ADVANCING SEDIMENT SOLUTIONS IN THE SEVEN MILE ISLAND INNOVATION LABORATORY

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In 2019, the U.S. Army Corps of Engineers (USACE) Philadelphia District partnered with the State of New Jersey, The Wetlands Institute, and the USACE Engineer Research and Development Center to launch the Seven Mile Island Innovation Laboratory (SMIIL). The initiative is designed to advance and improve dredging and marsh restoration techniques in coastal New Jersey through innovative research, collaboration, knowledge sharing and practical application. SMIIL efforts are enhancing the science and engineering that supports dredging and beneficial use placement practices by clearing shoals from the federal New Jersey Intracoastal Waterway for navigation and innovatively placing that sediment on multiple sites described herein. Regional Sediment Management and Engineering with Nature principles and practices serve as a strong foundation for SMIIL actions. Efforts are successfully evolving the practice and advancing techniques for beneficial use of dredged channel sediments with innovative placements that support coastal resilience for habitats and communities.

Keywords: beneficial use of dredged material, natural infrastructure, Regional Sediment Management, Engineering with Nature, coastal resilience

INTRODUCTION

The United States Army Corps of Engineers (USACE), Philadelphia District has been participating in the national Regional Sediment Management (RSM) and Engineering with Nature (EWN) Programs with considerable lessons learned developed for channel dredging and placement activities in coastal New Jersey (NJ), especially since Superstorm Sandy devastated the region in 2012. Navigation managers from the Philadelphia District continue to partner with USACE's Engineering Research and Development Center (ERDC), the State of NJ's Department of Environmental Protection (NJDEP), stakeholders such as The Wetlands Institute (TWI), and the dredging industry to utilize EWN and RSM strategies in an innovative regional approach to restore navigation as well as enhance coastal resilience. Over the last decade, beneficial use placements of dredged material involving shoreline stabilization, natural infrastructure creation and marsh restoration have significantly increased in the region, helping to advance practices and policies that keep dredged material in the natural sediment system versus past disposal methods. In addition to the navigation mission, the Philadelphia District maintains a robust beach nourishment program along the NJ and Delaware coasts and serves as an EWN Proving Ground.

Following Superstorm Sandy, USACE and NJDEP took action to restore navigation and remove channel shoals, but also looked for opportunities to assist with shoreline and ecosystem recovery. Simultaneously, long-term strategies were sought to build a more resilient coastal system using clean dredged sediment of all types. Initial pilot projects were constructed on degraded marsh within NJDEP's Cape May Coastal Wetlands Wildlife Management Area using NJ Intracoastal Waterway (NJIWW) channel sediments, including thin-layer placement with predominantly fine-grained material near Avalon and habitat creation for endangered nesting birds with fine sand on Ring Island (Chasten et al. 2016).

The creation of the Seven Mile Island Innovation Laboratory (SMIIL) followed the initial pilots and has evolved the practice of beneficial use of dredged material (BUDM) in the region by expanding applications, developing new tools, addressing regulatory questions to reduce barriers, improving our understanding of risks and benefits, and increasing the acceptance of innovative BUDM projects using a science-based approach. Through the SMIIL, a systems approach is advancing techniques for dredging, managing and placing sediment, making the region a think tank to develop and demonstrate new methods and tools while providing a forum for sharing experience and knowledge. The concept brings technical and social domains together in a collaborative forum that advances science, practice, and innovation to preserve marsh integrity and enhance resilience for the natural resources in the region and surrounding communities.

