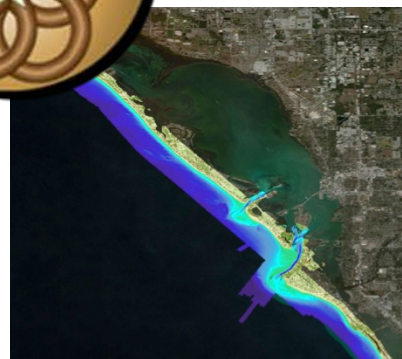
Reservoir Sediment Management & Analysis for Engineers

Analysis and Design of Dredging



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ERDC
Engineer Research and Development Center

Introduction

- In this lecture, we will discuss and overview dredging methods and practices. To include;
  - Description
  - How it works
  - Where has it been used before (maturity)
  - What to remember when planning

What is Dredging?

- Is the removal of sediments and debris from the bottom of lakes, rivers, harbors, estuaries, and other water bodies. It is a routine necessity in waterways around the world because of sedimentation.

Reservoir Dredging

- Accumulated sediments can be removed by suction using hydraulic pumps on barges with intakes. If cohesive sediments have ‘set up’, cutter heads may be required to break up the cohesive sediments.
- Dredging is expensive, so most often used to remove sediment from specific areas near dam intakes.

Reservoir Dredging

- If there is sufficient hydrostatic head over the dam, it can create suction at the upstream end of the discharge pipe to remove sediment and carry it over the dam as a siphon. Hydrosuction is typically limited to reservoirs less than 3 km in length, and to low elevations, where the greater atmospheric pressure facilities the function of the siphon.
- In China, hydraulic suction machinery is commonly used to stir the sediment within the reservoir with hydraulic and mechanical power, then to discharge the highly concentrated sediment-laden water out of the reservoir through siphons by the help of water head difference between upstream and downstream of the dam.

Reservoir Dredging

- If a reservoir is completely drawn down, mechanical removal can be employed using scrapers, dump trucks, and other heavy equipment to remove accumulated sediments. While still costly, mechanical removal is commonly less expensive than hydraulic dredging, and can remove coarser sediments, but it requires the reservoir to be drawn sown for enough to expose coarse sediment. Mechanical removal is best adapted to reservoirs that remain dry for parts of the year such as flood control reservoirs.

How it Works

- The dredging process consists of the following steps:
  - 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 material.

Two Types of Dredging

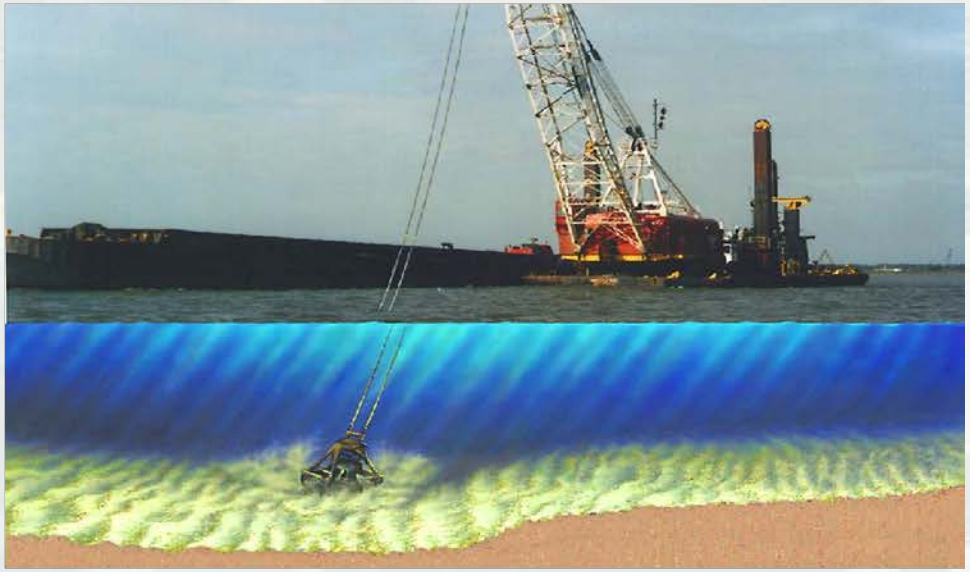
- **Maintenance Dredging:** Removal of sediments accumulated in the channel since the previous dredging project.
- **New Dredging:** Removal of sediment which have not been previously dredged (virgin sediments).

