TECHNICAL FEATURES, APPLICATIONS, AND ADVANTAGES OF AN EIGHT INCH AMPHIBIOUS DREDGE

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ABSTRACT

In the dredging industry, there are long standing applications in various sectors that are in need of new dredge designs and technologies. Increasingly, dredging contractors and builders are faced with new challenges, never before encountered that require applications of new types of equipment to meet their needs. It is when several requirements merge that the industry invests in the necessary research and development to develop a new style of dredge to meet a broad range of requirements in many industry sectors. This is the case of the new 8 inch amphibious dredge.

Keywords: Amphibious dredge, swinging ladder, environmental dredging, coastal restoration

INTRODUCTION

The 8 inch amphibious dredge, known as the "Amphibian", is a self-propelled, swinging ladder dredge, capable of dredging in the forward or reverse tracking modes. The track and floatation system on the Amphibian dredge has been around for several decades, however, not until the introduction of this machine, had it ever been fitted with a swinging ladder style dredging platform. The dredge is constructed of three dismountable sections, consisting of two 28,000 lb side tanks, each equipped with a dozer style track system, and a 42,000 lb dredge center section. The dredge center section contains all the various systems necessary to operate the dredge. This represents a total dredge weight of approximately 98,000 lb.

AMPHIBIOUS DREDGE FEATURES

Ladder

The swinging ladder (Figure 1) design allows the dredge hull, made up of the two side tanks and center section, to remain stationary while the ladder is manipulated, or swung, from side to side by way of a pivoting gimble and a hydraulic cylinder. The ladder itself is hinged at approximately 2/3 the distance of the ladder, allowing the excavator to be placed in a reverse dredging position. The lower 1/3 of the ladder is controlled by two ladder mounted hydraulic cylinders, allowing the dredge operator to adjust the position of the lower ladder portion during the dredging process. This gives the Amphibian dredge the capability of dredging in the reverse travel direction (Figure 2).

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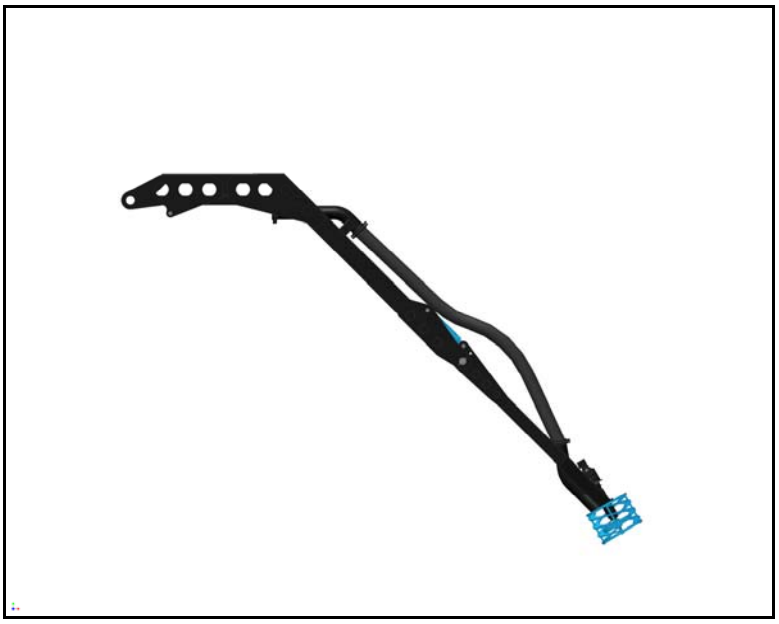

Figure 1. Ladder extended for dredging in the forward direction

Figure 2. Ladder manipulated for dredging in the reverse direction

Spud System

In deep water, the dredge's hull is held in position by three-spud system (Figure 3), made up of two forward spuds, and one aft spud. Because smaller dredges have lighter spuds, and thus, less penetration when dropped for holding power, the spuds are designed with "power down" capability. This feature allows the operator to use the power of the spud winch system to force the spud into the bottom for maximum penetration and holding power. It also provides a stable dredging platform, preventing a change in trim as the dredge's center of gravity shifts, caused by the swinging ladder. The two forward spuds are stationary spuds, while the aft spud is mounted on the centerline of the dredge and is a hydraulically manipulated. This spud is referred to as a "kicker" spud. The word "Kicker" means that the entire aft spud frame, known as the spud "gate", is horizontally pivoted at the top of the gate, and fitted with a horizontal hydraulic cylinder at the lower end of the gate. This horizontal cylinder, when extended, tilts the spud forward. As the spud is tilted forward, because the spud is held firmly in place by the spud point engagement with

