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Thin Layer Placement: Technical Definition for U.S. Army Corps of Engineers Applications

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PURPOSE: The following document provides a technical definition of thin layer placement (TLP) activities for U.S. Army Corps of Engineers (USACE) applications. A discussion of the development, history, and examples of TLP applications are also provided.

BACKGROUND: Sediments are routinely intentionally placed into the environment to achieve beneficial outcomes, including beach nourishment, wetland creation, and other activities (Landin et al. 1989; USACE 2015; National Research Council 1995). Many publications and reports document the beneficial use of sediment, including dredged materials, to support infrastructure and enhance ecological outcomes (Yozzo et al. 2004; USEPA and USACE 2007; Faulkner and Poach 1996). Recently, increasing interest has focused on the placement of dredged sediments in thin layers; this provides opportunities for sediment management, beneficial use of dredged material, and ecological restoration or enhancement (Wilbur et al. 2007; Smith and Niles 2016; Berkowitz et al. 2017). Several terms associated with TLP appear in literature (Table 1), highlighting the need for further discussion of the topic and a definition specific to USACE applications.

Table 1. Terms associated with TLP within available literature

Term	Source
Artificial sediment enhancement	La Peyre et al. 2009
Thin layer placement	USACE, others
Thin layer deposition	Ford et al. 1999
Sediment subsidy	Mendelssohn and Kuhn, 2003
Sediment slurry application/addition/amendment	Schrift et al. 2008
Sediment enrichment	Slocum et al. 2005
Thin layer sediment renourishment	Croft et al. 2008
Thin layer disposal	USACE, others
Marsh Nourishment	CPRA 2018

BENEFITS OF TLP: In the late 1970s, practitioners began investigating potential benefits of thin layer sediment applications (Reimold et al. 1978). The application of thin layers of sediment may have advantages over traditional, thicker sediment placement applications in a variety of environments where thicker layers of sediment pose potential challenges to natural resources, infrastructure, navigation, or other assets. For example, a number of reports document the benefits of thin layer sediment applications such as increased marsh elevation, improved soil stability, and enhancement of wetland functions while maintaining characteristic plant communities (Figure 1) (DeLaune et al. 1990; Mendelssohn and Kuhn 2003). Several studies document the benefits of TLP applications to marsh vegetation, with common wetland plants (e.g., *Spartina alterniflora*) displaying the capacity for rapid recovery following the deposition of a 0 – 30 cm thick layer of sediment. In some cases, the placement of thicker layers of sediment may smother established marsh vegetation, highlighting the benefits of using TLP in some contexts, compared to traditional placement approaches (Riemold et al. 1978). Ray (2007) provides a review of TLP projects conducted in coastal wetlands; however, thin layer applications have occurred in other contexts including open water placement.

Figure 1. Thin Layer Placement (TLP) of sediment in marsh environments (left) are designed to increase marsh elevation and prevent subsidence, while allowing vegetation to recover (right). Photo credits: Tim Welp (left) and Christine VanZomeren (right).

Open water applications, including TLP on bay bottoms, maintain sediment supplies within the system while enhancing benthic communities (Parson et al., 2015). For example, Wilbur (2007) reported that open water TLP applications resulted in enhanced benthic recovery following dredged material placement at a water depth of approximately 20 m. Others applied TLP to provide supplementary sediment in support of existing infrastructure. This approach was utilized as part of the Mouth of the Columbia River (MCR) Regional Sediment Management Plan, in which the TLP addressed littoral sediment needs by placing sediments to reduce scour along jetties, while avoiding potential negative impacts to navigation safety (e.g., mound elevations) and smothering of biological resources (e.g., fish and crabs) (Figure 2; Portland State University 2016; Roegner and Fields 2014). Alternatively, the practice of capping contaminated sediments with a relatively thin layer of clean dredged material in shallow water at a thickness on the order of the mixing depth of benthic activity may also be referred to as thin layer placement or thin layer capping (Merritt et al. 2010). The use of TLP achieved project objectives while avoiding potential negative impacts to benthic species associated with thicker sediment deposition techniques.

