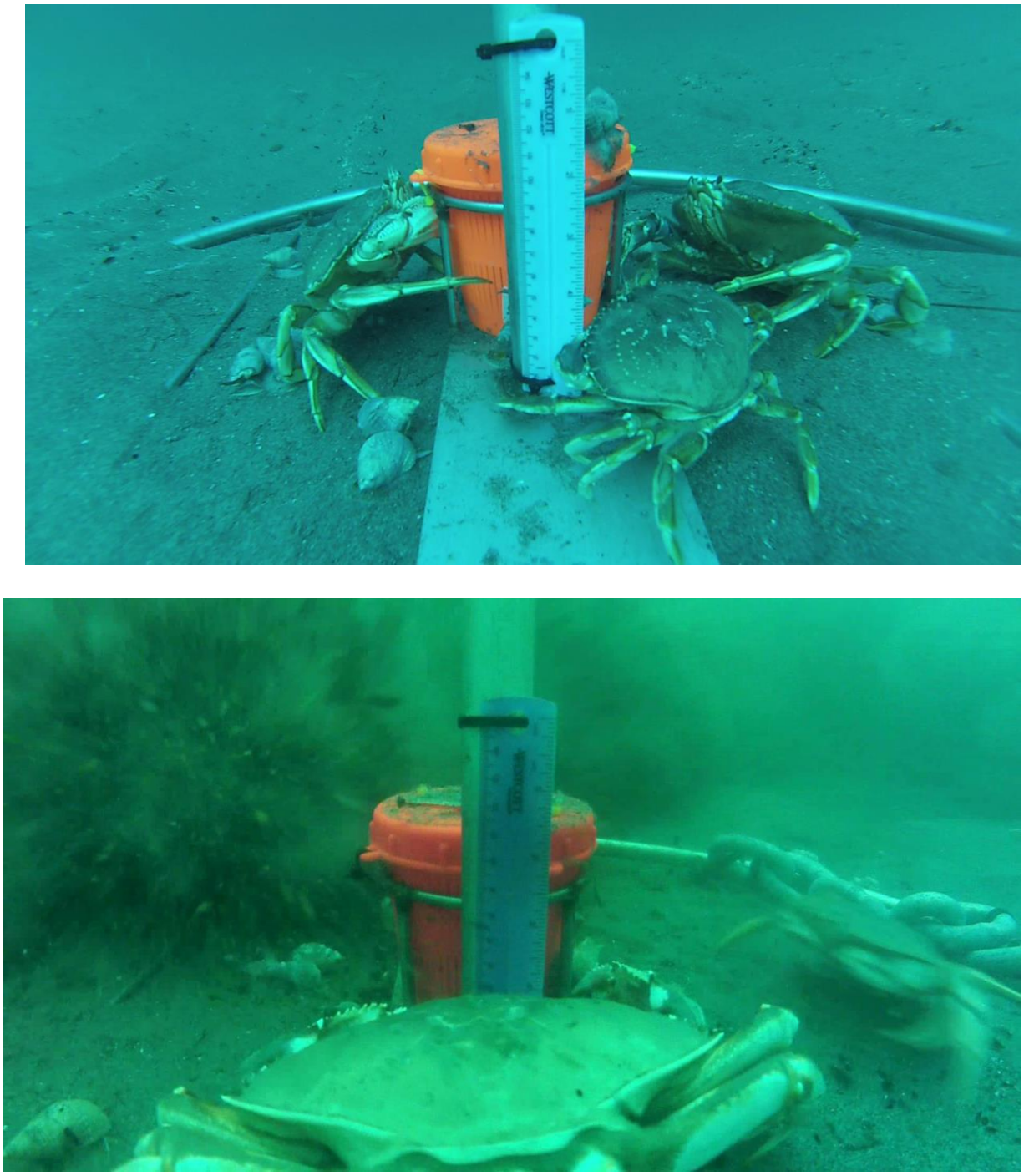
Results and Observations

As described above, as the initial demonstration site for the Mouth of Columbia River RSMP, the efficacy of nearshore thin-layer placement and attendant effects have been extensively researched and monitored at the SJS. In simple terms, the primary questions that these R&M efforts have been designed to address include: Does thin-layer placement work as a dredged material placement method; are there impacts on navigation safety; what are the impacts on crabs and benthic invertebrates; and where does the sand go?

Based upon direction from a series of science/policy workshops, the focus of biological resource monitoring at the SJS has been on the impact of dredged material placement on Dungeness crab mortality and mobility, as well as the overall benthic environment. The SJS "experiment" has in turn fostered an experimental approach to investigate effects of sediment deposition events on benthic communities. Under the direction of NOAA Fisheries, a variety of new or modified video and acoustic telemetry techniques have been employed at MCR, including "campods" (benthic video landers) to measure acute effects of placement including sediment depth and impact on fauna; acoustic telemetry to measure acute and cumulative impacts on crabs by using tags and monitoring movement/behavior; and benthic video sleds to compare invertebrate and fish abundances in different habitats. Essentially, a state of the art crab/benthic invertebrate monitoring program has evolved in conjunction with eight thin-layer placements at the SJS over the past 15+ years. The following table compares the various methods used to assess benthic impacts.

COMPARISON OF METHODS USED IN BENTHIC MCR BENTHIC IMPACT STUDY

METHOD	PURPOSE & ORGANISMS	DATA TYPE	PROS	CONS	FINDINGS
BENTHIC VIDEO SLED	• DETERMINE DENSITY AND SPATIAL DISTRIBUTION • LARGER MOBILE EPIFAUNA AND SESSILE INVERTEBRATES	• SURVEY • BEFORE-IMPACT-AFTER EXPERIMENTAL DESIGN	• RAPID SAMPLING • HIGH REPRODUCIBILITY	• VISIBILITY-LIMITED • SPECIALIZED ANALYSIS	• TEMPORAL EFFCT > TREATMENT EFFECT • N LOWER AT SJS THAN DWS
BAITED CRAB POTS WITH FINE MESH LINING	• TIME SERIES OF ABUNDANCE & SIZE • PRIMARILY CRAB, SOME GASTROPODS, FISH	• SIZE FREQUENCY DATA • INDIVIDUAL METRICS (SEX, LIMB LOSS, ECT)	• "HANDS ON" DATA • COMPATIBLE WITH OLDER DATA SETS. • VISIBILITY-INDEPENDENT	• REQUIRES 2 CONSECUTIVE CRUISE DAYS FOR 24-H SOAK	• NO TREATMENT EFFECT • MAINLY ADULTS • MALES > FEMALES
BENTHIC VIDEO LANDER (CAMPOD)	• ACUTE EFFECTS OF DEPOSITION • MOBILE MACROINVERTEBRATES & FISH	• PRESENCE/ABSENCE RELATIVE TO DEPOSITION • IMPACT-CONTROL EXPERIMENTS	• EASILY DEPLOYED AND ANALYZED • BEHAVIORAL OBSERVATIONS	• LIMITED BATTERY LIFE • VISIBILITY-LIMITED	• SIG IMPACT EFFECT • SEDIMENT LEVEL MINIMAL • SHORT DURATION
ACOUSTIC TAGS	• ACUTE AND LONG-TERM MOVEMENTS • DUNGENESS CRABS (STURGEON, SHARKS)	• IMPACT-CONTROL DESIGN • FINE SCALE, INDIVIDUAL BEHAVIOR	• VISIBILITY-INDEPENDENT • LONG TERM BEHAVIORAL DATA	• SPECIALIZED ANALYSIS • SPATIAL SCALE RECEIVER-LIMITED	• SLIGHT IMPACT EFFECT • HIGHLY MOBILE • MIGRATION NORTH? • CUMULATIVE EFFECT?
ENVIRONMENTAL BUOY	• COLLECT BIOPHYSICAL METRICS	• TIME SERIES • DEPTH STRATIFIED	• PROVIDES CONTEXT TO ALL DATA COLLECTION • CAPTURES EVENT SCALE • LONG TERM DATA (CLIMATE CHANGE)	• VISIBILITY-INDEPENDENT • LONG TERM DATA	• PHYSICAL CONDITIONS (HIGH TEMP, LOW DO) MAY EFFECT BEHAVIOR