the bottom, the dredge is moved forward through the water. The kicker spud system (Figure 4) design affords small truck transportable dredges the features of a spud carriage without the added size and flotation a spud carriage requires. This gives the Amphibian dredge agility in movement requiring no swing anchors or swing wires. At a push of a button, the Amphibian dredge can move forward, back, and change directions. A change of direction is accomplished by raising the two forward spuds, and swinging the ladder while the excavator and aft spud is engaged with the bottom. This pivots the dredge on the aft spud until a new direction is achieved. Once in the new position, the two forward spuds are again lowered and the dredge continues in its new direction.

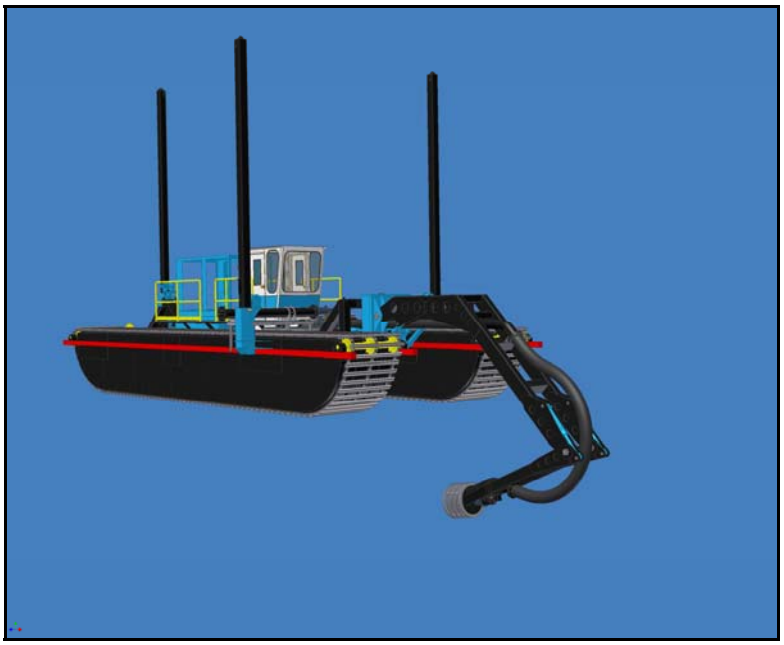

Figure 3. The Amphibian's three-spud system

Figure 4. Kicker spud assembly tilted in the forward position

Track System

The side tanks, around which the dozer style tracks rotate, provide the necessary flotation for the 98,000 pound dredge. These wide tracks result in a foot pressure of only 2.2 pounds per square inch while on dry land, and 1.7

pounds per square inch while traversing swampy terrain. When operating in the dredge in shallow water depths, where part of the dredge's weight is supported by the floatation of the side tanks, the dredge can be driven along the bottom while dredging takes place. These chain-driven tracks, each driven by a single two-speed hydraulic motor, close coupled to a planetary reduction gear, provide the locomotive force on both land and when floating free in the water. The Amphibian is capable of a land travel speed of approximately 2 miles per hour, an aquatic speed of approximately 1 mile per hour. The track system also gives the dredge the ability to climb a 60-degree incline.

Figure 5. Track mounted hydraulic excavator shown climbing from a freshwater lake

The track system possesses sufficient power to pull approximately 3,000 to 4,000 feet of 8 inch SDR 26 Polyethylene (HDPE) pipe behind the dredge as it travels to the dredging site. This allows the dredge to crawl across soft, swampy terrain and into bayous, lakes, or secluded waterways to perform dredging operations for coastal erosion, environmental cleanup projects, or around oil well installations. For areas with special circumstances and permitting, a side caster can be used in lieu of a pipeline. A side caster is a device affixed to the discharge pipe at the stern of the dredge. This device consists of a small nozzle that delivers the dredged material through the air to a site 300 to 400 feet away. The side caster can be adjusted to discharge the dredged material to the port or starboard side, as well as the stern of the dredge.