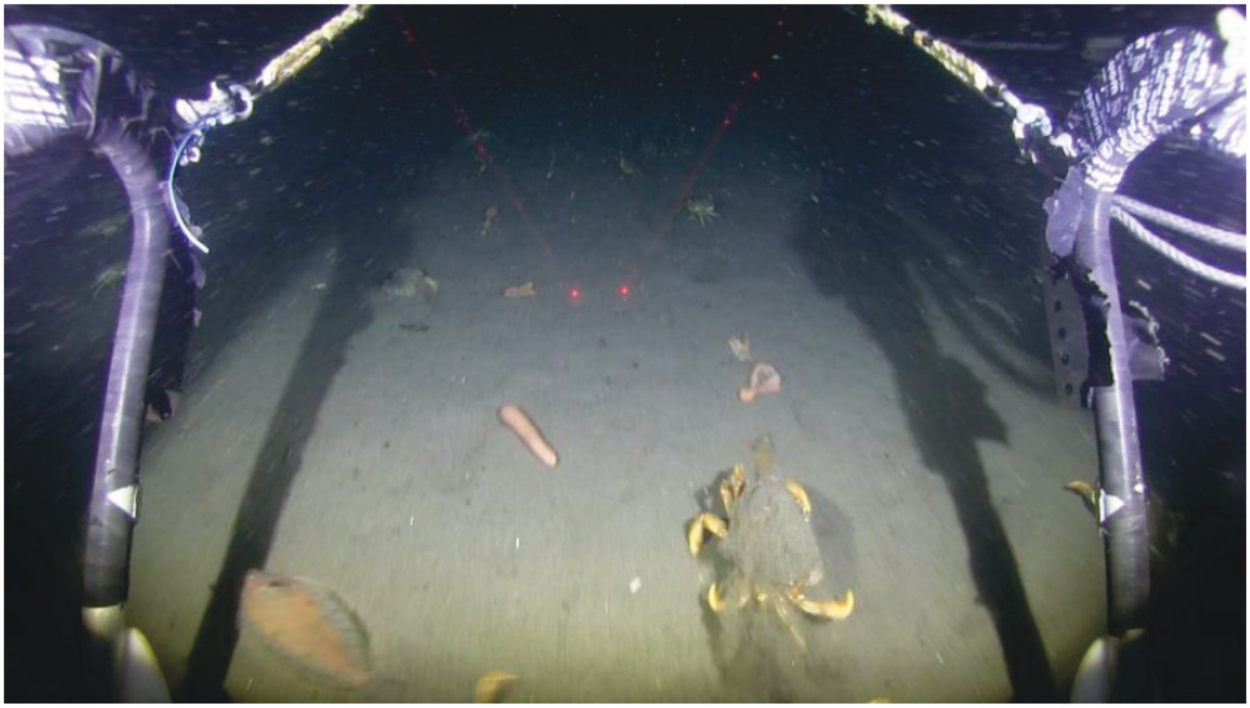

Figure 2. Benthic sled images of fish, worms, and crab emerging from sediment following an open water TLP application within the littoral zone (reproduced from Roegner and Fields 2014).

TLP CHALLENGES: While TLP has proven useful in wetland, subtidal, and open water contexts across the U.S., the wide variety of application methods and project objectives complicate defining the TLP concept (Table 2). Additionally, the ability to obtain a specific TLP thickness or target elevation remains limited by placement technique, equipment, project objectives, and other factors. Specifically, the thickness of material placed by a dredge is a function of the type of dredge equipment being used, how it is being operated, placement site conditions, and dredged material physical characteristics (e.g., dispersion or consolidation potential).

