Dredging 101: Fundamentals of Dredging

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# Course Syllabus

<table>
<thead>
<tr>
<th>TIME</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 to 8:15 am</td>
<td>Welcome and Introduction</td>
</tr>
<tr>
<td>8:15 to 9:45 am</td>
<td>Introduction to Dredging Equipment and Operations</td>
</tr>
<tr>
<td>9:45 to 10:00 am</td>
<td>Break</td>
</tr>
<tr>
<td>10:00 to 10:45 am</td>
<td>Environmental Aspects of Dredging Projects and Operations</td>
</tr>
</tbody>
</table>
Class Rules

• Please ask questions as you have them; do not wait until the end.
• Disagreements with the instructor are encouraged 😊
• Please share your perspective with the class.
• Participation is a MUST!!
Introduction to Dredging:

*Equipment and Operations*
Learning Objectives

• Understand what “dredging” is and what it looks like
• Most common reasons dredging is performed
• Basic knowledge of typical dredging equipment
• Understand the role of sediment management in project execution
• Broad recognition of placement alternatives
• Concept of beneficial use
Why do we (re)moving sediments?

- **Mining**: we want to use the resource
- **Beach Restoration**: we want to use the resource
- **Flood Control**: provide more hydraulic capacity
- **Irrigation**: provide more hydraulic capacity
- **Navigation**: provide more depth for vessel passage
- **Environmental Remediation**: remove contaminated sediments from the environment
What would our society be without dredging?

✓ Aggregate (sand, gravel, other) used for construction industry
✓ Marine-related activities a $360B/year industry (2013)
✓ 13% of our population lives in areas subject to flooding along rivers
✓ Over 14% of our agricultural production relies on irrigation
✓ 53% of US Imports and 38% of US Exports are by waterborne vessels ($1.6T/year)
✓ Millions of cubic yards of contaminated sediments are removed from US water bodies each year
Mining and beach restoration target “suitable sediments”

Dredging for flood control, irrigation or navigation removes whichever sediments are “in the way”, regardless of their characteristics

Dredging for environmental remediation specifically targets “contaminated sediments”
Sediment characteristics in a water body depend on waterbody and its watershed:
- Mountain streams – gravel
- Ocean waters – sand
- Lakes and rivers downstream from mountains - sand
- Rivers and streams through flatland valleys – silts and clays

“The rougher the terrain, the coarser the sediments”

The more developed (urban/agriculture) the watershed, the more anthropogenic constituents will be present in sediments.
Dredging – Unique Construction

- Typically, large heavy equipment
- Working surface is below water, so the operator (and observers) have no direct visibility
- Floating equipment moves erratically in horizontal and vertical directions
- Challenging safety environment
- Target is sediment of varying densities, but the addition of water (sometimes, lots of water!) unavoidable
- Sediment is heavy, difficulty to handle, and costly to transport
Hydraulic Dredges

Typical Equipment
Basic Operations
Produced Sediment Characteristics
Since Dredging = (re)moving sediments, dredging is often categorized by how sediments are moved:

I. Hydraulic dredges move sediments by means of slurry and pumps

II. Mechanical dredges move sediments by picking them up by means of grabs, buckets, etc.
...move sediments by making it into a slurry, and then pumping that sediment slurry.

- A **hopper dredge** is a ship that sucks up the sediment slurry and holds that slurry in the ship (hopper) until it gets to its destination.

- A **pipeline dredge** sucks up the sediment slurry and pumps it through a pipeline directly to its destination.
Hopper dredges are self-propelled, fully contained vessels.

Hydraulic excavation using dragheads (usually 2).

Pump slurry directly into hopper.

Vary greatly in size:
- Small and super-simple/basic mining hopper (inland river/lake)
- Small ocean-going hopper dredge
- Very large ocean-going hopper dredge
Hopper Dredges - Characteristics

- Hydraulic dredge system, so it pumps the sediments
- Vessels are ships (self-propelled)
- Require sufficient water depth and access
- Can travel long distances
- Dredging and unloading intermittent
- Draghead requires straight lines, even bottom, loose sediments
- Hopper meant to hold sediments; excess water is typically discharged as overflow
Pumped slurries 10 to 20% solids by mass

- Initial filling of hopper includes a large portion of water

If solids settle rapidly (sand), dredges often pump past the initial filling to increase economic load
Hopper Dredges - Unloading

- Once filled, dredging stops
- Vessel sails to unloading site
- Typical unloading methods
  - Bottom dump
    - bottom doors
    - split hull
  - Direct pump out
    - Pipe to placement site
    - Pump into open water (rainbowing)
Pipeline dredges are typically platforms with spuds for stability.

Most move side-to-side or forward, pulled by cables attached to anchors.

Hydraulic system pumps 10 to 20% solids (by weight) sediment slurry.

