ENGINEERING AND CONSTRUCTION ASPECTS OF THIN LAYER PLACEMENT OF SEDIMENT PROJECTS

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TAMU Ocean Engineering – EWN
Lecture Series
March 26, 2018
Who am I?

BS Mining Eng. UW-P, MS Ocean Eng. FIT. Am a research hydraulic engineer with over 25 years of experience working in the Coastal Engineering Branch at Coastal and Hydraulics Lab, USACE-ERDC. Work primarily with R&D of improving existing dredging and dredged material placement technologies, and developing new ones.
Outline

• What is thin layer placement (TLP)?
• General TLP project process flow
• TLP engineering considerations
• TLP construction considerations
What is “thin layer placement?”

- Placement of a thickness of dredged material that does not transform the receiving habitat’s ecological function (Wilber, 1992)
- Has also been used to describe placements ranging in depth from centimeters to 1 m

<table>
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<tr>
<th>Term</th>
<th>Source</th>
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<tr>
<td>Artificial sediment enhancement</td>
<td>La Peyre et al., 2009</td>
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<tr>
<td>Thin layer placement</td>
<td>USACE, others</td>
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<td>Thin layer deposition</td>
<td>Ford et al., 1999</td>
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<td>Sediment subsidy</td>
<td>Mendelssohn and Kuhn, 2003</td>
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<td>Sediment slurry application/addition/amendment</td>
<td>Schrift et al., 2008</td>
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<td>Slocum et al., 2005</td>
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<td>Thin layer sediment renourishment</td>
<td>Croft et al., 2008</td>
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</table>

(Berkowitz et. al.)
Oil and gas exploration in Louisiana wetlands soils usually unstable (high water and organic content) used board roads

- Submersible drilling barge built in 1934
- 1938 dredging of access canals
- Mechanical (dragline bucket) dredging vs. hydraulic dredging (low pressure spray) 1930s-1940s both used
History – “thin layer placement”

- 1950s mechanical dredges ruled
- Late 1960s early 1970s “spoil banks” determined enviro-bad
- High pressure spray placement first applied southern Louisiana 1979*

*Cahoon and Cowan 1988
Thin layer placement

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.

Berkowitz et al.
General TLP project process flow

- Nexus – sea level rise/degrading wetlands/limited dredged material placement areas.
- Must have a degraded wetlands that needs sediment added to be sustainable.
- Must have a sediment source (navigation channel and/or borrow area).
- Planning, engineering, and construction aspects required to attain that sustainability.
- Where getting sediment from, what kind of sediment is it, and how is it being used (specifically how excavating, transporting, and placing this sediment)?
Dredging a channel vs. restoring/maintaining a wetland
USACE, dredging contractor and wetland stakeholders
Different Perspectives!

https://qph.ec.quoracdn.net/main-qimg-b2f3c1af916f729567f8a57456b7b0c7-c?convert_to_webp=true  bryanRidgley.com
Sediment Source

Proposed Dredged Material

- Hydrographic survey (volumes)
- Core samples from proposed dredging depth
- Chemical analyses (contaminants)
- Water content
- Salinity
- Grain size distribution
- Organic content
- Atterberg Limits
- Column settling test
- Consolidation tests

Self weight
Standard oedometer
Sediment Management
Dredging

The process of excavating sediments and other materials from underwater locations for applications such as constructing new waterways, maintaining existing waterways, or obtaining sediment for purposes like land reclamation, beach nourishment, etc.

- The dredging process generally consists of the following stages:
  - Excavation (loosening or dislodging) of the material from the bottom.
  - Removal of the loosened material to the dredge vessel.
  - Transportation of the material to the placement area.
  - Placement of the material.
Factors in selection of dredging equipment

- Physical characteristics of sediments
- Quantities to be dredged
- Dredging depth
- Distance to dredged material placement area
- Physical environment of and between areas
- Contamination level of sediments
- Method of placement (thin layer placement)
- Production required
- Types of dredges available
- Environmental considerations
Majority of TLP Projects (outside Louisiana) have been conducted by smaller hydraulic cutterhead dredges.

