Developing an In-Lieu Sediment Remediation Fee Schedule for Elizabeth River

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ABSTRACT: The non-profit, Living River Restoration Trust (the Trust), was established in 2004 as the first sediment mitigation in-lieu fee program in the nation. The Trust is used by permittees to offset impacts associated with new dredging or filling of the river bottom, within the Elizabeth River in Southeastern Virginia, the proceeds of which are then used to fund sediment remediation projects. As part of a new EPA rule, all in-lieu fee programs are required to develop a fee structure for mitigation. To meet this mandate, the authors developed a comprehensive upfront fee structure for compensation in-lieu of executing sediment mitigation on the Elizabeth River. The in-lieu fee must cover costs for the Trust to execute the entire mitigation project, from site characterization through monitoring and maintenance, and also includes risk borne by the Trust when it takes over the responsibility; the challenge being that the "fee" must be set at the beginning of the project while many cost factors are unknown. One key aspect was the need to protect the long-term interests and minimize risk exposure to the Trust, yet develop an in-lieu fee structure that can effectively consider a variety of sites with potentially variable levels of available information. The authors reviewed published literature on cost data for remediation, other supporting documents available for local projects. The authors recommended a tiered approach for setting fees and determining project acceptance by the Trust. This paper discusses details of analysis methodology, recommended fee structure logic and plan for future modifications of the fee structure.

INTRODUCTION

The goal of the Trust was to develop a cost estimate for restoration projects on the Elizabeth River that are in compliance with recent regulations governing in-lieu fees for mitigation. The costs are to cover the entire project from site characterization through monitoring and long term maintenance, if applicable. They are to include the risks born by the Trust when it takes over the responsibility for remediation at a given site, and the value must be set at the beginning of the project while many cost factors are unknown. This goal is especially challenging when estimating remediation in an estuary system with potentially varying river and sediment conditions between various areas/reaches of interest.

Inherent in our analysis is the recognition that the Trust will find itself in the middle between two parties in the in-lieu mitigation program. On one side are the Trust's obligations which derive from contracts with the original permittee and from the permitting agencies. On the other side are the Trust's contracts with its service providers and suppliers. The authors agreed that it will be ideal for the Trust to be able to be able to consider and accept projects, even if additional studies are warranted to adequately characterize the future site risks. This means that it would be ideal to develop a tiered system of project review and acceptance, thus leaving the Trust the option to accept, reject, or defer decision on potential projects, based on site specific data and/or future data needs.

REVIEW OF HISTORIC REMEDIAL COST DATA

The complexities associated with judging the effectiveness of remediation projects are discussed in detail in the NRC (2007) report, "Sediment Dredging at Superfund Sites – Assessing the Effectiveness". In general, most sites have varying definitions of final success criteria, which implies that varying levels of effort were probably applied to achieve the clean up goals. This makes their cost comparisons trickier and thus warrants additional caution when deciphering that data. Regardless, the authors have reviewed data from over 10 years of remedial dredging and capping projects, which were already synthesized by others (Cushing, 1999; Cushing and Hammeker, 2001; ReTec, 2001). We added relevant project experience and cost information on projects with which the authors have been involved either directly, or on advisory roles.

Estes (2007) did an analysis on relative cost implications of various components associated with environmental remediation projects. The study focused on 64 projects for which data was available.

TABLE 1. Summary of Unit Costs for Key Components of Environmental Remediation Projects (modified from Estes, 2007)*

Item	Average Costs	Range of Costs	
		Min. Costs	Max. Costs
Dry Excavation ($/cy)	70	10	135
Mechanical Dredging ($/cy)	75	15	215
Hydraulic Dredging ($/cy)	60	15	195
Water Treatment ($/gal)	0.045	0.0035	0.165
Landfill Disposal ($/cy)	80	5	220
TSCA Disposal ($/cy)	200	10	480

** Costs escalated to 2009 U.S. Dollars based on COE "Civil Works Cost Index System, EM 1110-2-1304,Updated March 31 2008 using the Channels and Canals category (conversion from 2006 to 2009 is 1.088542 rounded to the nearest dollar, and modified as needed, for local conditions) - Note that only major elements of the remediation are listed here. The costs in the minimum and maximum ranges should be considered as outliers and thus should not be relied upon for planning purposes.*

A review of Table 1 indicates the inherent variability in such cost data. Depending on site specific considerations, the cost ranges can dramatically shift. This is especially true for the dredging and disposal elements, which combined affect the overall costs to the largest degree.