Selection of Dredging Equipment

- Physical characteristics of sediments
- Quantities to be dredged
- Dredging depth
- Distance to disposal (placement) area
- Physical environment of and between areas
- Contamination levels of sediments
- Method of disposal (placement)
- Production required
- Types of dredges available

Basic Types of Dredging

- Mechanical
  - Clamshell
  - Backhoe
- Hydraulic
  - Pipeline
  - Hopper
- Other/Combinations



Advantages of Mechanical Dredges

- Rugged and capable of removing hard packed materials
- Can remove debris
- Can work in tight areas
- Efficient for disposal at long haul distances

Mechanical Dredging

Mechanical dredges can excavate sediment at in situ percent solids

Limitation of Mechanical Dredges

- Difficult to retain fine loose material in conventional buckets
- Production low compared to pipeline dredges
- Resuspension can be an issue, especially in presence of debris

Where has it been used before

- Cogswell Reservoir on the San Gabriel River, California, was mechanically dredged in 1994 – 1996, with 2,400,000 m^3 removed and taken to a nearby upland disposal site, at a cost of $6.47/ m^3 (if planning and permitting are included) (Morris and Fan, 1998). Another 2,550,000 m^3 required excavation following a 2009 wildfire that increased erosion in the catchment (Los Angeles County Department of Public Works (LACDPW), 2012)

Self-Propelled Hopper Dredge

Advantages of Hopper Dredges

- Only dredge type for rough open waters
- Can move quickly to job under its own power
- Minimizes traffic interference
- Improves required depths quickly
- Economical for long haul distance

Limitations of Hopper Dredges

- Cannot work in shallow depths
- Cannot dredge continuously
- Excavates with less precision
- Difficulty dredging hard banks
- Difficulty dredging consolidated materials