Excavator

The excavator of the Amphibian dredge is a self-contained hydraulically driven underwater unit, powered by hydraulic motor, close coupled the a high torque planetary reduction gear, which is, in turn, close coupled to an alloy steel shaft. This shaft spins on anti-friction bearings in an oil filled tube, sealed with a Duo-Cone mechanical seal. Typically, these cutter drive systems require only periodic servicing and sacrificial wear part replacement. A positive static oil pressure is maintained by a ½ gallon static oil tank mounted above the dredge's deck level. This static oil provides an internal oil pressure that is constantly greater than the water pressure at the various depths, ensuring that oil leaks out, as opposed to water leaking into the drive in the event of a seal failure. Each static oil tank is equipped with a low oil sensor, that when activated, emits an audible and visual alarm on the operator's color touch screen and is recorded in the alarms menu.

The Amphibian dredge comes equipped with a standard basket style 5-blade replaceable edge cutter (Figure 6). A replaceable cutter edge allows the dredge operator to choose from a smooth edge or a serrated edge design. This design allows the dredge owner to replace the cast edge as a sacrificial wear part, rather than replacing the entire cutter blade. The 17.5 HP excavating system is capable of delivering 39,931 in/lb. of torque and 2,462 lb. of cutter force, which results in a material break out force of approximately 140 lb per linear inch of cutter blade for a smooth style edge style, and approximately 280 lb per linear inch of blade for the serrated style edge.

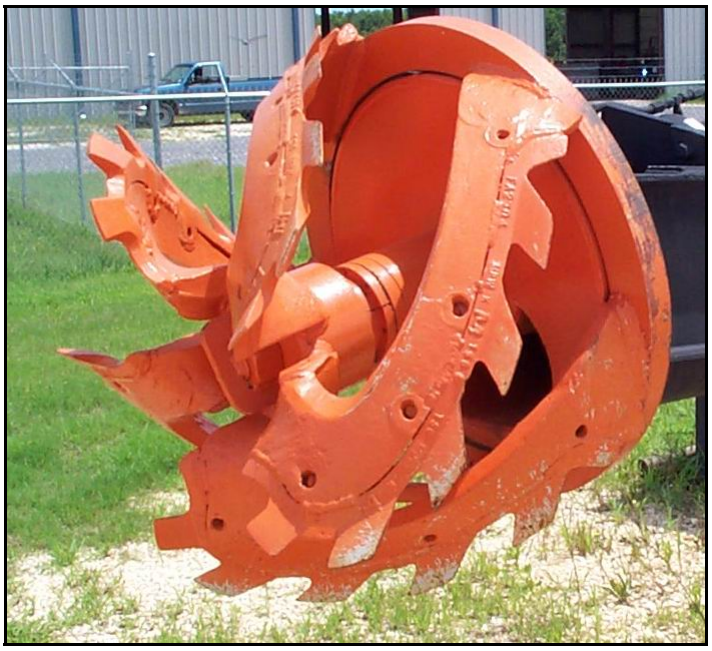

Figure 6. Standard basket style 5-blade replaceable edge cutter

As an option, the Amphibian can also be fitted with DSC's patented Environmental or "Viscous Excavator" shown in Figure 7. The major difference between the conventional excavator and the environmental excavator is that, with respect to the conventional style, the majority of the torque and horsepower is dedicated to the functions of undercutting and lifting a relatively compacted material into suspension. Silts, organics, and environmentally sensitive materials, on the other hand, are not normally found to be compacted, so the design of the environmental excavator allows the excavator to dedicate its torque and horsepower to the function of positively feeding the dredge's suction nozzle. This design principle, dating back to the time of Academes, incorporates a series of steel flights lined with hardened steel edges, which gently conveys the material towards the suction nozzle. While not yet tested in a controlled case study or laboratory test, existing customers report an increase in solids acquisition of 20% to 25%, and a reduction in material spillage. Because the undercutting action of the environmental excavator is greatly reduced, this excavator produces a minimal amount of turbidity resulting in the lowest level of resuspended solids of any form of excavation currently in use today.