Table 2. Examples of TLP project locations, application methods, habitats, and placement depths. Note that TLP applications utilized discreet thicknesses ranging from 0–36 cm, or an unspecified target elevation based upon project objectives. *

Location	Application method or equipment	Receiving habitat	Depth (cm)	Citation
Barataria Basin, LA	Manual spreading	Marsh	2–5	DeLaune et al. 1990
Bayou Lafourche, LA	Low pressure discharge	Marsh	13–36	Schrift et al. 2008
Blackwater NWR, MD	High pressure discharge	Marsh	Target elevation	Nemerson 2007
Blackwater NWR, MD	High pressure discharge	Shallow open water	Target elevation	Nemerson 2007
Coos Bay, OR	Mechanical spreading	Diked marsh	Target elevation	Cornu and Sadros 2002
Delaware Day, NJ	High pressure discharge	Diked marsh	Target elevation	Weinstein and Weishar 2002

Location	Application method or equipment	Receiving habitat	Depth (cm)	Citation
Fortescue, NJ	Low pressure discharge	Marsh	Target elevation	Dredging Today 2016
Galveston Bay, TX	Hydraulic cutterhead dredge	Open water; subtidal	7.5–20	Sallese 2012
Masonboro Island, NC	Low pressure discharge	Marsh	0–10	Croft et al. 2006
Mississippi Sound, MS	Hydraulic cutterhead dredge	Open water; subtidal	15	Wilber et al. 2007
Mobile Bay, AL	Spill barge	Open water; subtidal	< 30	USACE 2014
Narrow River, RI	Mechanical spreading	Marsh	10–15	USFWS 2014a
Pepper Creek, DE	High pressure discharge	Marsh	0–20	Wilson 2013
Portland, OR	Hopper dredge	Open water; subtidal	5–6.8	Roegner and Fields 2015
Sachuest Point, RI	Mechanical spreading	Marsh	2.5–30	Center for Ecosystem Restoration 2015
Seal Beach, CA	High pressure discharge	Marsh	25	USFWS 2014b
Venice, LA	High pressure discharge	Marsh	2.3 ± 0.5	Ford et al. 1999
Venice, LA	High pressure discharge	Shallow open water	11.6 ± 1.1	Ford et al. 1999
Venice, LA	Low pressure discharge	Marsh	0–30	Mendelssohn and Kuhn 2003
Vermillion Parish, LA	Low pressure discharge	Marsh	0–20	Graham and Mendelssohn 2013

* Hydraulic low pressure discharge (modified after Cahoon and Cowan, 1987) consists of an open-ended discharge pipe that is generally equipped with a diffuser (or spreader plate); a device placed to slow the velocity of slurry to provide better control over point placement and/or reduce impacts to wetland surfaces or in the water column. Hydraulic high pressure discharge involves the use of a contraction section at the pipeline outlet (typically a nozzle) that increases the slurry's exit velocity such that the resultant jetting action propels the slurry in an arc-shaped pattern (some literature sources refer to high pressure discharge applications as “rainbowing”; see Figure 1).

The engineering behavior and physical characteristics of dredged material vary with grain size distribution, organic matter content, mineralogy, and bulk density. In situ sediment is mixed with water in varying proportions, depending on the type of dredging equipment used. For example, mechanical dredges (e.g., clamshell bucket and backhoe) excavate material with near in situ density, while hydraulic pipeline dredging (e.g., cutterhead dredges) typically generate a dredged material slurry with solids content of approximately 15% by weight. During placement activities, a mechanically dredged, unconsolidated, fine-grained material being released from a dump scow in open water could result in a sediment layer thickness of less than 30 cm, representing a TLP application. However, that same barge filled with a sand-dominated sediment could result in >200 cm thick layers of material placed over them same area, eliminating such applications from the TLP by concept. Further, a hydraulically dredged sediment slurry will separate during placement, depositing coarse grained sediment in the immediate vicinity of the discharge point, while the fine-grained sediment spreads and flows further distances (Kungchum et al. 2017).

Therefore, the deposition layer thickness remains a function of hydraulic sorting processes, including the distance from the discharge location, duration of discharge and quantity of sediment, site topography or containment structure(s), and the density of the deposited material. These factors, along with the variety of project objectives, placement environments, and application techniques, pose challenges to establishing a concise, comprehensive TLP definition. As a result, a review of existing literature was conducted to identify key components defining TLP and synthesize those components related to USACE applications.