Hydraulic Pipeline/Cutterhead Dredge

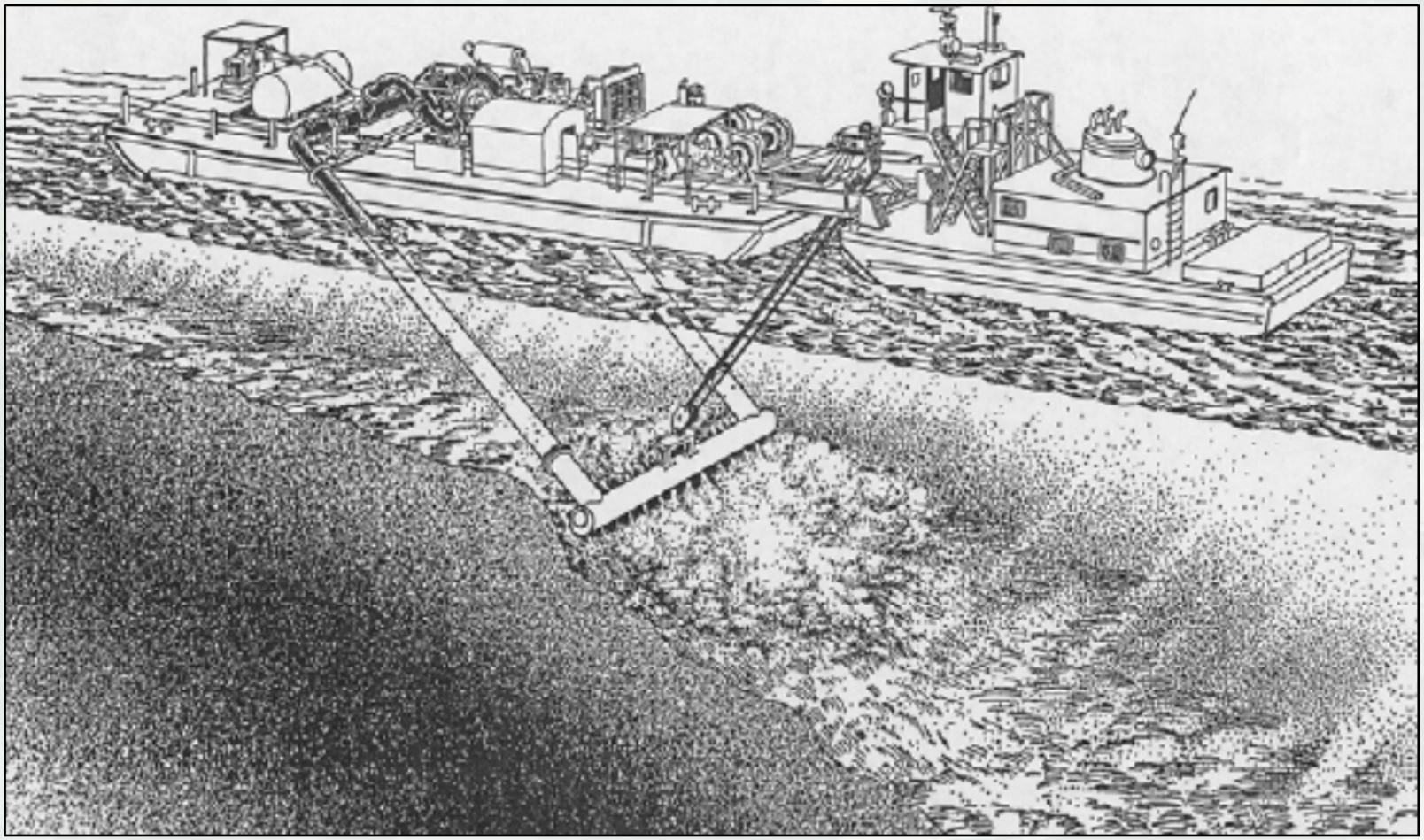
Advantages of Cutterhead Pipeline Dredges

- Capable of excavating most types of materials
- Can pump directly to disposal sites
- Can dredge almost continuously
- Can dredge some rock types without blasting

Limitation of Cutterhead Pipeline Dredges

- Limited capability in rough open water
- Most are not self-propelled
- Difficulty with coarse sand in high currents
- Pipeline can be an obstruction to O&M
- Debris in sediment can reduce efficiency

Water Injection Dredge



Dredge Material Disposal Methods

- Open Water Placement
  - Ocean – Estuarine – Lakes – Rivers
- Confined Disposal
  - Confined Disposal Facilities (CDFs)
  - Contained Aquatic Disposal (CADs)
- Beneficial Use Applications

Disposal Planning Considerations

- Planning Considerations
  - Project Requirements (Volumes and frequency of dredging)
  - Planning Horizon
  - Stage of Evaluation
  - Material Characterization (physical, dredgability, chemical/biological
  - Regulatory or other constraints

Open Water Placement

- Site Characterization
- Site Designation/selection
- Material Suitability
- Design Evaluations
- Operational Considerations
- Control Measures/Management Actions
- Monitoring
- Site Management Plan

