Thin Layer Placement (TLP)

Executive summary

North Carolina has approximately 235,000 acres of estuarine wetlands in its coastal waters, which provide essential nursery habitat for fish species, foraging and nesting sites for shorebirds and small mammals, shoreline stabilization and erosion control, and enhance water quality through nutrient and pollutant retention. However, those estuarine wetlands are increasingly threatened by sea level rise, saltwater intrusion, and erosion, and the 2021 CHPP called for expanding collaborations between state, federal, and private partners to protect and restore impacted wetlands through nature-based solutions. This CHPP builds on those 2021 CHPP recommendations by outlining the benefits, resource impacts, and policy and permitting concerns with thin-layer placement, which is a restoration, enhancement, and resilience strategy broadly defined as the application of sediments (primarily dredged material) to coastal wetlands in order to increase elevation and surface area, promote sediment accretion, and restore impaired habitat. During development of this CHPP, DEQ staff hosted a workshop to discuss thin layer placement and to share successes, challenges, concerns, and lessons learned associated with the ecological impacts of placing sediment on deteriorating wetlands, and feedback from staff attending the workshop was incorporated into this chapter of the CHPP. The information and guidance summarized in this chapter will serve as an additional resource for regulatory and resource agency staff, commission members, restoration practitioners, and researchers as additional thin layer placement projects are proposed in North Carolina.

Introduction

Preface

Thin layer placement (TLP) is a restoration, enhancement, and resilience strategy broadly defined as the intentional application of sediments (primarily dredged material) to coastal wetlands in order to increase elevation and surface area, promote sediment accretion, and restore impaired habitat. Further defined and described in Berkowitz et al. (2019), TLP is intended to maintain a natural mosaic of low- to high- wetland habitat and support associated ecosystem functions and plant and animal communities. TLP is often proposed for wetlands experiencing low sediment supply, subsidence, and erosion that subsequently have the inability to keep pace with sea level rise and / or do not have an adequate pathway for upland migration (Fig. 1). For the purpose of this document, TLP is viewed as a tool for enhancing the resilience of existing wetlands that are susceptible to or actively drowning and experiencing vegetation loss, interior ponding, and other deteriorating conditions. TLP is not viewed as a tool for the disposal of dredged material, for the creation of new wetlands, or for the mitigation of wetland impacts made elsewhere.

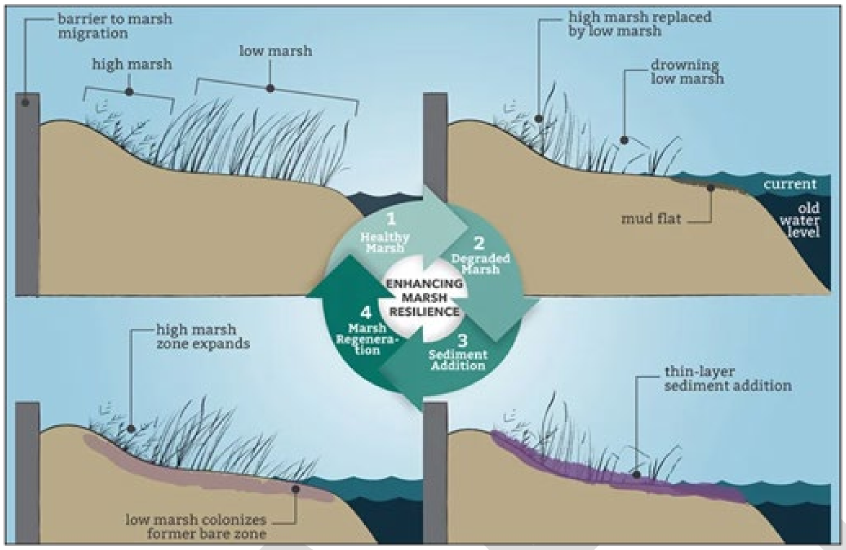

Fig. 1: Conceptual diagram of the thin layer placement process (Raposa et al. 2023).

In North Carolina, dredged material is typically disposed offshore, in upland spoil sites, or when appropriate, used for beach nourishment. However, there is growing nationwide interest in the Beneficial Use of Dredged Material (BUDM) for habitat restoration, including TLP and, while outside the scope of this document, other novel uses besides nourishment such as expanding estuarine shorelines and creating and enhancing islands and offshore artificial reefs. The 2021 CHPP amendment included preliminary discussions about TLP (see Chapter 5.3: Wetland Shoreline Protection and Enhancement with Focus on Nature-based Solutions) and recommended the development of parameters that could be used to evaluate the success of TLP in North Carolina (2021 CHPP Recommended Action 5.12).

CHPP staff, in consultation with the CHPP Steering Committee and coordinating agencies (NC Divisions of Coastal Management, Marine Fisheries, and Water Resources; Albemarle-Pamlico National Estuary Partnership; NC Coastal Reserve and National Estuarine Research Reserve), subsequently identified the need to include TLP as a priority issue for the 2026 CHPP amendment due to expressed interest and curiosity amongst several stakeholder groups including state and federal resource and regulatory agencies, landowners, conservation agencies, environmental non-profits, and local municipalities. For example, state and federal resource and regulatory agencies are interested in habitat trade-offs, resource impacts, permitting requirements, and project efficacy while landowners, municipalities, and environmental groups are interested in expanding options for restoring critical habitats that provide important ecologic and economic services.

Including TLP as a priority issue for the 2026 CHPP amendment also aligns with several conservation and restoration initiatives described in the NC Division of Coastal Management 2022-2026 Estuarine Shoreline Strategy[1], NC Division of Water Resources 2021-2025 Wetland Program Plan[2], 2024 NC Salt Marsh Action Plan and 2026 Implementation Roadmap[3], and the Albemarle-Pamlico National Estuary Partnership 2025-2030 Comprehensive Conservation and Management Plan[4].

The Evolution of TLP

The disposal of dredged material in shallow estuarine environments historically involved side casting, or the simple movement of material "to the side" or away from a given project area, to create elevated intertidal berms that facilitated the recruitment of wetland vegetation but did not necessarily support any kind of ecological function. An early rudimentary study exploring the effects of placing dredged material onto a *Spartina alterniflora* salt marsh in Brunswick, Georgia showed that within one growing season, invertebrate communities recovered and plants were able to penetrate through up to approximately 20 cm of sediment (Reimold et al. 1978). Over the past several decades, TLP has primarily involved the hydraulic dredging, liquification, and pumping of sediments through a high-pressure spray nozzle. The resulting "slurry" is subsequently applied in a rain-like consistency over the surface of a recipient wetland (Fig. 2).

[1]The 2022-2026 Estuarine Shoreline Strategy aims to explore the implementation of resilience strategies including thin layer placement and the protection of marsh migration pathways.
[2]The 2021-2025 Wetland Program Plan aims to determine status and trends in wetland acreage, condition, and functions while promoting statewide wetland restoration and protection.
[3]The 2024 Salt Marsh Action Plan and 2026 Implementation Roadmap aim to facilitate and advance salt marsh research and assessment to protect and restore existing salt marshes and improve salt marsh function, including the advancement of beneficial use tools.
[4]The 2025-2030 Comprehensive Conservation and Management Plan includes proposed actions that refine and implement regional wetland protection and restoration strategies by mapping, monitoring, and identifying critical habitats.

Fig. 2: Typical method used for thin layer placement (Image Source: U.S. Army Corps of Engineers)

TLP can also involve direct, low-pressure end-of-pipe discharge when slurry application is not feasible due to logistical or resource constraints. End-of-pipe discharge involves the distribution of sediment through passive sheet flow or the manual re-working of sediment over the wetland surface. While it can be successful (see Feigin et al. 2026), this approach often results in non-uniformity in sediment distribution because relative to fine sediments, coarser materials tend to drop out of suspension and form mounds near the discharge pipe (Davis et al. 2022; Whitbeck et al. 2019). Additionally, end-of-pipe discharge can scour the marsh surface and bury plants that are most proximate to the discharge pipe. Regardless of application method, TLP is often done in conjunction with shoreline stabilization measures (e.g., living shorelines, breakwaters, wave attenuators) that help retain material within the system. This topic is discussed further in subsequent sections.

2026 CHPP Objectives

The following sections are intended to provide a comprehensive review of existing literature (i.e., research studies and guidance documents) and large-scale case studies primarily along the east coast of the United States. This review will provide insight into lessons learned and best practices to consider for planning, implementing, and monitoring successful TLP projects. This paper will also highlight relevant TLP policies and regulations and the results from a multi-agency stakeholder workshop held on March 30, 2026 (Appendix B) that identified permitting and resource concerns, research and information needs, and knowledge gaps associated with the implementation of TLP in North Carolina.

In North Carolina, TLP remains relatively unexplored at large scales relative to other states (e.g., Georgia, Maryland, Delaware, New Jersey, New England states) that have permitted and implemented TLP projects beyond the experimental stage (see more in "Eastern U.S. Case Studies"). TLP projects are currently ineligible for permitting under the North Carolina Coastal Area Management Act (CAMA) and Dredge and Fill Law but may be approved through a variance from the NC Coastal Resources Commission (further discussed in "Regulation, Policy, and Permitting"). The information summarized throughout this document build significantly on existing guidance developed by the North Carolina Division of Coastal Management (further discussed in "Guidance Document Review") and is therefore intended to serve as a source document for regulatory and resource agency staff, commission members, restoration practitioners, and researchers as TLP projects are proposed and considered for variance. Overall, this document will ensure stakeholders are well positioned to evaluate TLP proposals and if needed, help inform next regulatory steps as determined by the Coastal Resources Commission.

Further detailed in the "Looking Ahead” and "Specific Recommended Actions" sections, we recommend future work that evaluates potential candidate areas for TLP in North Carolina. We also recommend the development of a multi-agency TLP or beneficial use workgroup to move forward TLP efforts and, if warranted, establish best practices specific to the state. Overall, the information provided in this document highlights the growing trend of implementing novel beneficial use projects within coastal ecosystems that are susceptible to negative impacts from environmental change.

Abbreviated Primary Literature Review

Experimental research within the last 10-20 years has examined the impacts of TLP on coastal wetland function to determine optimal conditions for restoration success (see short reviews by VanZomeren and Piercy 2020 and Ray 2007). Recent work has broadly considered the importance and response of sediment characteristics and biogeochemistry, the thickness or amount of applied material, target elevation and change over time, the response and recovery of plant and animal communities, and long-term resilience to sea level rise and environmental change.

Sediment Characteristics

Comparing sediment characteristics between source materials and potential recipient wetlands is one of the most important considerations associated with TLP. Traditionally, compatible source material is that which shares similar physical and chemical properties (e.g., grain size, bulk density, organic matter content) as the recipient wetland to ensure normal ecological function (sometimes referred to as "like-on-like" application). At low elevations, tidal wetlands are typically characterized by anoxic, organic and nutrient-rich fine sediments (over 90% silt + clay) with low rates of decomposition. Wetland sediments are among the most productive on Earth and support high above and below ground biomass and facilitate the accumulation of and potential long-term storage of carbon. In North Carolina, compatible source material would most likely derive from the maintenance dredging of federal or private navigation channels, canals, and other large excavation projects (e.g., marina basins, etc.).

Some evidence suggests that material compatibility is not always important. For example, Raposa et al. (2023) and VanZomeren et al. (2018) have shown that the application of coarse sediments (i.e., sand and other terrestrial sources comprised of 75% sand and 25% silt + clay) on wetland surfaces is effective at maintaining biological productivity (i.e., the growth and survival of plant and invertebrate communities) while enhancing wetland elevation and preventing further sediment loss as long as a specific range of bulk densities (i.e., the degree of sediment compaction) is maintained to support the growth of target plant species. Further, the application of coarse sediments can sequester legacy contaminants[5] within recipient wetlands especially when amended with emerging activated carbon technologies (e.g., biochar, compost, etc.). These emerging technologies are designed to enhance the adsorption and retention of pollutants (Gilmour et al. 2018; Patmont et al. 2014) and ameliorate sulfide (a toxic metabolite) accumulation in sediments (Anchor QEA 2025), though these technologies can also increase soil respiration and methane emissions without subsidizing plant growth (Wilburn et al. 2024).

There may be other risks associated with material incompatibility. While "unlike-on-like" application can effectively maintain biological communities and surface elevation, it generally takes longer for recipient wetlands to return to ambient conditions (Harris et al. 2021; La Peyre et al. 2009). For example, the application of coarse sediments impacts sediment biogeochemistry and reduces rates of carbon accumulation because coarse sediments are more oxygenated and less rich in organic matter compared to fine sediments (Wilburn et al. 2024). A mismatch in sediment properties can therefore alter wetland ecosystem services and increase greenhouse gas emissions if there is a shift from anaerobic (without oxygen) carbon accumulation to aerobic (with oxygen) carbon decomposition. Additionally, the application of coarse sediments can impact ecological

[5]In North Carolina, the contamination of sediments with heavy metals, per- and polyfluoroalkyl substances (PFAS), and other degradation-resistant chemicals are a major concern associated with TLP and the beneficial use of dredged material especially within the Cape Fear region. Since the detection of high concentrations of PFAS in the Cape Fear River about a decade ago (Sun et al. 2016), these compounds have accumulated in a wide variety of organisms and environmental media (Ehsan et al. 2023). Any proposal to use dredged sediments for TLP would therefore have to undergo enhanced scrutiny to determine the concentration, distribution, and fate of PFAS and other contaminants within a given project area. These considerations are further outlined in the "Guidance Document Review" and Resource and Regulatory Concerns" sections of this paper.

interactions even if broad metrics used to describe plant and animal communities (e.g., diversity and abundance) do not change. The application of coarse sediments, for example, can promote crab burrowing and alter other invertebrate behaviors that extend beyond typical one-to-five-year monitoring periods (Raposa et al. 2023).

Sediment Processes and Biogeochemistry

Assuming "like-on-like" material application, recent work has shown that TLP typically preserves and can even enhance belowground biomass, microbial activities, and important biogeochemical functions (e.g., carbon and nitrogen retention) relative to other types of restoration (e.g., living shorelines and rip rap revetments to control edge erosion, native plantings to stabilize existing sediment, land acquisition to facilitate wetland migration, etc.) and to wetlands not subject to TLP. The application of new material to wetland surfaces introduces organic matter and nutrients that supplement sediment microbial communities and their metabolic processes (Bartolucci and Fulweiler 2026; Cornwell et al. 2025; VanZomeren et al. 2018) but increase the risk that sulfide and other dissolved gases accumulate (Berkowitz and VanZomeren 2020). However, these processes most likely respond to an initial "fertilization effect" and ultimately diminish in the long-term before returning to ambient, though sustained, conditions over time (Morris and Staver 2024). TLP can also help maintain the role of tidal wetlands as net greenhouse gas sinks, though some studies have reported variable but enhanced methane emissions even with "like-on-like" application (Bartolucci and Fulweiler 2024; Punchkoff and Lawrence 2022). The overall effects of TLP on sediment biogeochemistry are location-specific, highly variable, and represent an area needing additional research. There is also very limited understanding of how TLP impacts microbial interactions and long-term carbon and organic matter dynamics.