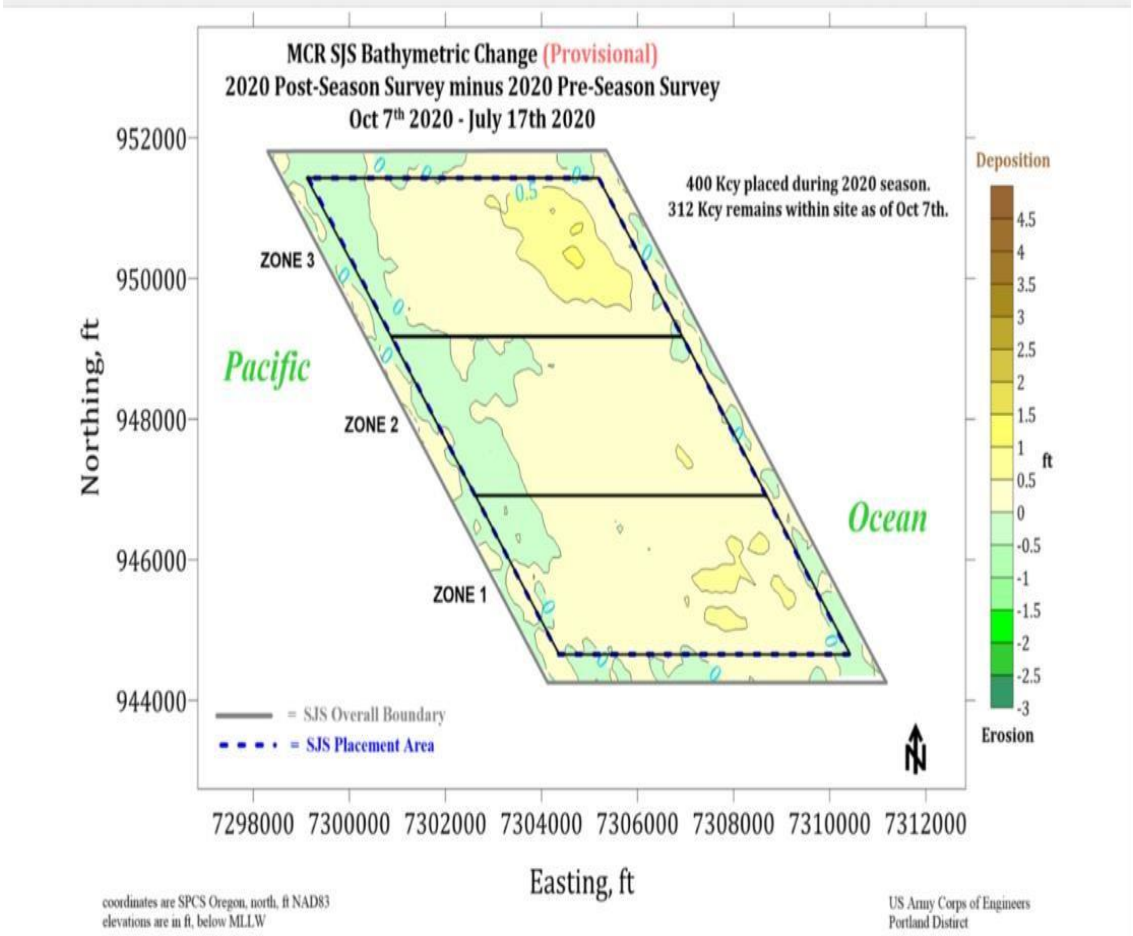


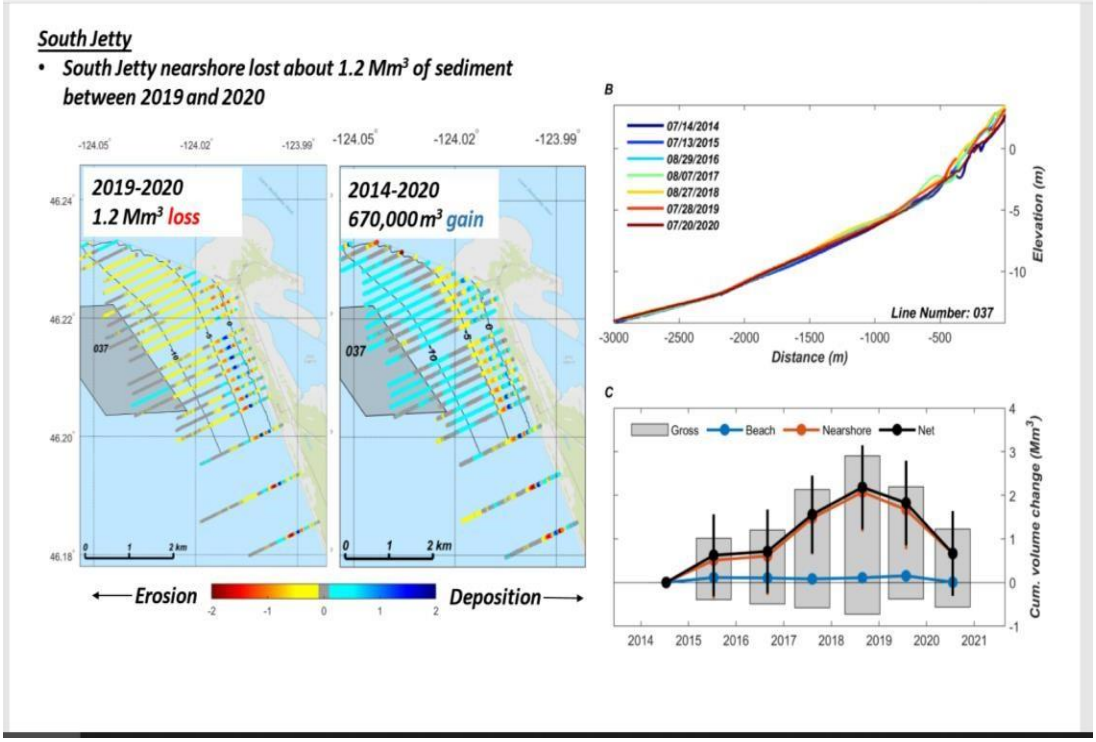
Impact of a placement sediment plume on Dungeness crabs recorded with a benthic video lander.

The South Jetty Site has emerged as a model for beneficial use placement within the MCR nearshore environment. It has proven to be a viable placement site both in terms of dispersiveness of material into the nearshore and from an operational perspective. In general, it appears that some of the material placed there is retained within the proximity of the South Jetty and leads to deposition both along the jetty and the Clatsop Plains shoreline. It also

appears that it is helping to reduce the bottom scouring that was a key factor in its selection as a placement site. However, its major value may be that it has demonstrated the efficacy of thin-layer placement as a method of nearshore placement of dredged material. No biological resource impacts have been observed. Monitoring of crabs indicates no evidence of increased mortality and no long-term effects. At placement, crabs move out quickly, the majority to the north; they return to the dump site within an hour or two after placement. Unknown are cumulative effects and the extent of northward migration.

At the LCSG's December 2020 meeting, a presentation of July 2020 observations of coastal change and sediment transport at MCR placement sites by a joint venture of the U.S. Geologic Service (USGS), Deltares, WDOE and Oregon State University indicated that the South Jetty nearshore lost about 1.2 million cy of sediment between 2019-2020. This contrasts with a net gain of 670,000 cy between 2014-2020. This change raises concerns about impacts to the South Jetty and about the potential for breaching of the Clatsop Spit. The need was identified for further research on whether this change in sand volume is related to dredge material placement or to changes in environmental conditions (e.g., wave climate, fluvial supply).


MCR SJS Bathymetric Change (Provisional)
2020 Post-Season Survey minus 2020 Pre-Season Survey
Oct 7th 2020 - July 17th 2020
400 Kcy placed during 2020 season.
312 Kcy remains within site as of Oct 7th.
ZONE 3
ZONE 2
ZONE 1
Pacific
Ocean
= SJS Overall Boundary
= SJS Placement Area
Deposition
Erosion
ft
Northing, ft
Easting, ft
952000
950000
948000
946000
944000
7298000 7300000 7302000 7304000 7306000 7308000 7310000 7312000
coordinates are SPCS Oregon, north, ft NAD83
elevations are in ft, below MLLW
US Army Corps of Engineers
Portland District


South Jetty
South Jetty nearshore lost about 1.2 Mm³ of sediment between 2019 and 2020
2019-2020
1.2 Mm³ loss
2014-2020
670,000 m³ gain
Erosion
Deposition
B
07/14/2014
07/13/2015
08/29/2016
08/07/2017
08/27/2018
07/28/2019
07/20/2020
Line Number: 037
Distance (m)
Elevation (m)
C
Gross
Beach
Nearshore
Net
Cum. volume change (Mm³)

Management Direction

At a January 2020 science/policy workshop, the LCSG addressed questions about the future management of the SJS: Assuming that we have progressed from a series of pilot projects to a routine placement and monitoring program at the South Jetty Site, what is the threshold for no harm in terms of placement volume? Are we comfortable that the site's recertification process scheduled for 2022 will provide the appropriate process and timing for assessing the need for adaptive management of placement and monitoring at this site? The group concluded:

- ***The SJS has transitioned from being an experimental or demonstration site to being a permanent, long-term placement site for materials dredged from the MCR.***
- The current CWA Section 401 water quality certification authorizes placement of up to 500,000 cy. Given the goal to minimize the material sent to the DWS, increasing the maximum capacity to 600,000 cubic yards should be considered. This would be an upper limit rather than an annual amount, with the expectation that in most years the volume would be less. Subject to the one-foot increase in mounding threshold, a capacity of 600,000 cy appears to be a safe upper limit that avoids adverse impacts to the fishery and to navigation safety.
- An increase in the site area should also be considered to facilitate placing a greater amount of material without creating mounding impacts.
- Oregon's Water Quality Certification is due for renewal in 2022. That recertification process will be the appropriate time to evaluate any future increase in the site's footprint and maximum volume. It will also be an opportunity to design a long-term R&M program that addresses questions such as cumulative impacts to crab populations and whether the introduction of food bait has impacts, positive or negative.
- Based upon results to date, additional research and monitoring of dredging impacts are not a priority at this site. Rather, there is a need to establish a program to monitor key indicators annually that could act as triggers to identify unintended affects and adaptive management. There should also be periodic (every 5 years) evaluation of infauna impacts and fish utilization. The Water Quality Recertification process represents an opportunity for such an evaluation.

The December 2020 presentation to the LCSG on coastal change and sediment transport suggests the need for additional monitoring and modeling of sediment transport at the SJS and close monitoring of potential impacts to the South Jetty and the Clatsop Spit.

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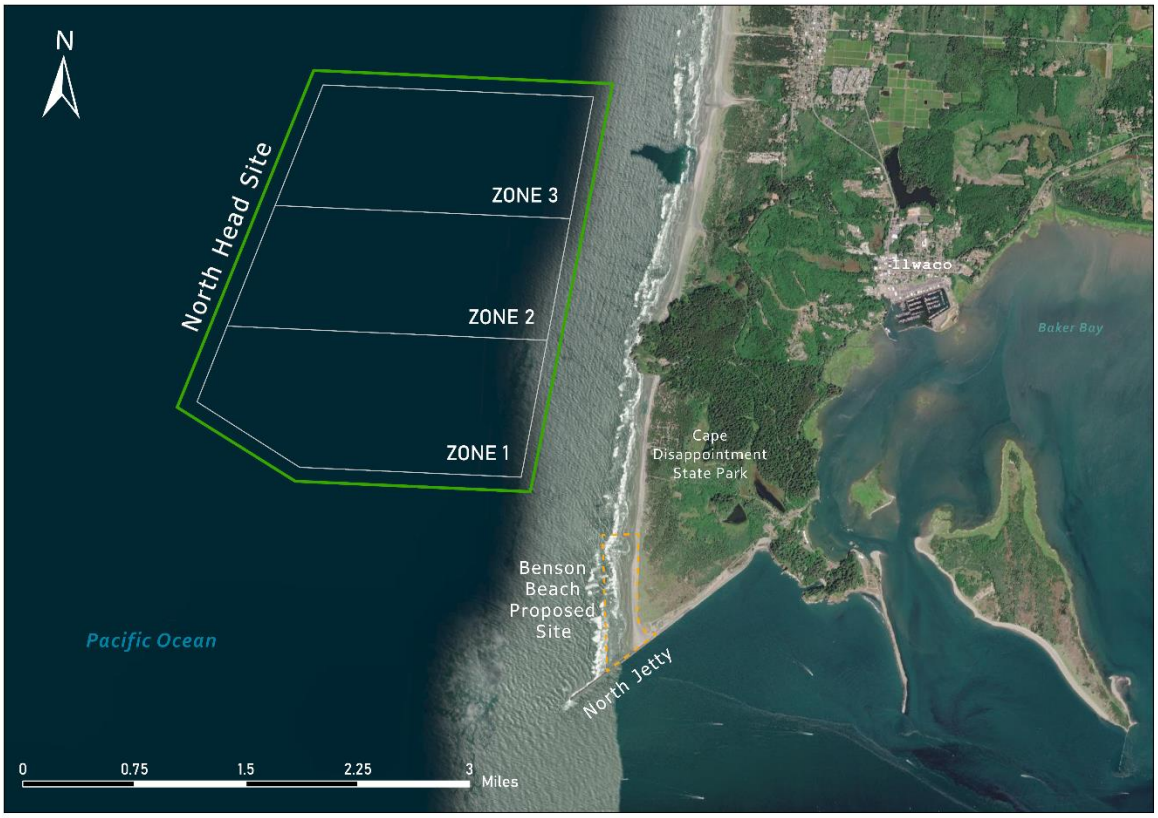
(2) North Head Nearshore Site (NHS)

Description



As with the South Jetty Site, this placement location was identified through early science/policy workshops and confirmed in the 2011 RSMP as the priority area north of MCR to explore for beneficial use feasibility and, specifically, for dispersion of materials along Benson Beach and Peacock Spit.