Figure 7. Patented environmental "Viscous Excavator"

To add even further to its environmental dredging capabilities, an optional environmental hood can be added to the excavator assembly to encapsulate the exposed portion of the excavator when dredging. The hood traps the solids within the hood, allowing the flights of the environmental excavator to move the material towards the suction before becoming lost in the water column. A venturi eductor is mounted at the top of the environmental hood to remove any suspended solids within the hood and deliver them directly to the dredge pump suction piping.

Dredge Pump

The pumping system of the Amphibian dredge utilizes a high efficiency dredge pump with an 8 inch suction and an 8 inch discharge diameter (Figure 8). The dredge pump is a proprietary design, and is manufactured of high-chrome alloy. The 19.5 inch diameter, 3-vane, warped vane impeller is capable of a nominal pump capacity of 2,000 GPM at a total dynamic head of 185 feet, and is capable of a spherical particle passage of approximately 3.5 inch. The pump is mounted at dredge deck level to prevent damage while traversing rough terrain and is driven by a close-coupled, closed-loop, hydrostatic transmission. Utilizing the hydrostatic drive allowed DSC engineers flexibility in determining onboard engine and pump configurations, affording a more balanced weight distribution, while at the same time, maintaining compact dredge dimensions. In addition, mounting the pump at deck level, affords the operator easy and immediate access to the suction cleanout and maintenance personnel easy access to the pump for periodic wear part replacement, without the need for an additional support vessel. The packing gland of the standard dredge pump can be replaced with a mechanical seal arrangement, thus allowing the dredge the ability to dredge lake or waterway shorelines while standing on dry ground.

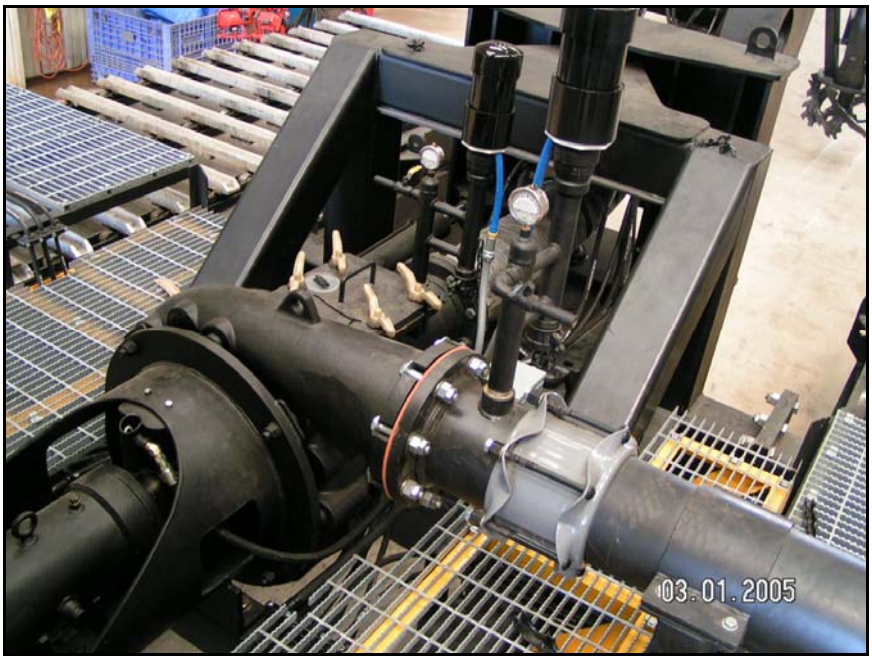

Figure 8. Amphibian's 8 inch high-efficiency, high chrome dredge pump

Prime Mover

The dredge is powered by a Caterpillar 3126B, radiator-cooled, Industrial diesel engine capable of producing 275 BHP @ 2,400 RPM. This electronically controlled diesel engine is EPA and CARB Tier II compliant and features Caterpillar's premium gauge package, alarms, and shutdown system. The engine is housed in a custom-built enclosure with four large easy access doors and a residential grade exhaust silencer. For dredging in sensitive areas, a sound attenuated engine enclosure with a hospital grade exhaust silencer is also available as an option.

Operator Controls

The climate-controlled operator's cabin incorporates the latest in dredge control technology. The dredge controls utilizes a Programmable Logic Controller, known as a PLC, to control the functions of the various control circuits.