In order to develop guidance level base construction costs for remedial projects, the authors reviewed historic project cost information from a variety of sources. These included projects reported in technical conference proceedings such as the Western Dredging Association (WEDA), Battelle Contaminated Sediments Conferences, data and information available from public agencies such as the U.S. Environmental Protection Agency (USEPA) and the U.S. Army Corps of Engineers (USACE). In addition, data and information from personnel experience of the authors were also incorporated. Further, the costs were escalated to 2009 costs using inflation adjustment factors as discussed earlier to make all the comparisons as equivalent as possible.

In order to capture the past trends on projects, the authors first analyzed the trends (range in costs and average costs) for three tiers of projects:

- **Tier 1 Projects** – Generally projects with less than 10,000 cy of removal volume; some of these were pilot scale projects, or hot spot dredging projects, or ones that had high levels of environmental regulatory scrutiny;
- **Tier 2 Projects** – These are generally projects with remedial dredging volumes between 10,000 and 100,000 cy, and represent the range of projects that the Trust is most likely to encounter, and
- **Tier 3 Projects** – These are generally projects with greater than 100,000 cy of removal volume; economies of scale generally start to influence these costs.

The authors narrowed the list of projects to those with characteristics more applicable to the Elizabeth River. Those factors included similar regulatory environments, similar site conditions, comparable tools and techniques for remediation, potential applicability of the technology for the Elizabeth River (especially dredging and disposal methods), and post dredged sediment management methods (such as backfill and capping). The analysis of trends for this subset of projects was used to derive the recommended cost ranges for potential Trust mitigation projects (see Table 2).

TABLE 2. Summary of Observed Remedial (Dredging) Construction Costs[1]

Tier	Remediation Volume Range (cy)	Range of Observed Costs & Average[1] ($/cy)	**Recommended Cost Range for ERP Projects & Average[2] ($/cy)**
Tier 1	1,000-15,000	200-2,900 (1,060 avg.)[3]	**300-700 (avg. 520)**
Tier 2	15,000-100,000	40-790 (290 avg.)[4]	**110-600 (avg. 290)**
Tier 3	>100,000	20-960 (250 avg.)[5]	**40-410 (avg. 180)**

[1]These are the authors' observations from historic dredging data and have been adjusted in some cases to account for local project issues which the authors were aware of. Note that these costs do not include non-construction costs (such as design, planning, permitting, project management, agency oversight, etc).

[2]In general, these represent the authors' recommendation as a planning level number, noting that local site specific conditions could greatly affect these costs. Note that these costs do not include non-construction costs.

[3]Higher end denotes projects with small dredging volumes (<5,000 cy), pilot projects with unique local restrictions, or hot spot dredging, and in some cases, several passes of dredging.

[4]Denotes efficient mid-size volume projects, generally dredging, with some backfill/cap after dredging – lower range denotes projects with local, on-site disposal.

[5]Efficiencies of (volume) scale come i to play here; higher end denotes project with on-site incineration and higher levels of contamination than normal; and in some cases, several passes of dredging.

