

digging them up

WI DEPARTMENT OF NATURAL RESOURCES



Hydraulic dredging project

Digging contaminated sediments up, or dredging contaminated areas, actually removes toxic sediments from the waterway for treatment or disposal. Several kinds of dredges are available for cleanups. Each varies in cost and effectiveness. As with any strategy to address contaminated sediments, the initial conditions of the sediment, (the type and extent of contamination, the kind of soils, water conditions, etc.) play a large role in what dredges are chosen.

Dredging provides the only opportunity to remove contaminants from the aquatic ecosystem, often breaking their link to the food chain. It is the fastest way of achieving cleanup goals and restoring a site. New dredging technologies enable us to remove

polluted sediments more quickly, cleanly, accurately and effectively than ever before.

Many people fear that dredging will stir up contaminated sediment and release toxins into the water column or relocate them downstream. Although dredging can resuspend some contaminants, the amount is generally minimal compared to what the sediments may already be releasing downstream. For example, a 1998 dredging pilot project on the Fox River in Wisconsin removed a PCB hotspot that leached as much as 4-5 kg of PCBs to the river in a year. The dredging itself released just over 2 kg of PCBs, only half of what the hotspot would have released without the dredging. And, by removing the hotspot, the dredging prevented future PCB releases from that site.

It is also important to remember that, if the sediments are significantly polluted, the river bottom and river water are already degraded. Dredging may disrupt the bottom of the river, but that probably doesn't matter much if the bottom is polluted. And while dredging may slightly increase pollution levels in the water over the short-term, the contaminant levels are probably already high. In the case of the Fox River, PCB levels in the water currently exceed the state's water quality criteria by as much as 50,000 times. The dredging projects only raised the levels slightly for a short period of time, and they permanently removed hotspots of PCBs that were contributing to the high levels in the water.

Dredging and sediment management technologies and techniques have come a long way in minimizing resuspension and transport downstream. Dredges designed specifically for removing contaminated sediments use special cutting heads and suction to reduce the amount of resuspension. These new dredges have successfully removed sediments with extremely low resuspension rates.

Specific dredging techniques can also reduce sediment resuspension. First and foremost, an experienced dredge operator is crucial to the success of the project. Many people who deal with contaminated sediment remediation note that the dredge operator's experience and abilities can have a profound effect on the amount of resuspension.¹⁵

¹⁵ USEPA Great Lakes National Program Office, 2001.



Hydraulic dredge operator on the Fox River

The dredge operator can affect resuspension almost as much as the choice of the dredge.

- If the dredge goes too fast, resuspension increases.
- If the dredge cuts too deeply, more sediment will be loosened than the dredge can handle.
- If the cut is too shallow, dredges with moving cutter-heads may dislodge the sediments with too much energy, like an electric mixer half-way out of the batter.

Various types of monitors (video, sonar, etc.) can provide feedback to operators as they are dredging so that they can adjust as they go along, reducing resuspension and adjusting the characteristics of the dredged material to fit treatment specifications. Finally, an increasing number of projects are using Global Positioning Systems, or GPS, for added dredging precision.

A variety of tools can be used to help contain any sediments or contaminants that dredging does stir up. Solid barriers, like coffer dams or sheet piling, can be placed around dredge sites to keep resuspended sediments from moving downstream. Though expensive and difficult to insert and remove, these structures will withstand strong water currents, wind, boat wakes, ice heave, and other disturbances. Cheaper and easier to work with, silt curtains and silt screens can be anchored to the bottom and held up with floats. Silt curtains do not allow water to pass through them, whereas silt screens allow

water to flow through. Both types of barriers are increasingly used to contain resuspended sediment, with very good results. If oils are released in the dredging process, oil booms and absorbent mats can be used to soak them up.

In practice, dredging has effectively removed contaminated sediments with virtually no losses to the environment. The short-term risks of minimal sediment loss must be weighed against the long-term benefits of removing the bulk of the contamination from the ecosystem, thereby eliminating the risk of further detrimental effects at that site.