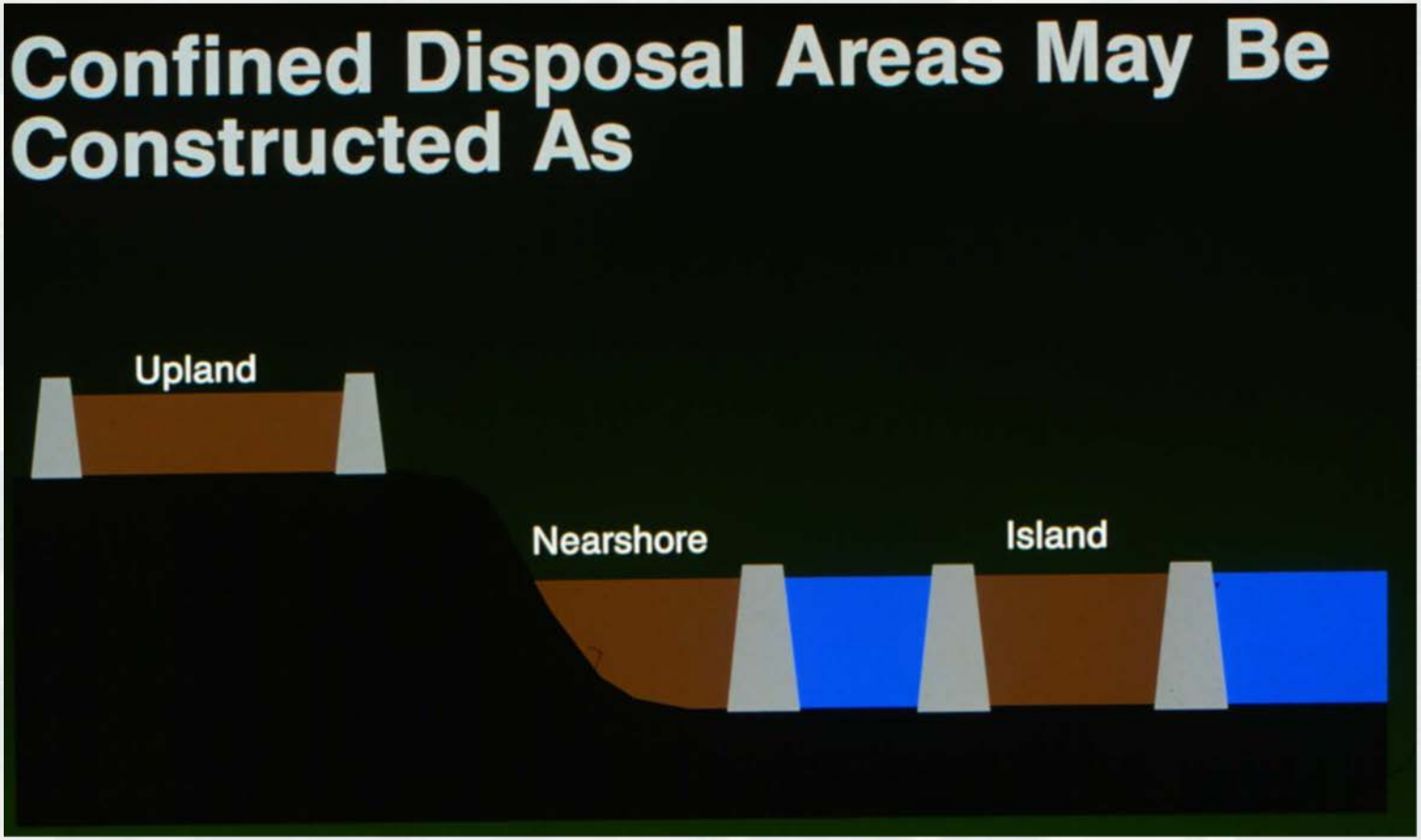
Confined Disposal Facilities

- CDFs used because:
  - More economical for some projects
  - Most common option for material unsuitable for open water
- Regulated under CWA
  - Discharge to US water by definition
  - 404 Permit
  - 401 State Water Quality Certification

Confined Disposal Planning

- Site characterization/selection
- Engineering design
- Operational considerations
- Contaminant pathways and controls
- Long-term management
- Monitoring

Confined Disposal Areas



Contained Aquatic Disposal (CAD)

Beneficial Use Applications

- Beneficial Use is alternative of first choice
- Needs and opportunities
- Material Suitability
- Logistical constraints
- Regulatory requirements vary