Placement Volume, Elevation, and Vegetation Response

It is important to note that TLP projects are associated with an "ugly phase" characterized by temporary wetland disturbance, plant smothering, and localized increases in turbidity. Approaches to minimizing any adverse impacts from construction activities are highlighted in subsequent sections and are discussed relative to necessary trade-offs and potential long-term benefits of properly executed TLP projects. While temporary impacts are inevitable during initial sediment placement, our review of existing literature mostly shows successful plant recovery and growth after one or two growing seasons with longer recovery times (up to four years) that are typically correlated with placement volume as discussed below (Fig. 3).

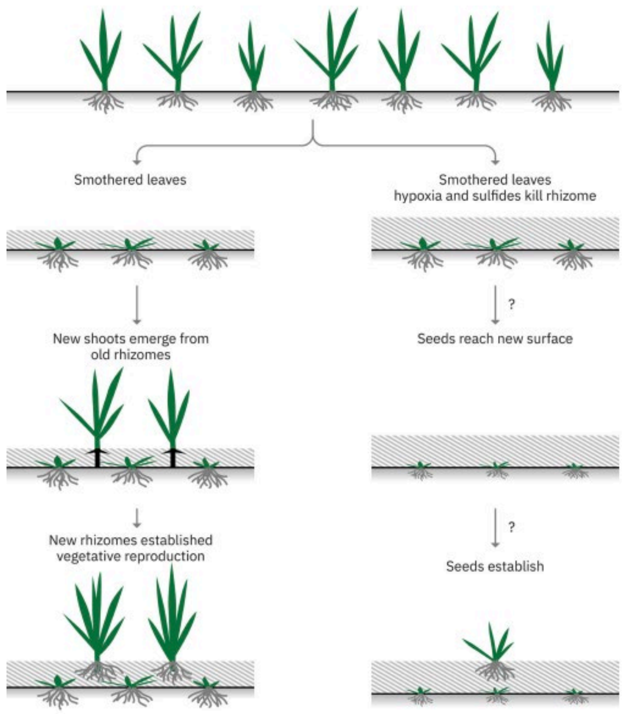

Fig. 3: Expected wetland vegetation recovery as a function of placement volume and thickness. Figure modified from Anchor QEA (2025) as adapted from Mohan et al. (2016) and Wilber and Engler (1993).

The response of wetland vegetation to sediment placement is partially dependent on the amount (volume) of material applied and may be the most important consideration and concern associated with TLP. The optimal amount or thickness of the applied sediment layer is highly project-specific and guided by the interaction between sediment characteristics, local tidal frames and resulting elevation-biomass relationships (Fig. 4; Raposa et al. 2023; Davis et al. 2022). For example, early studies in Louisiana by Schrift et al. (2008) and Slocum et al. (2005) used comprehensive multi-factorial treatment designs to test sediment applications along an elevation gradient and to compare results to control (equally degraded) and reference (goal or target condition) wetlands that received no sediment. Ultimately, the natural recovery and growth of native plant species was governed primarily by adequate tidal inundation, elevation gain, high organic matter content and bulk densities, and rhizome survival that were all sustained with sediment applications that ranged between 5-12 cm thick along the elevation gradient (Schrift et al. 2008; Slocum et al. 2005). TLP should therefore deliver enough sediment that achieves and maintains a target elevation within the intertidal zone, ideally near the mid-range between sea level and mean high water.

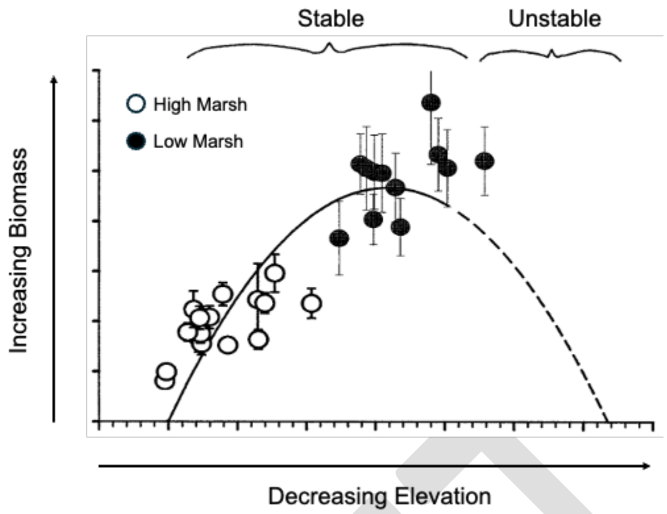

Fig. 4: The relationship between wetland elevation (horizontal axis) and plant biomass (vertical axis) within a typical *Spartina alterniflora* salt marsh. Open circles represent average measurements taken within high marsh sites while closed circles represent average measurements taken within low marsh sites. Vertical bars represent the error associated with each measurement. Overall, plant biomass peaks at certain elevations within the local tidal frame and decreases when elevation is too high (less tidal inundation) or too low (more tidal inundation or drowning). Figure modified from Morris et al. (2002) and adapted from NC DEQ (2025).

There are no absolute thresholds (e.g., 5, 10, 15 cm) that define TLP success, though previous work has demonstrated some trade-offs associated with a wide range of placement volumes and thicknesses relative to project goals and local hydrological characteristics (Appendix A). Generally, wetland vegetation and associated ecological functions recover more quickly the less material is applied, but this does not mean that longer recovery times associated with more material are indicative of unsuccessful projects. For example, Punchkoff and Lawrence (2022) and VanZomeren et al. (2018) showed that in Connecticut and New Jersey wetlands, respectively, sediment layers as thin as 5 cm increase above and belowground plant productivity and biomass, enhances carbon dioxide uptake, and reduces the potential for accumulating toxins and greenhouse gases in as little as six months. Raposa et al. (2023) showed that within a few years at several wetland sites across the National Estuarine Research Reserve System, 10 cm additions increased sediment accretion rates and elevation gain that were expected to withstand long-term subsidence compared to control sites. Stagg and Mendelssohn (2010) report similar successes with applications up to 36 cm in Louisiana wetlands. Regardless of placement thickness, plant recovery can be expedited by pre-seeding sediment slurries prior to application or with supplemental plantings after application. In some cases, 100% of post-application plantings can survive and either reach or exceed the richness and density of reference sites (Howard et al. 2020).

For projects that aim to maintain existing "low marsh" edges that sit at lower elevations within the tidal frame and less inundated "high marsh" interiors that sit at higher elevations within the tidal frame, low marshes tend to recover more quickly than high marshes regardless of placement thickness. Studies have generally shown a more positive initial response to TLP from wetlands dominated by low marsh plant species (e.g., *Spartina alterniflora*) compared to those dominated by *Spartina patens* or other higher marsh species (Raposa et al. 2023; Payne et al. 2021). Some studies also suggest that interior, low-elevation ponds within drowning wetlands might benefit the most from TLP (La Peyre et al. 2009; Mendelssohn and Kuhn 2003). However, the response to and recovery from TLP is most likely inconsistently reported across wetland elevations and species. For example, higher marsh species may simply take longer to reach similar metrics (e.g., biomass, stem density, etc.) as their lower marsh counterparts (Raposa et al. 2023). These results underscore the importance of evaluating TLP impacts on species besides *Spartina alterniflora* and establishing adequate monitoring timeframes.

Higher placement volume correlates with higher initial elevation gain and increases the likelihood that habitats convert between sub-tidal open water ponds, intertidal low and high marsh, and supratidal uplands that sit entirely above the tidal frame. For projects that aim to enhance long-term resilience to particularly high rates of sea level rise and wetland loss, habitat conversion associated with the application of large amounts of sediment could be a desirable outcome assuming created uplands eventually convert back to intertidal wetlands (Anchor QEA 2025). Habitat conversion may also be desirable to achieve project goals associated with the restoration of habitats specific to birds or other taxonomic groups. While TLP can be successful with a wide range of placement volumes, there are risks associated with over-application such as permanent smothering, over-compaction and elevation loss, excess turbidity and leakage, and lower plant productivity over time (Correll et al. 2024; Graham and Mendelssohn 2013). Elevating wetlands too high or above the appropriate tidal frame can also facilitate the colonization of invasive species such as the common reed *Phragmites australis* and reduce available fish habitat below mean high water. Additionally, final "as built" elevations are difficult to predict, particularly with issues associated with fine sediments such as excessive drainage, compaction or consolidation (Myszewski et al. 2017).

Faunal Community Response

Compared to plant communities, research investigating the response of faunal communities to TLP is sparse and primarily emphasizes the impacts of sediment placement on subtidal benthic communities. However, previous work has shown that intertidal benthic invertebrate communities (e.g., snails, crabs, worms, other epi- and in-fauna) recover at a rate that corresponds to placement thickness (Tong et al. 2013) and material compatibility (Wilber et al. 2006). That is, benthic faunal communities will recover more quickly the less material is applied through vertical or lateral migration from adjacent areas, particularly if fine sediment is applied to the wetland surface. While recovery rates are typically determined by calculating the abundance of individual species, overall community recovery (i.e., structure and function) is dependent on maintaining local hydrological and vegetation characteristics once sediment is applied to the wetland surface (Tong et al. 2013). For example, sediment applications that convert intertidal to supratidal environments can result in community shifts that favor more mobile, terrestrial invertebrates (McAtee et al. 2020; Wilber et al. 2006). Lastly, the response of nekton and avian communities to TLP is even less studied but is also predominantly dependent on changes to vegetation cover and elevation over time (NJ DEP 2023). Regardless of placement thickness, significant initial changes in faunal communities are expected but most likely temporary assuming projects are planned and implemented responsibly.

Natural Sediment Deposition and Horizontal Movement. Aside from artificial processes like TLP, wetlands susceptible to natural overwash, flooding, and associated sediment deposition events (e.g., hurricanes or inland storms) can build and sustain wetland elevation, plant growth and biological productivity even under moderate to high (up to 16 mm per year) sea level rise scenarios (Baustian and Mendelssohn 2018; Baustian and Mendelssohn 2015; Walters and Kirwan 2016; McKee and Cherry 2009). These same natural events can deposit too much sediment or, depending on additional factors such as wind, waves and flooding velocity, can significantly scour or erode wetland ecosystems (Walters and Kirwan 2016; Hill et al. 2020; Guntenspergen et al. 1995). Overall, the ability of natural events to provide long-term resilience to changing environmental conditions is unpredictable and highly dependent on the thickness and texture of deposited sediment, storm frequency and intensity, and resulting long-term changes in sediment accretion and organic matter accumulation.

Horizontal sediment movement and distribution is another important consideration when evaluating the impacts of TLP on wetland surfaces. For example, Ganju (2019) showed that higher marsh elevations are more susceptible to "slumping" (e.g., structural failure and subsequent decrease in elevation) or post-application erosion due to sediment redistribution. Additionally, the horizontal movement of sediments can impact adjacent habitats (e.g., shellfish beds, submerged aquatic vegetation, etc.) especially if TLP projects do not incorporate erosion control measures during and after sediment placement. Impacts to adjacent habitats are localized, however, and the long-range export of material is unlikely (Thorne et al. 2019). Nonetheless, the significance of localized impacts can be reduced by placing sediments in less sensitive habitats (e.g., avoiding nursery areas, submerged aquatic vegetation, active shell fishing or high-quality waters, etc.) or areas within larger marsh systems. TLP can also be coupled with other nature-based strategies (e.g., living shorelines) to develop a more holistic restoration approach that incorporates the protection of adjacent habitats.

Long-Term Resilience

There is general consensus that TLP is an effective tool for mitigating wetland loss (Morris and Staver 2024). However, the amount of time TLP protects wetlands from further deterioration is determined by placement thickness, the number of repeated applications, and existing environmental conditions. Recent work has shown that over time, wetlands in North Carolina that received just one sediment application continued to build elevation compared to those that did not receive sediment and expedited the rate at which wetlands reached an elevation that could otherwise take decades to achieve (Davis et al. 2022). As another example, TLP efforts in Rhode Island provided a recipient wetland with an estimated 67–320 years of ambient elevation gain and subsequently with long-term resilience to environmental change (Raposa et al. 2022).

Most of the studies described in previous sections are based on relatively short-term impacts and monitoring data that only lasted a few years. Longer studies over five years indicate that while ecosystem function remains stable over time, recipient wetlands can still deviate from baseline or control conditions (Cheng et al. 2025). Further, modelling studies have shown that Virginia wetlands subject to TLP will not retain elevation capital or provide long-term protection against particularly high rates of sea level rise (over 15 mm per year), though increased resilience is more likely with wetlands characterized by existing, gently sloping migration corridors without physical barriers (e.g., bulkheads or other infrastructure) to migration (Barksdale et al. 2026). Overall, the extent to which TLP contributes to long-term wetland resilience most likely varies by geographic location and is dependent on a suite of project-specific factors and objectives. This degree of uncertainty underscores the need for large scale pilot studies across diverse wetland types, some of which are described in subsequent sections.

Eastern U.S. Case Studies

Some of the earliest "slurry" applications of TLP were conducted in Mississippi River Delta wetlands. While initial applications were considered disposal, the region began to leverage dredge projects for wetland restoration in response to rapid sea level rise and sediment deficits that prevented wetlands from maintaining or gaining elevation. Hence, early work along the U.S. Gulf Coast aimed to find the balance between disposal and beneficial use by determining the amount of material placed on wetland surfaces that would limit negative impacts to the ecosystem (Ford et al. 1999; DeLaune et al. 1990; Cahoon and Cowan 1988). For the purpose of this document, we emphasize recent studies conducted along the east coast of the United States and within wetland ecosystems (tidal freshwater to salt marshes) subject to tidal patterns similar to those found in North Carolina. However, additional studies along the U.S. west and Gulf coasts are summarized in Appendix A.