As can be noted from Table 2, the range of costs is widely varying. A closer look at the historic cost data of completed remedial projects reveals the following, with respect to the economic advantage in having local dredged material disposal options available for cost effective dredging projects:

- **Local Disposal** - Where effective local disposal was available for placing the sediments, costs ranged from $14/cy to $600/cy, for projects with at least 10,000 cy of sediments. Since the one project that had the lowest range of on-site CDF cost was implemented similar to a navigational dredging project, it would be prudent to account for a more realistic range of costs in the range of $50/cy to $200/cy, when a local disposal facility is available at a reasonable cost within close proximity of the dredge area. Where on site incineration was needed, costs escalated to the $500/cy to $1,600/cy, with costs generally in the range of $1,000/cy to $1,500/cy. For smaller volume projects (<7,500 cy), costs ranged from $240/cy to as high as $2,900/cy.
- **Off-Site Disposal –** For sites with off-site disposal, for low levels of contamination, the costs generally varied from $100/cy to $500/cy. In cases with extremely high levels of contamination, the costs were more on the order of $700/cy to $3,000/cy. Where contaminant levels were non-detect, or negligible, off-site costs dropped down to even the <$25-50/cy range in some cases.

The authors also reviewed project information from their own professional experience and generated remedial costs for capping and backfills. In general, an allocation of $150,000/acre-$300,000/acre should be sufficient for most normal caps, noting that local site specific conditions can affect these costs considerably.

TABLE 3. Summary of Capping Project Costs*

Tier	Capping Type and Area (Acres)	Observed Costs ($/acre)	Comments
Tier 1	Backfill (1-50 acres)	50,000-150,000	Backfill assumes sand placement, without much controlled tolerances, but generally ranging from 6 inches to a foot maximum.
Tier 2	Sand/Armor Caps (1-50 acres)	100,000-400,000	This assumes controlled placement, generally with a 3-6 inch tolerance, of a base sand layer, a geotextile filter, and an armor stone for erosion protection. Shown costs are reflective of cobble sized armor stone – larger stone sizes will result in incremental costs.
Tier 3	Reactive Caps (1-100 acres)	200,000-750,000	Costs for these caps are a function of the nature of the chemical that needs to be protected, and the specific nature of the reactive cap (activated carbon, organoclay, etc). Site specific designs and tests are often needed for these types of cap designs.

**Note that these costs are based on authors experience from previous sites; the true costs can actually vary widely depending on local site specific conditions, including type and details of the backfill/cap layers*

ESTIMATING TOTAL PROJECT COSTS

Table 4 presents a summary of the various non-construction costs derived based on past project data as well as author's combined professional experience.

TABLE 4. Definition of Total Project Cost as a Percentage of Construction Cost

Item	**Lower risk**	**Higher risk**	**Comment**
Construction estimate	Base cost	Base cost	Base estimate for construction.
Add applicable percentage increases for Total Project Fee:			
Remedial Investigation /Feasibility Study	3%	20%	Low end from local projects in VA; high end from complex site data
Design	4%	12%	Low end from local projects in VA; high end includes more aggressive treatment and/or pre-design studies
Permitting	1%	4%	High end when setting new precedents
Program and Construction Mgmt.	15%	20%	Includes cradle to grave projects, including during construction
Construction QA and Environmental Monitoring	8%	15%	Varies with size and level of effort
Construction Contingency	20%	60%	For poorly planned projects, contingency need can range up to 120%
Bonds & Insurance	2%	4%	Based on typical remediation projects
Government oversight	0%	7%	So far this is not applicable to the Trust; however these costs generally are incurred by responsible parties at 2 to 7 percent.
Legal	1%	5%	Contracting and permit conditions review and negotiations
Community Relations	1%	3%	Varies with duration, frequency and scale of outreach
Administrative Costs	5%	5%	Allowable Trust cost
Potential Add-On Costs to Determine Total Project Costs*	**60%**	**155%**	

** If upland sources are not characterized or controlled, and the Trust agrees to take on such projects, an additional add-on cost of approximately 5% (for well characterized upland sites requiring minimal controls) to 150% (for sites requiring detailed characterization/controls), resulting in a total add-on cost range of 65% to 305%.*

As can be seen from the table above, Total Project Costs includes many costs other than actual remedial construction. These costs are typically hidden and mostly unaccounted for, or unpublished in literature. However, they do indicate true additional non construction costs that would ultimately affect the "Total" project costs to the Trust.