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CREATION OF THE INNOVATION LABORATORY

In 2019, the Philadelphia District partnered with NJDEP, TWI, and ERDC to launch the Seven Mile Island Living Laboratory (Rochette et al. 2019), a concept adapted from the "Living Lab for Mud" used in the Netherlands (Ecoshape 2018). The initiative is designed to continue to improve dredging and marsh restoration techniques in coastal NJ through innovative research, collaboration, knowledge sharing and practical application for constructed projects. The name was quickly upgraded to an Innovation Laboratory (SMIIL) to reflect the expanding scale of the program. The location was chosen because: it is a marsh-dominated Atlantic back barrier system in a region rich in historic datasets; builds on ongoing collaboration and research between the Philadelphia District and ERDC; TWI is centrally located within SMIIL to provide technical expertise, field support and public outreach; federal and state navigation channels have sandy and cohesive sediment as a resource; it contains a number of historic and recent monitored innovative beneficial use projects; and a significant amount of land there is managed by the State of NJ. A SMIIL Working Group creates an opportunity for practitioners and natural resource managers to provide input, learn, and share expertise, manage challenges, and bring science and practice to the SMILL to better understand the system, tradeoffs and approaches.

BUILDING MOMENTUM THROUGH SMIIL

The SMIIL concept brings technical and social domains together in a collaborative forum that advances science, practice, and innovation for the region. Through key partnerships, monitoring, design, construction and adaptive management, SMIIL efforts evolved to a new level with follow-on projects that used both sand and cohesive channel sediments to build and trial new nature-based solutions. Tedesco et al. (2021) provides a summary of projects including the initial pilots at Avalon and Ring Island and the follow-on projects at Great Flats, Sturgeon and Gull Islands (Figure 1 and Table 1).

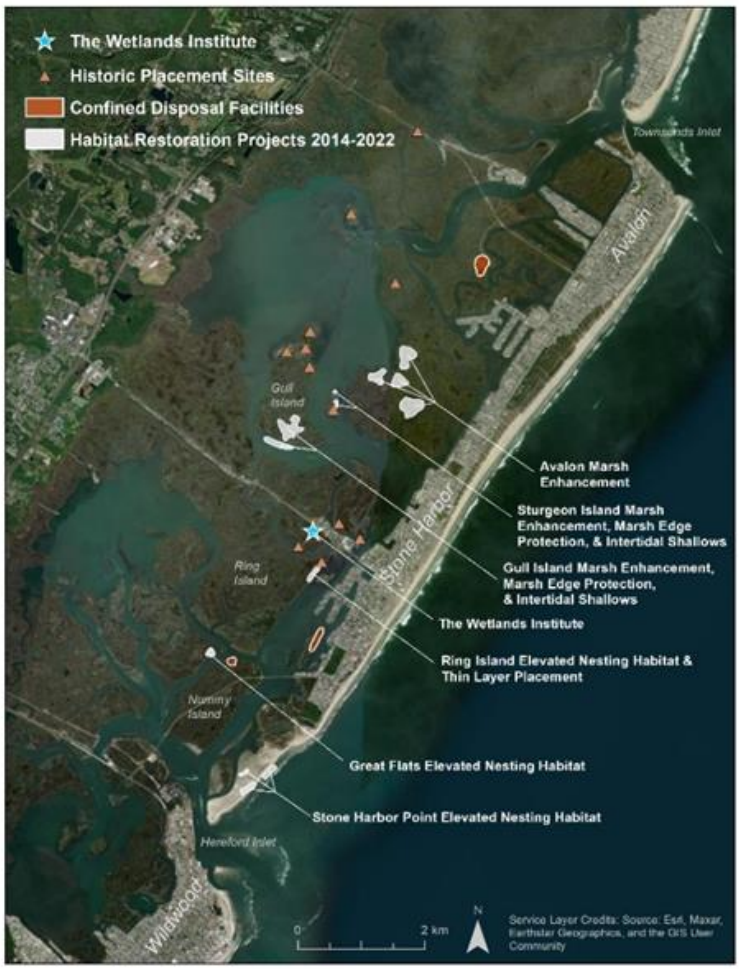

Figure 1. Map of BUDM projects in SMIIL. Summarized in detail in Table 1.