Vary greatly in size:
- Truckable dredges (inland rivers/lakes)
- Small to medium-sized dredges (larger rivers, coastal channels)
- Very large, ocean-stable dredges
Pipeline Dredges - Examples
Pipeline Dredges - Characteristics

- Considerable mobilization/demobilization effort and cost
  - Transport dredge, pipe, ancillary vessels to site
  - Construct pipeline to placement site
- Hydraulic dredge, so it pumps the sediments
- Dredging is continuous (save downtime)
- Can dredge hard/compacted sediments with proper cutter
- Pipeline can be physical barrier for traffic
- Not very mobile
- Placement site must be reasonably near dredging site
- Produces high discharge with dilute suspension
Mechanical Dredges

Typical Equipment
Basic Operations
Produced Sediment Characteristics
Mechanical Dredges

- Moves sediment by picking it up in a bucket, grab, or similar device
- Removed sediment is placed
  - Nearby on land or in water
  - on/in adjacent barge (most common)
  - directly in a truck/rail car
  - on the shore
Mechanical Dredge - Characteristics

- Can be operated from shore or from a barge
- On-barge dredges
  - Seldom self-propelled
  - Not very mobile
  - Spuds, cables, anchors, and tugs for movement and positioning
  - May be permanently mounted or land-based equipment secured to barge
- On-shore dredges
  - Limited by reach and shoreline conditions
- Dredging continuous (save downtime), but production is cyclic, i.e. “one scoop at a time”
- Functional in any water depth
- Operates effectively near docks, piers, and other obstructions
- Can dredge hard, compacted sediments
- Water addition during dredging much less than hydraulic dredges
Clamshell Dredge - Examples
Common Bucket Types

- Conventional Clamshell Buckets
  - Digging buckets
  - Flat-cut buckets
  - Hydraulic buckets
- Environmental Buckets
  - Retrofit enclosed bucket
  - Cable-Arm® bucket
  - Positive-closure buckets
Ancillary Equipment

- Dredges requires substantial support from other marine vessels (Hopper dredges less than others)
  - Move and position dredge
  - Reposition anchors
  - Pipeline management
  - Silt curtain management
  - Barge movement
  - Personnel changes
  - Monitoring/inspections
• After excavation by a dredge, sediment must be transported to the placement site.

• Transport options
  • Hydraulic (pipeline) transport
  • Bulk Transport
    • Hopper Barge
    • Dredge Hopper

• Transportation method must be
  • Compatible with dredging equipment and placement site
  • Capable of moving sediment at the rate of dredging
Hydraulic Transport Systems

• **Advantages**
  • Closed system
  • Direct connection with hydraulic dredge systems
  • No rehandling

• **Disadvantages**
  • Sediment must be diluted for transport
  • Significant detention may be required to meet WQ standards
  • Reclaiming in situ density (if needed) of fine sediments requires significant time and proper management
Dredged sediment placed in hopper barges and transported to placement site

Mechanical placement in barge is most common; most barges too small to handle hydraulic discharge

Some water is added during the dredging process; much less than pumping

Barges sometimes decant additional water to maximize transport efficiency
Barge Transport

- Bottom-dump barges convenient for open-water placement
- Sediment rehandling may be necessary at placement site
  - Mechanical rehandling systems
    - Essentially same as initial dredging process
  - Hydraulic rehandling systems
    - Requires dilution similar to other pumping systems
• Hydraulic and mechanical dredges exist with sediment storage hoppers built into the vessel
• These “hopper dredges” tend to be self-propelled
• When the sediment storage hoppers are full, dredging stops and entire vessel sails to placement site for unloading.

• Unloading mechanisms include:
  • Bottom-dump hoppers
  • Unloading by dredging mechanism (mechanical or hydraulic)
Dredged Material Management
Open Water Placement

- Environmentally suitable dredged sediment can be replaced into aquatic system
- May be utilized with any dredging method
- Many US ports rely on this economical approach
- Common placement techniques
  - Side-casting
  - Shallow-water placement
  - Ocean/Deep-water disposal
✓ Dredged sediment replaced in the immediate vicinity of dredging location
✓ Used in many locations, especially those with active sediment transport systems
✓ Used with mechanical or hydraulic dredge systems
✓ Eliminates transportation cost
✓ Some sediment may return to dredging location
✓ Examples
  o Active riverine systems (e.g. Lower Mississippi River)
  o Coastal systems
Unconfined placement

• Sediment transported away from dredging site, then discharged without confinement
• Barge or hydraulic transportation systems
• Unconfined placement locations may be
  • Aquatic
  • Nearshore
  • Upland
Confined Placement

- Sediment transported away from dredging site, then discharged into a confined placement area
- Confined placement locations may be in-water, near-shore, or upland
- Confinement provides detention to allow fine sediments to settle and meet effluent quality criteria
- Settled fine sediments have very low permeability, resulting in slow consolidation and low sediment densities for long periods of time (years)
Confined Placement Areas

 ✓ Fine sediments require containment to allow solids to settle so that effluent meets state and federal water quality standards
 ✓ Engineered containment dikes provide adequate depth for clarification.
 ✓ Supernatant discharged over weir structure
Fine sediments require containment to allow solids to settle so that effluent meets state and federal water quality standards.