Choosing a dredge

Dredges are suited to remove different kinds of sediments under different conditions. No dredge is suitable for all circumstances; each has its own set of pros and cons that may or may not meet the goals set for a particular cleanup. Two sets of criteria must be considered when choosing a dredge: the characteristics of the site and the characteristics of the dredge. Site characteristics are important because some dredges handle different kinds of sediments and water conditions better than others. The ultimate fate of the dredged material makes the dredge characteristics important. Often, treatment and disposal methods require dredged material to be delivered at a certain rate and in a certain condition. Selecting the best dredge for the job means making sure not only that it can handle the on-the-ground conditions, but also that it produces dredged material at the right rate and with the right charac-

teristics for further treatment and/or disposal. Dredge-specific characteristics like availability and cost also factor in.

Site Characteristics

Type of sediment – Some dredges handle coarse, loose sediments while others deal more effectively with packed sediments. Also, some dredges are able to chew through minor debris, others cannot.

Depth of water and sediments to be dredged – Each dredge is able to dredge to a certain depth. Some perform better in shallow water than others.

Amount of sediment to be dredged – Some dredges are good for small jobs, others for large ones.

Water current – The anchoring mechanism varies with the dredge. Some anchors can handle currents, while others require still water.

Site access – Some dredges are more maneuverable than others. Maneuverability counts when working in close quarters or where

“Don’t let the differences in dredge cost be the major factor in dredge choice. The physical constraints of the site, the type of dredging, and the ultimate fate of the dredged material are the critical factors that will determine the best dredge for the job.”

– Jan Miller
Environmental Engineer
US Army Corps of Engineers

obstacles need to be avoided. In particularly small or hard to reach areas, hand held dredges and/or divers may be used.

Dredge Characteristics

Amount of water that comes up with the dredged material – Treatment technologies can handle different amounts of water in the dredged material. When excess water is pulled up with the sediments, it adds to the cost of the project in two ways. First, it adds extra weight and volume that needs to be transported. Second, treatment and disposal options will likely require sediment dewatering (see p. 37). The extra costs can be worth it, however. Hydraulic dredges tend to bring up the most water with sediments, but they offer one of the cleanest ways to dredge. In the dredge table on page 28, this characteristic is described as the percent solids by weight. The greater the percent solids, the less water the dredge brings up.

Range of production rates – Transportation methods and treatment technologies can only handle so much dredged material at a time. If the dredge is producing dredged material too slowly or too quickly, a storage site may be needed to either accumulate enough to transport or hold sediments that must wait to be treated. In the dredge table on page 28, this characteristic is described by cubic yards of sediment dredged per hour.

Dredge accuracy – The dredge needs to be very accurate for two reasons. First, it needs to ensure that all the contaminated sediments are removed. Second, it needs to minimize the amount of clean sediment brought up with the contami-

nated sediments. Clean sediments that are needlessly dredged must be transported, treated and disposed after mixing with contaminated sediments, adding to the project’s cost.

Resuspension – The dredge descriptions below note the resuspension issues particular to each dredge. Resuspension rates vary by the dredge, site characteristics, and the experience of the dredge operator. For further discussion of resuspension see p. 17.

Cost – Costs vary widely with each project. Site and sediment conditions, treatment technique and project goals all help determine costs. Generally, dredging costs range from \$15 to \$50 per cubic yard. Bigger jobs are cheaper because of economies of scale. In other words, the fixed costs (mobilizing the dredge, setting up the dredge site, etc.) can be spread out for larger jobs, working out to fewer dollars spent per cubic yard of sediment dredged. Most Great Lakes cleanups are small, less than 500,000 cubic yards, and tend to be at the higher end of the price range per cubic yard dredged.¹⁶ The cost differences between dredges are small enough that cost should be one of the last considerations when picking a dredge. The physical constraints of the site and the dredge along with the requirements for the ultimate treatment and disposal of the sediment are of primary importance.

¹⁶ Miller, Jan. 2001.

ENVIRONMENTAL MECHANICAL DREDGES

Environmental clamshell dredge



Pros

- Widely available.
- Brings up a high percentage of solids.
- Has special fittings that reduce resuspension 30-70% below the traditional clamshell dredge.
- Horizontally, it is a very precise digging tool. It is excellent in close quarters.
- Can be used in very deep water.
- Can be used with very consolidated sediments.

