EVALUATING ALTERNATIVES TO IMPROVE DREDGING EFFICIENCY AND COST-EFFECTIVENESS FOR INLAND MARSH RESTORATION PROJECTS

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ABSTRACT

Over the past decade, the State of Louisiana's Office of Coastal Protection and Restoration (OCPR) has perceived an increase in dredging costs for projects involving the placement of dredged sediment for inland marsh restoration purposes. The State of Louisiana is anticipating developing a new statewide program with the objective of providing a balance between completing marsh restoration projects while controlling overall project costs. This study was conducted to evaluate the international, national and regional dredging industry for existing market drivers, available innovative dredging technologies, contracting methods, and program approaches that could be implemented to meet the State's objectives. An international team was compiled to research these topics and concluded that revisions could be made to optimize the dredging component of the current restoration program. The report included the findings of the team's research and provided recommendations in the following areas:

- Dredging Market Analysis – This analysis compared the United States (US) and international dredging industries to determine what attributes of the expanding worldwide market might be applicable to Louisiana.
- Innovative Technology – Innovative dredging technologies that are currently available were evaluated to determine applicability for improving efficiency of State of Louisiana inland marsh restoration projects.
- Regional Inland Marsh Restoration Plan – Historical marsh restoration project data and dredge equipment capabilities were analyzed to identify the optimal site size, dredge and volume, ideal fill locations, and schedule for restoration projects to be implemented by OCPR.
- State Government Ownership of Dredges – Dredge ownership was evaluated to determine if purchasing a dredge would be cost-effective for OCPR and if it would be consistent with recommended components of the Inland Marsh Restoration Plan.
- Bidding, Contracting, and Project Management – Various contracting and bidding methods were evaluated to determine the highest-ranking techniques to reduce costs for OCPR restoration projects and confirm industry commitment to OCPR given the targeted dredging work needs.

Keywords: marsh restoration, dredging, coastal protection, Louisiana, cost

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INTRODUCTION

The State of Louisiana's Office of Coastal Protection and Restoration (OCPR) currently has a relatively inconsistent dredging program that varies annually in the number and size of projects. This variability is primarily caused by fluctuations in the available funding from year to year. However, due to anticipated legislative changes in the methodology used to distribute the royalties generated by the production of oil and gas in the Gulf of Mexico, the State of Louisiana is expecting a significant increase in available funding for coastal restoration projects including those involving dredging. This anticipated increase should provide a consistent and steady source of revenue that will allow Louisiana to develop a state dredging program as part of the overall coastal program.

Photo 1. Inland marsh restoration utilizing a hydraulic dredge and piping to a fill location.

OCPR provided bid data on 28 projects bid and constructed between 1997 and 2009, for a total cost of $327 million. These projects included barrier island restoration and marsh restoration using hydraulic dredging. Hydraulic dredge volumes for inland and nearshore marsh, and offshore barrier island projects were found to range from 73,600 cubic meters (m^3; 96,300 cubic yards [cy][11]) in 2002 to 5,000,000 m^3 (6,500,000 cy) in 2008. Data analysis showed that reported unit costs for these marsh projects ranged from $1.75 to $10.00 per m^3 ($1.34 to $7.65 per cy). Historically, OCPR projects have involved restoring a single project area by mobilizing one dredge and excavating one borrow site. Photo 1 shows hydraulically dredged material being placed in an inland marsh fill site. The procurement of inland projects are unit price bid contracts with the payment either for dredging by the volume removed from the borrow area or for the volume of material placed. Over the past decade, OCPR has observed an increase in dredging costs for projects involving the placement of dredged sediment for restoration purposes. While a portion of this increase is attributed to the rising costs of fuel, labor, and steel, it is OCPR's opinion that project cost may also be affected by other factors, including: the performance risk born by a contractor associated with the current contracting procedures; a lack of competition among a small group of bidders; and a national dredging community that has very little capacity for additional projects. In anticipation of developing a new statewide program that maximizes the coastal restoration of south Louisiana while controlling costs, OCPR retained ARCADIS U.S., Inc. (ARCADIS) and a team of experts (Ecology & Environment [E&E], Alkyon, and Louisiana State University professor) to evaluate the international, national, and regional dredging markets for new and immerging technologies, contracting methods, dredging techniques, and program approaches that historically have not been implemented in Louisiana for application to the statewide dredging program.