Table 4 provides a means to extrapolate an estimated total construction cost to an estimated total cost for the project covering all costs from site characterization through long-term monitoring and maintenance. As can be seen from the table, the total cost of a remediation project is considerably higher that the estimated cost of construction alone, and the authors strongly recommended that the Trust should consider its total costs in developing the mitigation fee schedule.

RECOMMENDED FEE SCHEDULE

The authors recommended that the following general approach be taken in developing estimated project costs for purposes of setting fees and determining project acceptance by the Trust:

1. Determine an estimated unit project construction cost, considering the dredging or capping components potentially involved;
2. Adjust the construction costs and/or add other applicable construction costs for source control, off-site liabilities, project uncertainties, etc., to determine a total construction cost that will meet all requirements of the remedy; and,
3. Determine an estimated unit total project cost by escalating construction costs to account for other non-construction cost components.

TABLE 5. Summary of Recommended Fee Schedule for ERP Projects

Level 1 Fee– FS/RD Level of Available Information

Site specific cost estimate, based on a specific remedy, adjusted by an additional factor for non-construction cost components (60% to 155% depending on site-specific factors, and assuming all upland sources have been controlled). If upland sources are not under control, apply an additional factor of 5% to 150%, depending on nature and type of controls that are needed.

Level 2 Fee – RI Level of Available Information

Base Rate of $600 per cubic yard dredged (based on an average 3 foot cut), plus $200,000 per acre for cap/cover) for a total of approximately $3,100,000 per acre; an incremental cost of approximately $1,033,000 per acre would be added for each additional one foot cut depth. The Level 2 fee would be adjusted annually for inflation.

Optional Level 3 Fee – For Additional Studies

Estimate in the range of $200,000 to $500,000, depending on the type of studies that are needed to fill the data gaps at the site.

RISK MANAGEMENT CONSIDERATIONS

The authors recommended the Trust take appropriate steps to manage risk, such as:

- Apply the considerations for cost estimates in a conservative manner;
- Use an incremental and/or phased approach when considering projects for acceptance and in sequencing implementation;
- Consider the risk management strategies:
  - Decline high risk projects
  - Consider phased buy-in or tiered fee structures
  - Allow for reopeners
  - Purchase insurance, and
  - Use conservative contracting, including liability transfer contracts.

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REFERENCES

Cushing, B. 1999. "Identification and Evaluation of Remedial Dredging Difficulties." Western Dredging Association, Journal of Dredging Engineering, Vol. 1, No. 2.

Cushing, B., and M. Hammaker. 2001. "Environmental Dredging: Methods, Trends, and Case Histories." Proceedings, 21st Annual Meeting of the Western Dredging Association and 33rd Annual Texas A&M Dredging Seminar, Houston, Texas.

Estes, T. 2007. "Environmental Dredging Project Costs – The Mystery, the Mystique … The Muddle." Proceedings, 4th International Conference on Remediation of Contaminated Sediments, Savannah, Georgia.

Palermo, M., Mohan, R, and Costello, M. 2009. "Setting In-lieu Fee Structure for Sediment Remediation on the Elizabeth River". Technical Memorandum for Elizabeth River Project and Living River Restoration Trust, Norfolk, Virginia.

Palermo, M., P. Schroeder, T. Estes, and N. Francingues. 2008. "Technical Guidelines for Environmental Dredging of Contaminated Sediments." Technical Report ERDC/EL TR-08-29, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Palermo, M. and K. Gustavson. 2009. "In-Situ Volume Creep for Environmental Dredging Remedies." Proceedings, 5th International Conference on Remediation of Contaminated Sediments, Jacksonville, Florida.

ReTec. 2001. "Sediment Technologies Memorandum for Lower Fox River and Green Bay, Wisconsin." Report to Wisconsin DNR, Green Bay, Wisconsin.

National Research Council. 2007. "Sediment Dredging at Superfund Megasites – Assessing the Effectiveness." The National Academies Press, Washington, D.C.

US Army Corps of Engineers (USACE). 2008. "Civil Works Construction Cost Index System", Report EM 1110-2-1304, Washington, DC.