Table 1. Summary of BUDM projects in the Seven Mile Island Innovation Lab

Project *funding (year(s))*	Volume of Sediment (acreage)	Placement Methods	Sedi-ment Type	Project Goals and Outcomes
Sturgeon Island Restoration *USACE (2020/2022)*	15,291 m^3 /18,349 m^3 (elevation: 2.43 hectares / edge protection: 1.42 hectares)	• Split (via y-valve) direct on marsh. Distribution pipe & spray. Partial then full containment. • Direct off marsh edge w/ distribution pipe & floating discharge pipe. • Indirect thru tidal channels.	Mixed, mud & fine sand	• Marsh elevation enhancement for wading bird nesting habitat. • Tidal delta enhancement. • Subtidal placement berm for marsh edge protection. • Ongoing monitoring of elevation, site usage and vegetation establishment.
Gull Island Restoration *USACE (2020)*	30,582 m^3 (elevation: 8.90 hectares/ edge protection: 2.23 hectares)	• Split (via y-valve) direct: – On marsh, uncontained, spray nozzle. – Off marsh edge, floating pipe w/ spreader plate. • Indirect thru tidal channels.	Mixed, mud & fine sand	• Enhanced marsh elevation for high marsh nesting birds. Marsh restoration across range of elevation goals. • Subtidal placement berm for marsh edge protection. • Turbidity impacts were localized, short lived, & on scale of storm levels.
Great Flats Nesting Habitat *USACE (2018/2021)*	4,587 m^3/ 2,294 m^3 (0.49 hectares)	• Direct on marsh to create sandy containment berm. Build to target elevation.	95% fine-medium sand	• Build transitional early successional upland habitat for colonial beach nesting birds. • Planned adaptive management to reestablish elevation and disturb vegetation on roughly 3-year cycle.
Ring Island Marsh Enhancement and Nesting Habitat *USACE /NFWS (2015/2018)*	5,352 m^3/917 m^3 (0.81 hectares)	• Direct, spray from barge at marsh edge; no containment. • Direct, spray from barge at marsh edge with grading and containment	95% fine-medium sand	• Build transitional early successional upland habitat for colonial beach nesting birds. • Planned adaptive management to reestablish elevation and disturb vegetation on roughly 3-year cycle.
Avalon Marsh Enhancement *USACE /NFWS (2015-2016)*	42,051 m^3 (18.21 hectares)	• Direct pumping on marsh with spreader plate. • Containment with coir logs.	mud & fine sand	Placement over 2 years into fully contained areas for elevation enhancement and pool infilling.

Sand-based projects include elevated nesting habitat creation, thin layer placement, and marsh edge protection features. The creation of elevated nesting habitat for threatened and endangered beach-nesting birds involved habitat tradeoffs to build elevation above storm flood elevations. Ecological considerations were used to set target elevations and the need for early successional habitat set the desire for repetitive placement to disrupt vegetation establishment. Building elevation was accomplished by uncontained pumping onto the marsh platform until sufficient material accumulated. Berms were then constructed to contain sediment to achieve transitional upland elevations at about 1.7 meters(m) North Atlantic Vertical Datum of 1988 (NAVD88). Unconfined placement allowed for thin layer accumulation (3 to 12 cm) of fine sediments on the surrounding marsh platform that were augmented with additional accumulation in localized areas that received sheet flows from dewatering of the contained placement (Figure 2). Two years post placement, site elevation had lowered by 0.6m and spread over the marsh platform through a combination of subsidence, dewatering and sand transport dominated by wind. This provided an opportunity for adaptive management providing for channel maintenance and the reestablishment of habitat elevation and early successional conditions. These sites have a 2 to 3-year return frequency that pairs repetitive maintenance dredging needs with ecological and habitat goals.