METHODOLOGIES

ARCADIS assembled a team of international, national, and local experts to compile the industry information and present the data in a manner that OCPR can utilize in future policy development. In addition to ARCADIS, team members included E&E, Alkyon (a subsidiary of ARCADIS based in the Netherlands), as well as

[11] All values in this report were calculated in United States customary units and converted to standard international (SI) units for the purposes of the WEDA XXXI Technical Conference & TAMU 42 Dredging Seminar. Please reference the original United States customary units for the most accurate values.

Dr. Joseph Suhayda of Louisiana State University. Data were collected from multiple sources including historical data provided by OCPR, historical data from the United States Army Corps of Engineers (USACE) Navigation Data Center, case studies, industry and trade organizations, industry directory publications, personal communications with representatives of the dredging industry, interviews with industry experts and USACE dredging project managers, internet searches, literature reviews, and dredging industry statistics.

RESULTS

Dredging Market Analysis

Results of the World Market Analysis indicate that dredging volumes worldwide have more than doubled since 2000. The fastest growth has been seen in the Middle East (1400%), Australia (260%), China (170%), and Europe (150%). While there has been a dramatic increase in dredging volumes in the international market, the unit costs associated with dredging have decreased over the same period. This decrease in unit cost is primarily due to the combination of recent investments in the modernization of an aging fleet and innovation and sustainability by the international dredging community. One of the most significant factors in the cost reductions seen in the international dredging market are the technological advances in trailing suction hopper dredges (TSHDs). Large reclamation projects in areas such as Hong Kong, Singapore, and Dubai have provided the incentive for the development of increasingly larger hopper dredge vessels, which, due to economies of scale, have resulted in lower costs per cy. The average unit cost of all sizes of international dredging projects using trailing suction hopper dredges decreased by nearly half between 1980 and 2005.

Unlike the international market, the volume of material dredged in the United States (US) has slightly declined over the past 15 years while the cost of dredging projects has increased (see Figure 1; USACE 2011). In the US, the dredging market is primarily driven by dredging needs of the USACE for management of the nation's navigable waters, and not to restore marsh sites. Over the past 15 years, the overall price of dredging for USACE projects (including maintenance and new work) has gradually increased from approximately \$3 per m^3 (\$2 per cy) in 1995 to over \$8 per m^3 (\$6 per cy) in 2010.

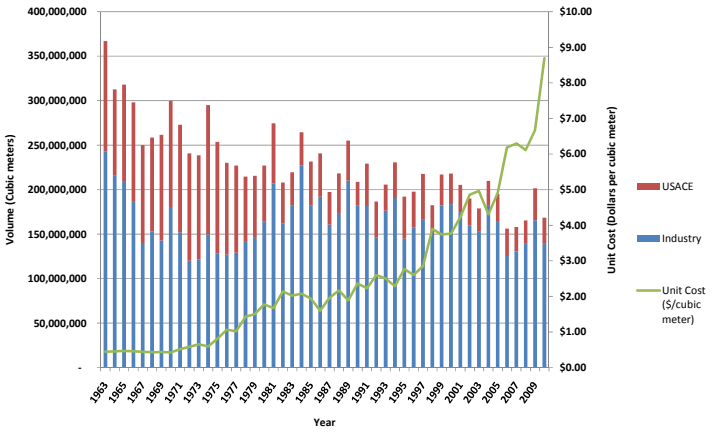
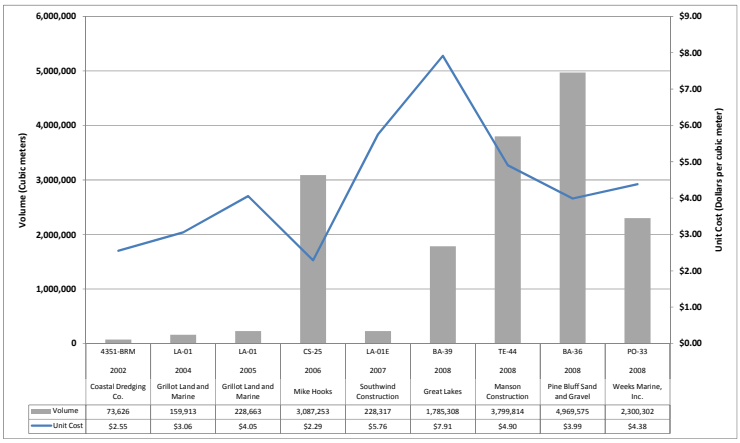


Figure 1. Total dredging volumes and total unit costs of USACE dredging contracts constructed by USACE- and industry-owned dredges 1963 – 2009 (Source: USACE Navigation Data Dredging Statistics 2011).