Cons

- Production rate is low compared to hydraulic dredges.
- Does not work well in strong currents.
- Needs high overhead clearance.

The next section describes many kinds of dredges. At the end of the section, a table provides specific data on each dredge, along with some pros and cons for each dredge.

Digging It Up: Mechanical Dredges

The most widely available dredges in the US, mechanical clamshell dredges excel at removing debris and pulling sediments out of waterways without adding much water. They are most suitable for removing gravel, sand, and very cohesive sediments like clay, peat, and highly consolidated silt. They can operate in very tight spaces without interfering with shipping. Many mechanical dredges tend to leak and resuspend large quantities of sediment; however, several kinds of mechanical dredges have been specially designed to minimize leaking and resuspension. These dredges are the only mechanical dredges that should be considered for contaminated sediment cleanup.

Types of dredges

There are two basic types of dredges: mechanical and hydraulic. Closely related to earth moving equipment like backhoes, mechanical dredges use mechanical force to scoop up sediments and load them onto a transportation vehicle or directly into a land-based containment area. Hydraulic dredges work like vacuums, using strong pumps to suck up contaminated sediments from the bottom. Generally, hydraulic dredges resuspend less sediment than mechanical dredges as they operate. Dredges that use a combination of mechanical force to loosen sediment and hydraulic force to pump it up are often referred to as hybrid dredges. Some hydraulic dredges use special pumps, called pneumatic pumps, to raise sediments from the bottom. Pneumatic pumps pull up less water and disturb the bottom much less than a regular hydraulic dredge.

BOB QUEEN, WI DEPARTMENT OF NATURAL RESOURCES



Shielded cutterhead of hydraulic dredge

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*Enclosed Bucket Dredge
and Cable Arm Dredge*

These are clamshell dredges that were specially designed to minimize resuspension. The clamshell dredge gets its name from how it looks. Clamshell dredges have a bucket made of two halves; together they resemble a clamshell. The bucket is attached by a cable to a crane that is mounted on a flat-bottomed barge or on land. The barge can be moved short distances by anchors, but must be towed for longer trips. To dredge, the operator drops the open clamshell into the sediment. As it is pulled up, the halves close together, trapping the sediments inside. It dredges sediments by the bucketful and dumps them into a barge or scow. Clamshell dredges are classified by how much sediment they can hold in their buckets – anywhere from 1 to 50 cubic yards. Typical clamshells hold between 2 and 10 cubic yards per bucket.

The enclosed bucket and Cable Arm dredges seal shut with gaskets and tongue-in-groove joints to fully contain contaminated sediment. The Cable Arm has the added advantage of being better able to control how far it dredges into the sediment. It can also remove sediments in layers, leaving a flat surface after dredging. It can dredge more precisely than the clamshell, bringing fewer clean sediments up with the polluted ones. Enclosed bucket and Cable Arm dredges resuspend 30 to 70% less sediment than clamshell dredges.

