Underwater Sand and Gravel Recovery

The dilemma facing every pit owner is how to recover material below water. Alternatives investigated in this paper are:

1. Lattice Boom Clam/Dragline on Crawlers
2. Conventional Dragline on Crawlers
3. Overhead Crane Floating Clam Dredge
4. Suction Dredge
5. Tower Dragline

Basic Questions

1. How much material do I want to move annually ?

2. How coarse is my material ?

3. How deep is my deposit ?

Once these questions have been answered, the choices narrow very quickly.

Scenario 1….Less than 350,000 t/yr, 30ft depth, sand and gravel with river boulders.

If your deposit extends less than 30ft below the surface, you work from shore,you have a lot of choices ranging from excavators to small draglines which can be procured very inexpensively. The problem with excavators is the inability to stack material therefore this solution is not usually attractive despite the excellent ability of the machines to excavate material.

Small friction type draglines are commonly used such as the Northwest 9570, Bucyrus Erie 88B and Northwest 190D but it is expensive to keep these machines running and it is becoming increasingly difficult to find people willing and able to operate them. You really don't want to have long range plans for your pit governed by the abilities of a 30 year old dragline.

Suction dredges are out of the question unless the deposit is uniform, clean sand without any boulders.

The best choice, although it is little known in the US is to use a small crawler based 4-rope clamshell dredge sitting on the shore working the toe of the slope and swinging the spoil into windrows along the shore. These dredges are designed to operate below water and are power up, power down duty cycle hydraulic machines.

To lower the clam fully open, the right joystick is shifted to the top right corner. The clam opens fully and then the holding and closing lower together automatically without allowing the clam to close.

When the clam hits bottom, load sensors in the winch circuits sense this and automatically stop both winches. The operator then shifts the right joystick to the bottom left. This signals the closing winch to haul in and when enough rope has been recovered to close the clam, the holding winch is then automatically hauled in. The two winches then share the load, 60% on the closing, and the closed and fully loaded clam is hauled up.

A totally inexperienced operator is able to run the machine with only a few hours training.

This control system is absolutely necessary otherwise, as with a friction machine, you never know if your clam is open when it hits bottom, you don't know if it is fully closed when you haul up and you often come up half full or less. With a friction clam, it is almost immpossible to work blind underwater and you go through a lot of wire rope.

The advantage of a 4-rope lattice boom clamshell dredge is the ability to dig deep at low radius which enables you to use a much larger bucket than you use on a dragline which operates at long radius to obtain depth.

For the same price as a large excavator, you can buy a lattice boom clamshell dredge on crawlers capable of up to 3000t per 10 hour shift and capable of digging to 80ft depth below the base of the machine without any tagline.

Scenario 2….Less than one million tons per year, sand and gravel with river boulders, depth of 80ft.

This is really where you separate the men from the boys. Draglines are out due to the depth, suction dredges are out due to high operating costs and the presence of boulders, excavators are out due to depth and lack of ability to stack.

One solution that has been tried is to dig your pit to 30ft deep using a dragline and then come back and use a floating clamshell dredge which looks like an overhead crane to dig the pit deeper. The dredge excavates material using a clamshell bucket and deposits it in a hopper which de-waters material and feeds it onto a floating conveyor chain to shore.

These machines are expensive to purchase, require a lot of maintenance and do not produce close to expected levels. An 8yd dredge is normally unable to fill a 24 inch conveyor.

The problem with these machines is that they have only one degree of freedom…that is, the bucket goes back to the same location. The digging strategy is to dig pits and hope the material keeps sliding back in to fill the holes as you go to allow continued digging. Most of the time, material will not slide in and you dig holes. The clam is forever falling over and if you are not careful, you will bury it in a slide.

Cost per ton over the lifespan of the pit is very high due to the need for initial dragline excavation and later clamshell recovery.

The second alternative you have is to use a small combination clamshell dragline lattice boom dredge working from a spud barge.

The strategy is to use the clamshell or dragline sitting from shore to dig a starting area down to 30 or 40 feet. The machine is then mounted on a spud barge against the shore and works as clamshell to 80ft depth or more, simply swinging the material onto shore. The machine works along the shore and the pit expands as it collapses.