Consistent with national trends, OCPR has also seen an increase in project costs. Based on the data provided by OCPR, yearly average unit costs of marsh restoration projects (inland, nearshore, and offshore) have ranged from \$2.13 per m^3 (\$1.63 per cubic yard)in 1997 to \$6.34 per m^3 (\$4.85 per cubic yard) in 2008. Figure 2 shows the unit costs and volumes of inland marsh restoration projects that were constructed between 2002 and 2008. These projects

have ranged in cost from $2.29 per m^3 ($1.75 per cy) in 2006 to $7.91 per m^3 ($6.05 per cy)in 2008. It should be noted that the highest unit cost was associated with Project BA-39, which was constructed using an "in-place" payment method, while the remaining projects shown were constructed using the "cut-fill" method. Based on a review of available cost information, the ARCADIS team concluded that, with few exceptions, the price of hydraulic dredging for OCPR restoration projects was reasonable and consistent with the market price for hydraulic dredging at the time.



	4351-BRM	LA-01	LA-01	CS-25	LA-01E	BA-39	TE-44	BA-36	PO-33
	2002	2004	2005	2006	2007	2008	2008	2008	2008
	Coastal Dredging Co.	Grillot Land and Marine	Grillot Land and Marine	Mike Hooks	Southwind Construction	Great Lakes	Manson Construction	Pine Bluff Sand and Gravel	Weeks Marine, Inc.
Volume	73,626	159,913	228,663	3,087,253	228,317	1,785,308	3,799,814	4,969,575	2,300,302
Unit Cost	$2.55	$3.06	$4.05	$2.29	$5.76	$7.91	$4.90	$3.99	$4.38

Figure 2. Comparison of unit costs and volume of dredged material for OCPR inland restoration projects.

The domestic dredging industry in the US is protected by various cabotage laws, including the Foreign Dredge Act of 1906 and the Merchant Marine Act of 1920 (also known as the Jones Act), which prevent foreign interests from operating in domestic waters. These laws limit dredging actions to US-built hulls, US-owned fleets, and US-crewed ships. During interviews, representatives of the dredging industry were in agreement that opening the US dredging market to foreign dredging companies would not positively impact the national dredging industry. Interviewees suggested that a significant need for jumbo TSHDs has not been established in the US market. Additionally, they stated that capacity of the national dredging industry is not the issue; rather, there is a lack of regular funds to support consistent dredging competition. A decreasing market has resulted in a lack of incentive to invest in modernizing the national dredging fleet. Results of interviews revealed that significant investments in upgrading the fleet, which will result in an increase of the overall domestic dredging capacity, as well as investments in research and development of new technologies, will be made only if there are significant financial incentives. Based on feedback, a new market would need to be consistently funded at a relatively high level for an extended period time (a 3- to 5-year period) to effect increased capital investments.

Innovative Dredging Technologies

The restoration of Louisiana inland marshes has specific requirements and restraints that limit the dredging technologies applicable for use. Inland marshes generally have a water depth of 1 meter (3.5 feet) or less, and the corresponding open waterways and channels are approximately 1 to 2 meters (4 to 8 feet) in depth. Interviewees indicate that there is significant debris in the borrow locations which regularly affects production rates of dredging equipment.

Three main types of dredges are currently used internationally for the development of restoration projects: the backhoe dredge/grab dredge/dipper dredge (BHD/GD/DIDs), TSHDs, and cutterhead suction dredges (CSDs). Of the three major types of equipment used for restoration worldwide, TSHDs have the largest production rate, followed by CSDs, with BHD/GD/DID reporting the smallest production rates. Efficiencies have also resulted from

modernization of key components (i.e., pumps, pipelines, and other ancillary equipment), but the most significant factor in the increased production and resulting decrease in unit rates is the construction of "mega dredgers". The large, long-term dredging programs in Hong Kong, Singapore, and Dubai have provided a stable market that has encouraged significant capital investments. International companies have constructed new vessels that are capable of average production rates quadruple that of the largest dredges previously available.