PLC's have been the standard in manufacturing automation since the 1960's and is a reliable and time proven technology. Unlike PC based controls, PLC controlled circuits are not susceptible to hard drive crashes, viruses, and antiquated software issues. Since the diesel engine is an electronically controlled engine, all data transmitted by the Caterpillar diesel engine such as fuel burn rate, HP, torque, temperatures, pressures, etc. are sent to the PLC via a communication cable and displayed or recorded for the operator's use. PLC and electronic/hydraulic controls facilitates the remote mounting of hydraulic control valves, removing the need to mount them under the control console. This removes the heat and noise associated with console mounting of hydraulic valves.

The PLC is directly connected to a color touch screen (Figure 9) operator interface. This means that the operator has a screen that displays information under several different menus and can change from menu to menu at the touch of a button located on the screen. While screens typically have a standardized arrangement of buttons and information, each screen can be quickly and easily tailored to the dredge operator's preference. In addition, ancillary equipment information such as boosters, and GPS system information can be brought into the touch screen by radio, satellite, and cellular signals. A cellular modem can be added so that manufacturer's technicians can "dial up" the dredge and access the dredge's control circuits to assist the dredge operator in troubleshooting a possible system problem.

In the event a system problem does arise, the touch screen has a system-troubleshooting menu that allows the operator to quickly determine which piece of hardware needs attention. The operator can quickly isolate the source to a switch, a power board, or a simple connection without leaving the operator chair.

The alarm menu in the color touch screen records and displays the latest 64 system alarms, which can only be deleted by the use of an administrative password. Each alarm item displays the alarm name, time, and value. All alarms and/or information from the entire dredge control system can be recorded and stored on a flash card using the onboard flash card recorder included as part of the color touch screen. Depending on the number of items recorded, the flash card can store up to a year of information and can be removed for easy downloading to a laptop or desktop computer. This feature makes it possible for dredge managers to easily generate managerial reports or conduct management reviews.

The operator chair (Figure 9) is a special ergonomically designed padded chair with all the necessary dredge controls built into each armrest. It is no longer necessary for the operator to bend or reach to change a setting or adjust a control while dredging or maneuvering. The bottom of each armrest has a large access panel to provide quick and easy access to the control mountings. Changing a control switch or dial can be accomplished in a matter of minutes resulting in minimal downtime. Our system design engineers designed the system to ensure that in the event of complete touch screen failure, the dredge can still be operated manually until a replacement is received and installed.

Figure 9. Operator control console with ergonomically designed operator chair and touch screen.

Global Positioning and Control System

The Amphibian dredge can come equipped with a GPS Dredge Positioning and Management System (Figure 10). The system utilizes two separate satellite receivers, each mounted on the bow and stern of the dredge. This configuration gives the dredge's position as well as an accurate heading when stationary with sub-meter accuracy. These receivers, coupled with ladder angle and depth transmitters, tell the system software the position and depth of the excavator. The system comes complete with a standard laptop PC. As the excavator is manipulated across the cut, the system paints a color on the computer screen that coincides with the current dredging depth. These depths are recorded in the software allowing the operator or management personnel to produce a detailed 3-D graphic of the dredged area (Figure 11). The system is affordable and can be expanded to enhance its capabilities. Hydrographic survey equipment as well as local tide level transmitters can be added at an additional cost.

The GPS Dredge Positioning and Management System displays the position of the excavator in real-time and prevents the operator from passing over material as the dredge is advanced or moved laterally to the next cut. It also allows the operator to leave the dredging area and return the dredge to the exact spot when dredging operations resume.

Figure 10. Typical GPS Computer Screen Display

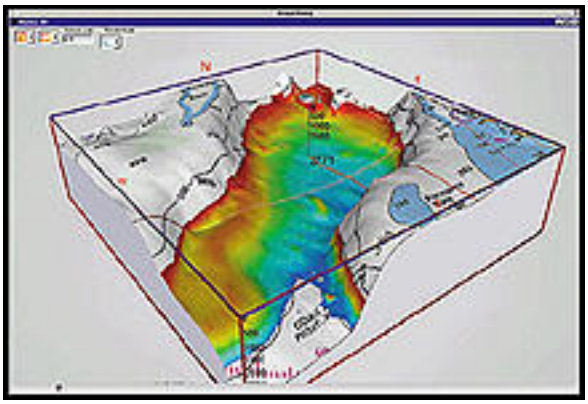

Figure 11. 3-D Computer Graphic of Dredged River

Hydraulic System

In addition to the dredge pump's hydrostatic drive, other hydraulic circuits are also supplied by a variable-displacement hydraulic piston pump. This pump design keeps hydraulic flow to a minimum unless a demand for hydraulic flow and pressure is present. This translates into lower hydraulic oil temperatures, higher overall system