10 inch diameter discharge Ellicott 370 “Dragon”

10 inch diameter discharge Ellicott 470 SL

14 inch diameter discharge “Fullerton”

http://www.dredge.com
Wetland Mapping and survey data

Elevation and topography (high resolution and accuracy)
Detailed topographic hydrological analysis (flow paths, directions)
Property boundaries, roads, rights-of-way, utilities, benchmarks, structures

LIDAR Ranging (local 5 mm @ 400m)
GPS weak link

Terrestrial LIDAR

Airborne LIDAR

The smaller the tide range: the tighter (more accurate/higher density) you want your survey.
Wetland Geotechnical investigation

Soil description/grain size
Chemical analysis of soils
Some measure of bearing strength for equipment access
Foundation sediment consolidation behavior (oedometer)
## Engineering considerations: balancing objectives

Using communication and simple tools to facilitate discussions and negotiations – balance economic/efficient placement versus ecological goals

<table>
<thead>
<tr>
<th>CELL</th>
<th>HABITAT TYPE (USFWS)</th>
<th>ACRES (horizontal extent)</th>
<th>BIOLOGIC PRIORITY (USFWS)</th>
<th>Constructibility rank (depth, compactness)</th>
<th>Cell Area Rank</th>
<th>Capacity rank</th>
<th>NJDOT - equal rank</th>
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Sediment containment structures

Hay bales

Blackwater Bob Blama

U.S. Fish and Wildlife Service, San Diego NWRC
Sediment containment structures

Coir logs

Anacostia, Bob Blama

Avalon NJ
Sediment containment structures

Biodegradable filter socks

Fortescue - New Jersey DOT
Sediment containment structures

Biodegradable burlap
Sediment containment structures

Sediment itself
Sediment containment structures

Existing topography

Avalon NJ
Sediment containment structures

Vegetation

Avalon NJ
Ongoing discussion:
Sediment containment structures
Good, bad, or ?

Avalon NJ
Construction considerations: shore equipment

- Helicopters are recommended for personnel, supply and equipment movement to reduce surface vehicle traffic. All other surface traffic should be by small boat, airboat or hovercraft to the extent practicable.
- Wheeled and tracked vehicles should be used only as a last resort, when less destructive equipment cannot perform the task. Wheeled and tracked vehicles with low contact pressures are preferred due to the reduction of surface effects.
- In areas where the marsh is already stressed and/or beginning to break up, and in most salt marsh, use airboats at high tide only. This may mean limiting the times of operation when water levels are low.
- Lightweight pontoon equipment with special underside coatings (Teflon, for example) can reduce tracks and compression of vegetation and soils in wetlands, however, towing/skidding pontoon equipment can cause channeling and may be inappropriate in some wetland types.
- Keep loading to a minimum to reduce ground pressure.
- Minimize the numbers of vehicles used.
Construction considerations: shore equipment

Low ground pressure vehicles – generally less than 2 psi

All examples are approximate, and will vary based on conditions
Hovercraft: 0.7 kPa (0.1 psi)
Human on Snowshoes: 3.5 kPa (0.5 psi)
Rubber-tracked ATV: 5.165 kPa (0.75 psi)
Diedrich D-50 - T2 Drilling rig: 26.2 kPa (3.8 psi)
Human male (1.8 meter tall, medium build): 55 kPa (8 psi)
M1 Abrams tank: 103 kPa (15 psi)
1993 Toyota 4Runner / Hilux Surf: 170 kPa (25 psi)
Adult horse (550 kg, 1250 lb): 170 kPa (25 psi)
Bagger 288 Excavation machine: 170 kPa (25 psi)
Passenger car: 205 kPa (30 psi)
Wheeled ATV: 13.8 kPa (2 psi)
Adult elephant: 240 kPa (35 psi)
Mountain bicycle: 245 kPa (40 psi)
Road racing bicycle: 620 kPa (90 psi)
Stiletto heel: 3,250 kPa (471 psi)
Marsh buggies, not swamp buggies!

Marsh Buggies

WILCO

Swamp Buggies

Marsh Buggies Inc.
Construction considerations: equipment operations

• Minimize travel by good daily planning.
• Access routes shall be planned to have minimum impact to wetlands. Maximize use of open water, dikes, existing roads and trails, and previously disturbed areas or areas which will be impacted by the project such as dredged material disposal areas; minimize crossing of undisturbed marsh.
• The straightest route usually is not the least damaging route.
• All vehicles must remain in designated work areas and access routes. No roaming or cross country travel is permitted.
• Access routes and work areas should be clearly staked or otherwise marked so that operators know exactly where they are permitted to go.
• For hydraulic dredging disposal operations, the applicant shall provide a description, with any necessary plats and drawings, of the locations and methods of discharge pipe assembly and movement, how and when it will be moved during operation, and how it will be removed upon completion, including the types of tracked or wheeled vehicles to be used. Where possible, the equipment moving the pipe should remain in place rather than tracking in and out between moves.
• Reduce turning maneuvers. Where available, use open water or other means for turns. Do not lock a track to turn equipment.
Construction considerations: pipeline discharge

- Traditional open pipeline discharge (low pressure spray)
- High pressure spray placement

A primary distinction - the deposition pattern......

