# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FOR THE:
**TOLEDO HARBOR DREDGE TASK FORCE**

**GREAT LAKES RESTORATION INITIATIVE PROJECT**
**USEPA GRANT # GL-E00523**

PREPARED FOR:
**OHIO LAKE ERIE COMMISSION**
**111 SHORELINE DRIVE**
**SANDUSKY, OHIO 44870**

**AND**

**TOLEDO-LUCAS COUNTY PORT AUTHORITY**
**ONE MARITIME PLAZA**
**TOLEDO, OHIO 43604**

PREPARED BY:
**HULL & ASSOCIATES, INC.**
**3401 GLENDALE AVENUE**
**SUITE 300**
**TOLEDO, OHIO 43614**

**DECEMBER 2012**

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# EXECUTIVE SUMMARY

This Toledo Harbor Sediment Management and Use Plan (THSMUP) was developed to assist the Toledo Harbor Dredge Task Force (Task Force) in identifying and implementing a sediment management and use strategy for the Toledo Harbor Federal navigation channel and commercial/recreational non-federal channel that represents a consensus-based approach of the diverse stakeholders represented by the Task Force. The THSMUP was funded through United States Environmental Protection Agency (USEPA) Great Lakes Restoration Initiative (GLRI) Grant # GL-E00523 to the Ohio Lake Erie Commission (Ohio LEC). The purpose of the GLRI grant is to evaluate alternatives to current open-lake placement practices and to provide recommendations for sediment management and use options including habitat restoration units (HRUs) and other beneficial use concepts. Ohio LEC sub-granted the funding to the Toledo-Lucas County Port Authority (TLCPA), who retained the Hull & Associates, Inc. (Hull) technical team (Hull Team) to develop the THSMUP. The Hull Team is comprised of engineering, science, and consensus-building professionals from Hull, Moffatt and Nichol, ARCADIS, Great Lakes Marketing, and Proudfoot Associates.

The Port of Toledo, Ohio, is the most heavily dredged port in the Great Lakes and is a critical component of the economic viability of Northwest Ohio. The Port facilitates commerce throughout the entire Great Lakes and supports international commerce and commodity transportation through the St. Lawrence Seaway. To keep the Port operating, up to 1 million cubic yards (CY) of sediment is dredged annually from the Toledo Harbor's Federal and non-federal channels. Recently, approximately 850,000 CY of material is typically dredged annually from the Federal channel comprised by the 18-mile Lake Approach Channel in Maumee Bay and western Lake Erie basin and the 7-mile River Channel in the Maumee River. This amount varies by year based on lake levels and available funding. A significant backlog exists to reach the fully authorized channel depths. An additional, 100,000 CY of material is annually dredged from the non-federal channel to support local recreational/commercial entities located along the river and outside of the Federal channel.

Sediment dredged from the Toledo Harbor is currently managed by a combination of open-lake placement and through placement into confined disposal facilities (CDFs) - with a minor portion of dredged material being beneficially used. In 2009, USEPA encouraged the U.S. Army Corps of Engineers (USACE) to continue exploration of beneficial uses of dredged material, including

island creation/enhancement, which would benefit aquatic and avian species and reduce the amount of sediment placed at the open-lake placement site. In 2010, the Ohio Environmental Protection Agency (Ohio EPA) expressed concern that continued open-lake placement, in its current form, was an unsustainable practice due to potential environmental impacts and re-suspension of dredge material in the shallow western basin of Lake Erie. Ohio EPA also expressed concern about the potential impact of open-lake placement on excessive sediment/nutrient loading to the western basin of Lake Erie and stated that a less environmentally harmful way of dealing with the dredged sediment must be found, funded, and implemented.

Because of potential environmental impacts resulting from the annual re-suspension of large amounts of sediment (and accompanying nutrients) in the shallow western basin of Lake Erie, in addition to the limited remaining space available in the existing CDFs, local stakeholders are pursuing alternatives to current sediment management practices. This THSMUP identifies and prioritizes practicable, implementable, economically sound, and environmentally acceptable options, which could be implemented by federal, state, municipal, and private entities that must dredge areas of the Toledo Harbor to maintain safe conditions for marine commerce, recreational navigation, and other purposes.

The THSMUP identifies the following:

- recommended short-term (1-5 year) options and supporting documentation;
- recommended long-term (30-year) options and supporting documentation;
- funding needs and a listing of potential funding sources and activities (including concepts of suggested legislative and regulatory changes); and
- timelines for implementation of recommended options.

While current upland management strategies to reduce the generation of sediments are discussed briefly in this report, such strategies for management or reduction of sediment are not included as part of this project. Rather, the focus of this project is solely the management of dredged material as it is related to federal and non-federal dredging. Additionally, this THSMUP evaluates potential roles of environmentally enhanced dredging techniques such as hydraulic dredging and open-lake placement with controls. This THSMUP includes an evaluation of in-water (submerged HRUs, emergent HRUs, a new CDF, open-lake placement with controls, and a new open-lake placement area located in deeper water without controls), nearshore (wetland

restoration), upland (agricultural field improvements and beneficial use for non-structural fill) sediment management and use options. Conceptual structural designs and preliminary costs for each option considered were developed to assist with the evaluation, and while are not necessarily accurate for budget purposes, are at an acceptable level of detail for comparative purposes.

Options were ranked and prioritized through a comparative scoring analysis, which focused on general physical attributes, logistics, geographic attributes, historic and projected dredging volumes, habitat areas, initial relative cost estimates, and stakeholder input on the relative importance of six major categories of technical criteria. These criteria included feasibility, ecological benefits/effects, environmental impacts/effects, human benefits/effects, economic benefits/effects, and implementation cost. The goal of the comparative scoring analysis was to complete a fair, equitable evaluation of options that can be very dissimilar in overall design, relative ecological impacts/benefits, cost, and implementation.

The final ranking and prioritization of the sediment management and use options considered the technical scoring and weighted factors assigned by the Task Force for the six major categories of technical criteria. For each sediment management and use option evaluated in this THSMUP, a group of two engineers and two scientists from the Hull Team assigned technical scores ranging from 1 to 5, with higher scores representing benefits and/or minimal complications/complexity, to attributes identified within each major category of technical criteria. The Task Force reached a consensus on weighting factors assigned to each technical criteria category, ranging from 0-100, with higher values representing a higher degree of relative importance of each technical criteria category compared to one another. For each sediment management and use option evaluated, the weighting factors were multiplied by the technical scores assigned for that option. The options evaluated were ranked in descending order, from highest score to lowest score, to represent the prioritization of most-preferred to least-preferred options as determined by the comparative analysis.

The comparative analysis was first completed assuming each single-option would accommodate 30 million cubic yards of dredged material over 30 years. Results of the single-option evaluation indicate that agricultural field improvements, wetland restoration and shoreline protection, shallow water emergent HRU, and beneficial use options scored the highest. Following the single-option evaluation, higher ranking single-options were considered for

incorporation into a combination option capable of accommodating the 30 million cubic yards of dredged material over 30 years recognizing that due to logistical complexity and impacts of large project "footprints," a combination of options might be more appropriate. A combination of options allows for more flexibility with respect to feasibility, practicality, and costs and provides for opportunities to balance better the environmental, ecological, human, and economic impacts and benefits. Wetland restoration and shoreline protection, agricultural field improvements, open-lake placement with controls, and beneficial use were selected for the combination scenario since they each scored highest in at least one technical criteria category during the single-option evaluation. When compared to the single-options, the combination option ranked the highest, demonstrating that this combination option best balances environmental, ecological, and economic benefits and impacts while minimizing overall unit cost.

This THSMUP presents a comprehensive sediment management solution for the Toledo Harbor that is practical, protective of human health and the environment, represents a consensus of the stakeholders, provides direction for implementation, and is essential to securing implementation funding. Implementing such a strategy will require following any appropriate protocols related to environmental reviews, permits, and other processes that consider engineering and science principles as well as community concerns and issues raised by stakeholders. Ultimately, the Task Force and stakeholders will be responsible for incorporating the recommendations from the THSMUP into a strategy that can be implemented.

The evaluations completed were of sufficient level of detail that allowed for the development of conceptual plans and costs for an evaluation and comparison of sediment management and use options for material dredged from the Toledo Harbor. The evaluations were completed with the assumption that no significant change to USACE operations would occur. The conceptual designs and cost estimates presented in this THSMUP should not be considered final project designs and final project cost estimates. The conceptual designs and estimated costs were developed with a sufficient level of detail and effort to account for major construction and implementation costs so that a prioritization of sediment management options could be completed by the Hull Team.

Comparative cost estimates were developed based on 2012 dollars using consistent assumptions and procedures to serve as a guide to the Task Force in planning next steps and to secure potential implementation funding. When a specific option is selected for

implementation, a site-specific design and evaluation, along with a detailed cost estimate, will need to be completed to determine that the sediment source from a specific geographic location is suitable for a specific end use and location. Since the comparative scoring analysis identified the agricultural field improvement option as a preferred option that can be implemented relatively quickly and that can be used to manage dredged material over the long-term, additional refinement of the design and costs were completed to better position the option for a pilot project or for full-scale implementation.

The refined costs were based on a re-evaluation of the major design components, including the most economical dredging and operational methods available, and a better defined site-specific potential placement location. Since the appropriateness of using dredged material for a given beneficial use is dependent on the type and concentration of chemicals in the material, a comparison of sediment quality to appropriate sediment environmental and ecological screening criteria was completed. With the exception of material dredged from River Miles (RM) RM-1, RM-2 and RM-4, the USACE has determined that all Federal channel dredged material is suitable for in-water use (i.e. open-lake placement) based on chemical, elutriate and bioassay testing, and water quality and bioaccumulation modeling. This determination is based on historic USEPA/USACE protocols and guidelines pursuant to Section 404 of the Clean Water Act.

The Hull Team compared reported concentrations of select chemicals analyzed in Toledo Harbor bulk sediment samples collected from the Federal channel in 2010 by the USACE to appropriate upland environmental and ecological sediment screening criteria so that decisions could be made regarding the environmental and ecological suitability of the implementation of an upland sediment management and use option. It is generally accepted that sediment screening criteria should not be used alone for decision-making and should be used in tandem with other lines of evidence, such as bioassay and bioaccumulation data. The results of the preliminary screening suggest that material dredged from the Federal channel is generally suitable for upland uses (e.g. agricultural field improvement, non-structural fill), with the exception of material dredged from RM-4 and LM-1.5. Prior to implementing an upland beneficial use option for sediments dredged from RM-4 and LM-1.5, additional Tier 2 through Tier 4 sediment characterization testing might be necessary to evaluate site-specific biological and toxicity testing.