efficiency, and increased fuel utilization. Speed control of hydraulic cylinders and winches are controlled by Pulse Width Modulators, or PWM modules. These electronic modules control the partial opening of hydraulic valves by sending a series of DC electric pulses at various pulse intervals. The closer the pulse interval, the more the hydraulic valve opens. This technology gives the operator the ability to control the speed of hydraulically controlled components by a numerical input into the color touch screen. The operator can easily input the minimum and maximum speeds for each hydraulic component, thus creating an endlessly customizable operation.

The hydraulic valve functions are controlled by DC electric solenoids. Along with DC electric solenoids comes a control system issue called Reflected Magnetic Field, or RMF. As the DC solenoids de-energize, a voltage pulse is created by the collapse of the magnetic field around the solenoid. This voltage pulse, transmitted back through the control wiring, damages old conventional style relays by pitting or fusing the relay contacts. Incorporated in the Amphibian's control circuitry is a power board specially designed by DSC to replace conventional contact relays, thus eliminating this age-old problem. The solid-state circuitry of this power board means there are no contacts, as in conventional relays, and therefore no damage caused by RMF.

The hydraulic valves (Figure 12) are remotely mounted within the engine enclosure and are easily accessible for inspection and maintenance. Several 4-way hydraulic control valves are mounted onto a specially designed aluminum alloy valve manifold. This manifold replaces individual, possibly obsolete hydraulic valves previously used in dredge control circuits with smaller, screw in, pressure relief, and flow control cartridges. The 4-way control valves are ANSI spec sub-plate mounted valves allowing dredge operators to replace the brand of one valve with another brand. This configuration also reduces the amount of necessary hydraulic piping, and facilitates the mounting of control valves in a central location for easy troubleshooting. The hydraulic system of the Amphibian dredge uses environmentally safe, Chevron Clarity biodegradable hydraulic oil. Unlike vegetable-based hydraulic oils, this mineral-base oil does not have a shelf life and offers greater longevity and system performance characteristics.

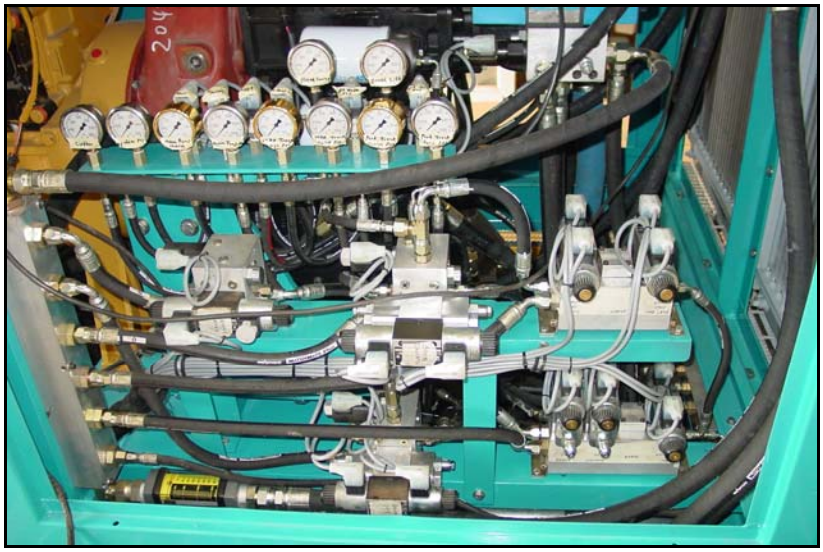

Figure 12. Centrally located hydraulic control valves and gauges for ease of maintenance

WHY BUILD AN AMPHIBIOUS DREDGE?

In order to answer that question I think it's best that we examine a few examples of projects well suited for this type of dredge.