This system works extremely well and allows you to get the full mix of material in your deposit. You eliminate the risk of sliding your machine into the water and you are able to work at short radius which means you can use a small machine and large bucket. If you start your pit this way, you never have to come back with sophisticated and costly solutions to work an existing pit to greater depth. One low cost machine is able to work the entire pit from beginning to end.

You can even mount a stacker on the spud barge if you want to get your material even further from the shoreline.

The third solution is to use a tower dragline after you have dug your entire pit to 30 or 40ft depth. These machines are simply draglines without a boom. A winch tower is set up on one shore and sheave tower is set up on the opposite shore. The concept is to drag a bucket along the entire width of your pit and dump the material at your feet. The downfall of this approach is that it is slow due to long haul in and long pay out and difficulty in shifting.

Perhaps the biggest downfall of the tower dragline is the inablity to stack material. You also have the expense of needing a dragline to dig the first 40ft depth and the tower dragline to get the remainder…..two machines.

Scenario 3….More than one million tons per year, sand and gravel with river boulders, clay seams and 80ft depth.

Now you have a problem. Conventional dragline, suction dredge, overhead crane clamshell dredge and tower dredges all fall short on production levels and on costs.

The solution is to use a large crawler based, lattice boom clamshell / dragline from shore or spud barge along the shore. One machine is able to work the pit from the beginning until the end,

through the full range of depth and materials encountered.

For example, the PLM2025 crawler based, lattice boom combination clamshell/dragline has clamshell rating of 45,000 lbs at 85 ft radius. This machine is able to reach the toe of the slope from 85 feet away to a depth of 80ft or more if required. At radius exceeding 85 feet, the clamshell rating reduces.

For additional security, the machine can be mounted on a 60ft square spud barge to eliminate risk of slides. This machine is able to produce 1.5 to 2.0 million tons per year from the shoreline at 80ft depth without double shifting. Cost per ton is impressively low and the machine has an expected life of 40,000 hours before the first major overhaul.

Shot Rock, Depth Beyond 20ft

The only machines able to handle shot rock are draglines and lattice boom clamshell dredges. The material is heavily fractured into pieces ranging in size from baseballs to tombstones.

A PLM 2025 combination clamshell / dragline is able to excavate this material in both modes from shore or from a spud barge in clamshell mode down to 80ft depth in the standard configuration and deeper if needed..

The choice of clamshell design is critical and this is where experience and common sense are required. If the material is primarily rocks with very little sand and gravel. Seven tine pineapple grabs do an excellent job of recovery.

If the material contains a lot of fines, pineapple grabs will not work and a GP bucket with spade lip and teeth is a better choice.

Draglines need to be quite large in order to handle this material otherwise the bucket skips over the stones.

The PLM2025 is able to produce up to 2 million tons per year deep water recovery of shot rock using single shifts. (2000 hours).

Increasing the Depth of an Existing Pit

If my pit is already dug to 30ft or so and my deposit extends to 100ft, what do I do ?

Three choices:

1. Lattice Boom Clamshell Dredge
2. Overhead Crane Clamshell Dredge
3. Tower Dragline

The first and best choice is to use a crawler or pedestal mounted Lattice Boom Clamshell Crane working from shore or from a spud barge. These machines work a large area without shifting. Material is taken down in benches and digging pits in the bottom is completely avoided.

Recovered material can be placed in a de-watering hopper with chain conveyor or can be placed in a self-discharging hopper barge alongside. The self-discharging hopper barge is about 50ft x 100ft and is capable of carrying 1000t of material. The barge is filled alongside the dredge and is moved by winch to a discharge station where it unloads similar to a “slinger” in under 30 minutes.

The second choice is an overhead crane clamshell dredge. The disadvantage of this system is that it digs pits in the bottom as the digging strategy and is very slow at recovering material that does not freely flow.

Spoil is loaded into a de-watering hopper which feeds a chain conveyor to shore.

The third choice is the Tower Dragline but this is awkward, slow and does not stack material. It does have the advantage of being a shore based machine.

Conclusion

The only machine that covers the full range of conditions encountered in sand and gravel pits from the very beginning to the end is the lattice boom, crawler based combination clamshell / dragline.

These machines are inexpensive, easy to operate, versatile, have long life expectancy, are easy to move and have high residual value.