It is recognized that prior to implementing a specific sediment management and use option identified in the THSMUP, additional monitoring and/or data evaluation might be necessary to ensure the implementation of that option is feasible and protective of human health and the environment at the location for which it is being considered. Such determinations might consist of evaluations of existing data and/or the collection of new site-, use-, or material-specific data to characterize the physical suitability (e.g. grain size, texture, plasticity, organic content, etc.) engineering suitability (e.g. compatibility, consolidation, shear strength, etc.), and environmental suitability (e.g. chemical concentrations, toxicity, leaching potential, etc.) of site-specific sources of dredged material and a final use/placement option. Additionally, the beneficial use of dredged material may likely require a materials management plan, which details the logistics of using dredged material for upland uses, including stormwater controls, record keeping, and methods to be implemented. This plan would be closely coordinated with Ohio EPA to ensure compliance with applicable regulations and standards.

Prior to actual implementation of a sediment management and use option, the Task Force should complete, as appropriate, the following site-specific characterization activities and evaluations:

1. complete more detailed design cost sensitivity analyses which will also help identify best mix (relative volume) and timing of individual components (original allocations used for evaluation/discussion purposes in the combination approach will likely change);
2. engage site-specific discussions with controlling entities and regulatory agencies;
3. dialogue with elected legislators regarding needs/range of required legislation/funding needs;
4. initiate pilot projects (e.g. open-lake placement with controls and agricultural field improvement option);
5. review findings of the USACE Section 204 study and the Phase II Phosphorus Task Force report when they become available, and adjust the approach to reflect new findings, if appropriate;
6. review and incorporate future open-lake placement data monitoring phosphorus dynamics of dredged material and open-lake placement methods, as required by the 2012 Section 401 WQC;
7. complete additional laboratory and field testing to address active consolidation rates for relevant scenarios; and
8. complete more detailed evaluations of alternative dredging techniques compared to infrastructure costs associated with sediment transportation to specific sediment management and use options.

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CDF | Confined Disposal Facility |
| CFR | Code of Federal Regulations |
| CIG | Conservation Innovation Grant |
| CMAG | Coastal Management Assistance Grant |
| COC | Contaminant of Concern |
| CY | cubic yard |
| DMDF | Dredged Material Disposal Facility |
| DQOs | Data Quality Objectives |
| ESL | U.S. Environmental Protection Agency Region 5 Ecological Screening Level |
| FCV | Final Chronic Value |
| Federal channel | Toledo Harbor Federal Navigation Channel |
| ft | feet |
| FY | Fiscal Year |
| GI | General Investigation |
| GIS | Geographical Information System |
| GLC | Great Lakes Commission |
| GLPF | Great Lakes Protection Fund |
| GLRI | Great Lakes Restoration Initiative |
| HAB | Harmful Algal Bloom |
| HDPE | High-density Polyethylene |
| HELP | Huron Erie Lake Plain Region |
| HMTF | Harbor Maintenance Trust Fund |
| HRU | Habitat Restoration Unit |
| Hull | Hull & Associates, Inc. |
| kg | kilogram |
| kWh | kilowatt hour |
| LECBA | Lake Erie Charterboat Association |
| LEW | Lake Erie Waterkeeper |
| LEPF | Lake Erie Protection Fund |
| LM | Lake Mile |
| LTSMP | Long-Term Sediment Management Plan |
| LWD | Low Water Datum |
| M | million |
| mg | milligrams |
| MTA | Metroparks of the Toledo Area |
| NOAA | National Oceanic and Atmospheric Administration |
| NPS | Nonpoint Source |
| NRCS | Natural Resources Conservation Service |
| NWR | National Wildlife Refuge |
| ORNL | Oak Ridge National Laboratory |
| Ohio DNR | Ohio Department of Natural Resources |
| ODOT | Ohio Department of Transportation |
| Ohio EPA | Ohio Environmental Protection Agency |
| Ohio LEC | Ohio Lake Erie Commission |
| O&M | Operation and Maintenance |
| OWDA | Ohio Water Development Authority |
| PAHs | Polycyclic hydrocarbons |

## LIST OF ACRONYMS AND ABBREVIATIONS (CONT.)

| | |
|---|---|
| PCBs | Polychlorinated biphenyls |
| PED | Planning, Engineering, and Design |
| Port | Port of Toledo |
| RM | River Mile |
| QAPP | Quality Assurance Project Plan |
| RSL | Regional Screening Level |
| SOGL | Sustain Our Great Lakes |
| SRV | Sediment Reference Value |
| S.U. | Standard Units |
| SWIF | Surface Water Improvement Fund |
| Task Force | Toledo Harbor Dredge Task Force |
| TEC | Threshold Effect Concentration |
| THSMUP | Toledo Harbor Sediment Management and Use Plan |
| TLCPA | Toledo-Lucas County Port Authority |
| USACE | U.S. Army Corps of Engineers |
| USDA | U.S. Department of Agriculture |
| USEPA | U.S. Environmental Protection Agency |
| USFWS | U.S. Fish & Wildlife Service |
| USGS | U.S. Geological Survey |
| VAP | Voluntary Action Program |
| WPCLF | Water Pollution Control Loan Fund |
| WQC | Water Quality Certification |
| WRDA | Water Resources Development Act |

# 1.0 PROJECT BACKGROUND AND OBJECTIVES

## 1.1 Introduction

The Port of Toledo (Port) is a major Northwestern Ohio transportation center located on the Maumee River in Toledo, Ohio. Figure 1 provides a Toledo Harbor Project Area Map. The Port plays a critical role in the local, state, and national economy. Fifteen marine terminal operators handle over 700 vessel calls and 12 million (M) tons of cargo per year (Toledo-Lucas County Port Authority, 2012). Nearly 7,000 jobs are supported by cargo operations with over $380 million in direct business revenue received by the businesses dependent upon the cargo handled at the Port (Martin Associates, 2011).

The Port is the most heavily dredged port in the Great Lakes. Dredging the Toledo Harbor Federal Navigation Channel (Federal channel) and commercial and recreational non-federal navigation channels (non-federal channel) is critical in maintaining adequate depths for commercial and recreational navigation. Up to 1M cubic yards (CY) of sediment is dredged annually from the Toledo Harbor's Federal and non-federal channels. Recently, approximately 850,000 CY of material is dredged annually from the Federal channel comprised by the 18-mile Lake Approach Channel in Maumee Bay and western Lake Erie basin and the 7-mile River Channel in the Maumee River (USACE, 2012). Approximately 100,000 CY of material is annually dredged from the non-federal channel to support local recreational/commercial entities located along the river and outside of the Federal channel.

Sediment dredged from the Federal and non-federal channels of Toledo Harbor is currently managed through a combination of open-lake placement and through placement into confined disposal facilities (CDFs), with a minor portion of dredged material being beneficially used. Over the last five years, an average of approximately 53,000 CY of material was dredged annually from the non-federal channel and placed into existing CDFs. In recent years, up to 800,000 CY of material was dredged annually from the Federal channel and deposited in the open lake placement area with a minor volume being placed in the CDF (material that fails to meet Federal guidelines and applicable state water quality standards). Open-lake placement of the Toledo Harbor dredged material from the Federal channel began around 1985 and is currently the primary means of dredged material management for the U.S. Army Corps of Engineers (USACE). Although most of the material currently meets United States Environmental Protection Agency (USEPA) guidelines for open-lake placement, in 2009,

USEPA encouraged the USACE to continue exploration of beneficial uses of dredged material, including island creation/enhancement, which would benefit aquatic and avian species and reduce the amount of sediment placed at the open-lake placement site. In 2010, the Ohio Environmental Protection Agency (Ohio EPA) expressed concern that continued open-lake placement, in its current form, was an unsustainable practice due to potential environmental impacts and re-suspension of dredge material in the shallow western basin of Lake Erie. Ohio EPA also expressed concern about the potential impact of open-lake placement on excessive sediment/nutrient loading to the western basin of Lake Erie and stated that a less environmentally harmful way of dealing with the dredged sediment must be found, funded, and implemented.