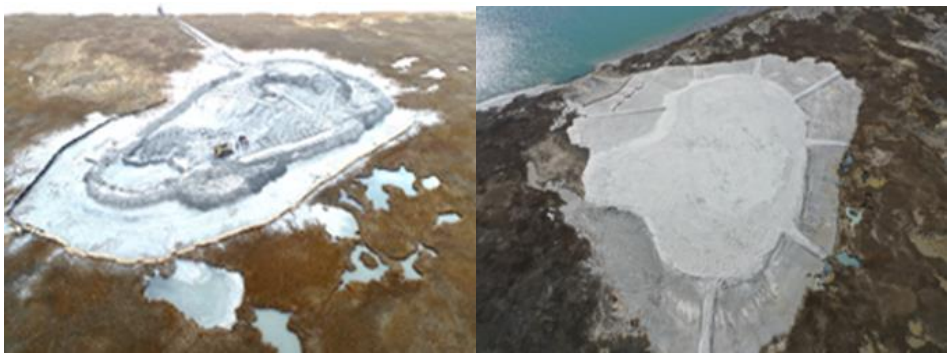

Figure 2. Sandy elevated nesting habitat at Great Flats during initial construction in 2018 (left) with placement resulting in 0.9 to 1.2m of elevation gain on the habitat area and 3-12cm of thin layer accumulation on the surrounding marsh plain. Adaptive management in 2021 (right) reestablished target elevations and early successional conditions (photos courtesy of Gary Paul).

Cohesive sediment-based projects focused on marsh elevation enhancement, marsh edge protection and intertidal shallows creation and enrichment. Gull Island and Sturgeon Island are low lying, marsh islands at risk of drowning. At each island, a suite of projects was constructed to address different ecological goals and trial new approaches (Figures 3 and 4). Projects focused on marsh elevation enhancement were minimally contained or uncontained and utilized natural elevations, pipe end positioning to maximize flow pathways, and tidal channel networks to spread material and build elevation capital. Marsh edge protection features and intertidal and subtidal shallows were constructed or enhanced using a floating pontoon for subtidal or indirect placement via tidal channels. Marsh edge protection berms resulted in 0.3 to 0.8 m of elevation gain up to the marsh edge and retained 50% of the volume 16 months post placement (Perkey et al. 2022). Initial measurements are documenting wave attenuation from the feature. Fall et al. (2022) documented low turbidity during placement that was short lived and very close to background levels for the system. Reine (2022) documented rapid recovery of benthic communities associated with the marsh edge protection berm and enhancement of intertidal and subtidal shallows.