Eastern U.S. states are at various stages of implementing large-scale TLP projects (Fig. 5). For example, North Carolina, South Carolina, and Virginia are currently in the exploratory phase and have no regulatory pathway for TLP with limited (if any) experimental studies. Georgia, Maryland, and Delaware have successfully conducted few large-scale TLP projects, though the planning, permitting and implementation processes are not yet streamlined, and quantified monitoring results are rarely reported. New England states such as Rhode Island, Connecticut, Massachusetts, and New York also have limited success with TLP projects, the results of which are sparsely reported in primary or gray literature. Based on our review, New Jersey has established perhaps the most robust beneficial use regulatory framework (to include TLP) that extends beyond the pilot stage. The state has developed a programmatic approach to beneficial use that includes collaborations between regulators, dredgers, and landowners that begin with engaging new policies that first and foremost address environmental needs that are also of value to dredgers. Establishing buy-in is therefore a crucial pillar amongst stakeholders. While developing a catch-all approach (relative to a case-by-case approach) to TLP and beneficial use might streamline project development and implementation, it may not always generate desirable outcomes. Case studies from each of these states are summarized below.

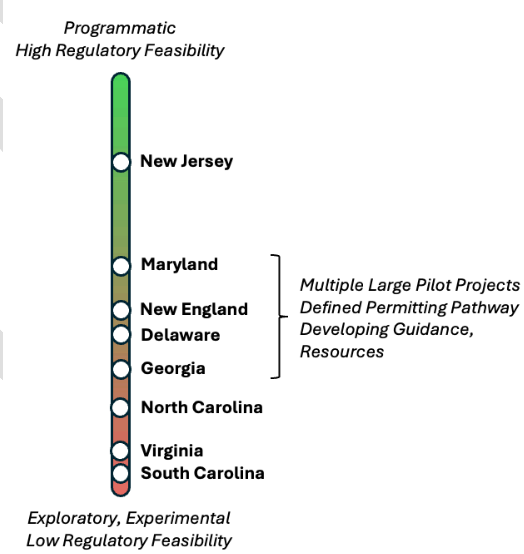

Fig. 5: Eastern U.S. states and their relative position along the TLP implementation spectrum as subjectively determined based on a review of regulatory feasibility, number and scale of reported TLP projects, and available TLP and beneficial use resources.

North Carolina

Studies specific to North Carolina have been relatively limited, small-scale, and strictly experimental (Fig. 6). Wilber et al. (1992) first evaluated impacts of sediment placement (1-20 cm) on Gull Rock in Hyde County and found that recipient wetlands remained well-vegetated, albeit less dense, and that while resulting sediment properties (e.g., higher bulk density and lower organic matter content) differed from reference sites, faunal distributions (i.e., peracarid crustaceans, oligochaetes, and polychaetes) and cursory sampling of large mobile macroinvertebrates and fishes were indicative of productive wetlands. This study also highlighted the uncertainty associated with the effects of pre-application conditions on post-application results. For example, differences in sediment and vegetation characteristics could have resulted from differences in initial concentrations, biomass, susceptibility to disturbances, etc. that are difficult to realize without standardizing monitoring criteria.

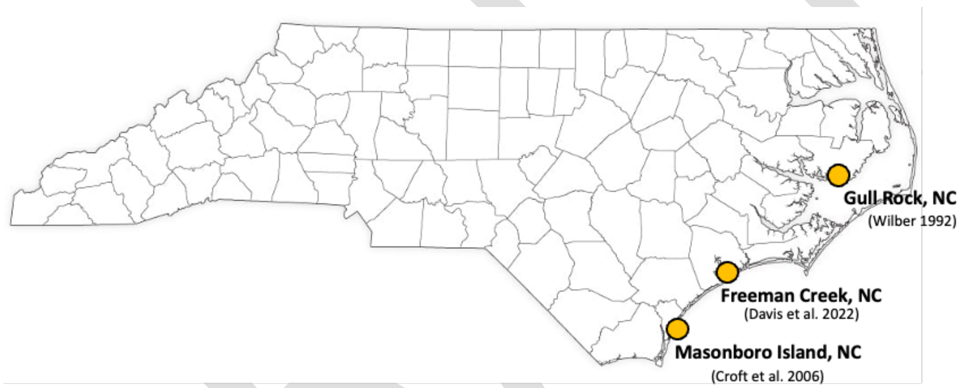

Fig. 6: Experimental (plot level) thin layer placement studies conducted in North Carolina.

On Masonboro Island in New Hanover County, the placement of fine sediments (2.5-10 cm thick) had a positive effect on deteriorating marsh plots after two growing seasons by increasing plant density and with sediment properties returning to pre-application conditions (Croft et al. 2006). However, there was evidence that placement increased the mobility and degradability of wetland sediments especially with thicker (near 10 cm) applications. Faunal response to sediment placement was also highly variable. At Freeman Creek in Camp Lejeune, Onslow County, Davis et al. (2022) reported positive gains (approximately 6 cm) in elevation and vegetative biomass that were maintained over five growing seasons. These net gains exceeded control sites.

Georgia

In addition to the early study conducted by Reimold et al. (1978) previously described, Georgia has conducted two more recent large-scale TLP pilot projects. In 2019, the Georgia

Department of Natural Resources in collaboration with the Georgia Federal Consistency Program, the U.S. Army Corps of Engineers, The Nature Conservancy, and Jekyll Island Authority placed approximately 5,000 cubic yards of sediment 15-25 cm thick over five acres of healthy *Spartina alterniflora* wetlands to increase wetland resilience to sea level rise (Appendix B; https://coastalgadnr.org/JekyllCreek). After five years, 84% of vegetation had regrown with most success at the wetland edge (Fig. 7). However, re-vegetation took longer than anticipated and did not support the vision of full re-growth between 3-5 years. Benthic species diversity decreased, and there was no evidence that the placement site met reference site conditions. Overall, project partners highlighted that monitoring could have been improved but was limited due to funding constraints.

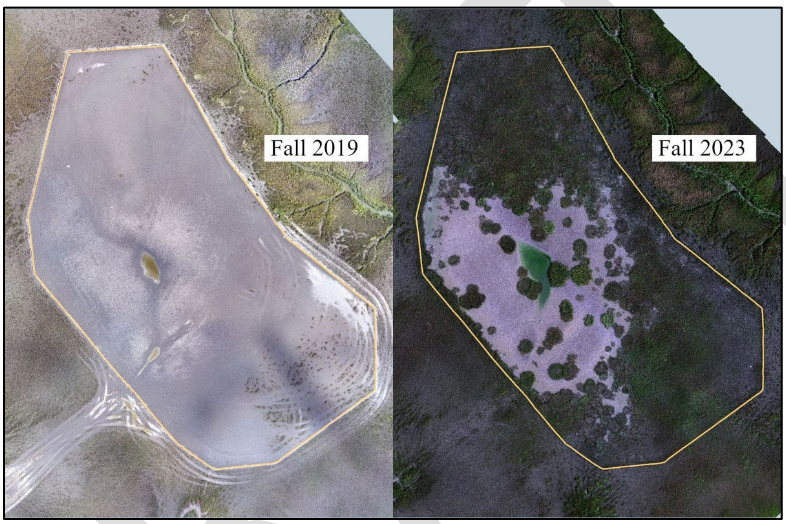

Fig. 7: Wetland vegetation growth (2019-2023) following thin layer placement on Jekyll Island, Georgia. Image courtesy of the GA Department of Natural Resources (https://coastalgadnr.org/JekyllCreek).

A TLP project conducted in Brunswick, Georgia with robust engineering considerations yielded more success (Mohan et al. 2021). In this study, sediments (a combination of sand and silt) up to 30 cm thick were hydraulically conveyed onto degraded wetlands at an angle (between 30 and 45 degrees) that ensured uniform distribution of sediments across the wetland surface. While coarse sediments distributed more evenly than fine sediments, project partners were able to optimize the placement of fine sediments with a baffle plate and temporary access road within the marsh to control the location of the discharge pipe. While the inclusion of an access road optimized placement, it resulted in additional environmental impacts that required post-project restoration. However, physical and vegetative monitoring conducted over a two-year period indicated strong natural recolonization of vegetation and the re-establishment of benthic invertebrate species.

New Jersey

Several TLP pilot projects have been implemented within the barrier island sounds and Delaware Bay regions of New Jersey (Harris et al. 2025; NJ DEP and TNC 2023; Harris et al. 2021; VanZomeren et al. 2018). In summary, up to approximately 80 cm of dredged material was placed on degrading wetlands within these regions to increase and maintain optimal tidal elevations for native wetland species (particularly *Spartina patens*), increase the cover and health of native wetland vegetation, and return all other metrics to baseline conditions unless changes were expected from habitat conversion. An assessment of short-term impacts revealed that while recipient wetlands quickly recovered ecosystem services associated with biochemistry, water quality, and nutrient retention, placement sites experienced initial plant smothering, weaker sediment strengths, and subsidence from over-compaction. Some revegetation (more than 50%) occurred after three growing seasons and matched control sites, but not with the target species. Subsequent longer-term monitoring revealed that gradual improvements in sediment properties and vegetation growth were accompanied by elevation gains estimated to offset impacts from sea level rise by 18-28 years. However, these projects collectively resulted in uneven sediment distribution, variable rates and success in invertebrate, avian, and nekton recovery, and difficulty in detecting small elevation changes even after ten years. Overall, these results may not represent the most desirable outcome and underscore the need for detailed planning and design phases. Elsewhere in the state, TLP has been successful when coupled with hydrological restoration to restore wetlands to regularly flooded elevations that facilitate and maintain the rapid recovery of *Spartina alterniflora* (Feigin et al. 2026).

Delaware

While the state has few reported case studies, the Delaware Department of Natural Resources and Environmental Control conducted a TLP project in Pepper Creek, Sussex County within a low elevation wetland system situated adjacent to both a dredging project and adjacent higher elevation reference wetlands (DNREC 2016). This project involved the hydraulic dredging and placement of approximately 35,000 cubic yards of sediment up to 15 cm thick. While project results were not quantified, project partners reported elevation gains and successful revegetation.

Maryland

Early TLP efforts in Maryland were experimental and part of a long-term climate adaptation strategy associated with the Blackwater National Wildlife Refuge and in collaboration with The Conservation Fund, Audubon Mayland-DC, the U.S. Fish and Wildlife Service, and the Maryland Department of Natural Resources (McCullough et al. 2021; Whitbeck et al. 2019). This project involved predictive and suitability modelling to implement the first TLP project in the Chesapeake Bay region. In summary, approximately 26,000 cubic yards of dredged sediment up to 15 cm thick were applied over 40 acres of a subsiding and fragmented wetland comprised of *Spartina alterniflora, Spartina patens,* and the bulrush *Schoenoplectus americanus* with the goal to create higher elevation wetlands for the saltmarsh sparrow *Ammodramus caudacutus* and to increase wetland resiliency to sea level rise and storm impacts. While project partners observed significant revegetation and recolonization of wetland bird species, the proliferation of invasive *Phragmites australis* remained a long-term problem.

In 2024, the National Oceanic and Atmospheric Administration in collaboration with the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers conducted a large-scale TLP pilot study at Deal Island Wildlife Management Area (Fig. 8). This project involved the application of 167,000 cubic yards of material up to 46 cm thick over 72 acres of low wetland habitat. Sediment placement was accompanied by straw bales to contain material and supplemental plantings over two growing seasons. Overall, the project was effective at restoring densely vegetated habitat but took several years to reach equilibrium. The project also required re-plantings and the installation of new straw bales over time to ensure long-term success (Davis et al. 2025; Appendix B)

Fig. 8: Wetland vegetation growth (2024-2025) following thin layer placement at Deal Island Wildlife Management Area. Image courtesy of Dr. Jenny Davis, NOAA (Appendix B).

New England

Relative to the southeast, northeast U.S. marshes are generally less productive in terms of plant biomass, positioned higher in the tidal frame, and experience larger tidal ranges and lower relative rates of sea level rise. As a result, New England wetlands generally respond to TLP more quickly (and with less material) relative to southeast and mid-Atlantic U.S. wetlands. For example, pilot studies in wetlands across Connecticut, Rhode Island, New Hampshire, and Massachusetts have shown that sediment layers between just 5-10 cm promoted rapid revegetation, enhanced carbon dioxide uptake, and reduced methane emissions (Punchkoff and Lawrence 2022; Payne et al. 2021). However, larger placement volumes up to 48 cm thick have also been shown to build elevation capital without compromising the recovery of plant and animal communities in sandier microtidal regions of New England (Raposa et al. 2022).

TLP projects have also been implemented in urban New York wetlands. For example, the deepening of New York Harbor yielded 42 million cubic yards of material between 2004 and 2014, a portion of which was used beneficially within the Jamaica Bay region. One of the larger-scale TLP projects was conducted within a barren, non-vegetated mudflat which received supplemental plantings and 8,000 cubic yards of sediment an average of 20 cm but up to 100 cm thick. Like many other projects across the U.S. east coast, *Spartina alterniflora* and associated wetland ecosystem services recovered quickly with less material but eroded and did not recover with applications over 20 cm thick (Frame et al. 2005). More calculated efforts in recent years suggest that low elevation urban wetlands receiving no more than 15 cm of sediment recover to nearly 100% of reference conditions (i.e., based on percent cover and stem height) after two growing seasons, though restored higher elevation wetlands take longer to respond (Haight et al. 2026).

Guidance Document Review

In response to the growing number of peer-reviewed studies and pilot projects, several agencies and organizations have developed TLP guidance documents including the U.S. Army Corps of Engineers (USACE) and Fish and Wildlife Service (USFWS), National Estuarine Research Reserve System (NERRS), National Oceanic and Atmospheric Administration (NOAA), The Nature Conservancy (TNC), and other consulting, engineering, and research groups such as the Southeast Regional Partnership for Planning and Sustainability and the Georgia Coastal Research Council. In 2022, the North Carolina Division of Coastal Management in partnership with the Divisions of Marine Fisheries, Water Resources, and Wildlife Resources Commission and the USACE (Wilmington District), USFWS (Raleigh Field Office), and NOAA National Marine Fisheries Service (Southeast Regional Office) developed guidance for site assessment and monitoring of TLP in North Carolina (NC DCM 2022). This guidance was intended to help permit applicants design TLP projects in a way that optimized project scoping, interagency permitting reviews, and future outcome evaluations and provided a starting point for progressing TLP in the state. This and other documents are summarized below and highlight lessons learned and best practices for designing, implementing, monitoring, and adaptively managing large scale TLP projects informed by research and case studies like those described above (Fig. 9). These guidance documents also discuss important logistical, engineering, and funding considerations.

Fig. 9: Process flowchart for thin layer placement. Figure modified from Anchor QEA (2025) and adapted from Piercy et al. (2023).