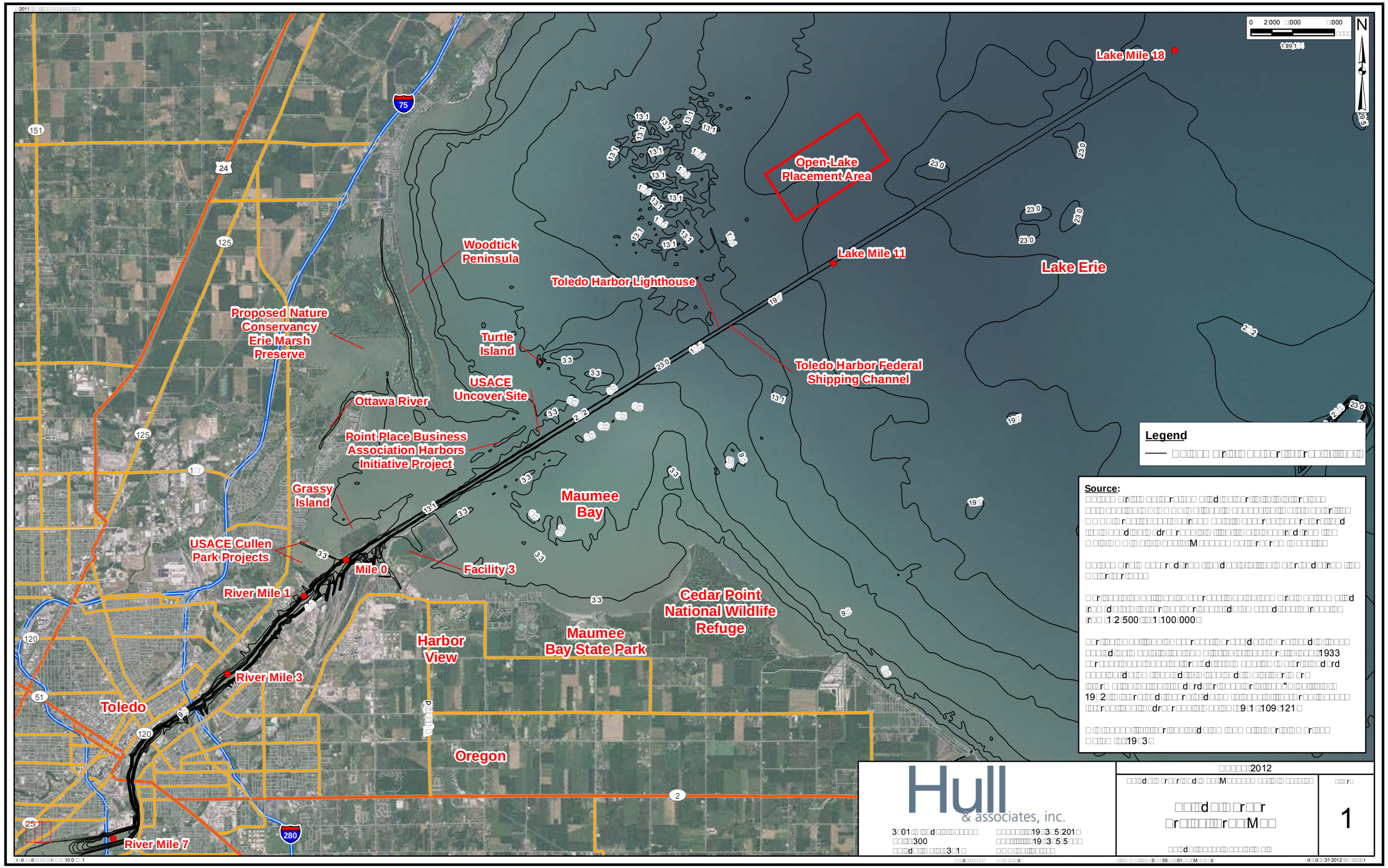
Harmful algal blooms (HABs), which include the toxic and non-toxic forms of *Microcystis aerunginosa,* a blue-green algae, have been increasing during the summer in Lake Erie since the mid-1990s (Conroy et al., 2005). Additionally, increasing phosphorus concentrations promote the growth of the toxic strain of *Microcystis* (Davis et al., 2009). Some stakeholders are concerned that increased turbidity and the re-suspension of nutrient-laden sediment during open-lake placement might increase the relative bioavailability of phosphorus and contribute to HABs. The Ohio Phosphorus Task Force was convened in 2007 to identify various phosphorus sources and impacts to Lake Erie and to recommend management strategies. The Ohio Phosphorus Task Force estimated 1,096 metric tons (Ohio EPA, 2010) while recent USACE communication estimated 913 metric tons of total phosphorus added as a result of open-lake placement. However, bioavailability associated with phosphorus release is unknown but is a function of many factors which influence the forms and availability of phosphorus including competing constituents (e.g. iron, aluminum), wind conditions, wave action, and temperature. As part of this effort, open-lake placement of dredged material was identified as a potential contributor and it was suggested that discontinuing open lake placement could improve net phosphorus removal in Lake Erie (Ohio EPA, 2010). The Ohio Phosphorus Task Force also identified a lack of data related to open-lake placement of dredged material and its effect on phosphorus bioavailability. USACE will complete additional testing to evaluate these potential impacts in 2013 as required by the 2012 Ohio EPA-issued Section 401 Water Quality Certification (WQC). As required by the Section 401 WQC, the USACE must prepare a sampling plan and protocols for approval by Ohio EPA to conduct phosphorus monitoring during the 2012 dredging season.

Unlike other maintenance programs where dredged material is largely comprised of sand, which can often be readily put into beneficial use, Toledo Harbor sediments are largely comprised of finer grained materials (silts and clays), which present relatively significant challenges to direct use, including dewatering. With limited remaining available storage capacity existing in nearby CDFs, as well as the need to keep some CDF space in the event of an emergency response (e.g. spill), and the State of Ohio's opposition to current open-lake placement practices, the implementation of a sediment management and use approach that addresses the sediment management challenges of the Toledo Harbor is essential for the continued long-term operation of the Port.

The Toledo Harbor Dredge Task Force (Task Force) was assembled in 2010 in part to develop a sustainable approach to Toledo Harbor sediment management and to give participating member organizations a voice in decisions related to dredge material management. The Task Force currently includes members from the following organizations: Toledo-Lucas County Port Authority (TLCPA), maritime industry, Lake Erie Charterboat Association (LECBA), U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS), U.S. Fish and Wildlife Service (USFWS), USACE, Great Lakes Commission (GLC), United States Geological Survey (USGS) Water Science Center, Ohio Department of Natural Resources (Ohio DNR), Ohio EPA, Ohio Department of Transportation (ODOT), Ohio Department of Development, Ohio Lake Erie Commission (Ohio LEC), Metroparks of the Toledo Area (MTA), Lucas County, City of Oregon, City of Toledo, Ohio Sea Grant, and Western Lake Erie Waterkeeper (LEW). Participation by representatives of Task Force member organizations does not necessarily represent the views or endorsements of the respective organization. Staff members of Congressional representatives are invited to attend Task Force meetings to learn about Toledo Harbor issues and to stay informed on Task Force activities. The attendance of Congressional representatives' staff does not constitute Congressional officeholders' endorsement, in whole or in part, of the Toledo Harbor Sediment Management and Use Plan (THSMUP), of any sediment management and use option, and of the selection of options considered in the THSMUP.

Since 2010, the Task Force has been exploring potential short- and long-term sediment management and use options for materials dredged from the Toledo Harbor. In 2010, the Ohio LEC received funding through a USEPA Great Lakes Restoration Initiative (GLRI) Grant (Grant # GL-E00523) to assist the Task Force in developing a THSMUP that identifies interim and

long-term dredge material management and beneficial use options and opportunities for the federal and non-federal channels at the Toledo Harbor. The Ohio LEC sub-granted the funding to the TLCPA, who retained a team led by Hull & Associates, Inc. (Hull) to facilitate the Task Force with developing and implementing a solution for the sediment management and beneficial use challenges facing stakeholders of the Toledo Harbor. The Hull Team includes professionals from Moffatt and Nichol, ARCADIS, Great Lakes Marketing, Proudfoot Associates, and Hull.


Lake Mile 18
Open-Lake Placement Area
Lake Mile 11
Lake Erie
Woodtick Peninsula
Toledo Harbor Lighthouse
Proposed Nature Conservancy Erie Marsh Preserve
Turtle Island
Toledo Harbor Federal Shipping Channel
USACE Uncover Site
Ottawa River
Point Place Business Association Harbors Initiative Project
Grassy Island
Maumee Bay
USACE Cullen Park Projects
Mile 0
Facility 3
River Mile 1
Cedar Point National Wildlife Refuge
Harbor View
Maumee Bay State Park
River Mile 3
Toledo
Oregon
River Mile 7
Legend
Source:
Hull & associates, inc.
2012
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## 1.2 THSMUP Purpose

The purpose of the THSMUP is to identify and prioritize practicable, implementable, economically sound, and environmentally acceptable options, which could be implemented by federal, state, municipal, and private entities that must dredge areas of the Toledo Harbor to maintain safe conditions for marine commerce, recreational navigation, and other purposes.

The THSMUP identifies the following:

- recommended short-term (1-5 year) options and supporting documentation;
- recommended long-term (30-year) options and supporting documentation;
- funding needs and a listing of potential funding sources and activities (including suggested legislative and regulatory changes); and
- timelines for implementation of recommended options.

The prioritization of general management options were based on evaluations focused on general physical attributes, logistics, geographic attributes, historic and projected dredging volumes, habitat areas, initial cost estimates, and stakeholder support, as presented in the following sections.

## 1.3 Quality Assurance Project Plan Compliance

Prior to initiating work for this project, the Hull Team completed a Quality Assurance Project Plan (QAPP), which was approved by USEPA in June 2011 and subsequently revised in November 2012 to reflect additional activities completed as part of this grant. The QAPP presented the sediment management and use option evaluation approach, established data quality objectives (DQOs), and identified project-specific quality assurance and control procedures. The suitability of the data used in the completion of evaluations included in this THSMUP was evaluated in accordance with the procedures established by the QAPP prior to its use. Data were qualitatively and quantitatively assessed to determine whether the quantity, type, and overall quality of data were suitable for its intended use and if appropriate procedures were used in the generation of that data.

Work performed under this project relied primarily on existing data, also known as secondary data, and generally did not generate any direct environmental data measurements. All existing

data and studies were evaluated according to the procedures outlined in the QAPP. The quality of secondary data was evaluated based on quality criteria relating to:

1. available and appropriate quality assurance and quality control information;
2. valid research design;
3. scientifically-accepted data collection/laboratory analysis methods;
4. appropriate data interpretation;
5. type of data;
6. age of data;
7. geographical appropriateness and representation;
8. temporal appropriateness and representation;
9. technological appropriateness and representation; and
10. economic and socio-economic appropriateness and representation.

The data quality criteria evaluation was completed by qualified professionals experienced with industry standards regarding precision, accuracy, representativeness, completeness, comparability, and sensitivity in accordance with the procedures established by the QAPP. All data used to develop this THSMUP was determined to meet project DQOs established by the QAPP and are used without limitation, with few exceptions. In several instances, sufficient data meeting project objectives could not be obtained, so it was necessary to use data of unknown/non-verifiable quality to develop the THSMUP. Unknown/non-verifiable data presented in the THSMUP is marked as “not-verified” where appropriate.

Data verification, validation, and integrity were determined through self-assessments completed by project personnel. Data were reviewed for accuracy, representativeness, quality, and sufficiency and checked for errors in transcription, calculations, and data input. Data entered into spreadsheets and drawings were checked against the original data measurements. Calculations were completed by an engineer and checked by a peer reviewer prior to inclusion in the THSMUP. Cost estimates were prepared by, and reviewed under the supervision of, professionals who are competent in construction cost estimating, possess a working knowledge of construction, and capable of making professional determinations based on experience.

## 1.4 THSMUP Limitations and Constraints

While current upland management strategies are discussed briefly in this report, upstream efforts or options for management or reduction of sediment are not included as part of this project. Rather, the focus of this project is solely the management of dredged material as it related to federal and non-federal dredging.

A variety of in-water and upland options were ranked and prioritized through a comparative scoring analysis. The goal of the comparative scoring analysis was to complete a fair, equitable evaluation of options that can be very dissimilar in both overall design goal and implementation. For example, the design and implementation of a wetland and CDF can be very different based on the primary goals of habitat creation versus sediment containment, respectively. This comparative scoring analysis also allowed for the evaluation of a combination of options being considered. The prioritized options identified in the THSMUP were evaluated initially based on criteria including direct physical attributes, capacity, cost, and stakeholder support.