DEFINING TLP: Defining TLP promotes clarity for practitioners and the public regarding sediment applications. Additionally, the development of a comprehensive definition provides an opportunity to distinguish TLP from other sediment placement practices, since TLP includes unique application thicknesses, placement techniques, and outcomes (Wilbur 1992; Ray 2007). However, a number of TLP definitions appear in the literature, resulting in confusion regarding the classification and communication of the application, potential benefits, and limitations of this technique. For example, Wilbur (1992) defined TLP as follows:

> "Any disposal of dredged material involving the purposeful, planned placement of material at thicknesses that are generally believed to either greatly reduce the immediate impacts to biota or greatly hasten the recruitment of native biota to the material without transforming the habitat's ecological function."

This definition contains several valuable elements, including the fact that TLP activities should remain purposeful and consider potential impacts and benefits to natural resources. However, as written, the definition specifies that TLP applications involve dredged material, potentially excluding other source materials. Additionally, the usage of the term "disposal" has declined in recent years as the scientific community and the public increasingly view dredged materials as a beneficial resource.

LaPeyre et al. (2006) provides the following definition for TLP activities in a marsh nourishment centric context:

> "A relatively new restoration strategy that can refer to either the direct placement of a thin-layer of sediment through spray or hydraulic dredging or from the "spilling" of a thin-layer of sediment over marsh that is adjacent to an uncontained restoration project."

This definition also includes several important components, including the potential of TLP to support restoration. However, the definition limits TLP applicability to a particular technique (e.g., spray application) and purpose (e.g., marsh restoration).

The USACE Engineer Research and Development Center (ERDC) Dredging Operations Technical Support (DOTS) program has conducted several TLP-related activities, including the development of a website highlighting TLP concepts, pilot projects, and associated literature (*http://tlp.el.erdc.dren.mil/*). That resource contains the following definition:

"Thin Layer Placement broadly encompasses the purposeful placement of sediment or dredged material in a manner that produces a specific layer thickness or ground surface elevation necessary to achieving the overall project objectives. In TLP projects, the layer thickness typically ranges from a few centimeters to some fraction of a meter, depending upon the variation in ground surface or water levels at the site, and the functional objectives the placement is intended to achieve."

This definition contains many of the positive elements identified by Wilbur (1992), Ray (2007), LePeyre (2006) and others. Additionally, it incorporates the concept of a target elevation as opposed to the sole criterion of a placed thickness.

The following list highlights important components of a comprehensive TLP definition:

- TLP sediment applications should be purposeful.
- TLP sediments should not be limited to dredged material sources.
- TLP projects can support infrastructure objectives.
- TLP activities should be environmentally acceptable.
- TLP projects provide opportunities to create, maintain, enhance, and/or restore ecological function.
- The TLP definition should not specify particular layer thickness or application techniques.
- The term "disposal" should not be incorporated into the TLP definition.

Based on these factors and the previously completed work on the topic, a TLP definition was developed for USACE applications (provided below). This definition incorporates the desirable qualities of prior studies, while making the definition more inclusive and comprehensive to support the wide array of TLP projects being conducted (e.g., open water and marine placement activities). Additionally, the TLP definition may require periodic updates based upon new scientific information and/or advances in TLP practices. Further sub-categorization to address specific types of TLP activities (e.g., marsh vs. open water applications) may be required. Note that the definition is designed to be comprehensive, and intentionally does not specify a threshold thickness. This allows for flexibility based upon habitat (e.g., marsh surface, open water) and project objective (e.g., increase elevation, supplement sediment supply). For example, during marsh nourishment, TLP thickness thresholds are typically dictated by the capacity for vegetation to penetrate the applied sediment layer (Berkowitz et al. 2017). Similarly, in open water settings, TLP thickness may be limited by the ability of benthic organisms to avoid permanent burial (Roegner and Fields 2014). As a result, practitioners should determine and document specific TLP thickness thresholds based upon project specific objectives and site conditions.

TLP DEFINITION: Purposeful placement of thin layers of sediment (e.g., dredged material) in an environmentally acceptable manner to achieve a target elevation or thickness. Thin layer placement projects may include efforts to support infrastructure and/or create, maintain, enhance, or restore ecological function.

SUMMARY: This technical note (TN) current report provides background information regarding TLP, a brief discussion of TLP benefits, and reviews previously published definitions of TLP.

Based on those findings, a more inclusive, updated TLP definition is presented to support USACE applications.

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