Engineered containment dikes provide adequate depth for clarification.

Supernatant discharged over weir structure.

1-3 days settling time to meet WQ requirements typical.

Sand settles in mound at point of discharge.

Soft sediments form relatively flat low-permeability layer; high water content can remain for years or decades if not managed.
The US Army Corps of Engineers and US EPA provide guidance for designing, managing and monitoring dredged material placement sites in all environments:

- Open water placement
  - Bottom-dump discharge
  - Continuous discharge
- Near-shore placement
- Upland placement

Topics covered include:

- Water quality impacts
- Toxicity evaluation
- Short-term and long-term placement area management
Beneficial use of dredged material encompasses any positive use that avoids disposal.

- Habitat Restoration and Development
- Beach Nourishment
- Parks and Recreation
- Agriculture, Forestry, Horticulture, and Aquaculture
- Strip-Mine Reclamation and Solid Waste Management
- Construction/Industrial Development
- Multiple-Purpose
Beneficial Use of Dredged Material in the Great Lakes

Why Dredge?
Maritime transportation on the Great Lakes system generates more than $52 billion in revenue each year and moves an average of 300 million tons of cargo, making it an important economic driver and job creator for the region. Recreational boating is a $3.8 billion industry — and commercial navigation requires continued maintenance of harbors, ports, marinas, and shipping channels, which can be costly and comes with numerous challenges influenced by water levels and ice conditions associated with dredging.

Dredged Material Placement
- Slightly more than half of the dredged sediment includes enough contaminant removal from great industrial discharge, agricultural runoff, and other activities to require further disposal, typically in specifically designed “contaminated disposal facilities” orCDFs.
- Clean sediments material is often used for beach nourishment, making dredged material a desirable commodity in sand-starved areas.
- Open lake placement is a common practice and often the least expensive for managing clean dredged material. This practice does present some political challenges but is not universally accepted as the most desirable placement option in the Great Lakes region.
- In many cases, dredged material is cleaned enough to be managed not as a burden but as a sustainable resource, a commodity with value.

Community Involvement
- Community involvement is important in identifying local projects that are able to use dredged material instead of an original source material. Potential projects may include new construction, parking improvements, wetland restoration, habitat restoration, and many other uses.
- Feasibility services to promote dredged material reports can be accomplished by forming a committee, task force, or subgroup within existing local government entities and through public-private partnerships.

Beneficial Use as a Management Strategy
- Beneficial use of dredged material can help create capacity by extending the life of CDFs by recycling suitable material from the site.
- State and local beneficial use programs help identify ways to maximize the use of dredged material as a sustainable resource.
- Dredged material may contain sediments that can be used for beach nourishment, capping, land creation and improvement, harbor creation or restoration, riprap replacement, and for soil reinforcement.
- Beneficial use includes the use of recently dredged sediment as well as sediment recovery of CDFs to enhance habitat creation, public access, and economic development. Examples of beneficial use projects include:
  - 21st Avenue West, Duluth, MN: Placement of dredged material within areas of the 21st Ave West embankment to reduce water depth to help prevent vegetation growth in support of aquatic habitat.
  - Golf Course Turf Restoration, Duluth, MN: Placement of materials from the Duluth-Superior CDFs were used for turf restoration to a local golf course in Duluth, MN.
  - Cleveland Lakemore Nature Preserve, Cleveland, Ohio: After closing a CDF that reached its capacity, the peninsula was converted into a publicly accessible nature preserve and is home to hundreds of species of birds, butterflies, and mammals.
  - Cat Island, Green Bay, WI: A 2.5-mile wall barrier was built to reverse the remnants of the original earthworks of the Cat Island which were damaged during periods of high water levels.

Examples of Beneficial Use Applications
- Cat Island Restoration Project, Green Bay, WI
- Lorain Harbor CDF, Lorain, OH
- 21st Avenue West Pilot Project Demonstration, Duluth, MN
- Times Beach, Buffalo, NY
- Lorain Harbor CDF, Lorain, OH
- Lake Superior
- Lake Huron
- Lake Michigan
- Lake Erie
- Lake Ontario
- NY
- OH
- PA
- IN
- WI
- MN
- IL
- ONT
- MI

About the Great Lakes Dredging Team
The Great Lakes Dredging Team (GLDT) serves as the Great Lakes’ foremost dredging team and continually researches and recommends strategies to prevent, reduce, and mitigate the effects of excessive sediment accumulation. The GLDT, comprised of environmental organizations, local and state governmental agencies, and nations, is dedicated to installing innovative solutions for the Great Lakes. The team promotes clean and sustainable living practices to restore the health of the Great Lakes. Learn more about the Great Lakes Dredging Team and the Great Lakes Dredging Team Coalition at http://greatlakesdredging.net.
Barriers/Obstacles

- Regulatory obstacles – discussed in next session
- Mismatch of quantities and/or material types
- Timing/coordination
- Increased Cost
- Lack of local sponsor
- Funding restrictions
Conclusion of Session 1