This project does not include the specific design tasks necessary to implement a specific course of action. If a sediment management and use option is selected for implementation, a site-specific design and evaluation will need completed to determine that the sediment source from a specific geographic location is suitable for a specific end use and location. Such determinations will consist of evaluations of existing data and/or the collection of new site-, use-, or material-specific data to characterize the physical suitability (e.g. grain size, texture, plasticity, organic content, etc.) engineering suitability (e.g. compatibility, consolidation, shear strength, etc.), and environmental suitability (e.g. chemical concentrations, toxicity, leaching potential, etc.) of site-specific sources of dredged material and a final use/placement option. Additionally, a detailed cost estimate should be completed, including the estimated utility requirements to construct and operate the proposed option. Permitting might need to be completed prior to implementation of an option. Cost estimates reflect the level of detail of the completed conceptual design and reflect the methods of construction, assumptions, and available data. Because cost estimates rely on general project area data, and not site-specific data, a contingency cost was developed and incorporated as a separate line item.

## 1.5 Existing Studies and Current Status

Toledo Harbor sediment management is not a new issue for study, as there have been several studies prepared since the 1970s and studies of alternative options have been ongoing. The

USACE has performed extensive work in support of prior Long-Term Sediment Management Plans (LTSMP), a joint effort of an interagency group to address the Maumee River watershed, and through the Water Resources Development Act (WRDA) Section 204 Habitat Restoration Unit (HRU) Studies. Ohio EPA, NRCS, and local university researchers have also collected data on sediment transport to Toledo Harbor via the Maumee River. A list of relevant studies is provided in Table 1. This list is not meant to be exhaustive and does not include many reports and articles related to Toledo Harbor dredging. More information on the past options considered, as well as detailed background information on Toledo Harbor and Maumee Bay, can be found in many of these studies.

USACE-Buffalo District has investigated a variety of HRU projects within Maumee Bay using dredged material from Toledo Harbor. These studies have been initiated under Section 204 of the WRDA of 1992, “Beneficial Use of Dredged Material”, which authorizes the USACE to implement projects for the protection, restoration and creation of aquatic and ecologically related habitats, including wetlands, or to reduce storm damage to property, in connection with dredging for the construction or operation and maintenance (O&M) of an existing authorized Federal navigation project. As part of a Section 204 project, USACE contracted with Baird/URS to complete conceptual designs for three island HRUs being considered for the Section 204 study. All existing Section 204 Studies have transitioned to a General Investigations (GI) Study due to the costs of viable options exceeding the Section 204 project limit of $5,000,000. The City of Toledo is no longer the non-federal sponsor for the current GI study due to the match commitment conditions required under the new planning process. During the course of this study, USACE has been concurrently been conducting relevant sediment management studies, including the Section 204. Internal USACE policies prohibit the release of draft material prior to Agency Technical Review. The release of the final Section 204 report has been delayed several times. Additionally, changes in the USACE planning process and lack of non-federal matching funds have further delayed the release of the final Section 204 report and progress of the GI study. As a result, data and information contained in this concurrent study could not be included in the THSMUP. Findings from this study should be considered in the implementation of the THSMUP at the time of its release.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 1

## SUMMARY OF STUDIES RELATED TO TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE

| Study Title | Year | Description | Source |
|---|---|---|---|
| Beneficial Use of Dredged Material in Ohio as an Upland Soil Substitute: Contaminant Screening | 2012 | Contaminant screen of various ports, including Toledo, to determine potential beneficial use | Flottman, 2012 |
| Toledo Harbor Habitat Restoration Unit Conceptual Design Report Final - Draft | 2011 | Conceptual design for various habitat restoration units | URS/Baird, 2011 |
| Development, Calibration, and Application of the Lower Maumee River - Maumee Bay Model | 2010 | Hydrodynamic sediment transport-water quality model for the Lower Maumee River | LimnoTech, 2010 |
| Finding of No Significant Impact and Environmental Assessment for Operations and Maintenance Dredging and Placement of Dredged Material in Toledo Harbor | 2009 | This document assesses the environmental impacts of routine maintenance at Toledo Harbor, including dredging of the Federal channel and placement of the material in the open lake placement area. | U.S. Army Corps of Engineers (USACE), 2009 |
| Long-Term Dredged Material Management Plan within the context of Maumee River Watershed Sediment Strategy: Executive Committee Phase 4 Report with Environmental Assessment | 2001 | Updates on implementation of recommendations under the Phase 3 Report and presents recommendations for future actions and studies. | USACE, 2001 |
| Evaluation of Toledo Harbor Dredged Material for Manufactured Soil, Phase I: Greenhouse Bench Test | 2001 | Screening tests to evaluate the feasibility of manufacturing soil using dredged material from Toledo Harbor CDF | Sturgis et al., 2001 |
| Preliminary Environmental Assessment for Beneficial Reuse of Toledo Harbor Dredged Sediment for Shoreline Protection | 1999 | Determine the potential impacts of proposed uses and develop general recommendations for addressing potential adverse effects | Hull & Associates, Inc., 1999 |
| Long-Term Dredged Material Management Plan within the context of Maumee River Watershed Sediment Strategy: Executive Committee Phase 3 Report with Environmental Assessment | 1995 | Recommendations regarding the development of a long-term management strategy for Toledo Harbor dredged material | USACE, 1995 |
| Long-Term Dredged Material Management Plan within the context of Maumee River Watershed Sediment Management Strategy: Phase 1 Report | 1993 | Compilation of literature and field data collected, reviewed and summarized as well as initial formulation of problem and potential solutions | USACE, 1993 |
| Evaluation of Woodtick Peninsula and Recreation Hill/Upland Disposal Alternatives Using Toledo Harbor Dredge Spoil Materials | 1989 | Study of a potential upland recreation hill and Woodtick Peninsula restoration alternative | Hull & Associates, Inc., 1989 |
| Preliminary Report of Alternative Dredge Material Disposal for the Toledo, Ohio Harbor | 1987 | Preliminary evaluation of sediment management and use alternatives that provide twenty years of capacity. | Hull & Associates, Inc., 1987 |

In addition to the USACE study, the Ohio State University is currently completing a study on the economic feasibility of using dredged material in soil blending, including the use of modeling to optimize a network path from ports to soil blenders to end users. This work is expected to be completed in 2014. ODOT's effort to develop a standard specification for the use of dredged

material as structural fill has been put on hold, but would be important to consider should this work be resumed. Additionally, the State of Ohio is completing Phase II of the Ohio Phosphorus Task Force as part of a 2011 USEPA GLRI grant. As part of this project, current research findings will be incorporated into a broader consensus on potential management strategies necessary to address the harmful algal blooms in Western Lake Erie. While this project does not directly involve management of dredged material, its findings could have implications on future management actions regarding Toledo Harbor dredged sediment. The Phase II Phosphorus Task Force project is expected to be completed in the spring of 2013. Findings from the Phase II Phosphorus Task Force and other applicable studies should be considered in the implementation of the THSMUP.

In general, the primary uses of existing data and studies were to:

1. identify and technically describe all HRU and other sediment management and use approaches considered to date;
2. characterize the physical, ecological, economic feasibility, and final capacity of each sediment management and use option;
3. quantify the scoring attributes of each sediment management and use option;
4. estimate the quantity of material to be managed and relative cost-effectiveness for each beneficial use option (non-HRU alternative);
5. calculate anticipated sediment reductions associated with each sediment reduction alternative identified;
6. identify and evaluate options and more environmentally acceptable dredging techniques; and
7. rank and prioritize options through a comparative scoring analysis based on a number of technical criteria including feasibility, implementation cost, and ecological, environmental, human, and economic benefits/impacts.

# 2.0 WATERSHED SEDIMENT REDUCTION

Sedimentation remains a significant issue for the Maumee River basin, with more sediment being contributed to Lake Erie from the Maumee River than any other tributary. An estimated 3.3M tons of sediment enters Lake Erie each year (NRCS, 2011). Much of this sediment load is delivered as a pulse in a small number of storm events annually. Sediment runoff occurs during heavy and widespread precipitation events as well as moderate storm events on frozen or saturated ground.

Many regional and state plans have set sediment reduction goals for the Maumee and Lake Erie basins. The LTSMP called for a reduction of 130,000 tons, or approximately 10%. The Lake Erie Protection & Restoration Plan (Ohio LEC, 2008) calls for a 33% reduction in sediment runoff into Lake Erie, or 495,000 metric tons for the Maumee River.

Several groups, including Task Force member organizations, are addressing upland efforts to reduce the amount of sediment entering Maumee Bay and Lake Erie. Trends suggest that sediment runoff in the Maumee River basin has decreased. Average annual suspended sediment decreased approximately 7% between the timeframes of 1992-1996 and 2002-2006, from 801,600 metric tons to 743,894 metrics tons (Baker, 2007). Despite sediment reductions, nutrient runoff remains an issue for the western Lake Erie basin.

While upland management options are not presented as part of the THSMUP, this section discusses some of the ongoing work across the basin to address upland sources of sediment. It is not meant to serve as an exhaustive list of current efforts nor does it focus on efforts to reduce upstream nutrient runoff. Regardless of upstream sediment reductions, these practices alone will not be enough to address issues associated with open-lake placement of dredged sediment.

## 2.1 Agricultural Efforts

Sediment runoff from agricultural fields is the primary method of sediment delivery in the basin, due in part to the large percentage of cultivated cropland. Various programs and projects address sediment runoff on agricultural fields. Financial incentives for conservation practices include the Wildlife Habitat Incentive Program, Environmental Quality Incentives Program, Wetlands Reserve Program, Conservation Reserve Program, Conservation Reserve

Enhancement Program, Conservation Security Program, and the Grassland Reserve Program. These programs offer incentives to landowners to adopt or install conservation practices for a variety of environmental benefits, including reducing sediment runoff.

### 2.1.1 Crop Residue Management

Conservation tillage is a farming practice where a varying percentage (at least 30%) of plant residue is left on the soil surface, thereby reducing the potential of soil erosion by wind and water. Adoption of this practice began in the late 1980s, with over half of corn and soybean fields farmed with conservation tillage by 1995 (Richards et al., 2002). The USDA NRCS found that between 2006 and 2010, approximately 58% of cropland in the western Lake Erie basin employed some type of conservation tillage (mulch tillage or no-tillage) (NRCS, 2011). Estimates for potential soil runoff on agricultural fields vary widely based on the farming practices. For example, one study estimated that the potential sediment delivery for conventional tillage practices is 0.4 tons per acre per year, while reduced tillage practices and no-till practices are estimated to be 0.2 tons per acre per year and 0.1 tons per acre per year, respectively (Ouyang et al, 2005). Results from a 2011 NRCS study suggest that the average sediment loss rate for cropped land in the Great Lakes Region is 0.63 tons per acre per year (NRCS, 2011). The study found a 50% reduction in the amount of sediment entering rivers and streams due to current conservation practices throughout the Great Lakes region (NRCS, 2011). Without conservation practices, it is estimated that the average sediment loss rate in the Great Lakes Region would be 1.2 tons per acre per year. Actual rates of sediment loss are variable based on the level of treatment and the inherent erodibility of soils on a specific site. While these practices have been demonstrated effective at reducing sediment runoff, the impact on nutrient dynamics and runoff on agricultural land remain relatively unknown.