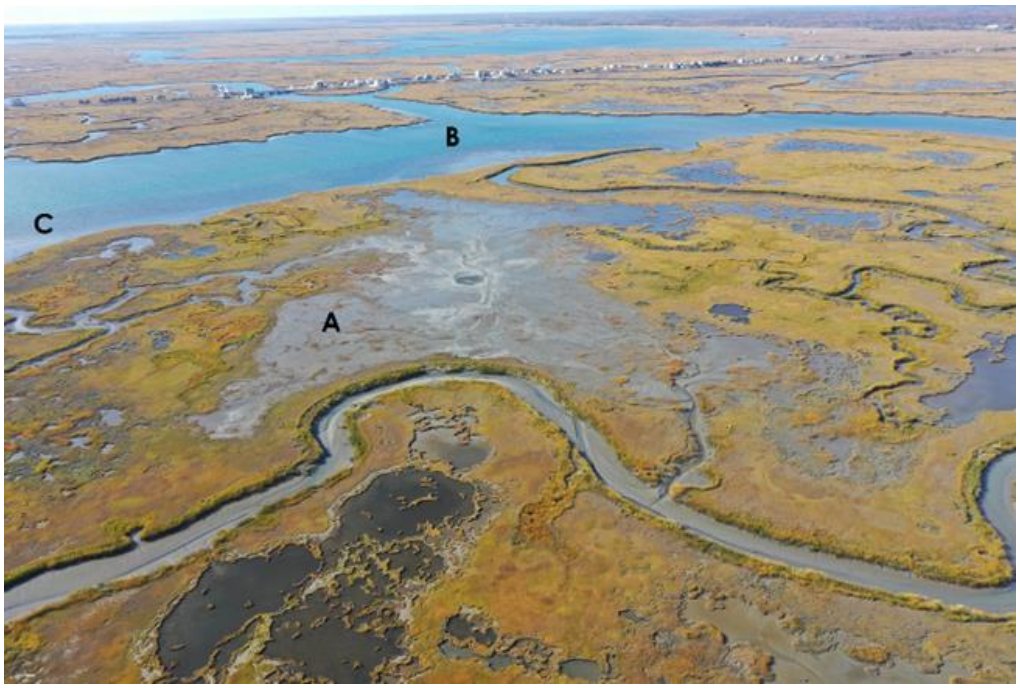

Figure 3. Constructed marsh restoration (A), marsh edge protection (B), and intertidal shallows enhancement (C) with fine sand and mud at Gull Island (photo courtesy of Gary Paul, 2020).