The North Head Site is located in Washington approximately 2.5 miles north of the North Jetty and directly offshore from North Head Point, with water depths ranging from 20 – 60 feet (6-18 m). Its dimensions are approximately 7,400 feet (2,255 m) long by 3,000 feet (914 m) wide on the beach side and 4,400 feet (1,341 m) long by 5,600 feet (1,707 m) long by 4,500 feet (1,372 m) wide on its ocean side. (Corner coordinates can be found in a 2012 Environmental Assessment prepared by the Corps.) Site capacity has not yet been estimated.

The NHS essentially acts as a nearshore partner or surrogate for onshore placement at Benson Beach. This site is intended to disperse sand to and thus reduce erosion at Peacock Spit and Benson Beach. It is intentionally a large placement site, as there are significant differences between the north and south portions of the area in terms of current circulation patterns and benthic fauna density (north = greater) and diversity (south = greater). Shoreline erosion also differs between the northern and southern halves of the site, with accretion occurring north of North Head and erosion steadily increasing south of North Head (Benson Beach).

History of Use

The identification of NHS as a potential beneficial use site initially occurred in a 2009 science/policy workshop under the auspices of the Southwest Washington Littoral Drift Restoration Project (see discussion of Benson Beach below). Management direction at that time included:

- In the short term, annually place approximately 500,000 cubic yards of dredged material that is rotated among a series of adjacent placement cells to minimize mounding and facilitate habitat recovery.
- Through modeling and monitoring, determine the long-term placement capacity based on the dispersive properties of the site.
- Respond to differing wave conditions by utilizing multiple (3-5) "runway approaches" for aligning placement pathways (dredge track lines).

Although identified as early as 2009, placement of dredged materials did not occur at the NHS until 2018. In the intervening period, the Littoral Drift Project prioritized onshore placement at Benson Beach, while the LCSG focused on a series of demonstration projects at the SJS, intended in part to better inform a placement program at the NHS. Discussion of how to move forward with placement at the NHS was reinitiated at a 2016 science/policy workshop, with delineation of a study area being the first item to be worked out. A combination of factors led to the identification of the current study area. The crab fishery pushed for an area north of North Head, while the Technical Team argued for south of it. As a compromise, a comparatively large study area was identified, the intent being to reflect the variable various ocean conditions and provide flexibility for placement within the area. The hope was that some sediment might feed Benson Beach and the shoreline to the north.

Unlike at the SJS where no mounding was the goal, the concept for placement at the NHS included constructing a two-foot high berm of dredged material in 35-50 feet of water. Project goals included:

- A one-time experiment to measure dispersion. If the site is shown to be highly dispersive, then further planning for placement at the site should occur. If the dispersive nature is slow or not in the right direction, then the site's viability is in question.
- Low-relief accumulation on the seabed using thin-layer placement.
- No effect on wave amplification.

Surveys of baseline ecological and substrate characteristics within the study area were conducted by the Corps in 2017, focusing on infaunal density and diversity. A five-year Clean Water Act certification was issued by the State of Washington in 2018 for a pilot project, the goal being to define the best location(s) within the study area for a permanent placement site(s) and an appropriate site capacity. In the first phase of the pilot project, approximately 51,000 cy were placed to create a two- foot high detectable feature (berm) approximately 5,000 feet in length to observe sediment dispersion.

At a December 2018 science/policy workshop, it was agreed that the Corps should proceed with a second stage of the pilot project in the southern portion of the site, with a change in orientation to be parallel to the beach. It was also agreed that a sediment transport model developed by USGS and modified to reflect different current regimes could be used as a surrogate for a tracer study, presuming funding was unavailable for such. The placement volume was limited to creating a berm not greater than two feet in height. The overall goal was to demonstrate that the Phase 2 area is a dispersive site, while understanding where the sand is dispersed.

The second phase of the pilot project entailed placement in 2019 of 100,00 cy along two transects, 50,000 cy on an east-west transect and 50,000 cy on a north-south transect. In conjunction with this placement, the Corps conducted sediment transport modeling, with the goal to identify transport pathways and the most beneficial locations for dredged material placement. Phase 2 was intended to respond to questions arising from the project's first phase:

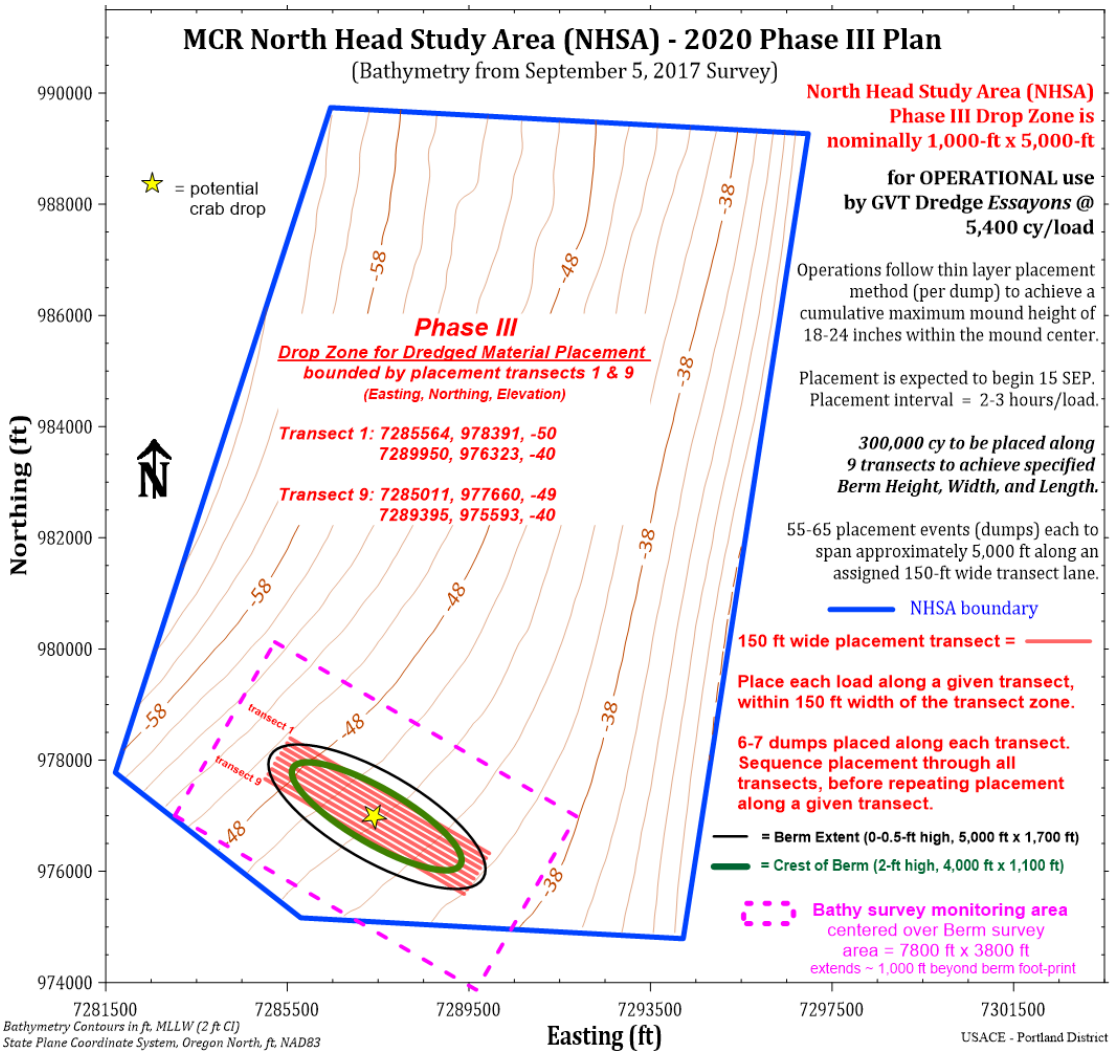
- Is there a preferential transport direction based on mound: transect orientation, i.e. will sediment placed in an east-west (cross-shore) berm be dispersed more readily than material placed in a north-south (alongshore) berm?
- Can a hopper dredge operationally place sediment on a north-south transect (alongshore) at the NHS?
- Does the northern end of the NHS exhibit a similar sediment transport rate as the southern end?

At a January 2020 science/policy workshop and a subsequent convening of a subset of the LCSG's management team, it was agreed that a third phase of the pilot project should be pursued if it can be demonstrated that new information will be obtained about the site and the dispersal of material placed there. Specific third phase elements included:

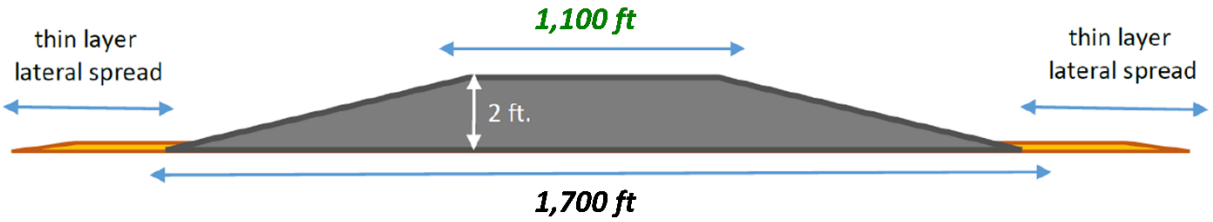
- Modify the sediment transport model so that it can be used as a surrogate for a sand tracer study to help determine sand movement.
- Proceed with a third phase of the pilot project that has as a primary purpose to assess sediment transport (preferential sediment direction) and that entails:
    - Creation of a longer-wider feature resulting in a two-foot "blob"-style berm, rather than a narrow berm, designed to assess dispersiveness.
    - Placement of a maximum of 300,000 cy.
    - Placement within the lower third of the existing study area.
    - No expansion of the authorized study area.
    - Placement post-September 15 to minimize conflicts with crab fishermen.
- Seek authorization of this third phase from WDOE, with no amendment of the 401 Water Quality certification requested at this time. The 2018 certification authorizes WDOE to approve modifications to placement within the current study area, including an increase in volume. An amendment can be requested at a future date to expand the

study area following analysis of the bathymetry and conversation with the dredge operators on the feasibility of placement/navigation safety.