Planning and Design

Planning and designing TLP projects require a diverse interdisciplinary team of local, state, and federal stakeholders consisting of resource agencies; regulatory and permitting agencies; restoration practitioners; research scientists; landowners; dredgers, engineers, and consulting agencies; and fishers and recreationists. This team should be charged with identifying suitable wetlands for TLP, determining target elevations[6], and developing quantifiable objectives, success criteria, and associated monitoring and adaptive management plans (discussed further in subsequent sections). Example objectives are provided below:

- Restore a certain area (e.g., 50 acres) of bare, drowned wetland with enough sediment to re-establish dense wetland vegetation (e.g., 80% plant cover)
- Raise an entire wetland system by a pre-determined elevation (e.g., 10 cm) to facilitate sediment accretion (e.g., 3 cm per year for five years)
- Provide enough resilience for a pre-determined number of years or sea level rise scenario (at least 10 years is recommended by Anchor QEA 2025)

[6]Target elevations should be identified for both construction and post-construction TLP phases to account for fluctuations in wetland surface elevation after placement. Project teams should also establish a range of acceptable outcomes given potential differences in "as-built" versus designed wetland elevations that result from uncertainties in the absolute volume of material that is contained or lost post-application.

An alternatives analysis that includes the "no action" alternative should be conducted to ensure that TLP is the most effective long-term solution for achieving project objectives while recognizing and accepting trade-offs associated with the conversion between subtidal, intertidal, and supratidal habitats (discussed in further detail under "Resource and Regulatory Concerns"). For example, facilitating natural marsh migration without TLP may be most appropriate and cost-effective in areas with adequate natural sediment supply and migration corridors[7]. Additionally, wetlands subject to erosive conditions stemming from high energy wave impacts rather than subsidence, inadequate sediment supply, or rising sea levels may benefit more from erosion control structures such as breakwaters or wave attenuators rather than TLP. In other cases, historically modified wetlands (e.g., from impoundments, ditching, damming, etc.), especially those in microtidal regions, likely benefit most from hydrological interventions that restore ambient flow conditions and facilitate sediment deposition, accretion, and overall ecosystem function.

Appropriate site selection is important for satisfying project objectives and success criteria (Fig. 10). Aside from selecting degraded wetlands[8] with compatible sediment properties as discussed previously, wetlands with short fetch, large tidal ranges, ample migration area, and gradual slopes (1-3%) are generally exposed to less wave energy and are more likely to retain and accrete sediment. In this case, fine sediment placement is most appropriate and suitable (Myszewski et al. 2017). Wetlands with long fetch and steep slopes are more susceptible to sediment loss and may benefit most from coarse sediment placement. Site selection is also driven by matching dredge projects (and availability of source material) with recipient wetlands that meet restoration needs, are in close proximity to each other, and are financially and logistically feasible. TLP projects are predominantly executed in partnership with the U.S. Army Corps of Engineers due to their existing contracting resources and capacity to dredge large volumes of compatible material. However, smaller projects can be achievable with private excavation companies. In some cases, piloting TLP projects on public or state and federally managed lands can streamline project coordination and permitting (Hametz et al. 2025). Regardless of the site selected, nearby

[7]In North Carolina, for example, a highly developed region with many barriers to natural marsh migration (e.g., New Hanover County) may not benefit from TLP as much in the long-term compared to scarcely developed regions with higher migration potential (e.g. Hyde County). On the other hand, more developed regions could benefit more in the short term from TLP since options to enhance regional wetland resilience through facilitating wetland migration are limited.

[8] Stakeholders that participated in the NC DEQ multi-agency stakeholder workshop (hereafter referred to as "TLP workshop") indicated that identifying "degraded" wetlands may not be the most effective way to determine whether a site is a good candidate for TLP. Instead, practitioners should consider wetlands that are "at risk" of vegetation loss and ponding while also accounting for factors such as a site's proximity to existing infrastructure, the proposed dredge area and established migration corridors. North Carolina stakeholders also believe that just because a marsh is near a dredge area does not automatically make it a good candidate for TLP.

wetlands that do not receive sediment should be used as controls (i.e., an equally degraded wetland) and references (i.e., a goal or target) to evaluate project performance.

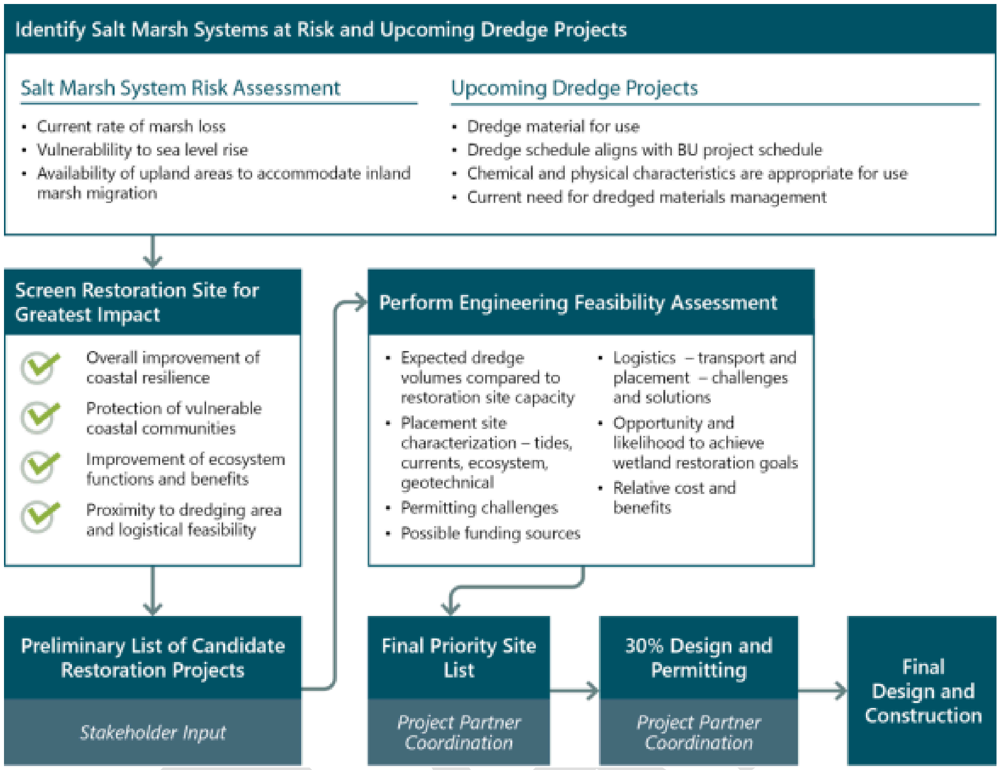

Fig. 10: Design process for thin layer placement. Figure adapted from Anchor QEA (2025).

Once all sites are selected (source, recipient, control, reference), geotechnical analyses are needed to evaluate baseline conditions and ensure material compatibility. Metrics might include grain size, bulk density, porosity, permeability, organic matter and nutrient content, dissolved oxygen, trace metals, contaminants, redox (metabolic) potential, composition and abundance of benthic invertebrate communities, or others mutually agreed upon by project partners or those required by permitting or resource agencies. Existing guidance also unanimously recommends a baseline understanding of local hydrological characteristics (e.g., wave conditions, flow velocities, currents, tides, and water levels) to help determine and achieve target elevations. Depending on funding and available resources, hydrological studies can involve high resolution numerical modelling (e.g., the Mid-Atlantic Tidal Wetland Rapid Assessment Method and other predictive sedimentological models) or coarser remote sensing technologies such as Light Detection and Ranging (LiDAR) coupled with *in situ* transect surveys that use surface elevation tables, marker horizons, tide and wave gauges, and real time kinematic global position systems (RTK-GPS).

While TLP project designs are iterative and progress through conceptual, preliminary, and intermediate stages, near-final plans should include a defined TLP work cell with a built-in buffer zone for added flexibility in placement location, staging and access, pipeline crossings, the construction of erosion control and sediment containment structures, and avoiding impacts to adjacent habitats outside the work cell (Hametz et al. 2025). Work cells should also be sited an adequate distance from tidal channels or wetland edges to increase the likelihood that sediment is deposited and contained on top of the wetland surface platform (Piercy et al. 2023). Based on existing guidance, the most effective TLP designs reduce complexity by minimizing the number of placement areas within a single work cell, the number of individual containment structures, and the number of discharge and dewatering points. Basic metrics specific to engineering and construction are described below under "Implementation."

Lastly, the planning and design phases for TLP projects require a cost assessment to ensure that equipment, resources, and personnel are available for all construction activities and post-construction monitoring and adaptive management needs (Table 1). Establishing reliable long-term funding sources is therefore critical for successfully implementing TLP and other beneficial use projects. Correll et al. (2024), for example, suggest leveraging annual calls for federal grant applications intended to fund large-scale restoration projects under a phased approach (e.g., decoupling planning and design, construction and implementation, and monitoring and adaptive management) to help guarantee multiple years of funding. Otherwise, continuous funding is dependent on local and state regulatory commitments or legislation.

Table 1: Cost considerations for thin layer placement projects. Table adapted from Anchor QEA (2025).

Cost Items	Supporting Elements
Mobilization and Demobilization	• All costs to mobilize and demobilize equipment, material, and labor to the project site • Proof of insurance • Removal of temporary containment structures • Surveys of pre-construction conditions and post-construction conditions • Project Management
Submittals	• Pre-work submittals • Health and safety plans • Work plans • Cost breakdown • Baseline schedule and schedule updates • Daily/weekly/monthly reports • Maintenance and monitoring plan • Quality assurance plan
Site Preparation	• Preparatory grading • Construction of access roadways • Preparation of staging areas, material transfer areas, or slurry equipment • Erosion and sediment control measures • Temporary containment structures • Temporary warning signs
Dredging and Sediment Placement	• Dredge type (cutterhead, hopper, etc.) and application method (high or low pressure; slurry or end-of-pipe discharge) • Pipeline configuration and transportation distance[9] • Containment structures • Magnitudes of estimated quantities, units, and costs understood to have little uncertainty and are incorporated into construction bid schedule • Excluding change orders, construction cost estimate should be highly accurate with respect to final construction cost
Debris Removal and Disposal	• Tonnage of debris removed from the dredging template
Vegetation Establishment	• All labor, material, and equipment for vegetation re-establishment, including plugs, seeds, plants, soil preparation, staking, goose protection netting, etc. • Acceptable variance for initial acceptance of vegetation establishment
Monitoring and Maintenance	• Monitoring equipment such as settlement plates, grade stakes, etc. • Surveys, data collection, and reporting for monitoring and permit compliance • Re-establishment of vegetation • Regrading, if necessary

Implementation

Most topics within the implementation stage of TLP, such as engineering, labor, construction specifications, bidding, timelines, and contracting are highly technical and outside the scope of this document but are described with great detail in Piercy et al.

[9]For example, thinner and more precise applications requiring constant adjustments are more expensive compared to thicker, in-place applications where there may be more room for error

(2023). However, implementation teams should expect lengthy project durations due to site recovery times, delays from storm events, wetland growing seasons, and environmental work windows or time-of-year restrictions required to avoid or minimize impacts to sensitive habitats (e.g., nursery and anadromous fish spawning areas) during periods of peak productivity and biological activity[10].

Relevant to the purpose of this document, existing guidance emphasizes the importance of using biodegradable or temporary containment structures (e.g., straw bales, coir logs, earthen dikes, sandbags, geotubes, and other structurally diverse materials further described in Hametz et al. 2025) consistent with local sediment migration patterns that prevent sediment loss and impacts to adjacent habitats or, if nearby, navigation channels. However, Anchor QEA (2025) warns that "over containing" sediments can increase both project costs and overall environmental disturbance associated with their installation and removal. More permanent containment structures (e.g., offshore breakwaters, marsh toe revetments, oyster sills, etc.) can also be incorporated into project designs to facilitate long-term sediment containment and capture.

Monitoring, Adaptive Management, and Success

TLP is generally considered successful when the application of dredged material increases wetland elevation, supports and maintains desired foundational vegetation communities, sustains key ecological functions and processes, and satisfies pre-determined project objectives and success criteria as determined through long term-monitoring and regular reporting. North Carolina stakeholders also consider TLP successful if there is consistent sediment placement and containment across the marsh surface, adequate post-construction tidal flow, benefits that exceed financial and ecological costs, and demonstrable returns on investment and public perception. If monitoring indicates unsatisfactory project performance, adaptive management may be necessary to reach the desired outcome or minimal thresholds as defined by project partners (Table 2).

[10] In some cases, minimization measures and other best management practices such as turbidity curtains are used in lieu of time-of-year restrictions to contain suspended sediments until pre-determined conditions are met.

Table 2: Example monitoring metrics, effectiveness criteria, and potential adaptive management actions if criteria are not met. Table adapted from Correll et al. (2024).

Project Phase	Monitoring Metric	Performance Criteria	Adaptive Action
Construction	Target Elevation	Placement depth meets target	Adjust placement strategy to achieve target
Post Construction	Plant Cover	Percent cover of aboveground native biomass increases to pre-determined metric within three years	Conduct additional plantings and consider different species if elevation changed
Maintenance	Shoreline Position	Shoreline change rates less than a pre-determined rate	Stabilize shoreline against further erosion

Based on the results of the TLP workshop, stakeholders in North Carolina believe that at minimum, monitoring plans should include basic metrics such as vegetation abundance and recovery to include invasive species; the recovery and response of invertebrates, birds, fishes, and reptiles; changes in elevation; sediment properties; turbidity and water quality. Myszewski et al. (2017) showed that even simple monitoring of bulk density and organic matter content are effective precursors of plant growth and expansion (associated with higher bulk densities) and soil productivity (associated with higher organic matter content). Depending on funding and resource availability, monitoring metrics could also include hydrological responses; microbial processes; and quantifying ecosystem services such as flood reduction or economic benefits. In some cases, it may also be appropriate to monitor and mitigate for temporary environmental impacts associated with wetland mats, pipelines, or other construction activities and to integrate adaptive best management practices (like those typically used for stormwater and sediment and erosion control) during implementation. Ultimately, stakeholders in North Carolina also believe that securing reliable funding for long-term post-construction monitoring is important for ensuring success and generating data to support subsequent TLP projects.

While most guidance recommends at least quarterly monitoring for five years (Anchor QEA 2025; Hametz et al. 2025; Correll et al. 2024; Raposa et al. 2020; Myszewski et al. 2017) with associated maintenance to control invasive species or replant bare sediments, our review of existing documents suggests a best practice of monitoring throughout the entire project lifespan (before, during, and after sediment placement) at regular intervals and for up to ten years as determined *a priori* by project planning teams. Adequate monitoring must also reliably compare results from placement, control and reference sites using consistent and robust statistical methods. For example, Raposa et al. (2020) recommends more replication when there is higher spatial and temporal variation across sites. A scientifically rigorous Before-After-Control-Impact (BACI) design (Underwood 1992; Stewart-Oaten et al. 1986) can also be used to compare changes over time between placement, reference, and control sites to isolate TLP impacts from natural fluctuations in ecosystem state.