### 2.1.2 Vegetative Cover

Vegetative cover is defined for the purposes of this document to include both cover crop (e.g. alfalfa, rye, clovers) and buffers (e.g. filter strips, riparian buffers, windbreaks, wetland restoration) which reduce soil, water, and nutrient runoff through the use of plants to uptake and slow these materials. Vegetative cover also reduces the amount of fertilizer applied to fields since the vegetation prevents erosion of nutrient-rich soil.

In 1995, a pilot study was completed to develop a locally led plan for sediment reduction. As part of this project, it was estimated that each acre of buffer can reduce the amount of dredging

between 0.4-0.5 CY (NRCS, 1998). It was estimated that 30% of corn and soybean fields, or 58,330 acres, would need buffers in order to reduce the sediment load by 29,000 CY. In 1998, the NRCS and partners completed the Ohio Lake Erie Buffer Initiative, which resulted in 44,701 acres of new conservation buffers between 1997 and 2004 (Davis, 2004).

## 2.2 Other Efforts

In addition to efforts to reduce sediment runoff on agricultural fields, measures have also been taken to reduce the sedimentation associated with urban, forested, and industrial land. Efforts include rain gardens, best management practices associated with construction activities, and Runoff on these types of land is a relatively minor facet of the sedimentation problem in the Maumee River and western Lake Erie basins.

## 2.3 Watershed Sediment Reduction Summary

Upstream sediment management practices not only reduce soil erosion, but include a multitude of ancillary benefits such as habitat improvement and reductions in water, pesticide, and nutrient runoff. Sediment runoff in the Maumee River watershed has decreased over the last 30 years, likely as a result of best management practices on agricultural land (Richards et al., 2008). Current focus has shifted from reducing sediment runoff to reducing nutrient runoff, specifically dissolved reactive phosphorus. In July 2012, the State of Ohio announced the Ohio Clean Lakes Initiative, which aims to improve water quality and reduce HABs in the western Lake Erie basin. As part of this program, funding from the Healthy Lake Erie Fund is expected to be used to address nutrient runoff on agricultural lands, monitoring in the lake and tributaries, and establishing pilot projects with the goal of reducing HABs. While these efforts focus on nutrients, secondary impacts on soil runoff might be realized.

Even with continued upstream sediment reductions, upland efforts will not be sufficient to significantly reduce the amount of dredging in the near term. However, upland efforts are an important part of a holistic sediment management approach.

# 3.0 CURRENT DREDGING OPERATIONS, PLACEMENT AREAS, AND COSTS

## 3.1 Project Location and Description

For the purposes of this THSMUP, the Toledo Harbor project area is defined to encompass an approximately 15 square-mile area of Southeastern Michigan and Northwestern Ohio, as illustrated by the Toledo Harbor Project Area map presented on Figure 1. The project area is bounded to the west by Interstate 75, to the east by Cedar Point National Wildlife Refuge (NWR), to the north by the Michigan state line, and extends south past Cedar Point NWR. Toledo Harbor's Federal and non-federal channels are located in the lower seven miles of the Maumee River and the approach channel that extends 19 miles in Maumee Bay as described in the following Sections.

### 3.1.1 Federal Channel

A "Federal" channel is one that has been designated by Congress. Funding for maintenance dredging of the Federal channel was first initiated in 1866 through the Rivers and Harbors Act, with the Federal channel completed in 1892. Successive Acts increased the authorized depth from 15 feet in 1875 to 25 feet below low water datum (LWD)[1] in 1936 (USACE, 1995). Additional sections of the respective River and Lake channels were authorized to be deepened to 27 feet and 28 feet in 1960.

### 3.1.2 Non-Federal Channel

Portions of the Maumee River outside of the Federal channel must be dredged in order to facilitate safe navigation and docking at TLCPA facilities. The TLCPA is facing many challenges regarding sediment management and disposal activities associated with maintenance dredging in the Maumee River. The TLCPA's permit issued by the USACE for maintenance dredging of the recreational/commercial areas of the Maumee River between Grassy Island and the Interstate 75 bridge adjacent to the Federal channel in Toledo, Ohio (Department of the Army Permit No. 2000-00692) only allows for disposal of dredged materials into TLCPA-owned portions of Facility 3 (see Section 3.4.1.1).

## 3.2 Dredging Operations

[1] Elevation of the Low Water Datum (chart "0") is 569.2 feet (173.5 m) above Father Point, Quebec, Canada according to the 1985 International Great Lakes Datum.

An estimated 3.3M tons of sediment enters Lake Erie each year (NRCS, 2011). While Lake Erie receives a lower sediment load compared to other areas of the country, it has the highest sediment load of all of the Great Lakes (Richards, 2011). Further, the Maumee River discharges more tons of sediment per year than any other tributary of the Great Lakes. Long-term measurements of suspended sediment, or soil particles that are carried in water, has been conducted by Heidelberg University by combining field samples with stream discharge, measured through river gauges established by USGS. Suspended sediment load between 2002 and 2006 averaged over 740,000 metric tons (Baker, 2007). It is estimated that as much as one-third of all the sediment that passes by the Maumee River USGS gauge in Waterville, Ohio, which represents over 96% of the Maumee River watershed, is dredged from the Federal channel (USACE, 1993). Much of the annual sediment load is delivered in pulses in a small number of storm events.

### 3.2.1 Dredging Techniques

Currently, USACE contractors primarily use mechanical dredging (with a clamshell bucket) for dredging the Federal channel. The sediment is loaded onto a scow that transports it to the open-lake placement location where it is released from the bottom of the scow. This method has been the primary method over the last several years and is considered to be the least disruptive of the generally available options. The USACE is required to use the dredging method and placement that is least costly and complies with applicable environmental laws and regulations.

Non-federal dredging permit conditions typically require work to be done using an environmental clamshell bucket or a hydraulic cutterhead dredge. The sediment is beneficially used upland or loaded onto a scow that transports it to a CDF, where it is either pumped into the placement location or mechanically offloaded. In non-federal areas, sediments might contain legacy contaminants that would not meet existing Federal guidelines for open-lake placement, as the non-federal channel is not routinely dredged. Additionally, the extensive testing and evaluation for open-lake placement suitability is not cost-effective relative to the small quantity of material typically dredged from the non-federal channel compared to the quantity dredged from the Federal channel.

### 3.2.2 Dredging Schedule

As part of the conditions of the annual WQC, dredging and placement activities are only permitted between July 1st and March 15th to ensure that fish spawning activities are not disturbed. However, dredging normally does not occur during the winter due to weather and ice. As a result, annual dredging typically occurs between July and November.

### 3.2.3 Dredging Volume and Center of Gravity

#### 3.2.3.1 Federal

Due to shoaling of material, annual dredging of Toledo Harbor is required to ensure the Federal channel remains navigable for deep-draft commercial navigation. The USACE Toledo Project Office, which assists in managing the dredging of the Toledo Harbor Federal channel, provided estimates of the locations and volumes of dredged sediment between 2001 and 2010. The numbers provided are not exact and are estimated by the USACE to quantify the effort of work by the dredging contractor. Table 2 shows the total sediment dredged per year and per Federal channel location (River or Lake). Volumes are calculated as equivalent “in-place” CY based on pre- and post-dredging bathymetric surveys.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 2**

**VOLUME OF SEDIMENT DREDGED IN THE TOLEDO HARBOR FEDERAL CHANNEL BETWEEN 2001 AND 2010**

| Year | Volume Dredged from River Channel (CY) | Volume Dredged from Lake Channel (CY) | Total Volume Dredged from Federal (CY) |
|---|---|---|---|
| 2001 | 174,355 | 729,618 | 903,973 |
| 2002 | 133,500 | 300,000 | 433,500 |
| 2003 | 0 | 619,026 | 619,026 |
| 2004 | 0 | 689,900 | 689,900 |
| 2005 | 0 | 567,728 | 567,728 |
| 2006 | 0 | 620,852 | 620,852 |
| 2007 | 115,000 | 600,000 | 715,000 |
| 2008 | 0 | 540,000 | 540,000 |
| 2009 | 0 | 720,400 | 720,400 |
| 2010 | 50,000 | 734,052 | 784,052 |
| **Total Per Location** | **472,855** | **6,121,576** | **6,594,431** |

Notes
1. Data obtained from USACE reflects location and relative volume dredged between 2001 and 2010.

Between 2001 and 2010, the USACE dredged over 6.5M CY of sediment from the Federal channel, with an average of nearly 660,000 CY per year. The majority of the sediment (over 6.1M CY or approximately 93% of the ten-year total) was dredged from the portion of the Federal channel within Lake Erie (Lake Channel); less than 0.5M CY (or approximately 7% of the ten-year total) was dredged from the portion of the Federal channel within the Maumee River (River Channel). Dredging in the River Channel occurred in only four of the ten years discussed above.

Center of gravity calculations were performed on dredge data to determine areas of the federal navigation channel where the majority of dredging occurred over the last 10 years. The center of gravity was calculated separately for the River Channel and the Lake Channel. The River Channel includes Stations 0+00 through 291+00, and the Lake Channel includes Stations 291+00 to 920+00. The separation between Lake and River (station 291+00) was determined based on volumes rather than physical location in order to accurately calculate the center of gravities separately. Station 291+00 was selected because it was a transition point from a section of the channel that had a minimal amount (0 – 15,000 CY) of dredging required to a section that had a recordable amount (15,000 – 200,000 CY) of dredging required. Calculations were then performed on the combined data to establish overall center of gravity of dredging activity. A memorandum discussing the center of gravity evaluation is provided in Appendix A.

Much of the Federal channel dredging over the last 10 years was completed near the mouth of Maumee River, near River Mile 0 (RM-0), and approximately four miles lakeward of the river mouth as depicted by Figure 2, the Toledo Harbor Center of Gravity Map. The center of gravity for dredging within the Lake Channel was calculated to be Station 593+00, approximately 1.4 miles northeast of Facility 3 and 6.8 miles southwest of the open lake placement area. The center of gravity for dredging within the River Channel was calculated to be Station 146+00, approximately 1.1 miles southwest of the Interstate I-280/Maumee River crossing.