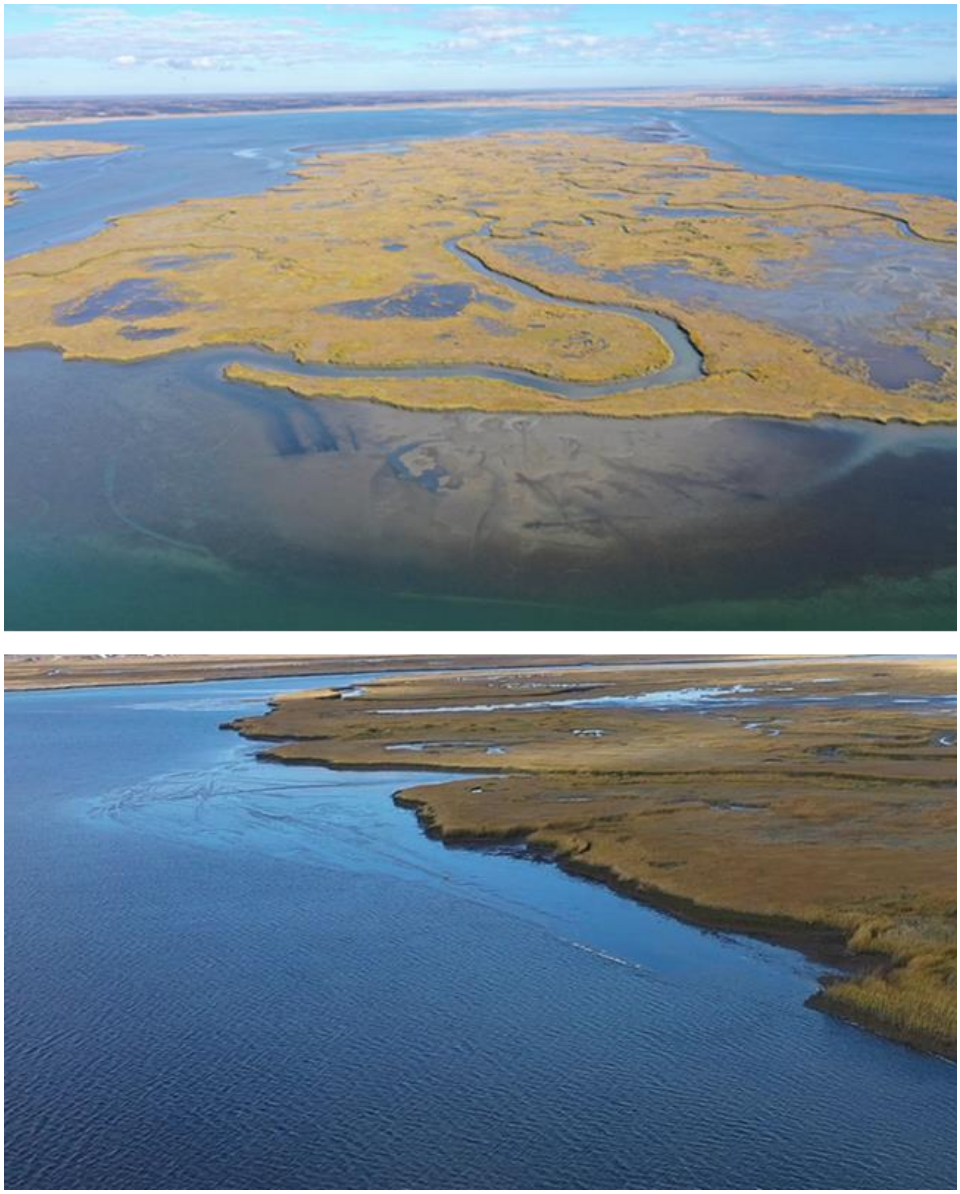

Figure 4. Marsh edge protection berm constructed via subtidal placement; 6,880 cubic meters of material resulted in wave attenuation (top photo) and intertidal and subtidal shallows were enhanced by indirect placement through tidal channels shallowing the bottom up to elevations where macroalgae flourish (bottom).

Innovative techniques including the sediment distribution pipe (Beardsley et al. 2022) were also trialed while working on building elevation on Sturgeon Island and testing marsh edge protection feature creation (Figure. 5). Marsh platforms were uplifted by 0.4 to 0.8m and after 2 years post-placement have stabilized. Vegetation has colonized larger portions of the platforms that were vegetated prior to placement, and vegetation has moved into many areas that were formerly below elevation ranges for *Sporobolus alterniflorus*. Significant vegetation establishment occurred in the second growing season post-placement predominantly via natural seed bank germination. Additional dredging and placements were completed at Sturgeon Island in the Fall of 2022. These projects used containment in the form of temporary water-filled barriers to build marsh elevation to transitional elevations for wading bird nesting, and through use of a Y-valve and pontoon system also strategically placed sandy sediments to create a sandy marsh edge protection system (Figure 6). Within three months of placement, the sandy marsh edge protection feature welded to the northern portion of the island building a sediment ramp and transporting sediments onto a portion of the marsh nourishing the marsh. Additional placements are planned for the southern portion of SMIIL in 2023, via dredging of the NJIWW channel and funded through the Bipartisan Infrastructure Law.

Figure 5. Trialing techniques to build elevation and marsh edge protection with cohesive sediments at Sturgeon Island using a sediment distribution pipe.