During the completion of the interviews with representatives of the major international companies and the Worldwide Market Analysis, the ARCADIS team did not discover any new innovative technologies that are currently being used in the international market that are unfamiliar to the national dredging community. The major improvements in production have been in investing in the current international fleet to maximize efficiencies of newer ancillary equipment and to increase the size of vessels.

Of the varying dredging technologies that have increased efficiencies in recent years, the most significant improvements have been made in the overall capacity of dredges and their total installed power. However, high-capacity dredges often require drafts that exceed depth limitations of typical Louisiana marshes, and therefore high-capacity TSHDs are not an optimal solution for OCPR. Similarly, recent improvements have been made to CSD cutter power, resulting in higher production rates and increased power for dredging harder soils. However, the current trend appears to be incorporating increased power and production rates in the development of jumbo dredges, which have a draft greater than what is accessible to Louisiana's marsh areas. These improvements may one day be applied to smaller CSDs with shallower drafts allowing access to marsh areas, and economies of scale could be realized. According to industry interviews, of the current national fleet of CSDs, the dredge which optimizes size, accessibility, and site requirements for marsh creation projects is the 51-centimeter (cm; 20-inch) CSD. It is common practice for dredging equipment manufacturers to customize the design and construction of dredge equipment. In cooperation with these companies, OCPR can design dredging equipment specific to restoration needs.

Inland Marsh Restoration Plan

OCPR can effectively reduce inland marsh restoration project costs by: scheduling state dredging projects around known USACE and private sector dredging projects; planning and coordinating parish and other agency projects together regionally; and grouping smaller inland marsh projects located in the same region into one larger contract. These strategies minimize mobilization and demobilization costs, which have increased from approximately 10% to 20% of overall project costs between 1997 and 2008. Therefore, as a first step in developing an Inland Marsh Restoration Plan, other existing and planned projects were identified for potential coordination. Given the annual rate of inland marsh loss, an annual target of 31 square kilometers (km; 12 square miles) was selected for inland marsh restoration plan development. Lastly, analysis was conducted to identify the optimal marsh fill site size and to determine a maximum dredge pumping distance from potential excavation sites.

Based on the annual production capacity of a 51-cm CSD within standard pumping distances, analysis concluded that the optimal site size is approximately 800 hectares (2,000 acres). This is equivalent to approximately 3 square miles or an eighth of the estimated wetlands lost annually. Depending on the target elevations, the required dredge volume to fill an optimal 800-hectare (2,000-acre) site would range between 4.9 million m^3 and 9.8 million m^3 (6.4 million cy and 12.9 million cy). Interviewees indicated that projects approximately 0.8 to 1 million m^3 (1 to 1.5 million cy) in size would be a breakpoint where unit costs would begin to lower due to economies of scale. Analysis showed that the Barataria Land Bridge project, the largest inland project by volume at 5 million m^3 (6.5 million cy), also had the lowest unit price per cy among all recent OCPR inland projects at $3.99 per m^3 ($3.05 per cy).

The maximum theoretical pumping distance for a 51-cm CSD was determined to be 27,000 to 30,000 meters (m; 90,000 to 100,000 linear feet). Therefore, 31 kilometers (km; 19 miles) was used as the maximum planning distance that each fill site should be located from an excavation site. In order to achieve these pumping distances, a minimum of four booster pumps would be required; otherwise, the maximum planning pumping distance is only 8 km (5 miles). Because production rates decrease as dredge pipeline lengths increase, pumping distances should be minimized to optimize production. Large cost savings could also be realized if multiple marsh fill sites were constructed using minimal pipeline moves because a significant portion of dredge costs are in pipe costs and moving the actual pipeline around. Therefore, fill sites should be as close as possible to one another to reduce pipeline costs and to allow construction of multiple sites simultaneously.