Existing guidance recommends the development of standard operating procedures (SOPs) for monitoring and adaptive management plans during the planning and design phases to ensure consistency across projects, to establish acceptable thresholds for monitoring criteria and duration, to standardize data for analyzing inter-project performance, and to develop appropriate budgets and project timelines. As TLP and other beneficial use projects expand nationwide, Reilly et. al (2026) specifically calls for improved reporting and standardization of project design, implementation, framework development and quantitative monitoring by 1) explicitly describing project goals and linking them to monitoring metrics, 2) defining success criteria, 3) using consistent terminology referencing sediment placement, 4) reporting placement depth, range, and initial elevations, 5) including local tidal range and datum, 6) clarifying controls versus references, 7) considering longer monitoring timeframes, and 8) sharing comprehensive results beyond peer-reviewed summaries.

Regulation, Policy and Permitting

Regardless of state policies, TLP proposals are subject to a myriad of federal regulations that could limit or even prevent their implementation (Table 3). Before submitting permit applications, project teams are typically encouraged to consult permitting agencies during the planning stage and throughout the project lifespan to ensure that federal requirements are satisfied and that preferred alternatives maximize long-term environmental benefits. Involving permitting agencies at the onset also helps with establishing budgets and project timelines for the completion of necessary documentation.

Table 3: Overview of federal natural resource laws, regulations, and associated agencies[11] that may be applicable to thin layer placement projects. Adapted from Kordesch et al. (2024) and Raposa et al. (2020).

	Law	Agency	Permit or Authorization	Regulated Activity or Resource
Water	Section 401, Clean Water Act	State Water Board (EPA Oversight)	Water Quality Certification	Discharges requiring a federal license or permit to comply with state or federal water quality standards
	Section 404, Clean Water Act	USACE	General Permit (Nationwide, Regional); Standard Permit (Individual); Letter of Permission	Discharge of dredge or fill material into waters of the U.S., including wetlands
	Section 10, Rivers and Harbors Act	USACE	Section 10 Permit	Work in, under, or over a navigable waterway
Water and Land	Coastal Zone Management Act	NOAA	Federal Consistency Determination	Project modifies land or water use in the coastal zone of a state with an approved Coastal Management Program
Species	Section 7 and 10, Endangered Species Act	USFWS / NMFS	Incidental Take / Biological Opinion (Section 7); Incidental Take Permit	Activities affecting species listed as threatened or endangered under the Act
	Marine Mammal Protection Act	USFWS / NMFS	Letter of Authorization; Incidental Harassment Authorization	Activities affecting marine mammals and their products
	Section 305(b)(4)(A), Magnuson-Stevens Fishery Conservation and Management Act	NMFS	Essential Fish Habitat Consultation	Activities affecting federally designated essential fish habitat and habitat areas of particular concern.
Cultural Resources	National Environmental Policy Act	Federal Lead Agency (EPA Oversight)	Environmental Assessment; Finding of No Significant Impact; Environmental Impact Statement	Major federal actions significantly affecting the quality of the human environment
	National Historic Preservation Act	State Historic Office / Federal Lead Agency	Memorandum of Agreement / Programmatic Agreement	Activities affecting cultural resources

Regulating and permitting TLP differs across state boundaries. In Maryland, Virginia, and Massachusetts, in-water unconfined placement of dredged material is not allowed under state enforceable policies unless it is used for beneficial use, restoration, or other projects

[11]USACE = U.S. Army Corps of Engineers; NOAA = National Oceanic and Atmospheric Administration; USFWS = U.S. Fish and Wildlife Service; NMFS = National Marine Fisheries Service; EPA = Environmental Protection Agency

intended to benefit aquatic resources (Anchor QEA 2025; MassDEP 2024). Georgia law allows TLP and other beneficial uses if the project is of public interest (Shudtz et al. 2025). In Delaware (DNREC; https://regulations. delaware.gov/AdminCode/title7/7504) and New York (NY DEC; https://dec.ny.gov /regulatory/permits-licenses/waterways-coastlines-wetlands), state regulations do not explicitly prohibit wetland fill (and therefore TLP), though any proposal to do so must be appropriately justified. In Connecticut (CT DEEP; https://portal.ct.gov/DEEP/Coastal-Resources/Coastal-Permitting/Overview-of-the-Connecticut-Coastal-Permit-Program), Certificates of Permission rather than formal permits can be issued for projects intended to restore degraded wetlands. As mentioned previously, New Jersey's administrative code speaks directly to dredged material placement (NJ DEP; https://www.law. cornell.edu/regulations/new-jersey/N-J-A-C-7-7-15-12).

In North Carolina, TLP is currently not permissible under the NC Coastal Area Management Act (CAMA) and Dredge and Fill Law which prohibit and classifies TLP as wetland fill. If submitted, an application for TLP would be denied but eligible for a variance from the Coastal Resources Commission, the state's rulemaking body. The Commission can elect to approve projects that technically violate state regulations if the following criteria are met:

- Strict application of state development standards would result in unnecessary hardships.
- Hardships result from conditions peculiar to the property (i.e., location, size or topography).
- Hardships did not result from actions taken by the petitioner.
- The variance is consistent with the spirit, purpose and intent of state development standards; will secure public safety and welfare; and will preserve substantial justice.

As such, applicants must demonstrate that a TLP project has public benefits consistent with protecting coastal resources, public benefits that outweigh the adverse impacts of the project, no alternate site available for the project, and a design and implementation plan that incorporates all means and measures to mitigate adverse environmental impacts (Table 4). The variance process also allows the Coastal Resources Commission to proceed with rulemaking to establish thresholds or other criteria for future, related projects. In addition to CAMA and the NC Dredge and Fill Law, TLP proposals would also require state authorization from the NC Divisions of Water Resources and potentially the Division of Energy, Mineral, and Land Resources or applicable town, city, or county permits.

Because there is growing interest in TLP and other types of beneficial use across the state, the NC Division of Coastal Management anticipates a potential need for future rulemaking that would authorize TLP and related projects through the typical CAMA permit process (see NC DCM 2022 for recent guidance on state-specific site assessments and monitoring). The syntheses presented here are therefore intended as a TLP source document to help inform next regulatory steps as needed.

Table 4: CAMA & Dredge and Fill Permit Considerations in North Carolina. Adapted from Shudtz et al. (2025).

Factors for Permit Denial	**Implication for TLP Project Applications**
General Factors	
The development is inconsistent with written state guidelines or local land-use plans.	Review guidelines and land-use plans to ensure project is consistent; discuss concerns with relevant agencies early in the project proposal phase.
There is a practicable alternative that would accomplish the overall project purposes with less adverse impact on public resources, considering engineering requirements and all economic costs.	Provide research and data on the benefits of TLP, including the value of ecosystem services such as hazard reduction and recreation opportunities that will benefit local communities; provide comparison to costs of offshore disposal or upland containment.
The proposed development would contribute to cumulative effects that would be inconsistent with specific written guidelines on various state Areas of Environmental Concern.	Emphasize that TLP intended and designed to have myriad positive environmental and ecosystem benefits; include monitoring and adaptive management plans.
Areas of Environmental Concern	
In coastal wetlands, the project would contradict any order to promote public safety, health, and welfare or to protect public and private property, wildlife, and marine fisheries in coastal wetlands.	Emphasize that TLP is intended to specifically achieve state goals and policies to promote public safety, health, and welfare and to protect property and wildlife in and around coastal wetlands; provide research and data on the benefits and success of smaller pilot projects.
In estuarine waters, a permit would also be denied per the state's Dredge and Fill law for having a significant adverse effect on public use of water, on the value and enjoyment of property of riparian owners, on public health, safety, or welfare; on conservation of public and private water supplies; on wildlife or fresh water, estuarine, or marine fisheries	Cite scientific research and data on the ecosystem services provided by healthy and intact coastal wetlands; on the property value increase; anticipate implementing best management practices for sediment and erosion control during project implementation period.
In a fragile or historic area or area containing environmental or natural resources of significance, the development will result in major or irreversible damage to one or more of the historic, cultural, scientific, environmental or scenic values or natural systems.	Emphasize how the proposed project will support and improve resilience in coastal areas; cite scientific research that show negative impacts of a "do nothing" alternative.
On public trust lands, the project will jeopardize the public rights or interests in those lands.	Highlight recreational opportunities, increased ecosystem resilience, and other public benefits TLP
In natural hazard areas, the project would occur in such a manner as to unreasonably endanger life or property.	Cite scientific research and data that demonstrates coastal marsh benefits for estuarine beaches, shoreline of estuarine and public trust waters, floodways and floodplains
Variance Approval	
The requested variance is consistent with the spirit, purpose, and intent of the rules, standards, or orders; will secure public safety and welfare; and will preserve substantial justice.	Cite language from CAMA and other state policies that support preserving coastal wetlands and their values; provide evidence of public benefits from healthy coastal wetlands and bird islands, such as recreation, hazard reduction, and productive fisheries.

Resource and Regulatory Concerns

While TLP may be an effective tool to enhance wetland resilience, there are several concerns associated with the impacts of sediment placement on long-term wetland function. Results from the TLP workshop indicated that material compatibility, invasive species, a lack of post-project regulatory oversight, unforeseen impacts to subtidal or intertidal fish habitat or adjacent habitats, and sediment contamination and associated risks to fish, wildlife, and public health would be of particular concern in North Carolina. Elsewhere, resource concerns are also generally associated with the following, all of which are most likely applicable to North Carolina:

- Lack of geographically relevant studies and regulatory approval pathways
- Sediment compaction and heavy equipment
- Plant smothering and recovery
- Establishing appropriate environmental windows and work moratoria
- Property ownership / land use conflicts
- Funding and equipment needs
- Ecological and water quality impacts
- Turbidity during initial placement and settlement of material
- Benthic and infaunal invertebrates
- Migratory birds and waterfowl
- Submerged aquation vegetation and shellfish
- Formation of sulfidic soils
- Length of time needed to meet "reference conditions"
- Cumulative impacts associated with repeated applications or amendments
- Establishing what qualifies as marsh restoration to justify TLP
- Establishing a definition for a "degraded" marsh
- Overdesigning projects
- Containing material once placed

During alternatives development, TLP may not be considered in the short-term as the "least environmentally damaging practical alternative" due to initial impacts from sediment placement on ecological function. However, reviewing agencies should consider and identify acceptable trade-offs between temporarily disruptive but long-term beneficial projects that prevent permanent wetland loss under future environmental change[12]. Alternatives development should also address concerns related specifically to habitat

[12]To alleviate additional resource and regulatory concerns, selecting extremely degraded sites with little ecological value minimizes risks but maximizes potential benefits.

trade-offs. Correll et al. (2024) suggest that like most restoration projects, TLP should be planned around ecosystem-based management rather than individual species management when evaluating trade-offs in project design. For example, while raising wetland elevation could help restore intertidal and upland habitat for certain avian or mammalian communities, it may also reduce intertidal and subtidal habitat for submerged aquatic vegetation, fish and aquatic invertebrate communities. Such tradeoffs merit consideration during project planning.

Information Needs

Based on reviews of primary literature, existing guidance documents, and results from the TLP workshop, there is a general need in North Carolina to evaluate more large-scale projects at the acreage scale that incorporate at least 10 years of monitoring to supplement recent and ongoing studies that are restricted to the experimental plot scale. Quantifying the response of fisheries and other faunal communities to habitat change represents another major knowledge gap. Lastly, there is a lack of information on the cumulative impacts associated with repeat sediment applications, and there is a need to develop high resolution regional models that project the outcome of sediment placement. For specific projects, information needed to effectively evaluate TLP projects includes the history of local wetland loss and future trends associated with migration corridors; the ecologic and economic function of recipient wetlands; detailed site mapping to include existing elevations, soil and vegetation characteristics, hydrological and geomorphological dynamics, and relevant archaeological surveys; and overall baseline site characterization.

Conclusion

TLP is an effective tool to enhance wetland resilience to environmental change by building elevation and facilitating sediment accretion within degrading ecosystems. To ensure success, projects must be carefully planned by a diverse team of stakeholders and subsequently executed, monitored, and adaptively managed with specified goals, objectives, and reliable long-term funding, resources, and support from research labs, contracting firms, funding agencies, and environmental organizations.

TLP projects at minimum should consider sediment compatibility, target elevation and thickness, and baseline hydrology and environmental characteristics that are compared between placement, reference, and control sites. Generally, recipient wetlands should maintain an elevation between sea level and mean high water to promote adequate tidal inundation and the natural growth of native plant species. While coastal states are at various stages of TLP implementation ranging from exploratory to well-established programmatic frameworks, there is persistent widespread interest in TLP and other beneficial use techniques to combat sea level rise and wetland loss. As a result, coordinated efforts to establish science-informed purpose and need statements, standard operating procedures, monitoring and reporting requirements, and permitting and regulatory pathways for emerging projects are both timely and critical for building stakeholder confidence.

In North Carolina, implementing TLP in the future will most likely occur on a case-by-case basis with local and regional factors in mind. Based on the success of projects elsewhere and the comfort level of North Carolina stakeholders, initial projects are expected to involve smaller-scale "like-on-like" application of dredged material (e.g., from a maintenance event) onto a deteriorating salt marsh (e.g., one experiencing active vegetation loss, interior ponding, inadequate sediment supply or migration pathway) with the goal of raising surface elevation enough to support the restoration of vegetated intertidal habitats and the facilitation of sediment accretion and long-term resilience to future change. Early projects would most likely also be coupled with robust temporary or permanent containment structures within isolated systems that minimize potential impacts to adjacent habitats or infrastructure.

Looking Ahead

The information presented in this document, including the results of the TLP workshop, represents an action item completed for the 2026 CHPP amendment. This paper is intended to enhance agency understanding of TLP and to ensure stakeholders are well-poised to evaluate projects as they are developed. Over the next five years and before the next CHPP update, DEQ staff will create a state-wide multi-agency workgroup to progress TLP (and possibly other beneficial use efforts) in North Carolina through regular meetings, additional workshops (e.g., those focused specifically on regulation, permitting, engineering, etc.) and discussions and to establish best practices specific to the state. This group could update existing guidance or develop a toolkit for North Carolina that includes standard monitoring procedures or design considerations. DEQ staff will also evaluate regional statuses and trends of existing wetlands across coastal North Carolina, incorporating new high-resolution land cover data obtained through the 2021 CHPP (2021 recommended action 5.1). DEQ staff will additionally leverage existing resources such as the NC Flood Resiliency Blueprint, NC Executive Order 305 Hub, Southeast Conservation Blueprint, Marsh Restoration Community Benefit Calculator, the U.S. Army Corps of Engineers Resiliency Urgency and Beneficial Use Map, and other geospatial tools to identify candidate areas that may benefit most from TLP with the ultimate goal of planning for ongoing and future environmental change to enhance wetland resilience.