The center of gravity for dredging within the overall Federal channel was calculated to be Station 559+00, approximately 0.9 mile northeast of Facility 3. In 1989, Hull calculated the Federal channel overall center of gravity based on dredge data reported between 1984 and 1988 ("Evaluation of Woodtick Peninsula Restoration and Recreational

Hill/Upland Disposal Alternatives using Toledo Harbor Dredge Spoil Material", dated July 1989). The overall center of gravity then was Station 568+00 (which is only a 900-foot difference from Station 559+00 calculated above). The locations of the overall center of gravity for dredging in the Federal channel calculated for years 2001 to 2010 and 1984 to 1988. Dredging of the Federal channel has not significantly changed over the last 30 years with respect to location and volume as depicted by Figure 2.

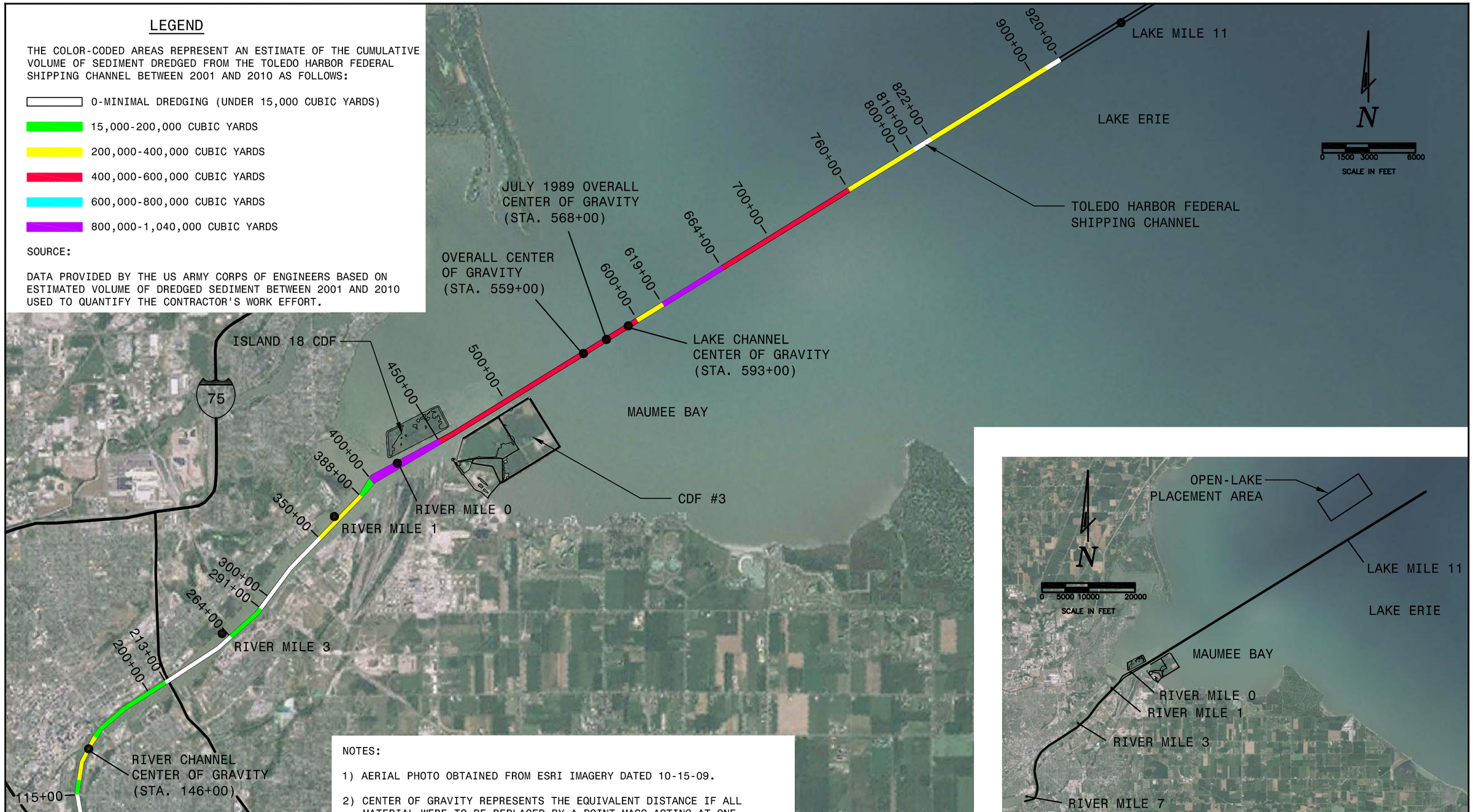
## LEGEND

THE COLOR-CODED AREAS REPRESENT AN ESTIMATE OF THE CUMULATIVE VOLUME OF SEDIMENT DREDGED FROM THE TOLEDO HARBOR FEDERAL SHIPPING CHANNEL BETWEEN 2001 AND 2010 AS FOLLOWS:

- 0-MINIMAL DREDGING (UNDER 15,000 CUBIC YARDS)
- 15,000-200,000 CUBIC YARDS
- 200,000-400,000 CUBIC YARDS
- 400,000-600,000 CUBIC YARDS
- 600,000-800,000 CUBIC YARDS
- 800,000-1,040,000 CUBIC YARDS

SOURCE:

DATA PROVIDED BY THE US ARMY CORPS OF ENGINEERS BASED ON ESTIMATED VOLUME OF DREDGED SEDIMENT BETWEEN 2001 AND 2010 USED TO QUANTIFY THE CONTRACTOR'S WORK EFFORT.




NOTES:

1) AERIAL PHOTO OBTAINED FROM ESRI IMAGERY DATED 10-15-09.

2) CENTER OF GRAVITY REPRESENTS THE EQUIVALENT DISTANCE IF ALL MATERIAL WERE TO BE REPLACED BY A POINT MASS ACTING AT ONE LOCATION. IT ESSENTIALLY REPRESENTS THE CENTER OF WHERE DREDGING HAS OCCURRED BETWEEN 2001 AND 2010 BY VOLUME OF SEDIMENT.

3) THE JULY 1989 OVERALL CENTER OF GRAVITY WAS REPORTED IN THE "EVALUATION OF WOODTICK PENINSULA RESTORATION AND RECREATIONAL HILL/UPLAND DISPOSAL ALTERNATIVES USING TOLEDO HARBOR DREDGE SPOIL MATERIAL", PREPARED BY HULL & ASSOCIATES, INC., DATED JULY 1989, USING DATA BETWEEN 1984 AND 1988.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GREAT LAKES RESTORATION INITIATIVE PROJECT
EPA GRANT #GL-00E00523-0
TOLEDO-LUCAS COUNTY PORT AUTHORITY AND THE OHIO LAKE ERIE COMMISSION


FIGURE 2
TOLEDO HARBOR 2001-2010

MAUMEE RIVER/LAKE ERIE, OHIO

| | |
|---|---|
| PROJECT NO.: TPA044 | SUBMITTAL DATE: SEPTEMBER 2012 |
| CAD DWG FILE: TPA044.100.0001 | PLOT DATE: 9/19/12 |

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#### 3.2.3.2 Non-Federal Navigation Channel Dredging

The amount of material dredged in the non-federal channel varies each year depending on project conditions and other special dredging projects. For example, approximately 78,000 CY was dredged for a new slip at the Great Lakes Maritime Museum for the James M. Schoonmaker in 2012. Table 3 shows the volume of sediment dredged from the non-federal channel since 2008. Volume was obtained from the TLCPA and is based on paid disposal fees. The volumes do not reflect actual volumes of material dredged from the non-federal channel. Rather, they represent the volumes of material placed into the TLCPA-owned portions of Facility 3. Since much of the non-federal channel dredging is completed by private Port terminal operators and marinas and are not routinely reported, the volumes provided are approximated representations of actual non-federal dredged volumes. Center of gravity calculations were not performed for the non-federal dredging since available data does not include specific dredging locations.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 3**

**VOLUME OF SEDIMENT DREDGED IN THE TOLEDO HARBOR NON-FEDERAL CHANNEL AND PLACED IN FACILITY 3 BETWEEN 2008 AND 2012**

| Year | Volume of Material Dredged from Non-federal Channel (CY) |
|---|---|
| 2008 | 39,760 |
| 2009 | 69,255 |
| 2010 | 30,650 |
| 2011 | 24,508 |
| 2012 | 101,800 |
| **Total** | **265,973** |

Notes:

1. Quantity of material dredged was obtained from the TLCPA and is based on paid disposal fees paid to the TLCPA for placement in Facility 3. Additional material dredged and beneficially used is not identified.
2. The 2012 volume includes an estimated 78,000 CY dredged for the James M. Schoonmaker slip. Dredged material was placed into City of Toledo-owned Penn 7/8.

## 3.3 Sediment Testing and Evaluation

Currently, placement of dredged material from the Federal channel is in accordance with 33 Code of Federal Regulations (CFR) § 335.7, which states that the Federal Standard is the alternative or alternatives identified by USACE that are the least costly alternative(s) consistent with sound engineering practices and meeting the environmental standards established by 40

CFR § 230 Section 404(b)(1) guidelines. These guidelines originate from the Clean Water Act and specify the testing and evaluation of the material, potential placement sites, and surrounding areas that might be affected by the placement of the material.

Typically, USACE collects and analyzes water and sediment samples from the Federal channel, open lake placement area, and open lake reference area every five years. The sediment evaluation as to whether the material is suitable for open-lake placement is made using the analytical results from these, and any supplemental sediment testing, in accordance with the procedures in the Great Lakes Dredged Material Testing and Evaluation Method (USEPA/USACE, 1998) and the Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual, also known as the "Inland Testing Manual" (USEPA/USACE 1991). Generally, sediment evaluation follows a four-tiered approach, involving site-specific testing and data evaluation. Tier 1 involves the use of existing data reported for general physical and chemical analyses to determine whether sufficient data exists to make determination on the suitability to place the material in the open lake placement area. Tier 2 involves the collection of additional data as well as modeling and evaluation. Tier 3 and Tier 4 involve biological effects-based testing and site-specific tests, respectively. Once sufficient data is gathered or collected, a determination is made as to whether the discharge will or will not have any unacceptable, adverse contaminant-related effects.

A decision on the suitability of open-lake placement is currently made based on compliance with Clean Water Act Section 404(b)(1) guidelines, which includes the issuance of a Clean Water Act Section 401 WQC by Ohio EPA and the issuance of a Coastal Management Program Consistency determination by Ohio DNR. Ohio EPA issues the Toledo Harbor WQC annually. As part of the 2012 WQC, Ohio EPA required USACE to submit a detailed phosphorus testing/monitoring plan for implementation during the 2013 dredging season. Data gathered during the 2013 dredging season will assist stakeholders to better understand the dynamics of nutrient re-suspension as a result of open-lake placement.