- Further assess the need for additional crab research at the NHS based upon what has been learned from the research to date. Proposed crab research includes a series of acoustic tag releases at differing levels of placement intensity with an expanded acoustic receiver array area that is expected to allow for enhanced temporal and spatial tracking. The purpose of this additional research is to answer questions about how migration patterns are affected by deposition and to identify any differences in how crabs react to the differing types of placements at the SJS and NHS. However, crab studies were curtailed due to the CoVID 19 pandemic.



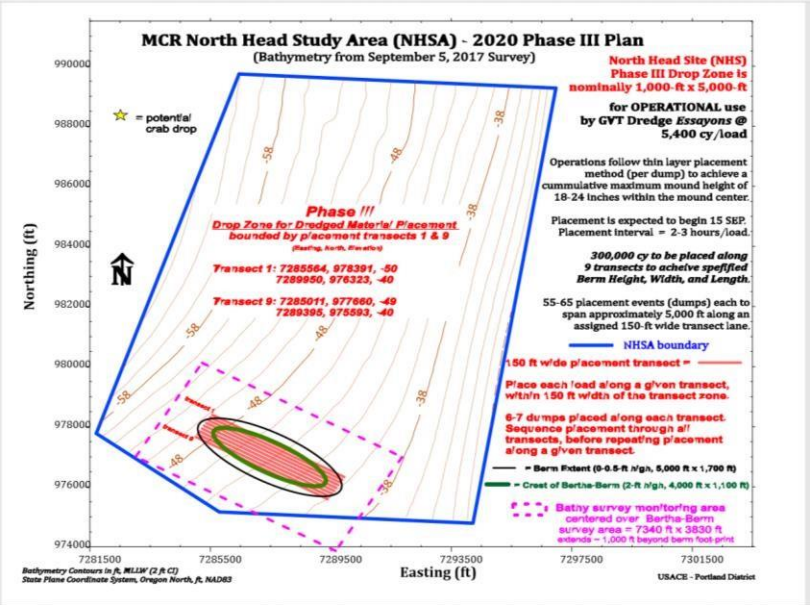
Phase III - Berm

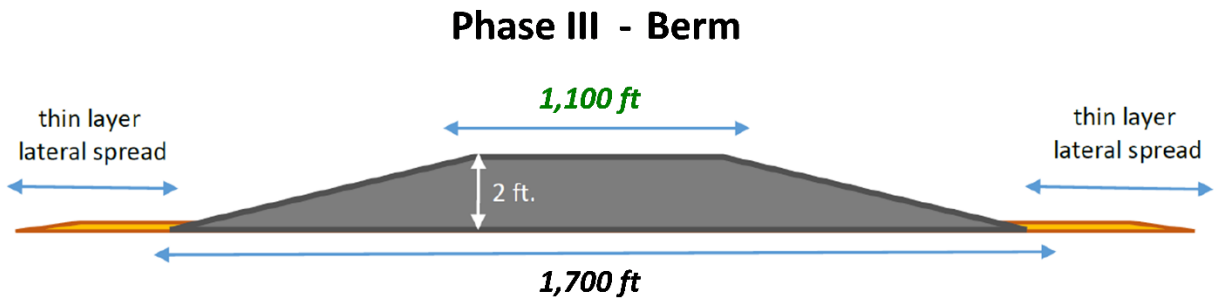


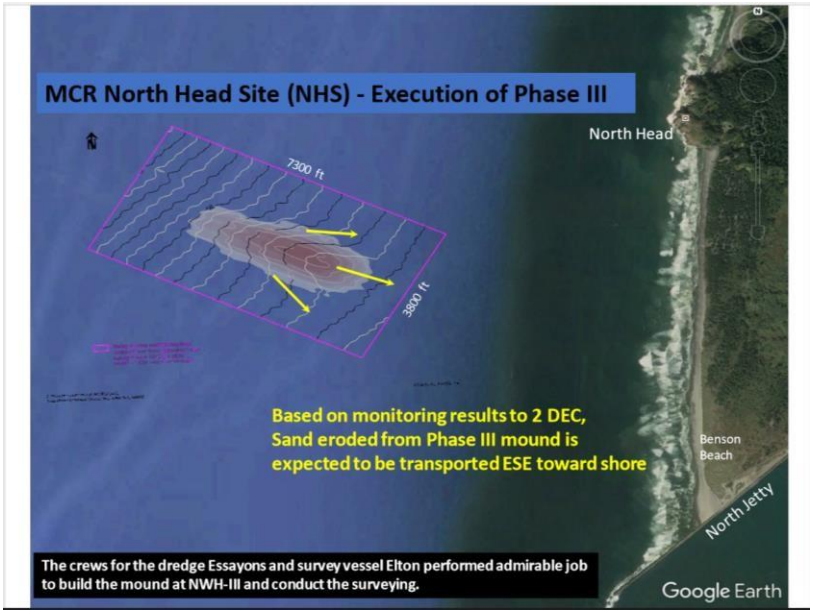
Subsequent to the January 2020 workshop, a subset of the LCSG's management team agreed that the focus of research should shift to sediment transport but that both crab and sediment transport research is supported if they can be scaled to remain viable, given available funding.

In the third phase of the pilot project, approximately 283,000 cy were placed according to the monitoring plan approved by the LCSG. A 2.3 foot mound was created, 4,900 feet long by 1,200

feet wide. Successive surveys conducted between mid-September and early December 2020 showed little to no sand movement initially, followed by significant transport of the sand from the mound and the adjacent seabed area beginning in late October. As of the final survey in early December, this sand was moving toward Benson Beach.







Results and Observations

Results to date from the three phases of the NH pilot project include:

- The NHS is a dispersive site, with sediment placed on both east-west and north-south transects dissipating at the same rate. Sediment is transported vigorously regardless of "mound" orientation. Transport direction could not be defined in the first two phases of the pilot project; in the third phase, monitoring of the mound placed in an east-southeast direction indicates that sand is being transported (per experiment design) toward Benson Beach. It appears that the NHS is less dispersive than the SWS, however.
- There was no wave height amplification associated with a 2-2.3 foot berm in 35-50 feet of water depth.
- The larger the site, the greater the opportunity to dispose of large volumes of material via thin-layer placement. A placement volume of 400,000-500,000 cy/year appears to be below a threshold of concern.
- Given good weather conditions, a hopper dredge can operationally place sediment alongshore and cross-shore at the NHS.
- While it does not appear that sediment is being more preferentially transported with different placements, placement at the southern end of the NHS would appear to have the greatest potential benefit to Benson Beach. In 2020, after several years of significant erosion, Benson Beach accumulated approximately 900,000 cy of sediment. It is not known at this time whether that accumulation is due to dredge material placement at NHS or to changes in environmental conditions, e.g. wave climate, fluvial supply or other conditions. Current plans for placement at NHS are not expected to

significantly reduce erosion at Benson Beach, however. To reduce erosion at Benson Beach, more sediment needs to be placed and placed more efficiently.

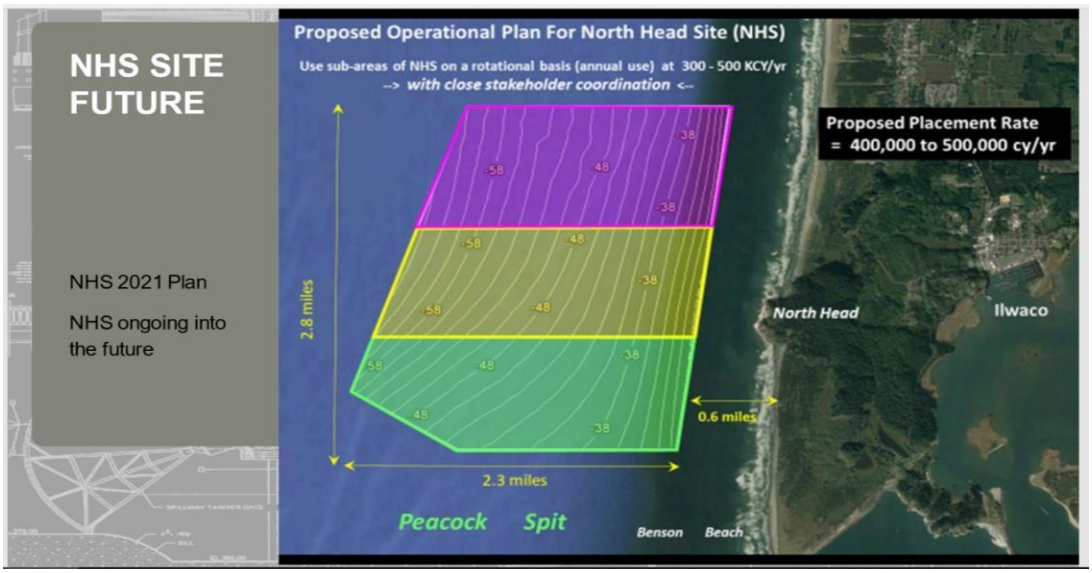
- Sediment transport modeling suggests that transport pathways are highly sensitive to wave height and direction. The highest sediment mobility is found on Peacock Spit and nearshore north of the MCR.