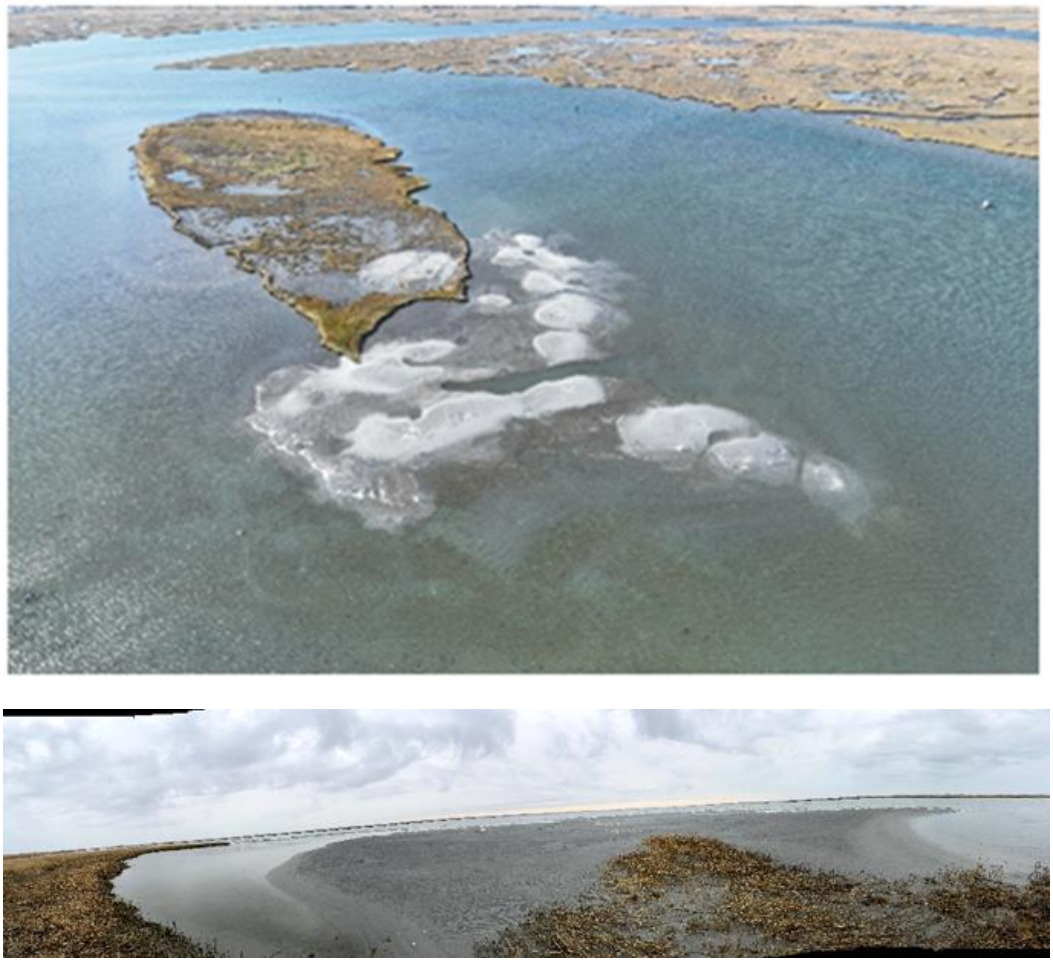

Figure 6. Strategic placement of sandy materials to build marsh edge protection feature at Sturgeon Island (top photo) and sediment welded to marsh edge and nourishing marsh with sediment 3 months post-placement (bottom).

Ongoing monitoring of the projects includes physical and geotechnical studies (elevation evolution, compaction, and dewatering; sediment transport and erosion; wave attenuation and turbidity generation {Fall et al. 2021; Fall et al. 2022}); hydrology and ecological studies (vegetation evolution, benthic community response {Reine 2022}), focal avian species response (Collins et al. 2021) and social science aspects involving communities (Thorne et al. 2022). Over 30 researchers from USACE, the State of NJ and various academic institutions are currently working on data collection and analyses for SMIIL projects and related practices. Future publications from ongoing research efforts will continue to share knowledge and encourage collaboration within SMIIL as well as regionally, nationally and internationally.

CONCLUSION

USACE is a "broker" managing sediment in federal navigation channels, a much-needed "currency" within the natural coastal system that also supports resilience of habitats and communities. Coastal New Jersey is experiencing sea level rise rates that are twice the global average, accelerating, and exceeding the accretion rates of vast areas of tidal marsh systems. Time is of the essence for advancing beneficial use of dredged material projects to create natural infrastructure and keep valuable sediment in the system versus past practices of removal and confined disposal.

Monitoring and technical advancements for channel dredging and placements continue in the Seven Mile Island Innovation Laboratory, but a primary success has been a paradigm shift leading to more BUDM implementation in New Jersey. Challenges are overcome through trust, persistence, proactive leadership, a continual focus on the best available science, and strong community engagement. All aspects have proven to be critical to moving forward, especially facing rapidly intensifying climate change impacts to vulnerable coastal environments.