The Inland Marsh Restoration Plan identified potential marsh restoration sites in each of the coastal planning units based upon analysis of aerial imagery and existing marsh losses experienced within these units including: St. Bernard Parish, Plaquemines Parish, and Terrebonne Parish. For example, in the Terrebonne Parish area, approximately 1230 km^2 (475 square miles) were investigated for marsh restoration. The feasibility of restoring this area was evaluated based on a maximum 31-km pumping distance, potential open water excavation areas, and production rates of one 51-cm CSD. As shown on Figure 3, potential marsh fill locations within feasible pumping distances of 31 km or less of excavation dredge locations (shown as a red dot) and open water areas with potential dredge excavation areas (shown by dashed blue lines) were identified. A significant factor in determining inland marsh restoration feasibility is the comparison between existing marsh loss (in area) and the production capability of one dredge (approximately 1.4 hectares [3.5 acres] per day) projected out over a contract period (e.g., one year). This led to the conclusion that multiple marsh restoration projects will be required and the costs and contracting mechanisms for a fleet of dredges should be investigated.

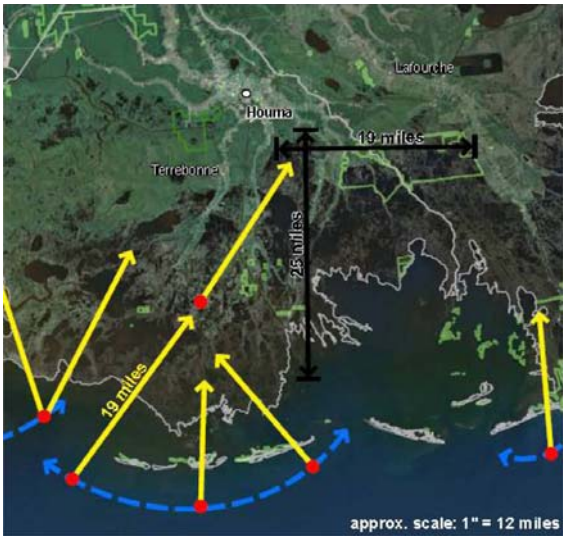


Figure 3. Feasible dredging distances in Terrebonne Parish.

State Government-Owned Dredges

The ARCADIS team evaluated alternative ways to reduce costs associated with the operation of a dredge. One alternative available to OCPR is to purchase a dredge, which would provide OCPR with the flexibility to meet the continuous need for marsh restoration projects. The ARCADIS team found that numerous states and municipalities own dredges. Typically, programs that justify ownership are based on consistent and localized navigation projects.

While the OCPR is defining the new state dredging program, dredge ownership may not be the most feasible and effective approach to the coastal restoration challenges in south Louisiana. As the program matures and develops reliable and predicable dredging projects, ownership may be a viable and cost effective solution. In the interim, leasing a dedicated dredge may be more appropriate for OCPR, due to the significant challenges that are associated with owning a dredge, including long-term support of a dedicated staff, repair and maintenance costs, and insurance. The long-term leasing of a dredge provides the flexibility to meet the continuous need of material for marsh creation projects, availability to work on a continuous basis, and to respond to unforeseen and peak dredging demands. A decline in dredging costs could be realized because of the reduction in mobilization and demobilization costs, as well as a reduced fluctuation in dredging costs due to market demand. The OCPR may be able to structure a lease option that will allow the agency to explore the cost benefits of a dedicated dredge without having to develop and maintain the in-house expertise of the overall support system. Based on a typical OCPR marsh restoration project, a long-term (36- to 60-month) dredge lease may present the economic benefits of owning a dredge, while avoiding the economic challenges associated with operating one.

Bidding, Contracting, and Project Management

In addition to conducting a dredging market analysis, the ARCADIS project team evaluated the state's current bidding and contracting program to determine if there are any alternate methods that may be utilized to minimize risks to OCPR and dredge contractors and therefore reduce costs. Currently, the state contracts on a per-project basis. For each project contract, a dredging contractor is selected, the dredge and its support equipment, pipelines, and crew are mobilized to the project site, construction is performed, and then all equipment and crew are demobilized until the next project is bid and contracted. A review of dredging projects around the country, around the Gulf Coast, and throughout coastal Louisiana has shown that the most expensive cost factor is the mobilization and demobilization. If that cost is reduced or omitted, dredging unit costs could be significantly reduced. Mobilization and demobilization costs could be reduced or avoided by continuously keeping a dredge engaged over multiple projects in one geographic area, and preferably, multiple years.