Management Direction

Based upon discussions over the past year on how to proceed with future NHS placements (post-pilot project phase 3), the intent is to transition the NHS from being a demonstration site to being a permanent, long-term placement site for materials dredged from the MCR. Management direction for the site includes:

- Use sub-areas of the North Head Site on a rotational (annual) basis at 300,000-500,000 cy/year, with close stakeholder coordination. This would minimize impacts to each sub-area and would be a good compromise to avoid impacts to fisheries.
- Place materials in other than a straight line.
- Evaluate the potential risks of increasing the volume of material placed above 500,000 cy/year, with different volumes of material placed within different portions of the NHS, e.g. 500,000 cy/year in the southern third of the North Head Site and less in the northern third.
- Assess the potential to expand the study area to the south closer to the North Jetty, recognizing the presence of various shipwrecks. Sediment would be expected to leave the site at a much faster rate in the site's southern portion, so there would be fewer impacts, including minimal impacts to crabs/crabbing.

Going forward, the Corps proposes that 400,000-500,000 cy be placed annually at NHS, using subareas on a rotational basis so that no more than one-third of the site is used in any given year. This rotation is intended to minimize overuse of the site and reduce inconveniences to the fishing fleet. At the same time, the southern subarea will be a priority, as it has the greatest potential for transport of sand to Benson Beach. While a mounding threshold of four feet has been suggested, the goal will be to maintain a berm of no greater than two feet in height. For 2021, the Corps proposes to place 400,000 cy. Additional Phase 3 surveys and pre-dredge surveys will help guide selection of the location for this placement.



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(3) Benson Beach Onshore Site

Description

The Benson Beach intertidal or onshore site is directly north of and adjacent to the North Jetty in Washington. Benson Beach was naturally created by the construction of the North Jetty. Because of a reduction of sediment input into its littoral cell, Benson Beach has significantly eroded. The Corps has been monitoring Peacock Spit since 1958 and has observed that its underwater shelf is shifting, contributing to Benson Beach erosion. The accreted sand that makes up Benson Beach appears to be migrating north within the northern Long Beach littoral zone. The present volume of new sediment transported north from the MCR is insufficient to offset the erosion at Benson Beach. Without Benson Beach, more rapid scouring would occur along the toe of the North Jetty, with greater potential for breaching in storm events.

A January 2020 Science/Policy workshop presentation by the Corps on *MCR Coastal Dynamics* illustrates that North Jetty construction in 1914-17 and upstream dams have led to significant accretion at Peacock Spit for at least 40-50 years, followed by equally significant erosion at Benson Beach. Washington State Parks and Recreation representatives indicate that oceanfront camping sites at Cape Disappointment State Park have been lost over the past several years, resulting in closing camping at oceanfront camp sites at the park between November – April.

Benson Beach Aerial View, 2019

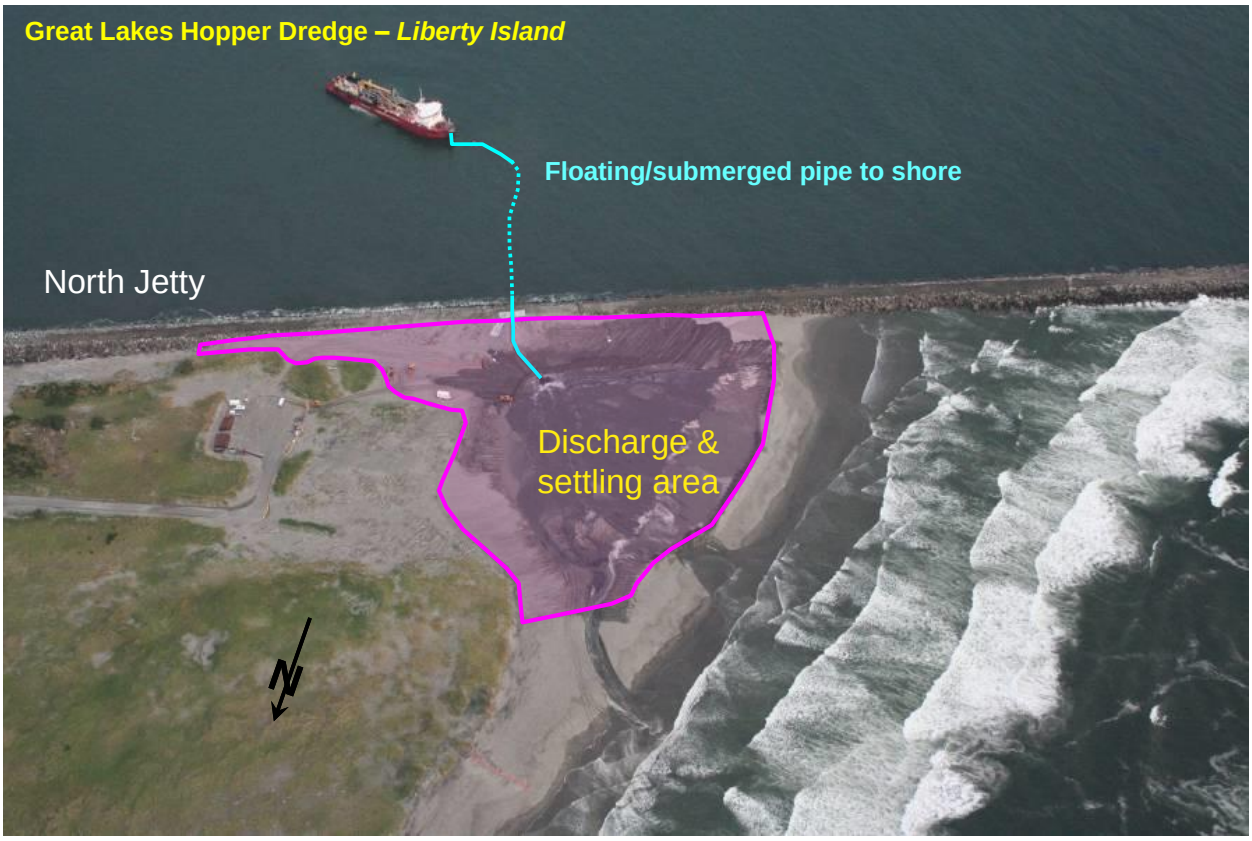
History of Use

There have been three placements of dredged material on Benson Beach, either in conjunction with North Jetty repairs (2004 - 40,000 cy; 2008 - 125,000 cy) or as a one-time event intended to specifically address onshore erosion (2010 - approximately 367,000 cy). In the 2004 and 2008 events, dredged material was placed via pump-ashore discharge from a dredge vessel to the shoreline. Temporary sand berms were used to retain sand during the pump-out; otherwise, much of the sand would have immediately been washed away. After the sand had settled out, bulldozers moved the sand to match the shoreline elevation. In the 2010 placement, sand was pumped into the intertidal zone where it was spread by wave and current action.

In the 2008 placement, approximately 125,000 cubic yards of sand dredged from the MCR navigation channel was pumped ashore to repair the foredune, which had been protecting the North Jetty root from wave surge action. The destruction of the foredune along the North Jetty was providing storm waters with a direct path to the unrepaired part of the jetty. During ocean storms, water was reaching the lagoon area and raising the existing water level, causing water to flow through the jetty. The 2008 placement was characterized by rapid loss of the sand placed due to a major storm event.

North Jetty Berm Repair Hopper Dredge Pump-out Activity: 2008

125,000 cy placed - **90% retained in project template**



In conjunction with the 2008 berm repair project, 2,300 feet of sand fencing was installed in September-October 2008 by WDOE's Coastal Monitoring & Analysis Program, with manpower from the Washington Conservation Corps and funding from the Corps. WDOE also produced a brochure to explain the purpose of the sand fence project and provided copies for distribution to Cape Disappointment State Park visitors. Sand fencing has been shown to act as a barrier to slow down sand grains being carried by the wind. Sand piles up behind sand fences and forms a dune. With the Benson Beach project, the goal was to prevent sand from blowing over the North Jetty into the Columbia River mouth, where it can interfere with the shipping channel.

Inspection in early October 2008 showed measurable sand accumulation within approximately 10 feet on each side of the fence lines. A severe winter storm in mid-December caused significant damage to the fencing, with storm surge submerging the Benson Beach parking area at one point and sweeping large woody debris through the area. Even with the extreme storm surge, the sand fence performed beyond expectation. By allowing sand accretion and dune creation before the storm occurred, the sand fence minimized negative impacts of the storm. The newly constructed dunes acted as protective barriers to the North Jetty and uplands.

Within six months of its installation (March 2009), over 2,000 cy. of sand had accumulated behind the fences, forming ridges along the fence lines, with the peaks nearly covering the top

of the fence. During Summer 2009, an additional 3,000 feet of fencing was placed to fill in the troughs between the fences and increase the sand accumulation along the dune ridges. In November 2011 (three years after initial construction), sand accumulated at least two feet high along all fences. This three-foot accumulation is equivalent to 3,333 dump trucks of sand added to the dune.

Lessons learned from the 2008-09 sand fencing project included: the fence did an excellent job of dune building but fence damage may have been reduced if additional ties along the fence posts had been installed to hold the fence in place against the force of rushing water and woody debris and if the amount of fencing recommended by the scientific literature had been installed. Only half as much fencing as necessary was installed. Since the fences were too far apart for full dune formation and intersecting effects, there was unequal distribution of sand, with dunes building on either side of the fences and wide troughs in the middle. In addition to continual monitoring of sand fence performance, project leaders recommended installation of additional fence and planting of native dune vegetation. Additional fencing is expected to help to break the wind flow over the top of the North Jetty berm and greatly help to minimize the effects of storm surge and overwash of the berm during winter storms. The planting of native dune vegetation, such as dune grasses, would significantly help in more permanent retention of the dunes. Another sand fencing project at Benson Beach in 2021/2022 is currently being scoped.

The 2010 one-time onshore placement of 367,000 cy grew out of the Southwest Washington Littoral Drift Restoration Project, an effort by the Coastal Communities of Southwest Washington to develop a long-term strategy for placement of dredged material in the littoral zone north of the North Jetty. The project proposed placement of material in an area approximately 1,000 feet north of the North Jetty along Benson Beach in Cape Disappointment State Park.

Initially proposed in a 2007 science/policy workshop and reaffirmed in 2009 workshops, the Littoral Drift Restoration Project entailed a $3.5 million pump-ashore demonstration project. Benson Beach was identified as the location in the littoral zone north of the North Jetty that would be expected to have the greatest benefit in terms of beach and drift restoration and the least effect on habitat impacts, as well as the most appropriate location for a demonstration onshore placement project. Environmental permitting was completed in 2008 for placement of up to one million cubic yards in the Benson Beach intertidal zone. The State of Washington contributed $1.69 million in incremental funding for the project, which was added to $1.8 million in Corps maintenance funding. Monitoring activities were funded under the Corps' Regional Sediment Management program. The project's goals included to restore the littoral drift, rebuild onshore sands, track sediment movement over time, and determine whether replenishing the littoral zone helps protect the North Jetty.