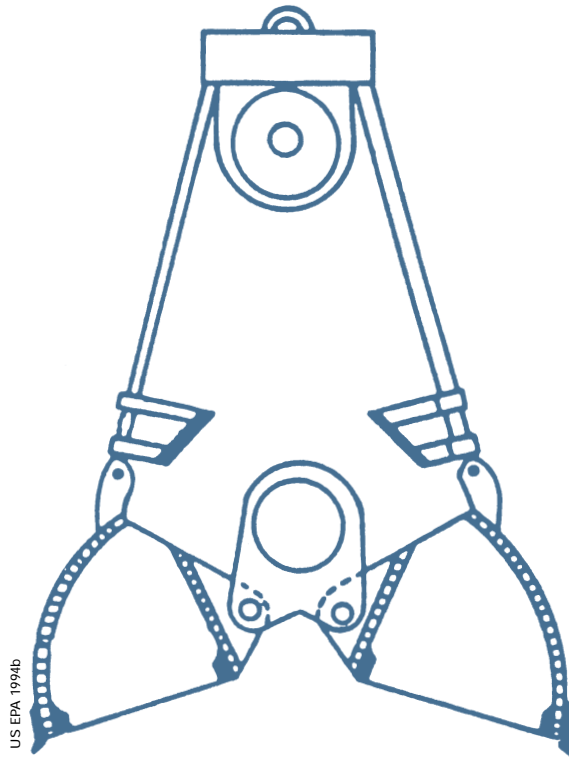


Figure 1: Enclosed Bucket Dredge

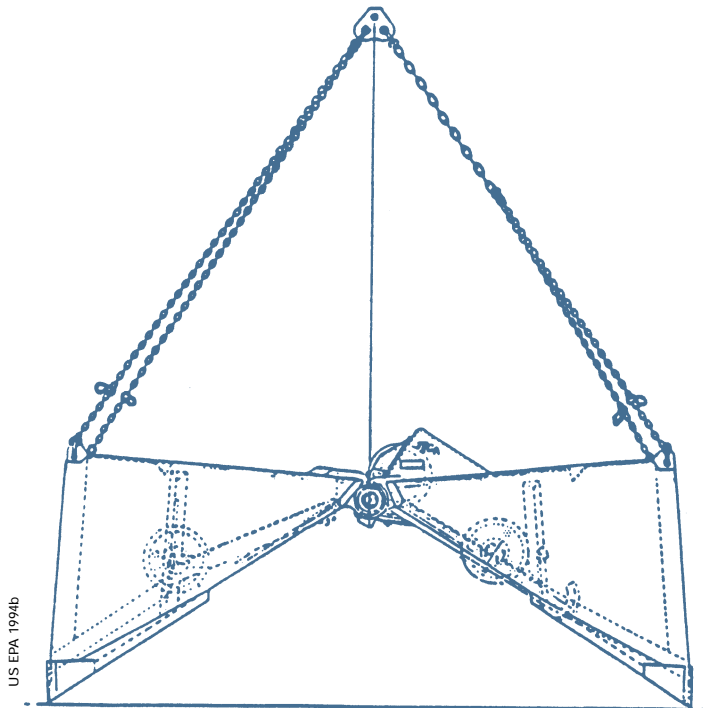


Figure 2: Cable Arm Dredge

Figure 3: Cutterhead Dredge



head that loosens the sediments so that the suction pump can pump them to the transport, treatment, or disposal site. For some jobs, the cutterhead can be removed and the suction pump can be simply used like a vacuum. Hybrid dredges are hydraulic dredges that use mechanical means rather than a simple cutterhead to loosen sediments. The dredge head support holds the dredge in the water. The dredge head support can be a simple cable, a special ladder with the dredge

attached at the bottom, or a sophisticated hydraulic arm.

Hydraulic systems suck in a slurry, a combination of sediments and water. Pneumatic systems pull in sediments with very little water in them. Unlike mechanical dredges, hydraulic and pneumatic dredges are closed systems: once the sediments enter them, they have no contact with their environs until they reach the transport, treatment, or disposal site. Since both types suck sediments in rather than just dig them up, they resuspend much less than mechanical dredges. The slight resuspension that does take place with hydraulic and pneumatic dredges occurs as the cutterhead dislodges sediments or the dredge head is moved.

Hydraulic dredges can be anchored and moved in several ways. Many use spuds, special poles that extend down from both sides of the dredge, to anchor to the bottom. The dredge can move by “walking,” using the spuds as legs. One spud is lifted and the dredge’s

HYDRAULIC DREDGES

Pros

- Much less resuspension than mechanical dredges.
- Some are widely available.
- Often very precise dredgers, bringing up minimal clean sediment.
- Faster than mechanical dredges.
- Closed system reduces environmental exposure.

Cons

- Tend to clog, increasing resuspension and interrupting job.
- Do not handle consolidated sediment well.
- Pipelines carrying sediment slurry may be navigational obstructions.