The team also evaluated strategies that may reduce overall program costs and invariably streamline the contractor selection process. One such strategy is to enter into a contract with an extended performance period, i.e., the Indefinite Delivery Indefinite Quantity (IDIQ) Multiple Award Task Order Contract (MATOC). An IDIQ MATOC approach would allow OCPR to award a small number of MATOC contracts to dredging contractors on the basis of a "Best Value" approach that considers non-price factors such as technical qualifications and past performance. After the MATOC contracts are issued, OCPR would then request competitive bids from each of the pre-qualified contractors for a specific project and award task orders based solely on cost. The IDIQ MATOC can allow OCPR the flexibility to award multiple projects to one or multiple contractors simultaneously, or to package multiple inland marsh restoration sites into one task order.

The ARCADIS team also investigated current project management practices and requirements placed on a contractor, i.e., risk factors that may drive up the cost of a restoration project. It appears that project costs increase associated with the risk of strict marsh fill tolerances (maintaining a marsh elevation over a specific performance period) and the resulting uncertainty restricting subsequent project start schedules. Contract performance specifications that address these concerns would reduce costs based on minimized perceived risk to the contractor.

CONCLUSIONS

Based on a comparison of international, national, and regional dredging project unit costs and OCPR dredging project unit costs, the ARCADIS team concluded that, with few exceptions, the price of hydraulic dredging for OCPR restoration projects was reasonable and consistent with the market price for hydraulic dredging at the time of construction. To meet OCPR's objectives, the ARCADIS team evaluated means to improve dredging project cost efficiency. The primary study conclusion was to maintain a consistently funded dredging program. Dedicated funding at a significant level with identified dredging goals will allow OCPR to become a market driver that will stimulate capital investments and subsequent innovations in the local dredging community, thereby increasing cost efficiencies and positively affecting marsh restoration costs. Additionally, a consistently funded program, and therefore, a recurring need for a dredge, may provide an incentive to consider a long-term lease of a dredge. Currently, purchasing a dredge is not in the best interest of OCPR. Operating a dedicated dredge is beneficial to entities that have a consistent and recurring need that cannot be met by the standard bid process with private industry. Based on developing an inland marsh restoration plan, the study concluded that OCPR should create projects in multiples of the optimal site size of 800 hectares (2,000 acres). Depending on target marsh surface elevations, the optimal site size would require a dredge volume ranging between 4.9 million m^3 (6.4 million cy) and 9.9 million m^3 (12.9 million cy). Based on a review of OCPR bid data for inland marsh restoration projects, the highest reported dredge volume of 5.0 million m^3 (6.5 million cy) had unit costs of $3.99 per m^3 ($3.05 per cy). Lastly, OCPR should consider utilizing IDIQ MATOC contracts. The IDIQ MATOC method offers the most flexibility by allowing OCPR to prequalify and select dredging contractors on the basis of best value while still maintaining the benefits of a cost-competitive bidding process.

With a decreasing market, national dredgers have not invested at the same rate as the international community in modernizing the national fleet. Interviews with national companies revealed that significant investments in upgrading the fleet, which will result in an increase of the overall domestic dredging capacity, as well as investments in research and development of new technologies, will be made if there are significant financial incentives. Based on feedback, a new market would need to be consistently funded at a relatively high level for an extended period time (a 3- to 5-year period) to effect increased capital investments. With the anticipated changes to the state's dredging

program, the national dredging community may have the financial incentive to begin making the investments necessary to provide the additional dredging services. A stable market beyond current USACE demands will also provide an increase in competition that should increase the development of innovative technologies suitable for the south Louisiana market. Therefore, OCPR needs to become a market driver for dredging.

Additional study conclusions were that a reliably funded dredging program will further benefit from coordinating projects with other state and federal agencies to maximize regional dredging effectiveness. A comprehensive and well-integrated inland marsh restoration plan for coastal Louisiana may require significant sediments beyond what can be dredged from inland sources. By developing a regional sediment management plan, addressing river diversions, offshore sediment sources, and other sources, these sediments can provide an additional source of dredged material for restoration purposes.

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