Profile data for the Littoral Drift Project was measured monthly for 15 months and showed that material placed against the toe of the foredune remained the longest. There was some measurable decrease in localized erosion during the first winter season, with a "healthier"

beach the following spring and summer. After that time, the material placed had almost completely washed away. Additional project details can be found at: https://lowercolumbiasolutions.org/projects/sw-washington-littoral-drift-benson-beach/

In conjunction with the 2018-2019 North Jetty Major Rehab Project, sand fencing was placed at the south end of Benson Beach.

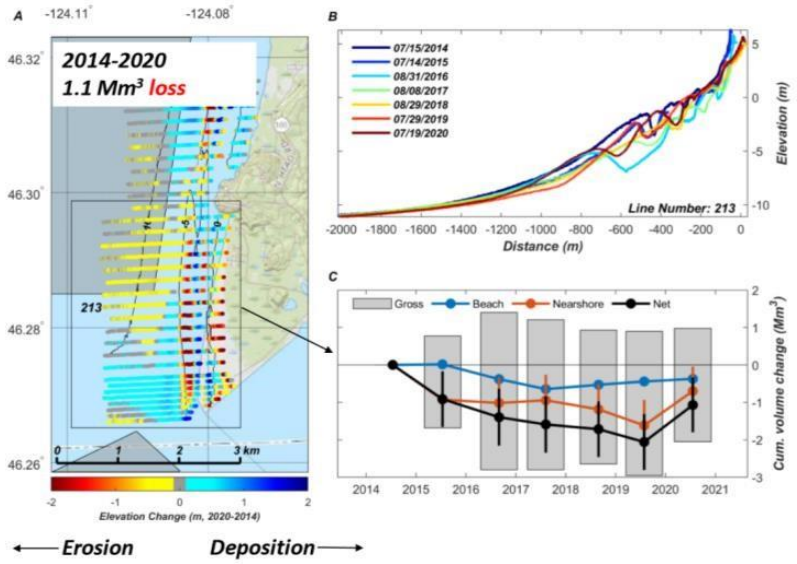
Results and Observations

- Construction of the North Jetty has changed the Peacock Spit, with waves / currents beating it down and diffusing it out. As the morphology changes, the patterns affecting Benson Beach change.
- Despite the placement of approximately one million cy of sediment in the SWS annually between 2014 and 2019, Benson Beach continued to erode during this period at approximately 420,000 cy/yr. As noted in the NHS section above, Benson Beach accumulated approximately 900,000 cy of sediment in 2020, reversing at least temporarily the erosion trend experienced over the 2014-2020 period. It is not known at this time whether that accumulation is due to dredge material placement at NHS or

to changes in environmental conditions. These recent gains, however, are not sufficient to reverse effects of steady erosion over the past few years. The dunes along Benson Beach are 1/2-1 meter lower than they were 6-7 years ago, making them more at risk for overtopping and associated erosion and flooding.

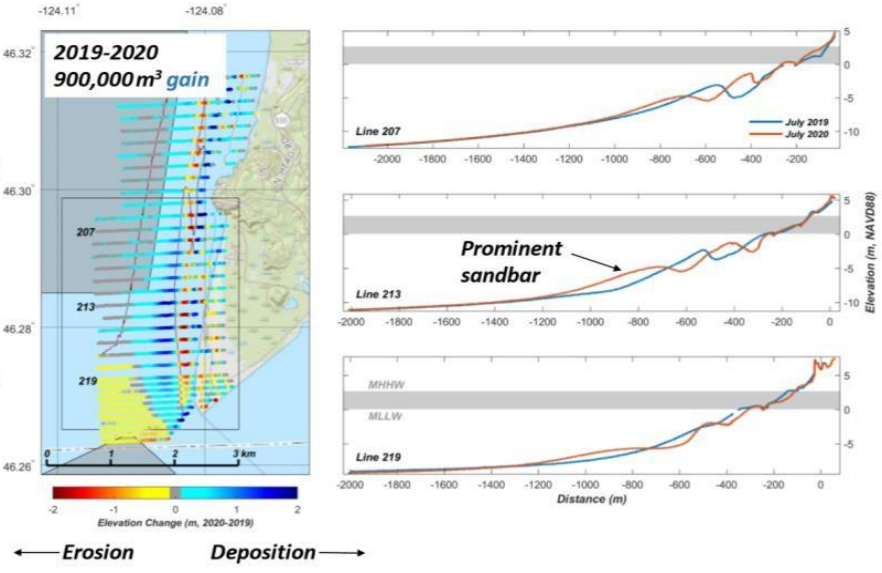
Benson Beach

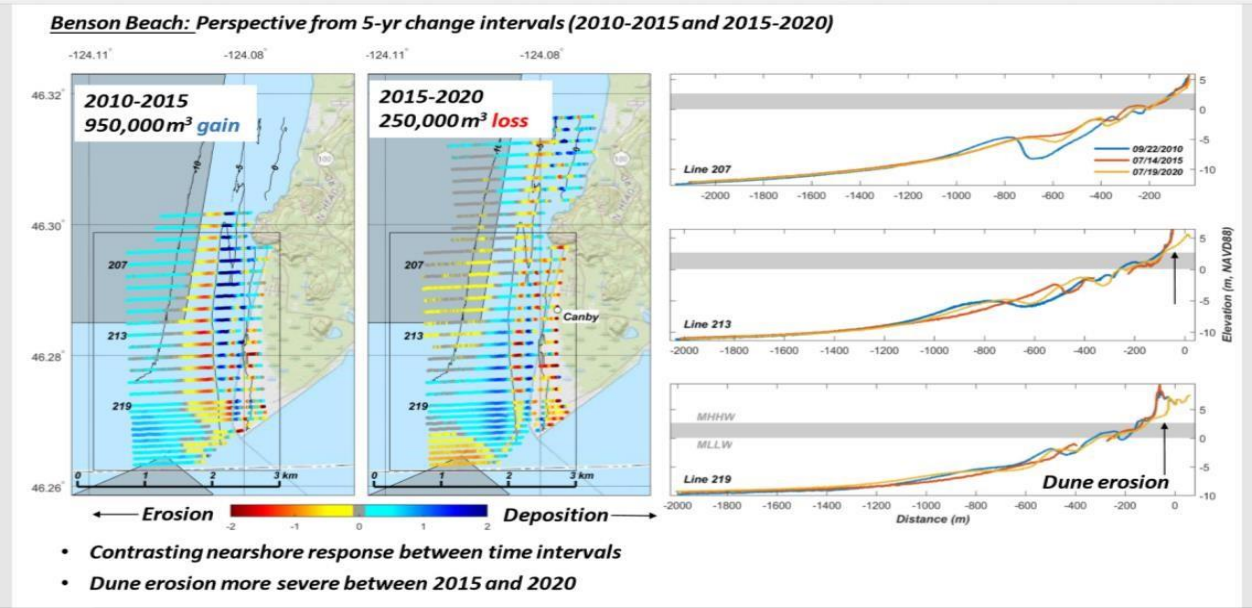
- *Beach volume increasing about 90,000 m³/yr since 2017*
- *Nearshore volume increased in 2020, but recent gains not enough to reverse effects of steady erosion of past few years*
- *2020 dune heights 0.5 to 1 m lower than 2014*



Benson Beach

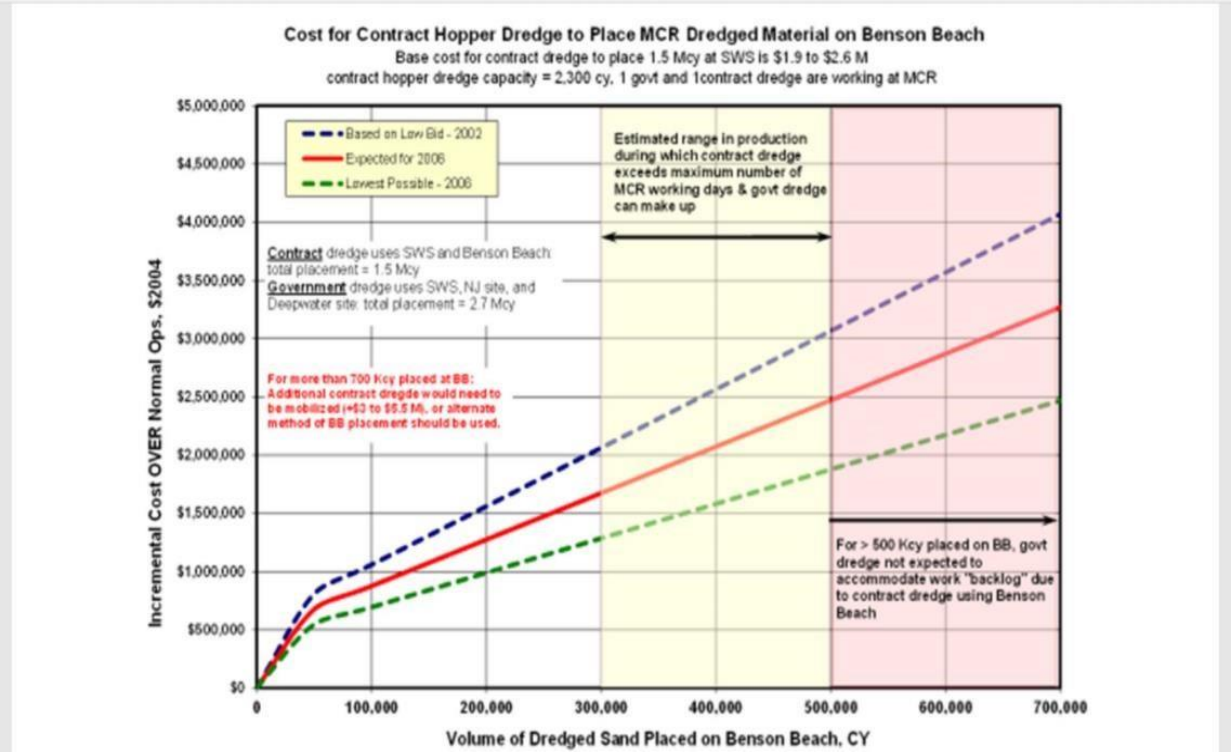
- *Benson beach accumulated about 900,000 m³ between 2019 and 2020 surveys*
- *Widespread accumulation in nearshore associated with prominent sandbar*
- *Is volume gain in nearshore related to changes in dredge placement?*





- As demonstrated by the NHS Pilot Placement Phase III, sand placed within the NHS disperses toward the beach, suggesting that placing dredged material between the NHS and SWS may most efficiently enhance the sediment budget of Benson Beach. However, there is a question of whether nearshore placement will have little, if any, impact on erosion at Benson Beach. There are also significant operational constraints due to the dangerous wave conditions in the area.
- It has not been determined what volumes of placement in the nearshore are necessary to make a difference on the beach and whether such volumes are achievable without causing mounding and inducing wave amplification.
- The need for onshore placement at Benson Beach can be justified based on safety and economic concerns, including loss of camping/other park infrastructure, loss of State Park revenues, safety to the public, etc.
- Past onshore placements at Benson Beach have had only short-term benefits; a program of ongoing onshore placement is needed to ensure longer-term benefit. Onshore placement needs to be coupled with strategies such as sand fencing to keep the sand in place.
- The prior Benson Beach onshore placement permit has expired and would need to be redone.
- The Corps indicates that, given operational and funding efficiencies, onshore placement at Benson Beach is best undertaken in conjunction with nearshore placement at NHS.