Specific Recommended Actions

1. DEQ staff will develop an issue paper that summarizes the best available science and guidance for TLP, including case studies, information needs, success criteria, an overview of important scientific and permitting considerations, policy and resource concerns, and outcomes from a multi-agency TLP workshop (this document).
2. DEQ staff will create a state-wide multi-agency workgroup to progress TLP and facilitate the establishment of best practices specific to North Carolina
3. DEQ staff will evaluate the status and trends of wetlands across coastal North Carolina, incorporating high-resolution land cover data obtained through the 2021 CHPP.
4. DEQ staff will leverage existing tools and data sources to identify candidate areas that may benefit most from TLP.

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Appendix A: Summary of Thin Layer Placement Projects Described Throughout This Paper

Site	State	Dominant Plant Species	Mean Tidal Range (m)	SLR Rate (mm yr^{-1})	Existing Marsh Elevation (m, NAVD88)	Project Goal	Project Size	Target Elevation Increase (cm)	Placement Thickness (cm)	Sediment Type	Marsh Recovery Time (years)	Study Duration (years)	Reference
Seal Beach National Wildlife Refuge	CA	*Spartina foliosa, Batis maritima*	0.34–3.56	0.98–6.23	1.34	Offset high SLR risk and subsidence, build elevation capital, enhance habitat for *Spartina foliosa* and Ridgway's Rail	10 acres	7.6	22–32	Coarse (84–85% sand)	1–1.5	1–3	McAtee et al. (2020); Thorne et al. (2019)
San Francisco Bay	CA	*Salicornia pacifica*	1.25	Not Specified	1.08–1.79	Enhance wetland resilience to rising seas; compare low to high marsh performance to TLP	0.7 x 0.7 m plots	10	7–14	Coarse (75% sand)	3	3	Raposa et al. (2023)
Elkhorn Slough	CA	*Salicornia pacifica*	1.60	Not Specified	1.43–1.86	Enhance wetland resilience to rising seas; compare low to high marsh performance to TLP	0.7 x 0.7 m plots	10	7–14	Coarse (75% sand)	3	3	Raposa et al. (2023)
Guilford Yacht Club	CT	*Spartina alterniflora*	1.70	4–6	Not Specified	Examine how differential thickness alters plant-soil carbon dynamics and promotes resilience to SLR.	1 x 1 m plots	5–15	5–20	Fine (84% silt and clay)	1–2	2	Puchkoff and Lawrence (2022)
Glynn County Marsh (Brunswick)	GA	*Spartina alterniflora*	Not Specified	Not Specified	Not Specified	Investigate capability of high salt marsh to recover from dredged material disposal	0.9 m diameter plots	Not Specified	8–91	Coarse sand	within 1 (under 23 cm placement thickness)	2	Reimold et al. (1978)
Glynn County Marsh (Brunswick)	GA	*Spartina alterniflora*	Not Specified	Not Specified	Not Specified	Evaluate considerations, impacts, and system recovery associated with TLP placement over a representative area	12 acres	Not Specified	15–23	Fine Sand and Silt	0.75	2	Mohan et al. (2021)
Jekyll Island	GA	*Spartina alterniflora*	Not Specified	Not Specified	Not Specified	Encourage plant growth at higher elevations, reducing the probability that the marsh grass will be degraded by increased saltwater inundation	5 acres	Not Specified	15–25	Fine (Unspecified)	3–5	5	https://coastalgadnr.org/JekyllCreek
Mississippi River Delta	LA	*Spartina alterniflora, Scirpus americanus, Vigna luteola, Potamogeton spp.*	0.40	9.40	open water marsh pond	Ameliorate SLR impacts; test sediment subsidies to counter subsidence; restore emergent vegetation.	1.24–106 acres	5–15, up to 30	0–22	Coarse and Fine (4-58% sand)	1–3	2–3	Mendelssohn and Kuhn (2003); Slocum et al. (2005); Ford et al. (1999); Stagg and Mendelssohn (2010)
Mississippi River Delta	LA	*Spartina patens, Schoenoplectus americanus*	Not Specified	3.6–17.7	Not Specified	Examine functional response of vegetated brackish marsh and interior ponds to sediment enhancement.	27–1373 acres	Varied By Location	15–20	Not Specified	within 1, pond sites only	1	La Peyre et al. (2009)
Leeville / Bayou LaFourche	LA	*Spartina alterniflora*	0.30	11.1	0.04–0.30	Increase elevation and enhance plant recovery following drought-induced marsh dieback	400 m transects within 1.24 acre plots	14–36	6–41	Not Specified	1–5	1–7	Schrift et al. (2008); Stagg and Mendelssohn (2010); Tong et al. (2013)
Bayou Dupont	LA	*Phragmites australis, Spartina alterniflora, Spartina patens, Scirpus americanus*	0.32	9.1	open water marsh pond	Increase soil surface elevation to support vegetation growth; prevent conversion to open water	160 acres	15	15	Not Specified	2	2	Howard et al. (2020)
Barataria Basin / Bay	LA	*Spartina alterniflora*	Not Specified	Not Specified	Not Specified	Examine effects of sediment addition on plant regeneration and productivity in a deteriorating marsh	1.44 x 1.44 m plots	8–10	2–10	Coarse and Fine (40% sand)	within 2 growing seasons	1.5	DeLaune et al. (1990)
Paul J. Rainey Wildlife Sanctuary	LA	*Spartina patens*	Not Specified	Not Specified	0.37	Determine if elevation change, soil compression, and sediment consolidation were differentially affected by different amounts of sediment; assess sediment effects on ecosystem function	4 x 4 m plots	Not Specified	2–20	Fine (82% silt and clay)	within 1, then subsided	2.5	Graham and Mendelssohn (2013)
Chesapeake Bay, MD	MD	*Spartina alterniflora, Spartina patens, Distichlis spicata, Juncus roemerianus*	0.74	Not Specified	0.40	Enhance wetland resilience to rising seas; compare low to high marsh performance to TLP	0.7 x 0.7 m plots	10	7–14	Coarse (75% sand)	3	3	Raposa et al. (2023)
Shorters Wharf	MD	*Spartina patens, Distichlis spicata, Spartina alterniflora*	0.24	Not Specified	Not Specified	Increase resiliency to SLR; restore elevation capital; extend lifespan of habitat for Saltmarsh Sparrow and Black Rail	40 acres	30	15–35	Semi Fine (68% silt and clay)	2	2	McCullough et al. (2021); Whitbeck et al. (2019)
Poplar Island	MD	*Spartina alterniflora, Spartina patens*	0.34	5.7	0.24–0.64	Mitigate marsh drowning and assess the effect of TLP on carbon sequestration and resilience under rising sea levels	30–50 acres	Varied By Location To Achieve 80% Low Marsh	15–30	Fine (Not Specified)	within 1	2–7 with longer model simulations	Morris and Staver (2024); Cornwell et al. (2025)
Waquoit Bay	MA	*Spartina alterniflora, Spartina patens, Distichlis spicata, Juncus roemerianus, Iva frutescens*	0.55	Not Specified	0.40–0.64	Enhance wetland resilience to rising seas; compare low to high marsh performance to TLP	0.7 x 0.7 m plots	10	7–14	Coarse (75% sand)	3	3	Raposa et al. (2023)
Great Bay	NH	*Spartina alterniflora, Spartina patens, Juncus gerardii, Distichlis spicata, Salicornia depressa, Schoenoplectus robustus*	2.7	4.17	0.73–1.05	Enhance wetland resilience to rising seas; compare low to high marsh performance to TLP	0.7 x 0.7 m plots	10	7–14	Coarse (75% sand)	3	3	Raposa et al. (2023)
Avalon	NJ	*Spartina alterniflora*	1.39	10	0.26–0.61	Increase marsh elevation and improve soil aeration to allow marshes to keep pace with SLR and restore deteriorated back barrier wetlands	100 m transects	73–91	5–83	Coarse and Fine (15-80% sand)	0.5–3.5	6	Harris et al. (2021); VanZomeren et al. (2018); Cheng et al. (2025)
Thompsons Beach	NJ	*Spartina alterniflora*	1.60	Not Specified	0.12	Offset elevation loss caused by historic farm impoundments and create conditions for plant recolonization	1.11 acres	49	42	Fine (100% silt and clay)	5	5	Feigin et al. (2026)
Sturgeon Island	NJ	*Spartina alterniflora, Phragmites australis*	1.3	4.2	0.5–1.3	Enhance surface elevation to support nesting bird habitat and stabilize the low-lying northern portion of the island.	13 acres	Not Specified	37–39	Fine (Not Specified)	3	4	Harris et al. (2025)
Jamaica Bay	NY	*Spartina alterniflora*	Not Specified	2.9–4.3	0.6–0.7	Increase marsh elevation, enhance bird habitat, and document lessons for future TLP applications.	1.5–2.5 acres	23-43	up to 100	Coarse and Fine	within 2 growing seasons	1–4	Hartig et al. (2024); Haight et al. (2026); Frame et al. (2005)
Masonboro Island	NC	*Spartina alterniflora*	1.2	Not Specified	Not Specified	Determine if placing dredged material on sediment-starved back barrier marshes could offset submergence without negatively affecting marsh function	6.4 x 6.4 m plots	8.5–10	0–10	Coarse Sand	1–2	2	Croft et al. (2006)
Masonboro Island	NC	*Spartina alterniflora, Spartina patens, Distichlus piscata, Borrichia frutescens*	1.2	1.9	-0.26–0.48	Enhance wetland resilience to rising seas; compare low to high marsh performance to TLP	0.7 x 0.7 m plots	10	7–14	Coarse (75% sand)	3	3	Raposa et al. (2023)
Freeman Creek	NC	*Spartina alterniflora*	0.8	12.3	-0.012 – -0.11	Increase elevation capital and marsh resilience to SLR by raising the platform to an optimal elevation for vegetative growth	8 x 3 m plots	Not Specified; Dependent on Elevation-Biomass Relationship	6	Coarse (90% sand)	within 1	5	Davis et al. (2022, 2017)
Gull Rock	NC	*Juncus roemerianus, Spartina alterniflora, Distichlis spicata*	Not Specified	Not Specified	Not Specified	Reduce environmental impacts associated with dredged material placement; describe long-term effects	Not Specified (8-12,000 cubic yards of material)	3–10	1–20	Fine (Unspecified)	within 1	10 years post-placement	Wilber (1992)
Ninigret Marsh	RI	*Spartina alterniflora, Spartina patens, Distichlis spicata, Juncus gerardii*	<1	2.83–4.78	-0.109	Restore high marsh species; increase marsh resilience to future SLR by building elevation capital; test the efficacy of sediment placement with adaptive management.	22 acres	18–30 Depending on Elevation Zone	10–48	Coarse (90% sand)	3–4	5–6	Raposa et al. (2022)
Narragansett Bay	RI	*Spartina alterniflora, Spartina patens, Distichlis spicata, Juncus gerardii*	1.2	Not Specified	0.40–0.64	Enhance surface elevation to support nesting bird habitat and stabilize the low-lying northern portion of the island.	0.7 x 0.7 m plots	10	7–14	Coarse (75% sand)	3	3	Raposa et al. (2023)
Coggeshall Marsh	RI	*Spartina alterniflora*	1	1.5–5.3	Not Specified	Increase resilience to SLR by boosting elevation to allow vegetation to recolonize; investigate impacts on nitrogen cycling	0.5 x 0.5 m plots	10	7–14	Coarse (90% sand)	4	1–4	Bartolucci and Fulweiler (2024, 2026)
Chesapeake Bay, VA	VA	*Spartina alterniflora, Spartina patens, Distichlus spicata*	0.76	5–6	0.19–0.46	Enhance wetland resilience to rising seas; compare low to high marsh performance to TLP	0.7 x 0.7 m plots	10	7–14	Coarse (75% sand)	3	3	Raposa et al. (2023)

Appendix B: Thin Layer Placement Coordination Workshop Report

Summary

The purpose of this workshop was to discuss thin layer placement (TLP) of sediment as a tool for enhancing wetland resilience and to share successes, challenges, concerns, and lessons learned associated with the ecological impacts of placing sediment on deteriorating wetlands. Workshop attendees were provided a scientific overview of TLP and how other coastal states manage projects related to TLP and the beneficial use of dredged material. These discussions included several case studies along the U.S. east coast from New Jersey to Georgia. The workshop included small group discussions on topics related to post-construction monitoring, best management practices, habitat trade-offs, success criteria, selecting appropriate placement sites, and identifying information needs. When evaluating the potential for TLP in North Carolina, workshop attendees highlighted the importance of clearly identifying the goals, objectives, purpose and need for these projects on a case-by-case basis while considering the above topics on a specifically defined local or regional scale. As a result, a collaborative multi-agency network of stakeholders is most likely needed to progress TLP in a responsible manner. Information gathered from this workshop will be incorporated into the 2026 amendment to the Coastal Habitat Protection Plan, which identifies TLP as a priority issue within the broader theme of planning for multi-decadal wetland change.

Introductory Remarks

Charlie Deaton, NC Division of Marine Fisheries (DMF) Habitat Protection Program Supervisor, began the workshop with introductions (see Subappendix A; attendee list) and an outline of the purpose and objectives of the meeting to inform the 2026 Coastal Habitat Protection Plan (CHPP) amendment (see Subappendix B; workshop agenda).

Daniel Govoni, NC Division of Coastal Management (DCM) Policy Section Chief, reinforced that the workshop was not intended to discuss the permitting, policy, or regulatory components of TLP; rather, it was intended to discuss the relationships between TLP and coastal habitats and resources. Nonetheless, Mr. Govoni summarized that TLP is not currently permissible in North Carolina because in most cases, the Coastal Area Management Act (CAMA) and associated guidelines for areas of environmental concern prohibit wetland fill. However, TLP could be permitted by the NC Coastal Resources Commission (CRC) through the CAMA variance process. There has been growing interest in TLP across coastal North Carolina, and NC DCM anticipates a potential need for future rulemaking that would authorize TLP through the typical CAMA permit process.