Additionally, the USACE and USEPA are in the process of revising the sediment evaluation guidelines to include one guidance document for both the Ocean and Inland Testing as well as to incorporate a risk management framework (Kreitinger, 2012). Risk management can include factors such as dredging windows, engineering controls, work sequencing, and modifying bioavailability of nutrients and/or contaminants of concern (COCs). Revisions to the Ocean

Testing Manual/Inland Testing Manual are expected to take approximately one year, with the revisions estimated to be completed in late 2013 (Joseph Kreitinger, personal communication, July 13, 2012). Incorporation of a revised sediment evaluation approach into the Federal Standard could impact the evaluation and management of Toledo Harbor sediment by allowing for the incorporation of risk identification (e.g. potential impacts to human health and the aquatic ecosystem) and management strategies (e.g. engineering controls) in order to mitigate environmental concerns.

### 3.3.1 Sediment Characteristics

Sediments dredged from the Federal channel are primarily silts, clays, and some fine sands (USACE, 2009). Traditional contaminants of concern include heavy metals, phosphorus, polycyclic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides. Detailed physical and chemical characteristics of Toledo Harbor dredged sediment are provided in the memorandum included as Appendix B. Results of the most recent evaluation of Toledo Harbor sediment with respect to open-lake placement, completed by USACE, is included as an attachment in Appendix B. This document summarizes sampling completed in 2010 and the associated sediment quality evaluation results. Maximum concentrations reported for bulk chemistry testing during the USACE's 2010 sampling events is summarized in Table B-1 of Appendix B.

### 3.3.2 Evaluation of Dredged Material for Specific End Uses

Geotechnical, engineering, chemical, and biological properties of dredged material should be evaluated when determining the suitability of dredged material for a specific beneficial use. Each beneficial use option requires different types of evaluation due to differences in structural requirements, human and ecological exposure, potential contaminant pathways, and receptors of concern.

Dredged material is typically evaluated for human and environmental risk through a process similar to that described above. Available data is compared to different sediment screening criteria based on the specific end use of the material (i.e. residential use, commercial use, and habitat creation). The seven sets of screening criteria include the following: U.S. EPA Regional Screening Levels (RSLs) for industrial soil, RSLs for residential soil, Ohio EPA Voluntary Action Program (VAP) direct contact soil standards for commercial/industrial land use, VAP direct contact soil standards for residential land use, Ohio EPA sediment reference values (SRVs),

U.S. EPA Region 5 Ecological Screening Levels (ESLs) for sediments, and Threshold Effect Concentrations (TECs) from MacDonald, Ingersoll, and Berger (2000).

Maximum concentrations reported for bulk chemistry testing during the USACE's 2010 sampling events is summarized by Table B-1 included in Appendix B. Additionally, an initial screening analysis was completed on the maximum concentrations and can be found in the memorandum provided in Appendix B-2. As shown in Table B-1, maximum reported concentrations from the 2010 sampling of Toledo Harbor sediments indicate that of one or more of thirty analytes exceed the SRV, TEC, or sediment ESL at 16 locations. However, Table B-1 also shows that the exceedance of the residential soil RSL for several PAHs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene and indeno[1,2,3-cd]pyrene) is limited to the results reported the results reported from the 2010 sampling at RM-4. Dibenz(a,h)anthracene slightly exceeded the residential soil RSL at LM-1.5. While exceeding the residential RSL of 0.39 milligram/kilogram (mg/kg), the maximum reported arsenic concentration from the 2010 sampling event (11 mg/kg) falls at the background concentration represented by the Huron Lake Erie Plain Region (HELP) SRV of 11 mg/kg and is therefore consistent with naturally-occurring arsenic levels. Therefore, most Toledo Harbor sediments may also be appropriately used for upland uses (e.g. agricultural field improvement, non-structural fill), with the exception of sediments dredged from RM-4 and LM-1.5. Prior to implementing an upland beneficial use option for sediments dredged from RM-4 and LM-1.5, additional Tier 2 through Tier 4 sediment characterization testing might be necessary to evaluate site-specific biological and toxicity testing.

With the exception of material dredged from RM-1, RM-2, and RM-4, the USACE has determined that all Federal channel dredged material is suitable for in-water use (i.e. open-lake placement) based on chemical, elutriate and bioassay testing, and water quality and bioaccumulation modeling. This determination is based on existing USEPA/USACE protocols and guidelines pursuant to Section 404 of the Clean Water Act. Material dredged from RM-1, RM-2, and RM-4 is currently required to be placed into Cell 2 of the USACE portion of Facility 3.

Prior to implementation of a specific beneficial use option, physical, chemical, and biological characterization of the material should be completed to ensure the dredged material is suitable for the proposed placement site. Additional samples should be collected at multiple sample locations to determine the variety of sediment types that exist. Because some sediment types

may be better suited for one option than another, the type of sediment testing and evaluation will be dependent on the proposed end use. For example, structural end uses may require compaction and shear strength testing while non-structural use options may require column settling and consolidation testing. Use of the dredged material to grow vegetation would likely require additional nutrient, pH, alkalinity, and salinity testing. If initial testing for a proposed end use suggests the material is unsuitable, further evaluations could be completed to identify whether treatment, amendments, or controls would make the material suitable for the proposed end use. Prior to implementing any end use option, the material must be evaluated with respect to potential contaminants of concern to ensure the use of the material is protective of human health and the environment.

Additionally, the implementation of a beneficial use project will likely require the completion of a materials management plan, which typically includes a detailed description of the end use of the material, the method of management practices at the site to be implemented in order to protect waters of the State and human health and the environment, stormwater controls, applicable setbacks from waterways and water supplies, and a record keeping and retention plan. Ohio EPA is currently developing guidelines for developing and implementing materials management plans during beneficial use projects. The materials management plan would likely include a site-specific human health and environmental risk evaluation, stormwater pollution and prevention plan, source material characterization, and procedures established to document the placement and use of the material. Development of a materials management plan would need to be closely coordinated with Ohio EPA.

Although Ohio EPA currently classifies dredged material as a waste product, they are currently developing a beneficial use regulatory program that establishes a tiered approach to guide the beneficial use approval process for dredged material and other waste products. The tiered approach could include pre-approval for certain byproduct categories (e.g. asphalt, concrete, etc.), general permits in which sufficient characterization data exists, and individual permits in which a material characterization plan would need to be developed. Ohio EPA is considering how to classify and regulate dredged material, including adopting risk-based health standards to ensure its use is protective of human health and the environment.

## 3.4 Federal and Non-Federal Dredged Material Placement Locations

Depending on the results of the sediment evaluation, dredged material from the Federal channel is placed into a CDF or at the currently designated open lake placement area. Material dredged from the non-federal channel is typically placed into a CDF.

### 3.4.1 Existing CDFs and Upland Placement Areas

Federally dredged material that does not meet the Federal Standard, as well as non-federally dredged material, is primarily placed into an existing CDF or beneficially used at an upland location with appropriate Ohio EPA surface water approvals.

#### 3.4.1.1 Facility 3

Facility 3, also called Site 3, was constructed in 1976. An extension was built in 1993 (USACE, 1995). The existing CDF is approximately 495 acres and is composed of three different areas as depicted by Figure 3, the Toledo Harbor Confined Disposal Facilities Map:

1. Cell 1 (CDF #1) is approximately 240 acres and is an L-shaped in-lake CDF. Cell 1 was constructed in 1976 and is currently not in use. This cell has been owned by the TLCPA since 1999 and is the area used by a contractor (S & L Fertilizer) to create a soil-like material for beneficial use.

2. Cell 2 (CDF #2) is approximately 155 acres and irregularly shaped, located adjacent to Cell 1. Cell 2 is owned by the USACE and was completed in 1993. It is currently not in use since all federal dredging is placed in the open lake placement area. However, any dredged material that does not meet Federal guidelines for open-lake placement is typically placed into Cell 2, reserved for spills, etc.

3. Cell 3 (TLCPA Facility 3) is approximately 100 acres and includes three separate sub-sections. Two areas are owned and operated by the TLCPA and sub-divided into the “wart” and the “banana”, and are approximately 17 acres. Portions of these units are managed by the TLCPA while others are leased to and operated by different entities. Non-federal dredged sediment is typically placed in Cell 3. The final sub-section is owned and operated by Toledo Edison for fly ash and other coal combustion byproduct management, and is located in the southwest corner of the CDF. Currently, the Toledo Edison site is not used for placement of material and is not being considered as part of the THSMUP.

TLCPA manages the “wart” and “banana” areas of Cell 3 as well as the “S&L” area of Cell 1. The “banana” area is currently being used for disposal while the “wart” area has reached capacity.

#### 3.4.1.2 Grassy Island

Grassy Island, also called Island 18, was constructed in 1962 with an initial capacity of 5M CY. It was expanded in 1977 by USACE. Grassy Island is approximately 150 acres and was used throughout the 1970s to place material from the Federal channel, but has not been used since 2007 (USACE, 1993). The dike breached after use and a temporary repair was completed in 2007. Grassy Island currently requires a permanent repair to a dike breach prior to being able to accept dredged material, but once repaired could accommodate 1.8M CY.

#### 3.4.1.3 Penn 7, Penn 8, and Riverside Park

The City of Toledo owns and operates the Penn 7, Penn 8, and Riverside Park facilities, which are located north of Interstate 280 along the banks of the Maumee River, to manage dredged material and other materials. These facilities are approximately 59 acres, 30 acres, and 52 acres, respectively, are not intended to accommodate significant quantities of material. Terrestrial habitat in these areas, if present, is of low quality. Much of Penn 7 is heavily vegetated with some open areas in the southern portion of the property. Penn 8 is mostly vegetated with low quality terrestrial species (e.g. cottonwoods, scrub grass, and phragmites). Riverside contains little to no vegetation and is currently being used to place material dredged from the USS Schoonmaker berth.