- At this time, pump ashore with a hopper seems to be the best technology. Its high cost ($1.9 - $2.6 million) is made especially challenging by the Corps' incremental cost policy.



- Much of the added cost for pump ashore is the mobilization and dismantling of the pipe infrastructure. In some parts of the country, the infrastructure is in place to pump ashore as needed. The MCR wave environment makes operation and maintenance of such infrastructure challenging. A more efficient and cost-effective approach would likely be to have a dedicated second contract dredge just to pump ashore; however, the cost of such a vessel would be exorbitant.
- The Portland District includes a Benson Beach onshore placement project in its budget request every year but it is not funded apparently because it is not directly tied to navigation needs. The squeaky wheel approach and unified messaging are needed to successfully compete for funding. Corps staff indicates that a best case scenario for funding is 2022, with 2023 more likely. An updated Water Quality Certification will be needed and cost sharing with Washington will likely be required unless the case can be made that placement is directly related to protecting the North Jetty.
- Regional efforts to bundle onshore projects in other areas along the Washington and Oregon coasts may reduce the mobilization costs on individual projects. However, this level of coordination and operation would require additional investment by the states and partnership with the Corps' Seattle District. Washington and Oregon Coastal Zone Management Programs are interested in taking steps to explore these opportunities as

funding allows. Pilot programs such as WRDA Section 1122 may also be options for one-time funding for onshore placement at Benson Beach.

- Increasing the volume of placement at the SWS at the end of the North Jetty may help reduce erosion at Benson Beach, but this has not yet been assessed. The current reconstruction of 200 feet of the North Jetty seaward may also help redirect sand to the Benson Beach area.

Management Direction

There is broad support for onshore beach nourishment along Benson Beach north of the North Jetty intended to minimize erosion at Benson Beach and Peacock Spit and allow for beach accretion. The priority strategy identified at the LCSG's January 2020 science/policy workshop is to compete for available federal funding for an onshore placement project. A work package for onshore placement was included in the Portland District's 2022 and 2023 budget request.

The strategy for competing for federal funding includes Corps/LCSG coordination on a funding request, development of unified messaging, and advocacy with Corps leadership, the Congressional delegation and other elected officials. Identifying and quantifying the potential losses and impacts of continuing erosion, as well as the environmental, economic, and social benefits of onshore placement, need to be part of that strategy.

In conjunction with seeking federal funding, the LCSG has agreed that it needs to continue to address how best to overcome the funding hurdle of having to pay the incremental cost above the standard cost for placement, especially if the Portland District is unsuccessful in obtaining full funding for onshore placement.

The need has also been identified for a feasibility evaluation that addresses the options for onshore placement, including semi-permanent pumping station, large capacity barge placement, etc.

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4. Clatsop Spit Onshore Site

Description

This beach nourishment site is located south of the South Jetty along Clatsop Spit in Oregon. Material deposited onshore in this beneficial use site is intended to build up the immediate shoreline to address concerns that a breach of Clatsop Spit could be caused by significant storm events and attendant wave action. Presently, new sediment flushed from the MCR is blocked by the South Jetty from reaching the Clatsop Spit shoreline. As a result, this shoreline is receding without the input of sediment into the littoral zone. The protective system of bars parallel to the shoreline is diminishing in size, reducing their wave breaking effects and posing an erosion risk to the spit and the South Jetty.

Portion of South Jetty and Northern End of Clatsop Spit

While information specific to placement at this site is more limited than for the other beneficial use sites, it is assumed that placement would occur in an area(s) proximate to the South Jetty and especially vulnerable to potential breaching. Consultation will be needed with Oregon Parks and Recreation Department (OPRD) on minimizing effects on clamming and other recreation uses. Additionally, the vicinity of this beneficial use site could be considered in the future for designation as a Western snowy plover managed area if additional habitat is required in order to implement the Western Snowy Plover Habitat Conservation Plan (USFWS, August 2010).

The beaches from Clatsop Spit south to Seaside are the most productive razor clam digging along the Oregon Coast. The abundance of razor clams on Clatsop Spit varies depending on the areas of the beach where larval clams settle. Razor clams tend to be larger on the southern end of Clatsop Spit than those on its northern end.

History of Use

To protect and stabilize the north end of the Clatsop Spit foredune adjacent to the South Jetty, the Corps constructed a "dynamic revetment" or berm in 2013. This area was identified in a 2016 science/policy workshop as the most vulnerable portion of the shoreline south of the South Jetty to potential breaching of Clatsop Spit's foredunes with a series of severe storms. More than 30,000 cy of gravel and cobble stones were deposited in a cul-de-sac-shaped berm

arcing 1,100 feet along the coastline. The berm is intended to emulate a natural, gravelly beach. The larger rocks in the berm move onshore in the face of waves and high tides, as opposed to sand being pulled offshore. A 2018 monitoring study indicated that the berm is functioning well in helping to stabilize the area. While the berm eroded more than 60 feet inland near the jetty, in a sacrificial area on the northern end, the structure has withstood multiple storm events. The project has an expected life cycle of 30-50 years, but will need more material added every 10-15 years, depending on the severity of future storms.

Dynamic Revetment Project, Base of South Jetty

At this time, no placement of dredged materials or associated research activities are proposed for this beneficial use site.

Management Direction

This Mouth of the Columbia River RSMP retains the Clatsop Spit onshore site as a potential beneficial use site within the Plan's network of sites. It is recommended that concept planning for future onshore placement activities be initiated as part of the renewal of Oregon's water quality certification process in 2022.

APPENDIX C
BIBLIOGRAPHY

The following list of references and background documents has been copied from the 2011 RSMP. Supporting materials used in preparation of this 2021 Update are posted as part of meeting summaries and presentations made at LCSG meetings held subsequent to completion

of the 2011 RSMP and are posted on the LCSG website: https://lowercolumbiasolutions.org/
Allan, Catherine, and George H. Stankey (2009). *Adaptive Environmental Management: A Practitioner's Guide*. The Netherlands: Dordrecht.

Allan, J.C., Komar, P.D. 2000. Are ocean wave heights increasing in the eastern North Pacific, *EOS, Transactions American Geophysical Union*, 81 (47), 561, 566–567.

Allan, J.C., Komar, P.D. 2002. Extreme storms in the Pacific Northwest coast during the 1997–98 El Niño and 1998–99 La Niña, *Journal of Coastal Research*, 18 (1), 175–193.

Allan, J.C., Komar, P.D. 2006. Climate controls on US West Coast erosion processes, *Journal of Coastal Research*, 22, 511–529.

Ballard, R.L. 1964. Distribution of beach sediment near the Columbia River, University of Washington, Department of Oceanography, Technical Report 98, 82 pp.

Braun, G.M. 2005. "White Paper: Benthic Infauna at the Mouth of the Columbia River." Prepared for the Institute for Natural Resources, Oregon State University. Tetra Tech ED, Inc., Bothell, Washington. May 2005.

Buijsman, M.C., Kaminsky, G.M., Gelfenbaum, G. 2003. Shoreline change associated with jetty construction, deterioration, and rehabilitation at Grays Harbor, Washington. *Shore and Beach,* 71, 15–22.

Buijsman, M.C., Kaminsky, G.M., Gelfenbaum, G. 2003. Shoreline change associated with jetty construction, deterioration, and rehabilitation at Grays Harbor, Washington, *Shore & Beach*, 71 (1), 15–22.

Buijsman, M.C., Ruggiero, P., Kaminsky, G.M. 2001. Sensitivity of shoreline change predictions to wave climate variability along the southwest Washington coast, USA, *Proceedings of Coastal Dynamics '01*, ASCE, 617–626.

Buijsman, M.C., Sherwood, C.R., Gibbs, A.E., Gelfenbaum, G., Kaminsky, G.M., Ruggiero, P., Franklin, J. 2003. Regional sediment budget of the Columbia River littoral cell, USA: Analysis of bathymetric- and topographic-volume change, *U.S. Geological Survey Open File Report* 02-281, 140 pp.

Byrnes, M.R. and S. Griffee. 2006. "Regional Sediment Transport Patterns Relative to Engineering Activities at the Mouth of the Columbia River, Washington/Oregon-Final Report". Prepared for USACE-Portland District by Applied Coastal Research and Engineering, Inc, Mashpee, Massachusetts.

Cowell, P.J., Stive, M.J.F., Niedoroda, A.W., de Vriend, H.J., Swift, D.J.P., Kaminsky, G.M., Capobianco, M. 2003. The coastal-tract (Part 1): A conceptual approach to aggregated modeling of low-order coastal change, *Journal of Coastal Research*, 19 (4), 812–827.

Cowell, P.J., Stive, M.J.F., Niedoroda, A.W., Swift, D.J.P., de Vriend, H.J., Buijsman, M.C., Nicholls, R.J., Roy, P.S., Kaminsky, G.M., Cleveringa, J., Reed, C.W., de Boer, P.L. 2003. The coastal-tract (Part 2): Applications of aggregated modeling to lower-order coastal change, *Journal of Coastal Research*, 19 (4), 828–848.

Environmental Protection Agency, Region 10, and U.S. Army Corps of Engineers, Portland District. 2005. Final Site Management/Monitoring Plan: Mouth of the Columbia River, Shallow Water Site and Deep Water Site. USEPA Section 102, Ocean Dredge Material Disposal Sites.