Characteristics to be considered:
- Dimensions of placement area
- Where you want sediment and where you don’t
- Type of sediment
- Dredge production
- Economics

Spraying distance 50 - 300 ft
Pipeline distribution configurations

Single point via nozzle

Single point via barge nozzle

Single point via pipeline

“Multiple” discharge manifold

Source: USFWS
Conceptual marsh topography changes as a result of DM placement and consolidation

1. Existing (pre-placement) marsh surface (solid green line)
2. Place DM slurry to initial fill elevation (solid tan line)
3. Over time, the DM consolidates (dotted tan line)
4. Original marsh surface also consolidates (dotted green line) due to weight of placed DM

US Army Corps of Engineers • Engineer Research and Development Center
Hydraulic classification
Prime Hook National Wildlife Refuge

USFWS
Pepper Creek, Delaware

Delaware Department of Natural Resources and Environmental Control
Avalon, New Jersey
Fortescue, New Jersey

New Jersey DOT
## Sediment placement grade control

- **Grade stakes**
- **Eyeballing against existing vegetation**

<table>
<thead>
<tr>
<th>Discharge Pipe Dia (in)</th>
<th>Velocity (ft/sec)</th>
<th>Flow (ft(^3)/sec)</th>
<th>Flow (GPM)</th>
<th>Slurry (yd(^3)/hr)</th>
<th>Sediment (yd(^3)/sec)</th>
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"Bleeder" Pipe for Levee Construction

Source: Naylor Pipe Company
Huston 1986
Confined Disposal Facility (CDF) / Dredge Sand Separator

The system is designed to take direct dredge flow or re-hydrated CDF material and separate sand from the discharge. The slings of the system requires the main HDPE pipe flow to be at a velocity of 2.1 to 5. feet per second to provide removal of most sand fractions. A slower velocity in the system will capture finer sands. The system can be matched to a specific flow and percentage of solids by changing the diameter of the main pipe, increasing the length of the main pipe run, adjusting the number of drop-off feet. The final system is designed to be operated in remote areas as using solar power. The addition of conveyor and stacker require a power source.

The sand in the flow ribbons along the bottom of the main pipe. When the sand hits a grate it falls through by gravity, lighter material continues in the main flow. The sand piles up in the drop tube, the weight of the sand displaces the water in the drop tube forcing the water up and out of the tube, thus dewatering the sand. The weight of the sand controls the pneumatic pinch valve. A preset dryness number controls the amount of sand in the tube by modulating the pinch valve opening, carries 800# of wet sand.

Heavy duty material conveyor, discharges to radial stacker

The pinch valve controls the discharge amount and weight released, this is controlled by a proportional valve. The level cell sends the signal to the controller board which controls the proportional valve. The set point is set on the controller board.

Heavy steel rectangular tubing welded frame, modular construction to allow transport, assembly required

Patented and Patents Pending
ERDC – Coastal and Hydraulics Laboratory

- ERDC: As one of the most diverse engineering and scientific research organizations in the world, ERDC conducts research and development in support of the Soldier, military installations, and the Corps of Engineers' civil works mission, as well as for other federal agencies, state and municipal authorities, and with U.S. industries through innovative work agreements. ERDC operates more than $1 billion in world class facilities at seven labs located in four states with more than 2,100 employees to administer an annual research program exceeding $1 billion.

- Coastal and Hydraulics Laboratory [Link](http://www.erdc.usace.army.mil/Locations/CHL.aspx)
  - The CHL team conducts research in all aspects of water interaction with sediment, structures and operations, dividing topics into two categories: coastal engineering and hydraulic research. Coastal engineering research aims to provide a better understanding of waves, currents and winds, as well as other natural shoreline forces such as shore and beach control erosion, flooding and storm prediction, and coastal dredging. Hydraulic research focuses on understanding and improving U.S. Army Corps of Engineers (USACE) water-related projects including navigation, flood control, hydraulic structures and reservoir operations.

- Student Opportunities at ERDC
  - [Link](http://www.erdc.usace.army.mil/Careers/Student-Opportunities/)
    - Pathways Programs
    - Contract Student
    - Internships
  - Human Capitol Office: [ERDC-HCO@usace.army.mil](mailto:ERDC-HCO@usace.army.mil)