Seven Mile Island Innovation Laboratory efforts are documented in a series of case studies of individual projects and within a framework of a landscape approach to dredged material management for multiple habitat benefits. Monitoring has documented and informed each project, and aids in the development of research and practical lessons learned that add to the science and practice of BUDM. Knowledge sharing is a key SMIIL goal and ongoing efforts will continue to produce guidance that can be used to advise practitioners and encourage collaboration. A rich collection of materials is available on the USACE Philadelphia District and The Wetlands Institute websites.

Moving forward, SMIIL partners will continue to innovate and build on past successes to inform best sediment management practices, encourage natural and nature-based solutions, and promote system resilience by cost-effectively and strategically keeping valuable sediment in the natural system. Additional projects developing sustainable dredging and placement techniques using NJIWW sediments are planned for 2023.

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REFERENCES

Beardsley, C., Welp, T., Harris, B., McFall, B., Tyler, Z., and Savant, G. (2022). "Sediment Distribution Pipe: Modeling Tool and Field Application," *WEDA Journal of Dredging*, v. 20 (1) 16-37.

Chasten, M., Goldberg, K., Pasquale, J., Piercy, C., Welp, T., and Golden, D. (2016). "Recent Experience with Channel Dredging and Placement to Restore Wetlands In New Jersey," *Proceedings, World Dredging Congress (WODCON) XXI.*

Collins, S., Ferguson L., Morey B., and Tedesco, L. (2021). "Cape May Wetlands Wildlife Management Area Habitat Restoration Monitoring and Evaluation," *Final Performance Report,* https://wetlandsinstitute.org/wp-content/uploads/2022/11/FG19-057_TWI_2019-2021_FINAL.pdf

Ecoshape (2018). "Living Lab for MUD" *Brochure,"* www.ecoshape.org.

Fall, K., Perkey, D., Tyler, Z., and Welp, T. (2021). "Field Measurement and Monitoring of Hydrodynamic and Suspended Sediment with the Seven Mile Innovation Laboratory, New Jersey," *ERDC/CHL Technical Report-21-9*, https://permanent.fdlp.gov/gpo185925/ERDC-CHLTR-21-9(1).pdf

Fall, K., Perkey, D., Tedesco, L., and Chasten, M. (2022). "Impact of Strategic, Unconfined, Dredged Material Placement on Turbidity Within a Shallow Back Bay System: Observations from Seven Mile Island Innovation Laboratory, NJ", *WEDA Journal of Dredging*, v. 20 (1) 38-49.

Perkey, D., Fall, K., Tedesco, L., and Chasten, M. (2022). "The Placement and Fate of Subaqueous Berms for Marsh Edge Protection and Intertidal Flats Enhancement", Working group Meeting Presentation, September, 2022. https://wetlandsinstitute.org/wp-content/uploads/2022/09/Perkey-BU-FGS-Marsh-Edge.pdf

Reine, K. (2022). "Summary of Benthic Macroinvertebrates at Gull and Sturgeon Islands, NJ, June 2020, July 2021, and August 2022," *Summary Report prepared by ERDC for the USACE, Philadelphia District.*

Rochette S., Chasten M., Tedesco, L., and Kopkash, G. (2019). "Seven Mile Island Innovation Laboratory, Overview and Purpose" *Fact Sheet,* updated fact sheet series available at www.nap.usace.army.mil; and https://wetlandsinstitute.org

Tedesco, L., Chasten, M., Ferguson, L., Collins, S., and Davis, C. (2021). "Using Dredged Sediments to Uplift Marshes, Build Subtidal Shallows and Provide Marsh Edge Protection in the Seven Mile Island Innovation Lab," *Delaware Estuary Science and Environmental Summit Presentation,* https://delawareestuary.org/delaware-estuary-science-and-environmental-summit/

Thorne, S., Kovacs, D., Gailani, J., and Suedel, B. (2022). "A Community Engagement Framework using Mental Modeling: The Seven Mile Innovation Laboratory Pilot Project, Phase 1," *ERDC/CHL Technical Report-22-12*.