Some Beneficial Use Categories

- Wetland Habitat/Bankline Protection
- Nearshore Nourishment
- Restoration
- Recreation
- Agriculture
- Habitat
- Construction Fill/Material

Dredging Example - Millsite Reservoir

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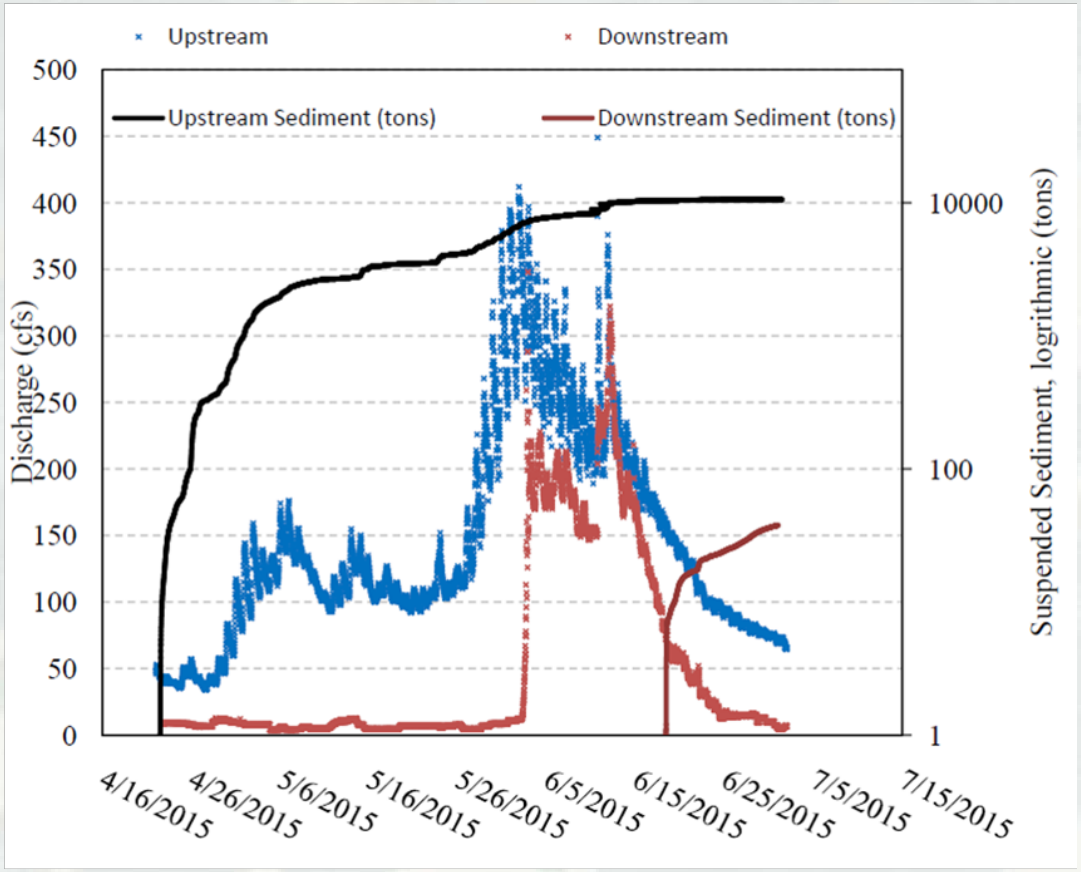
Saves 40% - 60% of total project cost

Potential for positive ecosystem benefits

But you'll still have to go to battle to get your permit!



References

- EM Dredging and Dredge Material Disposal
- EM Beneficial Uses of Dredged Material
- EM Confined Disposal of Dredged Material
- Technical Framework for Environmental Evaluations
- Inland Testing Manual
- Evaluation of Dredged Material Proposed for Disposal at island, nearshore, or Upland Confined Disposal Facilities
- Identifying, Planning, and Financing Beneficial Use Projects Using Dredged Material

Questions