Coastal Restoration

Each day, the State of Louisiana loses coastal land (Figure 13) equivalent to a football field in size to coastal erosion. Within Louisiana's 5,727 square miles of coastal wetlands, there exists:

- more than half of the tidal marshes found in the lower 48 states
- oil and gas pipelines that deliver more than a quarter of the nation's energy supplies

- the world's largest port system
- fisheries that supply more than a quarter of the seafood consumed in the lower 48 states

In the past, the main focus of dredging operations have been placed on navigational and commercial dredging, however, today, more and more attention is being paid to small secluded areas in this region. These small-secluded areas sometimes prove difficult to reach with the necessary equipment to launch a conventional dredge. The Amphibian can access these areas up to several miles off the beaten path to accommodate these dredging needs. The Amphibian is well suited for:

- Dredging small bayous that have become shallow from coastal erosion
- Restoring water depth to secluded, protected beaches and inlets
- Marshland restoration in tidal areas
- Wetland creation

Figure 13. Example coastal restoration

Environmental Projects

The capability of this design lends itself nicely to environmental projects. Utilizing the patented environmental "Viscous Excavator" and environmental hood, the Amphibian dredge is capable of dredging contaminated sediments at a high solids concentration with extremely low turbidity levels (Figure 14).

Figure14. Contaminated canal site.

Many applications of wetland creation projects are in areas that require the building of access roads to the dredge launch site and then removal of the access roads once the project is complete. Utilizing the Amphibian dredge fitted with a side caster eliminates the need for access roads, thus saving time and money. The dredge can traverse the newly created marshes or tidal areas with only 1.7 psi of foot pressure, preserving and protecting the newly constructed areas.

Aquaculture

Most all aquaculture farms that raise shrimp, catfish, crawfish, etc., have one main similarity in their design. Most all farms (Figure 15) are made up of a series of small individual ponds, each pond receiving new nourishing water from a common canal or pipe system at one end, and each having a weir system which spills water into a common canal or pipe system at the other. This way, poor health or given circumstances in one pond, does not adversely affect the heath of another. For this reason, the individual ponds are not interconnected. Periodically, these ponds require cleaning of waste material created by defecation, requiring the farm owner to remove the water from a pond and clean the bottom by mechanical means. Dredging provides a low cost means of performing these periodic cleanings, however, these farms usually have very limited space available to stage the equipment required to launch and retrieve a conventional style dredge. In addition, this would require the farm staff to launch and retrieve the dredge for each individual pond, which is very labor intensive. Utilizing the Amphibian dredge in this application would allow aquaculturalists to clean the ponds without draining. By utilizing the Amphibian dredge, the dredge could travel from pond to pond under its own power eliminating the need for cranes, trucks, etc.

Figure 15. Typical aquaculture farm.

Irrigation

Many irrigation districts across the United States, South Florida Water Management District for example, include many miles of canals not readily accessible by vehicles and large trucks. This lack of access makes the use of conventional dredges difficult due to the distance between launching areas and dredging sites. Considering that the Amphibian dredge can travel 3 miles over swampy terrain to a remote area in 1.5 hours. The Amphibian dredge is a viable candidate for this application. Utilizing a side caster, the Amphibian dredge can dredge while navigating the canals, and return the nutrient rich dredged material back to the surrounding farmlands from whence it came.

Figure 16. Irrigation canals.

Sand and Gravel Mining

Many sand and gravel mines have settling ponds (Figure 17) where less than 200 mesh fine waste sand material is deposited. This fine waste material is pumped from the classifying plant and allowed to settle before returning the water to the pit or dredging area. Every year or so, these settling ponds require deepening, and many sand and gravel operations lease small dredges for a short period of time to perform this task. Each time, a dredge is leased for approximately 1 to 2 months to perform the dredging, and then returned to the leasing company. This represents a cost to the sand and gravel operation of an estimated $60,000 to $70,000. Most sand and gravel companies have several locations within a relatively small geographic area. Some states, including Louisiana, allow highway transportation of the dredge without disassembly. Using the track drive, the Amphibian dredge can be easily driven from a float bed tractor-trailer, perform the needed dredging, return to the float bed under its own power, and be subsequently shipped to the next location to repeat the process.

Figure 17. Sand and gravel settling pond.

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