Research Overview

Dr. Jenny Davis, Research Ecologist with the National Oceanic and Atmospheric Administration (NOAA) Coastal Resilience, Response and Assessment Branch (CRABB), provided a broad overview of TLP and related methods for the Beneficial Use of Dredged Material (BUDM) with a presentation entitled Beneficial Use of Sediments for Habitat Restoration and Creation. The presentation began with a brief description of three beneficial use techniques to reverse or offset estuarine habitat loss:

- **Thin Layer Placement:** adding elevation to a deteriorating marsh to create more suitable conditions for marsh plant growth. This term is often used interchangeably with 'beneficial use.' However, TLP is just one type of beneficial use amongst others such as those defined below.
- **Thick Layer Placement:** creation of intertidal or upland habitat where it currently does not exist (i.e., habitat conversion).
- **Strategic Placement:** nearshore placement that allows for the natural distribution of sediments via waves and tides.

The remainder of the presentation focused on thin layer placement with an additional case study highlighting thick layer placement. Dr. Davis explained that the goal of each technique is to elevate existing wetlands that are vulnerable to sea level rise so that they are less vulnerable to sea level rise but remain within a vegetation-specific growth range. As such, target elevations are defined by marsh position relative to the tidal frame, and accurate placement of thin sediment layers on the marsh surface to achieve a specific target elevation becomes challenging. Dr. Davis emphasized that while TLP results in the short-term disruption of natural marsh processes, there are potential long-term benefits for marsh resilience.

Dr. Davis highlighted three TLP studies conducted in North Carolina, emphasizing that studies specific to the state have been limited and small-scale:

- Gull Rock (Wilber 1992)
- Masonboro Island (Croft et al. 2006)
- Freeman Creek, Camp Lejeune (Davis et al. 2019)

The bulk of Dr. Davis's presentation described two collaborative, large-scale case studies in Maryland: Deal Island Wildlife Management Area (thin layer placement) and Swan Island (thick layer placement):

Deal Island Wildlife Management Area

- Completed in 2024
- 167,000 cubic yards of material covering 72 acres
- Goal: raise majority of marsh platform to high-marsh elevation
- Sediment Source: Wicomico River
- Sediment Texture: fine
- Methods: sediments pumped across land (14 miles) to placement site and distributed by sheet flow across the marsh platform
- Placement Depth: up to 18 inches
- Containment Method: approximately 30,000 straw bales
- Plantings: hand planting over 700,000 native species over two growing seasons to discourage the establishment of invasive species.
- Outcomes and Lessons Learned

- Straw bales were effective containment structures except when the structure became compromised during a winter storm.
- Site access was challenging due to limited nearshore depth and submerged aquatic vegetation (SAV).
- Recommendation to "plant like crazy" wherever sediment is bare.
- Vegetative response is dynamic in early years and likely influenced by nutrients in deposited sediments and plant community changes in response to increased marsh elevation.
- Native vegetation that did not persist after the first year was replanted.
- Existing invasive common reed (*Phragmites australis*) on the site that was not treated before sediment placement had notably expanded by year two.
- It can take several years to reach equilibrium (i.e., target elevation profile)
- Created new habitat for salt marsh sparrow.

Swan Island

- Completed in 2019
- 60,000 cubic yards of material covering 12 acres
- Goal: create new habitat matrix (low and high marsh, dunes)
- Sediment Source: Chesapeake Bay Navigation Channel
- Sediment Texture: fine and coarse
- Methods: thick layer deposition of dredged material
- Placement Depth: a few centimeters up to one meter
- Containment Method: coir logs
- Plantings: hand planting approximately 200,000 native plants over two years
- Outcomes and Lessons Learned:
    - An as-built survey is needed to track changes over time and compare to intended design.
    - The containment structure remained in place.
    - It was more difficult to contain fine sediments, but installing fresh containment structure helped mitigate some loss.
    - Adjacent SAV was covered due to the loss of some fine sediments. While unintentional, it is necessary to evaluate whether potential trade-offs such as this are acceptable if they occur.
    - Creating high marsh was more successful than creating low marsh.

The Swan Island project was characterized by several performance thresholds and subsequent adaptive actions if thresholds were not met (see below). As such, Dr. Davis emphasized the need to identify a source of funding to support corrective action.

- **Vegetative Percent Cover:** If vegetation in planting zones did not spread to 50-75% of the total placement area, failing areas had to be replanted. If elevation changed, planting compatible species was required.

- **Sediment Surface Elevation:** If elevations did not remain within the appropriate range, additional sediment placement was required.
- **Shoreline Position:** If the designed shoreline did not maintain its position over time, the shoreline had to be rebuilt with additional sediment or plantings.

Dr. Davis concluded her presentation with closing thoughts and several best practices to consider for BUDM projects:

- Design for sediment leakage and plan/budget for additional fortification of containment structures.
- Plan/budget for replacing at least 50% of plants by the second year of the project.
- Attempt to control invasive species before sediment placement.
- Develop a monitoring and adaptive management plan with a temporal component to support corrective actions.
- Consider a range of acceptable outcomes.
- Offshore and upland disposal of dredged material deprives marshes of sediment that is critical for their survival (i.e., a "missed opportunity").
- Habitat trade-offs are inevitable.

At the conclusion of her presentation, Dr. Davis (JD) answered several questions from workshop attendees (A), which are paraphrased below:

- A: Who completed the work on Deal and Swan Island?
  JD: The work was contracted out but managed by the United States Army Corps of Engineers (USACE).

- A: Is there a way to determine a project's carrying capacity for plants and the nutrients needed to sustain them?
  JD: Due to variable site conditions, plant success is often driven by continuous planting and re-planting. Plant communities will most likely go through a "boom and bust" cycle until dense vegetation is established.

- A: For Deal Island, were straw bales used for containment allowed to naturally degrade?
  JD: Yes

- A: What is the strongest driving factor when determining placement depth?
  JD: Placement depth is incredibly project-specific, but it is important to establish boundaries. For example, identify a maximum allowable elevation or thresholds for other environmental variables.

- A: For Swan Island, can you discuss a bit more about comparing an as-built survey to intended designs?
  JD: Conducting as-built surveys are not part of the application process but are standard for projects on which NOAA participates. There was supposed to be more high marsh constructed from the dredged material, but during placement, some decisions had to be made on the fly which affected the end result.

- A: Was sediment characterized to ensure that dredged material matched that of the placement site?
  JD: Generally. At Swan Island, sand was used to construct high marsh and dune habitats. Fine sediments were used to construct low marsh.
- A: Are TLP projects ever paired with other types of marsh restoration, for example tidal flow restoration?
  JD: Most likely.
- A: Should thin layer placement specifically be defined as "no change in habitat" even though Deal and Swan Island were characterized by the destruction of existing vegetation and the conversion from low to high marsh?
  JD: While converting to a different marsh elevation, the habitat itself still functions as a marsh.
- A: Did the US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) have different perspectives on project goals?
  JD: Yes. The USFWS service is typically more upland habitat-oriented for bird populations while NMFS is more intertidal habitat-oriented for fish populations. State resource agencies requested them to scale back the volume of sediment used for the project.

State Resource Agency Panel

The workshop continued with a panel of representatives from several resource agencies outside of North Carolina to discuss progress on TLP and BUDM in other states (see Subappendix C; state resource agency panelist slides):

- Sarah Bouboulis, Coastal Programs Manager, Delaware Coastal Zone Management Program
- Tyler Kinney, Coastal Biologist, New Jersey Department of Environmental Protection
- Maggie Cavey, Beneficial Use Planner, Maryland Department of Natural Resources
- Jan Mackinnon, Program Manager, Georgia Department of Natural Resources

<u>Delaware</u>

Sarah indicated that in Delaware, they are in 'the thick of it' in terms of implementing TLP with only a few recent projects completed. There is a state-run dredge / beneficial use work group that meets regularly (approximately every 6-8 weeks) to ensure all participating agencies are on the same page and to check-on the status of active projects. This workgroup is comprised of researchers, restoration experts, the USACE, the Delaware Department of Natural Resources and Environmental Control (DNREC) Fish and Wildlife, the USFWS, and non-profit and contracting partners.

The state is currently developing a Dredge Material Management Plan to establish goals for how dredge material is used, including those uses that are not considered beneficial. While the USACE handles the majority of projects, Sarah indicated that the Watershed Stewardship Section of DNREC handles projects that involve dredging smaller waterways and evaluating potential resource impacts. Delaware often has issues with avoiding archaeological resources, and there are frequently challenges related to water quality and matching material types with restoration projects. For any beneficial use project in Delaware, adaptive management plans are required.

Looking to the future, Delaware is interested in better streamlining the process for BUDM projects (there is often a lot of “waiting around” due to permitting constraints, etc.) and working more closely with regulatory partners to develop a framework for establishing criteria that satisfies the concerns of all participating agencies (e.g., number and types of samples required to assess dredged material compatibility).

New Jersey

In New Jersey, TLP and BUDM projects have already been scaled beyond the pilot stage through a programmatic approach and careful coordination between regulators, dredgers, and landowners. Tyler indicated that building a successful network, not the science, is the most challenging barrier to overcome. Tyler emphasized that successful programs begin at the policy level, and it is important to establish clear standards that do not lead to continuous permit battles with every project that is proposed.

New Jersey created their programmatic approach to TLP and BUDM projects by first building trust with regulators to develop, pilot, and if successful, engage in new policies for establishing project planning programs and systems. Tyler emphasized that successful programs must first and foremost address environmental needs that are also of value to dredgers (i.e., establish buy-in) and recommended that projects begin with land owned by state and federal governments to ensure proper scaling and consistency. The state’s approach to TLP and BUDM is based on a logistics system and not a project-by-project approach: 1) regulators must develop methods for a programmatic approach once trust is earned, 2) landowners must develop and enforce a project development system to build trust, and 3) dredge teams must engage at the project level and buy-in to the concept of restoration.

Maryland

Maggie introduced the Maryland Beneficial Use Playbook and associated toolkit used by local counties and planners for navigating the BUDM landscape. The toolkit includes:

- Guidance Document: provides an overview of state regulations and associated considerations for dredged material management and types of beneficial use. This document can be used as a “grading system,” and it outlines standards and criteria for implementing successful BUDM (for example, ensuring sediment type and chemistry are compatible between dredged and placement sites).
- Digital Matchmaking Tool / MD Coastal Atlas: a spatial planning tool that allows users to identify restoration sites and match dredge projects with potential BUDM projects.
- Roadmap and Process Diagram: provides flow charts and decision trees that outline the process for planning and implementing successful BUDM projects.

Maggie serves as a liaison between the regulatory community and restoration practitioners. She offered tips on how to discuss TLP and BUDM with mixed audiences to gain public trust and support for these projects:

- Dredge 'spoil' appears negative or a 'bad thing' to the public. Sediment is not a waste but an opportunity to build resilience. Adopting the term 'dredged material' removes that negativity and is more meaningful.
- Talk openly about the 'ugly phase' of TLP (short-term temporary impacts).
- Humanize projects and create outreach products beyond simple fact sheets.
- Refer to TLP as 'elevation enhancement.' It is more easily understood by the public and captures all types of sediment placement (thin versus thick layer).

Maryland currently has a "random assortment" of TLP and BUDM projects. Maggie indicated that their long-term goal is to create a state-wide matchmaking program that includes innovative, out-of-water reuse (for example, covering landfill material with dredged sediment) and traditional TLP and BUDM projects. To achieve this goal, the state is in the process of developing a twenty-year dredge management plan and playbook. The state has coordinated workshops and developed specific funding calls for BUDM projects. The state is also in the process of conducting a Shallow Draft Channel and Restoration Assessment to identify areas of concern that would benefit from BUDM. Maggie concluded her presentation by highlighting a successful, recent TLP project and associated outreach materials at the Chesapeake Bay Environmental Center in Queen Anne County, Maryland.

<u>Georgia</u>

Jan provided an overview of TLP on Jekyll Island, Georgia in coordination with the Georgia Federal Consistency Program, the USACE, The Nature Conservancy, and the Jekyll Island Authority. This was one of just a few projects that have been implemented in the state. Unlike typical TLP projects, dredged material was placed on a healthy marsh rather than a deteriorating marsh. Details below:

- Completed in 2019
- 125,000 cubic yards of material (5,000 used specifically for TLP) over 5 acres
- Goal: keep dredged sediment within the system and increase marsh resilience to sea level rise.
- Sediment Source: Jekyll Creek and shallow areas of the Intracoastal Waterway
- Sediment Texture: fine
- Methods: direct pipe discharge with manual re-working of the material at low tide.
- Placement Depth: 6-10 inches
- Containment Method: coir logs
- Plantings: none

Jan discussed several outcomes and lessons learned from the project. Uncrewed Aerial Vehicle (UAV) imagery was used to evaluate aboveground plant biomass several years post-placement. After five years, 84% of the marsh had regrown primarily from the marsh edge inward. Revegetation took longer than anticipated and did not support the vision of full regrowth between 3-5 years. There has been no evidence that the placement site has "caught back up" with the reference site since monitoring began, and benthic species diversity has decreased with evidence of ponding along the perimeter of the placement site. Overall, Jan acknowledged that monitoring could have been improved but was limited due to funding constraints.

Panel Discussion

At the conclusion of their presentations, Sarah (SB), Tyler (TK), Maggie (MC) and Jan (JM) answered several questions from workshop attendees (A), which are paraphrased below:

- A: Most coordination appears to involve state and federal agencies' relationship with the USACE. Are there any examples of TLP or BUDM projects conducted by private organizations, non-profits, or smaller agencies?
  JM: The Jekyll Island project was completed on state-owned land, so it was easiest to work with the USACE.
  MC: The Chesapeake Bay Environmental Center project was led by Queen Anne County in Maryland. The County selected a contractor and managed the project.

- A: What type of marsh was selected for the Jekyll Island project?
  JM: The Jekyll Island site was 100% *Spartina alterniflora* and was selected based on its elevation at the time and its proximity to the dredge location.

- A: How have state resource agencies evaluated concerns with potentially contaminated dredge material?
  TK: The New Jersey Department of Environmental Protection has a section devoted to testing sediments to ensure they are safe (Sediment Innovation Lab).
  SB: Delaware is addressing this concern through framework development. The state might test sediments from both dredged and placement sites and place contaminated dredge material on already-contaminated placement sites.
  MC: The Maryland Beneficial Use Toolkit provides guidance on determining allowable contaminant levels in dredged material for BUDM projects. The Toolkit provides information about concentration thresholds and the number of samples needed to complete such an evaluation. Sediment is treated as hazardous material if it is determined to be unsafe for beneficial use.