Sucking It Up: Hydraulic and Pneumatic Dredges

There are four main components to hydraulic and pneumatic dredges: the dredge head, the dredge head support, the suction pump, and the pipeline to transport dredged sediments. Hydraulic dredges tend to be identified by their dredge heads, while pneumatic dredges tend to be identified by the type of pump they use. The dredge head is the part of the dredge that is inserted into the sediments. Often, the dredge head is fitted with a cutter-

momentum pivots it on the anchored spud. The first spud is then re-anchored and the dredge “steps” forward. The dredge itself moves forward with the water currents, by pulling itself along a guide wire, or by its own propulsion. Dredges can also use guide wires without spuds to move. For example, two anchor wires can be run parallel to the edge of the dredge site. A third wire runs perpendicular to and between the two anchor wires. The dredge cleans along the third wire. After sediments along the length of the third wire are dredged, the ends of the third wire are moved down the anchor wires so that the next row can be dredged.

Cutterhead Dredge

The cutterhead dredge is the most common hydraulic dredge. It uses a rotating cutterhead to loosen sediments. A hydraulic pump transports them to the treatment or disposal site via a pipeline that can be up to 15 miles long. Usually, the dredge is towed into position and anchored with two spuds mounted on the stern or anchored to sites on land. Two cables controlled by winches swing the dredge back and forth. Sediment shields, gas collection systems, underwater cameras, and sensors have all been used with this type of dredge to maximize accuracy and minimize resuspension.

Portable Hydraulic Dredge

A smaller version of the plain suction dredge, the portable hydraulic dredge is easily moved and effective in shallow water. Portable hydraulic dredges usually have pipes that are less than 24 inches in diameter.

P N E U M A T I C D R E D G E S	
Pros	Cons
<ul style="list-style-type: none"> • Brings up sediments with very little water, up to 80% of the sediments’ original density. • Very low resuspension. • Provides continuous, uniform flow of dredged sediment. • Effective at low power. • Closed system reduces environmental exposure. 	<ul style="list-style-type: none"> • Can clog, increasing resuspension and interrupting job. • When moved around dredge site can suck up lots of excess water.

Plain Suction Head Dredge

The plain suction head dredge is essentially a cutterhead dredge without the cutterhead. It works like a vacuum, simply sucking up sediments with a pipe. Water jets can be added at the suction mouth to help dislodge sediments, but they may increase resuspension. It can be maneuvered by cables and winches or by divers.

US EPA 1994b

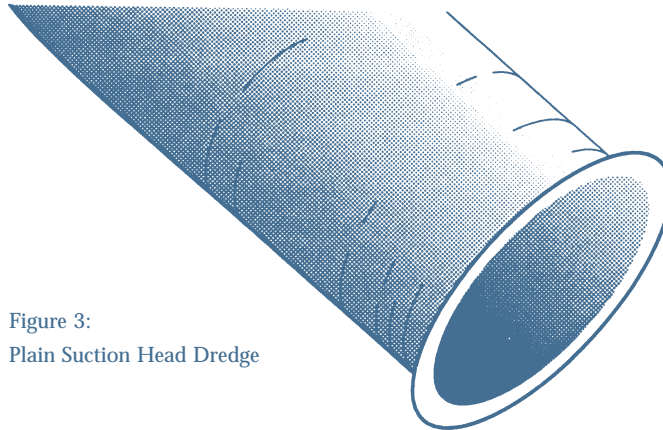


Figure 3:
Plain Suction Head Dredge



US ARMY CORPS OF ENGINEERS

Figure 5: Horizontal Auger Dredge

HYBRID DREDGES	
Pros	Cons
<ul style="list-style-type: none"> • Can work with a wider variety of sediments than hydraulic dredges. • Low resuspension compared to mechanical dredges. • Faster than mechanical dredges. • Closed system reduces environmental exposure. 	<ul style="list-style-type: none"> • Can clog, increasing resuspension and interrupting job. • Some cutter heads increase resuspension over hydraulic dredges. • Pipelines carrying sediment slurry may be navigational obstructions.

Horizontal Auger Dredge

This commonly used dredge has a type of screw, or auger, to break up sediment and carry it to the dredge pump. A retractable mud shield over the auger can control resuspension, but increases the probability that the dredge will clog. Four anchored cable wires hold the dredge in place and move it like a pendulum from side to side. The horizontal auger dredge can remove layers of sediment between 4 and 20 inches thick. Two common brands of horizontal auger dredge include the Mudcat and the Little Monster.