Environmental Tracing Systems Ltd 2007. Sediment Tracer Study Ocean Dredged Material Disposal Site, Mouth of Columbia River. Data Report. On behalf of U.S. Army Corps of Engineers (Portland District) and Moffatt & Nichol Engineers. February.

Environmental Tracing Systems Ltd 2007. Sediment Tracer Study Ocean Dredged Material Disposal Site, Mouth of Columbia River. Addendum to Data Report. On behalf of U.S. Army Corps of Engineers (Portland District) and Moffatt & Nichol Engineers. November.

ETS Limited 2011. South Jetty Dredged Material Disposal Site -- Sediment Tracer Study, Mouth of Columbia River. On behalf of U.S. Army Corps of Engineers (Portland District) and Moffatt & Nichol Engineers.

Gailani, J. Z., Smith, J. W., Kraus, N. C., McGee, D. D., Hands, E. B., Mayers, C. J., Moritz, H. R., Siipola, M. D., Slocum, D. B., Byrnes, M. R., Li, F., Dibble, T. L., Hollings, W. H., Lund, C., Sollitt, C. K., Standy, D. 2003. Monitoring dredged material disposal at mouth of Columbia River, Washington/Oregon, USA. Tech. rep., ERDC/CHL TR-03-05, U.S. Army Engineer Research and Development Center, Vickburg, MS.

Gelfenbaum, G.R. and G. Lesser. 2005. “Progress toward a Verified Sediment Transport Model for the Columbia River Estuary.” U.S. Army Corps of Engineers Portland District and Washington Department of Ecology by U.S. Geological Survey, Menlo Park, California.

Gelfenbaum, G., Lacy, J., Sherwood, C., Wilson, D., Chisholm, T. 2005. Estimating hydrodynamic roughness in a wave-dominated environment with a high-resolution acoustic Doppler profiler. *Journal of Geophysical Research*, Vol. 110.

Gelfenbaum, G., Buijsman, M.C., Sherwood, C.R., Moritz, H.R., Gibbs, A.E. 2001. Coastal evolution and sediment budget at the mouth of the Columbia River, USA, *Proceedings of Coastal Dynamics ’01*, 818–827.

Gelfenbaum, G., Roelvink, J.A., Meis, M., Buijsman, M., Ruggiero, P. 2003. Process-based morphological modeling of Grays Harbor inlet at decadal timescales, *Proceeding of Coastal Sediments ‘03*, East Meets West Productions, CD-ROM, 13 pp.

Gelfenbaum, G., Sherwood, C.R., Peterson, C.D., Kaminsky, G.M., Buijsman, M., Twichell, D.C., Ruggiero, P., Gibbs, A.E., Reed, C. 1999. The Columbia River littoral cell: a sediment budget overview, *Proceedings of Coastal Sediments ‘99,* 1660–1675.

Gibbs, A., Gelfenbaum, G., 1999. Bathymetric change off the Washington-Oregon coast, *Proceedings of Coastal Sediments ‘99*, 1627–1642.

Gregoire, C.O., T.R. Kulongoski, and A. Schwarzenegger. 2008. “West Coast Governors’ Agreement of Ocean Health: Action Plan.” Prepared by the office of the Governors of Washington, Oregon, and California.

Hickey, B., Geier, S., Kachel, N., MacFadyen, A. 2005. A bi-directional river plume: The Columbia in summer, *Continental Shelf Research*, 25, 1631–1656.

Holling, C. S. (ed.) 1978. *Adaptive Environmental Assessment and Management*. Chichester: Wiley.

Jenkins, M. 2009. Running the Bar: Steering Ships Through a Treacherous Waterway. *Smithsonian Magazine*, February 2009

Kaminsky, G.M., Buijsman, M., Gelfenbaum, G., Ruggiero, P., Jol, H.M., Gibbs, A.E., Peterson, C.D. 1999. Synthesizing geological observations and processes-response data for modeling coastal change at management scale, *Proceedings of Coastal Sediments '99*, 1660–1675.

Kaminsky, G.M., Buijsman, M.C., Ruggiero, P. 2001. Predicting shoreline change at decadal scale in the Pacific Northwest, USA, *Proceedings of the 27th International Conference on Coastal Engineering*, 2400–2413.

Kaminsky, G.M., Ferland, M.A. 2003. Assessing the connections between the inner shelf and the evolution of Pacific Northwest barriers through vibracoring, *Proceedings of Coastal Sediments '03*, East Meets West Productions, CD-ROM, 12 pp.

Kaminsky, G.M., Ferland, M.A., Cowell, P.J., Moritz, H.R., Ruggiero, P. 2007. Shoreface response to sediment deficit, *Proceedings of Coastal Sediments '07*, 633–646.

Komar, P.D., Li, M.Z. 1991. Beach placers at the mouth of the Columbia River, Oregon and Washington, *Marine Mining*, 10 (2), 171–187.

Lacy, J.R., Sherwood, C.R., Wilson, D.J., Chisholm, T.A., Gelfenbaum, G.R. 2005. Estimating hydrodynamic roughness in a wave-dominated environment with a high resolution acoustic Doppler profiler, *Journal of Geophysical Research*, 110 (C06014), DOI 10.1029/2003JC001814.

Landerman, L.A., Sherwood, C.R., Gelfenbaum, G., Lacy, J., Ruggiero, P., Wilson, D., Chisholm, T., Kurrus, K. 2004. Grays Harbor Sediment Transport Experiment Spring 2001—Data Report, U.S. Geological Survey Data Series Report 98.

McKillip, D.J. 2007. "Overview of the Historical and Ongoing Changes around the North and South Jetties at the Mouth of the Columbia River: A Preface to Regional Sediment Management." Prepared for the U.S. Army Corps of Engineers Portland District.

Moritz, H.R., Moritz, H.P., Hays, J.R., Sumerell, H.R. 2003. 100-years of shoal evolution at the Mouth of the Columbia River: Impacts on channel, structures, and shorelines, *Proceedings of Coastal Sediments '03*, East Meets West Productions, CD-ROM, 14 pp.

Moritz, H.R. 2003. "Mouth of the Columbia River, Shallow Water Ocean Dredged Material Disposal Site, Supplemental Evaluation of Optimized Site Utilization and Assessment of Potential Wave-related Impacts." Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, WA, by the U.S. Army Corps of Engineers, Portland, Oregon.

Moritz, H.R., G.R. Gelfenbaum, G.M. Kaminsky, N.C. Kraus, P. Ruggiero, J. Oltman-Shay, and D.J. McKillip. 2007. "Implementing Regional Sediment Management to Sustain Navigation at an Energetic Tidal Inlet." Proceedings of the Sixth International Symposium on Coastal Engineering and Science of Coastal Sediment Process, pp. 1768-1786.

Osborne, P., J. Cote, N. MacDonald, and W. Chen. 2007. “Measurements and Modeling of Waves, Currents, Sediment Transport at MCR and Benson Beach Nearshore”. Presented at the Sediment Trends in SW Washington Nearshore Zone Workshop, Ilwaco, WA. July 2007.

Pacific International Engineering. 2008. Southwest Washington Littoral Drift Restoration: Pilot Dredged Material Placement Site. Technical Memo. August 6.

Pearcy, W.G. 2005. “Final White Paper: Distribution and Abundance of Marine Fishes.” Prepared for the Institute for Natural Resources, Oregon State University. College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon. May 2005.

Pearson, W.H. 2005. “Issues Concerning Dungeness Crabs and the Demonstration Project for the Columbia River Nearshore Beneficial Use Project.” Prepared for the Institute for Natural Resources, Oregon State University. Marine Sciences Laboratory, Sequim, Washington. May 2005.

Ruggiero, P., G.M. Kaminsky, G.R. Gelfenbaum, and H.R. Moritz. 2006. “Beach Monitoring of Benson Beach 1997-2006: Quantifying Nearshore Morphological Change in Support of Regional Sediment Management”. Draft Data Series Report 06-USGS prepared by the U.S. Geological Survey, Menlo Park, California.

Ruggiero, P., List, J., Hanes, D. M., and Eshleman, J. 2006. Probabilistic Shoreline Change Modeling, 30th International Conference on Coastal Engineering. San Diego, California. American Society of Civil Engineers.

Ruggiero, P., Kaminsky, G.M., Gelfenbaum, G., Voigt, B. 2005. Seasonal to interannual morphodynamics along a high-energy dissipative littoral cell, *Journal of Coastal Research*, 21 (3), 553–578.

Ruggiero, P., Kaminsky, G.M., Gelfenbaum, G. 2003. Linking proxy-based and datum-based shorelines on a high-energy coastline: implications for shoreline change analyses, *Journal of Coastal Research*, SI 38, 57–82.

Ruggiero, P., Kaminsky, G.M., Komar, P.D., McDougal, W.G. 1997. Extreme waves and coastal erosion in the Pacific Northwest, *Proceedings of Waves ’97*, 947–961.

Sherwood, C.R., Jay, D.A., Harvey, R.B., Hamilton, P., Simenstad, C.A. 1990. Historical Changes in the Columbia River Estuary, *Progress in Oceanography*, 25, 299–352.

Sternberg, R.W., Creager, J.S., Johnson, J., Glassley, W. 1979. Stability of dredged material deposited seaward of the Columbia River mouth, in: Palmer, H.D., Gross, M.G. (Eds.), Ocean Dumping and Marine Pollution: Geological Aspects of Waste Disposal, Dowden, Hutchinson and Ross, Stroudsburg, pp. 17-49.

U.S. Army Corps of Engineers Engineer Research and Development Center. 2003. “Regional Sediment Management Program Project Brief: RSM Demonstration at Mouth of Columbia River, Oregon-Washington.” ERDC/RSM-DB7. June 2003.

U.S. Army Corps of Engineers, Portland District 2010. *Mouth of the Columbia River – North Jetty, South Jetty, and Jetty A Barge Offloading Facilities. Level 1 Sediment Evaluation.* CENWP-EC-HR. July.

Vavrinec, J., N.P. Kohn, K.D. Hall, and B.A. Romano. 2007. “Effects of Burial by the Disposal of Dredged Materials from the Columbia River on Pacific Razor Clams (*Siliqua patula*).” Final Report Prepared for the U.S. Army Corps of Engineers, Portland District under a Related Services Agreement with the U.S. Department of Energy Contract DE-AC05-76RL01830. January 2007.

Woxell, L.K. 1998. “Prehistoric Beach Accretion Rates and Long-Term Response to Sediment Depletion in the Columbia River Littoral System, USA”. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology, Portland State University, 1998.