- A: Any suggestions for local dredge operators who do not have experience with TLP or BUDM but may have an interest in bidding on these types of projects?
  TK: Contact those with experience (e.g., the USACE) for assistance. In New Jersey, the Department of Transportation Maritime Services has been a valuable resource for dredgers.

- A: Were any of the projects discussed considered compensatory mitigation for impacts associated with other development activities?
  SB: It has been discussed in Delaware but has not yet been authorized.
  TK: Not in New Jersey
  MC: Not in Maryland

JM: Not in Georgia

- A: What are the key policy decision points that allow projects to move forward?
  TK: It is most important to negotiate on the amount of data needed to guide successful restoration and satisfy participating agencies.

- A: Any projects that have less drastic impacts on vegetation in relation to building trust and alleviating concerns with habitat alteration?
  MC: It is difficult to completely avoid impacts to existing vegetation, especially for larger projects with high sediment volume.

Small Group Breakouts and Discussion

The final portion of the workshop involved small group discussions that addressed four questions developed by the workshop planning team and informed by attendees' input during the registration process:

1. What are your biggest concerns about sediment placement? What should be monitored? What does success look like? Do we need BMPs for sediment placement (e.g. suspended sediment control)? How to minimize impacts to adjacent habitats?
2. What do we need more information on to use sediment placement to increase marsh resilience?
3. These projects are happening in a changing ecosystem – how should we evaluate tradeoffs between current environmental impact and project longevity? What long term target should we be shooting for, end goal? How far out do you plan (i.e. SLR scenario?)
4. How do we define a degraded wetland to justify thin layer placement of sediment. How do you prioritize wetlands for TLP, what does that look like?

Attendees were organized into small groups and rotated between each question (roving flipcharts), building on previous groups' responses. Moderators for each question summarized key takeaways once all groups provided input:

<u>Question 1 Summary</u>

What are your biggest concerns about sediment placement? What should be monitored? What does success look like? Do we need BMPs for sediment placement (e.g. suspended sediment control)? How to minimize impacts to adjacent habitats?

<u>Biggest Concerns</u>

Success uncertainties were identified as a primary concern with TLP projects. Attendees noted that in some cases, TLP could do "more harm than good" especially if there is a lack of regulatory oversight once projects are implemented. As a result, it is necessary to develop an adaptive permitting framework that would be responsive to lessons learned.

Some attendees were concerned about effectively matching sediment types between dredged and placement sites. Likewise, there was concern about the impacts of contaminated sediments (e.g., heavy metals, forever chemicals, etc.) on placement sites and associated risks to fish, wildlife, and public health.

Lastly, attendees expressed concern over the potential loss of wetland function once sediments are placed (e.g., loss of SAV and fish habitat, introduction of invasive species such as *P. australis* or nutria).

Monitoring and Success Considerations

Attendees identified several parameters that could be monitored once sediment is placed on an existing wetland. These parameters could be validated with the NC Wetland Assessment Method (NCWAM) and the Uniform Mitigation Assessment Method (UMAM). Generally, attendees agreed that choosing what to monitor should be dependent on specific success criteria and may include some or all the following:

- Vegetation abundance and recovery, including invasive species
- Recovery and response of invertebrate, bird, fish, and reptile species
- Hydrology
- Elevation
- Funding costs
- Water quality and turbidity
- Soil chemistry, microbiome pre- and post-application
- Ecosystem services (e.g., reduced flooding, economic assessment)

Attendees stressed the importance of securing reliable funding for long-term post-construction monitoring, which could be a barrier to success. Likewise, attendees identified the need to develop standard operating procedures (SOPs) for monitoring to ensure consistency across projects (e.g., establishing relevant monitoring durations, identifying appropriate control and reference sites, etc.). These SOPs should account for potential site recovery time, impacts from storm events, environmental work windows, and marsh growing seasons. Some attendees agreed that SOPs should also require monitoring and mitigation for any temporary habitat and species impacts associated with wetland mats, pipelines, or other construction activities. As such, adaptive best management practices (like those typically used for stormwater and sediment and erosion control) should be integrated into TLP monitoring plans. Collectively, these factors would help restoration practitioners develop appropriate budgets and timelines for effective monitoring once projects are complete.

According to workshop attendees, TLP could be considered successful if there is evidence of consistent sediment placement and containment across the marsh surface, adequate post-construction tidal flow, and benefits that exceed financial and ecological costs. Successful projects are also those that evaluate public perception and demonstrate a return on investment.

Minimizing Impacts to Adjacent Habitats

To minimize impacts to adjacent habitats, attendees recommended that initial sediment placement should occur in less sensitive habitats (e.g., avoiding primary nursery areas, SAV, open shell fishing waters, outstanding resource waters, etc.) or areas within larger marsh systems. Attendees also recommended coupling TLP with other nature-based approaches (e.g., living shorelines) to develop a more holistic restoration strategy that incorporates the protection of adjacent habitats.

Question 2 Summary – Information Needs

What do we need more information on to use sediment placement to increase marsh resilience?

Attendees identified a suite of factors that need careful attention before TLP is used to enhance marsh resilience to sea level rise. They were broadly categorized as follows:

- Sediment contaminants and establishing acceptable thresholds
- Acceptable habitat trade-offs and adaptive management
- Evidence of need
- Sediment characteristics and texture
- History of wetland loss and future trends (couple with marsh migration efforts)
- Tidal, geomorphological, and hydrological information
- Projections of outcomes / modeling
- Detailed site mapping (elevation, soil and vegetation types, archaeological surveys)
- Additional demonstration and pilot studies
- Frequency of repeat sediment applications
- Current ecological and economic function of any given marsh system

Question 3 Summary

These projects are happening in a changing ecosystem – how should we evaluate tradeoffs between current environmental impact and project longevity? What long term target should we be shooting for, end goal? How far out do you plan (i.e. SLR scenario?)

Evaluating Trade Offs

Attendees highlighted the need to evaluate acceptable trade-offs relative to project-specific purpose and need. For example, trade-offs are different for projects that aim to either restore or create new habitat. Like environmental impact statements required for large projects, TLP proposals should consider an array of action alternatives, including the "no action" alternative, when evaluating acceptable trade-offs. In some cases, no intervention and the subsequent conversion of intertidal to subtidal habitat could be most appropriate. In areas with adequate natural sediment supply and undeveloped corridors, facilitating natural marsh migration may be most appropriate and cost-effective.

Attendees also discussed trade-offs between TLP and public trust rights. For example, sediment placement that results in the fill of canals or ditches or in the creation of new upland habitats may eliminate navigable waters and public trust resources. As such, it is important to consider TLP success relative to community and stakeholder benefits. One attendee noted that if TLP results in the creation of new upland areas, conditions should be in place to prevent new development on those areas.

Long Term Planning Scenarios

In North Carolina, the life span of TLP projects and the associated ecosystem services they provide would most likely be determined by several location-specific factors such as current and future rates of sea level rise, the ability to match dredge frequency and sediment availability to marsh vulnerability (e.g., number of applications needed), the time frame in which a restored marsh reaches equilibrium and recovers post-construction, and the potential for future development and subsequent barriers to marsh migration. Attendees cautioned that using sea level rise alone to justify TLP could result in the "convenient disposal" of dredged material. As emphasized throughout the workshop, it is therefore necessary to consider a variety of factors that specifically target the restoration of deteriorating wetlands. In some cases, wetland loss may be driven by other stressors such as boat wakes and wave impacts. Wetlands susceptible to multiple stressors could benefit from protective measures other than TLP such as wave attenuating structures.

Lastly, attendees compared long-term TLP planning and implementation to beach nourishment and prescribed burns. Attendees suggested that once established, TLP could be incorporated into local resiliency plans to garner additional public support and funding from municipalities. Compared to beach projects, wetland change is typically slower and less obvious which could impact public perception or support. However, stakeholders could show a higher risk tolerance with TLP and associated uncertainties since candidate areas for sediment placement comprise a relatively small fraction of total wetland area across the state.

Question 4 Summary – Prioritizing Wetlands for TLP

How do we define a degraded wetland to justify thin layer placement of sediment. How do you prioritize wetlands for TLP, what does that look like?

Attendees agreed that characterizing a wetland as "degraded" may not be the most effective way to determine whether a site is a good candidate for TLP. Instead, practitioners should consider wetlands that are "at risk" of vegetation loss and ponding while also accounting for factors such as a site's proximity to existing infrastructure, the proposed dredge area and established migration corridors. Attendees also emphasized that just because a marsh is near a dredge area does not automatically make it a good candidate for TLP.

Evaluating regional status and trends of existing marshes is particularly important (e.g., natural conditions, future change, tidal ranges, salinity, ecology). For example, a highly developed region with many barriers to natural marsh migration (e.g., New Hanover County) may not benefit from TLP as much in the long-term compared to scarcely developed regions with higher migration potential (e.g. Hyde County). On the other hand, more developed regions could benefit more in the short term since options to enhance resilience are limited.

Conclusion and Next Steps

When evaluating the implementation of and trade-offs associated with TLP in North Carolina, workshop attendees highlighted the importance of clearly identifying the goals, objectives, purpose and need for these projects on a case-by-case basis – rather than as a catch-all approach – while considering the above topics on a specifically defined local or regional scale. As a result, a collaborative multi-agency network of stakeholders is most likely needed to progress TLP in a responsible manner.

The information gained from this workshop will be incorporated in and directly inform the 2026 CHPP amendment. TLP will be addressed as a stand-alone issue paper within the proposed Planning for Wetland Change thematic area. This paper will synthesize the best available science and guidance related to TLP, identify research needs and knowledge gaps, discuss policy, permitting, and regulations, and highlight concerns and best practices related to TLP that may collectively inform next regulatory steps and identifying priority areas where TLP may be successful in North Carolina.

SUBAPPENDIX A: WORKSHOP ATTENDEES

First Name	Last Name	Organization
Aaron	Bunch	The Nature Conservancy
Abby	Williams	NC Coastal Reserve and NERR
Ana	Zivanovic-Nenadovic	North Carolina Coastal Federation
Anne	Deaton	NOAA National Marine Fisheries Service
April	Hall	NC Coastal Federation
Billy	Standridge	US Army Corps of Engineers
Brandon	Puckett	NOAA National Centers for Coastal Ocean Science
Byron	Toothman	NC Coastal Reserve and NERR
Caroline	Causey	US Fish and Wildlife Service
Carolyn	Currin	EA Engineering, Science, and Technology
Cat	Bowler	Audubon North Carolina
Catherine	Otero	NC Division of Water Resources
Cathy	Brittingham	NC Division of Coastal Management
Charlie	Deaton	NC Division of Marine Fisheries
Claire	Rapp	NC Coastal Federation
Daniel	Govoni	NC Division of Coastal Management
Derek	Detweiler	NC Division of Marine Fisheries
Emily	Hughes	US Army Corps of Engineers
Gregg	Currey	US Army Corps of Engineers
Gregg	Bodnar	NC Division of Coastal Management
Jacob	Boyd	NC Coastal Federation
Jenny	Davis	NOAA National Centers for Coastal Ocean Science
Jonathan	Lucas	NC Division of Coastal Management
Justin	Ridge	NC Coastal Reserve and NERR
Kate	Jones	NC Dept. of Natural and Cultural Resources
Kelsey	Beachman	Division of Coastal Management
Kristina	Hellinghausen	NC Division of Water Resources
Lisa	Wickliffe	NOAA National Marine Fisheries Service
Mary	Plummer	NC Dept. of Natural and Cultural Resources
Melanie	Flood	NC Natural Heritage Program
Michael	Meilinger	NC Division of Water Resources
Michael	Schafale	NC Natural Heritage Program
Michelle	Brodeur	NC Division of Marine Fisheries
Michelle	Moorman	US Fish and Wildlife Service
Molly	Bost	NOAA National Centers for Coastal Ocean Science
Paula	Gillikin	NC Coastal Reserve and NERR
Richard	Mahoney	NC Division of Coastal Management
Sara	Ward	NC Dept. of Natural and Cultural Resources
Sarah	Marschhauser	Audubon North Carolina

Shane	Staples	US Army Corps of Engineers
Stephen	Lane	NC Division of Coastal Management
Trish	Murphey	NC Division of Marine Fisheries
Whitney	Jenkins	NC Coastal Reserve and NERR
Zach	Harrison	NC Division of Marine Fisheries

SUBAPPENDIX B: WORKSHOP AGENDA

Thin-Layer Placement Coordination Workshop
to inform the Coastal Habitat Protection Plan (CHPP) update

Thin-layer placement of sediment (TLP) is a strategy to restore or maintain a tidal marsh's elevation relative to sea level, to support marsh resilience. The approach leverages a marsh's natural ability to withstand large, storm-driven sediment deposits. TLP mimics this natural process by applying layers of sediment, often dredged material, to the marsh's surface.

Date: Monday, March 30, 2026

Location: Duke University Marine Lab, Repass Lecture Hall, 135 Duke Marine Lab Rd, Beaufort NC 28516

Time: 10:00am - 3:00pm

Target audience: Resource agencies, researchers, restoration practitioners

Workshop Objectives – Participants will:

- Share and discuss the latest Thin-Layer Placement of sediment (TLP) research and project implementation best practices,
- Discuss state policies and challenges in assessing project proposals, and
- Identify information needs to inform policy and permitting.

Workshop Outcomes:

- Regulatory agencies can better assess the purpose, need, and habitat impacts/tradeoffs from proposed TLP projects,
- Researchers understand knowledge gaps and connect with restoration practitioners for potential study sites, and
- Resource managers incorporate perspectives presented into planning and policy through the CHPP.

Agenda

Time	Item
9:30am	Workshop check-in
10:00am	Welcome & Introductions
10:15am	TLP Research Overview – Jenny Davis, NOAA
10:55am	15-minute break
11:10am	Resource agency panel via Zoom • Sarah Bouboulis, DE Department of Natural Resources and Environmental Control • Tyler Kinney, NJ Department of Environmental Protection • Maggie Cavey, MD Department of Natural Resources

	• Jan Mackinnon, GA Department of Natural Resources
12:10pm	TLP – Tasty Lunch Provided! Thank you, NC Coastal Federation!
1:00pm	Small group discussion • What are your biggest concerns about sediment placement? • What do we need more information on to use sediment placement to increase marsh resilience? • These projects are happening in a changing ecosystem – how should we evaluate tradeoffs between current environmental impact and project longevity? • How do we prioritize wetlands for thin-layer placement of sediment?
2:45pm	Action Items & Next Steps
3:00pm	Adjourn

SUBAPPENDIX C: STATE RESOURCE AGENCY PANELIST SLIDES

to be added to final PDF