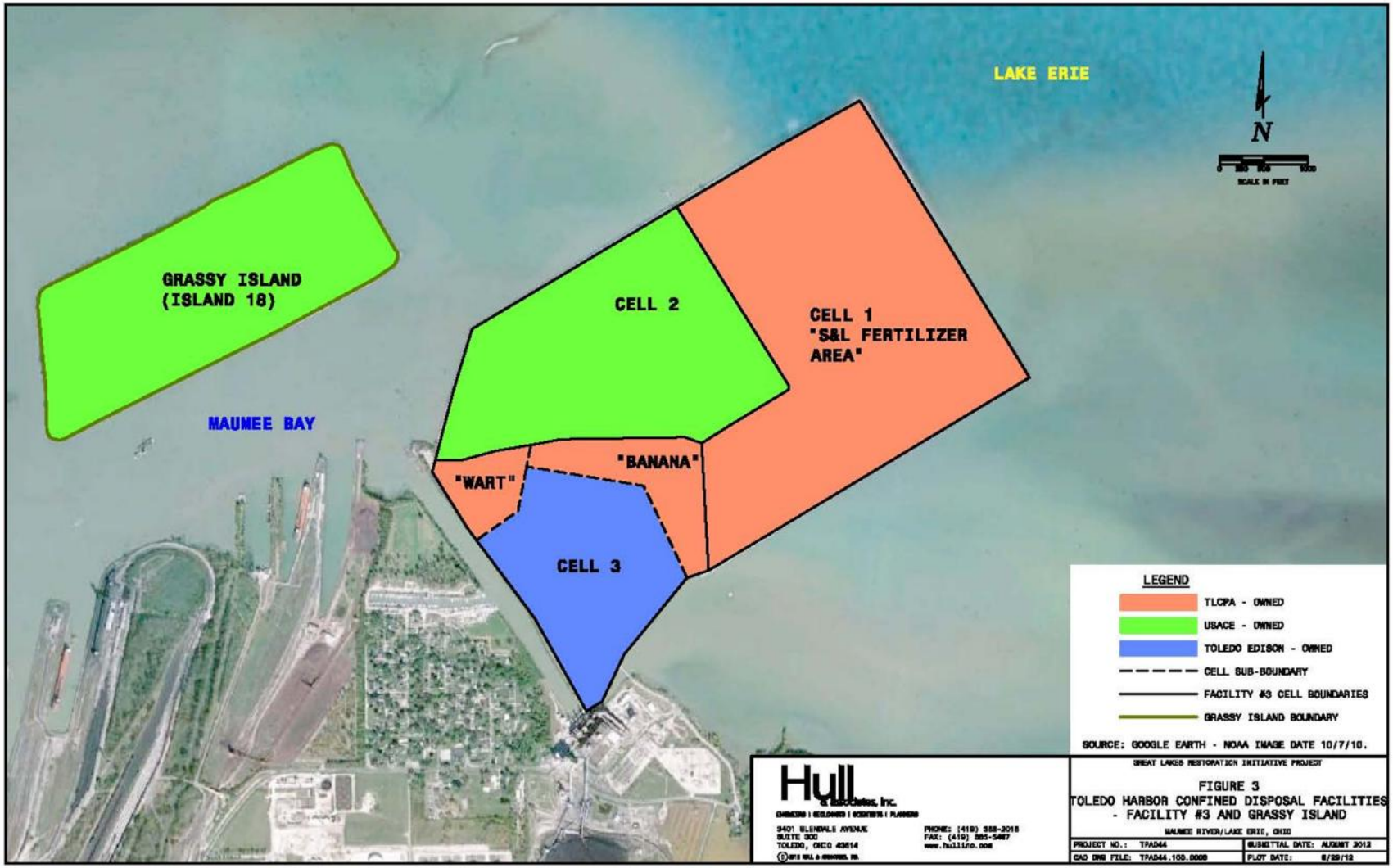
### 3.4.2 Open Lake Placement Area

Currently, the USACE places federally dredged material in the northeast half of the open lake placement area, located at approximately Lake Mile 11 (LM-11). Depths within this area are approximately 20-23 feet below LWD (USACE, 2009). This area has been permitted and in use since the mid-1980s. All federally dredged material that meets the Federal Standard is placed in the open lake placement area. The remaining useful life of the open lake placement area is unknown.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## FIGURE 3

## TOLEDO HARBOR CONFINED DISPOSAL FACILITIES MAP



## 3.5 Costs

Federal and non-federal dredging costs vary and are dependent on the type of equipment used, the volume of material dredged, and local economic factors. The USACE completes dredging through a Federal contracting process. Generally, the USACE awards one to two contracts per year for the Lake Channel and the River Channel dredging. Since these contract(s) involve removing a large volume of material over a relatively long period of time, the unit price is generally lower than non-federal dredging due to reduced mobilization/demobilization expenses and use of larger equipment. The recent average cost for dredging and open-lake placement of sediment from the Federal channel is between $5/CY and $6/CY. This rate has decreased in recent years due to the competition and availability of contractors interested in the dredging work. The USACE uses sonar surveys of the Federal channel prior to and after dredging to estimate "cut" volumes of sediment dredged. This serves as an attempt to quantify the contractor's level of effort during dredge operations. Due to the capacity of the sediment to hold water and buoyancy effects, the volume estimated between surveys also includes significant water that is mixed with the sediment while in-situ. Dredging costs are based on the reported cut volumes.

Non-federal dredging is typically completed by the Port terminal operators or contracted privately or through local stakeholders (e.g. City of Toledo and TLCPA). Since these individual projects remove small volumes of material from the non-federal channel over a relatively short period of time, the unit price is generally greater than the federal dredging. The non-federal dredge material cannot be placed in the open lake placement area. The material must be placed in an upland location or within a CDF, which adds to the overall cost. Any material placed in TLCPA-owned portions of Facility 3 is subject to a tipping fee ranging between $6 and $9, depending on the entity completing the dredging.

The volume of material and associated costs used for evaluating each option was based on the cut volumes removed from the channel and reported by the USACE. Unless specified, consolidation was not considered and no volume reductions applied.

## 3.6 Funding Sources for Federal and Non-federal Dredging

Authority for USACE to dredge Federal navigation channels is provided through public laws, including the 1986 WRDA as well as various Rivers and Harbors Acts. Funding to dredge the Federal channel is determined through the Congressional budget and appropriations process.

The USACE-Buffalo District generally recommends a funding level for each harbor, which is submitted to the Great Lakes Navigational Team, who then packages all requests across the Great Lakes into one submittal that goes through regional and national headquarters. The Office of Budget and Management makes a recommendation on funding levels, which is released in the President's budget every February in the year preceding the fiscal year. Due to budget limitations, projects are rarely funded at a level that allows for the entire channel to be dredged to authorized depths.

Funding to dredge the non-federal channel is the responsibility of private and public stakeholders completing projects within the non-federal channel. Parties involved in funding the dredging of the non-federal channel include Port terminal operators, marinas, TLCPA, City of Toledo, and other local stakeholders.

# 4.0 SEDIMENT MANAGEMENT AND USE OPTION EVALUATION METHOD

## 4.1 Introduction

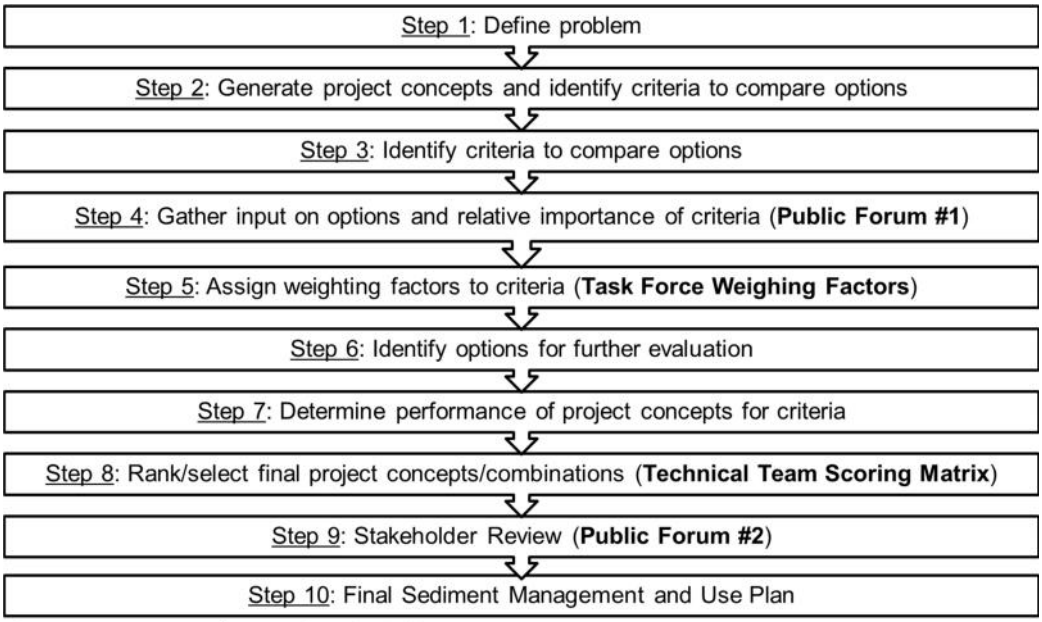
This THSMUP was funded by a USEPA GLRI grant and was developed to assist the Task Force in identifying and implementing a sediment management and use strategy for the Toledo Harbor Federal channel and commercial/recreational non-federal channel that represents a consensus-based approach of the diverse stakeholders represented by the Task Force. The purpose of the GLRI grant is to evaluate alternatives to current open-lake placement practices and to provide recommendations for sediment management and use options including HRUs and other beneficial use concepts.

Sustainable practices to manage dredged material from Toledo Harbor in a manner that balances economic and environmental aspects were evaluated by a technical team, led by Hull. This project included multiple steps, including public forums, evaluation, and comparison of sediment management and use options, and stakeholder review as depicted in Figure 4, Graphical Representation of the Toledo Harbor Sediment Management and Use Project Steps. Evaluation and comparison of options was completed by a technical team comprised of two engineers and two scientists. The technical team worked with the Task Force to complete the evaluation of sediment management and use options presented in the following sections. This evaluation incorporated many different factors such as cost, environmental benefit, and economic benefit. While these factors are very different, the evaluation approach incorporated a uniform method of comparing these factors to one another.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## FIGURE 4

## GRAPHICAL REPRESENTATION OF THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PROJECT STEPS




*Major project components/events are denoted in bold

The project technical team identified several management use option categories including:

- In-water - options that will be located in Maumee Bay (e.g. HRUs, CDFs);
- Nearshore - options that will be located along or near the shoreline (e.g. wetlands, shoreline protection);
- Upland - options that will be located on land within the western Lake Erie basin (e.g. agricultural improvements, monofills, brownfields); and
- Products - options that will involve the use of dredged material to create goods that have a market value (e.g. manufactured soil, structural fill).

These categories of options were discussed in an initial first public forum, where stakeholders had the opportunity to provide input on preferred options as well as share additional ideas for sediment management and use options and locations.

Preliminary options that were clearly infeasible or unreasonable, or did not have the potential to minimally satisfy most of the project objectives, were eliminated from further study. Options that

were carried forward were evaluated using a weighted matrix approach. The matrix incorporates the relative importance of six major categories of technical criteria (weighting factors) that were considered in the evaluation of each option. The major categories of technical criteria included:

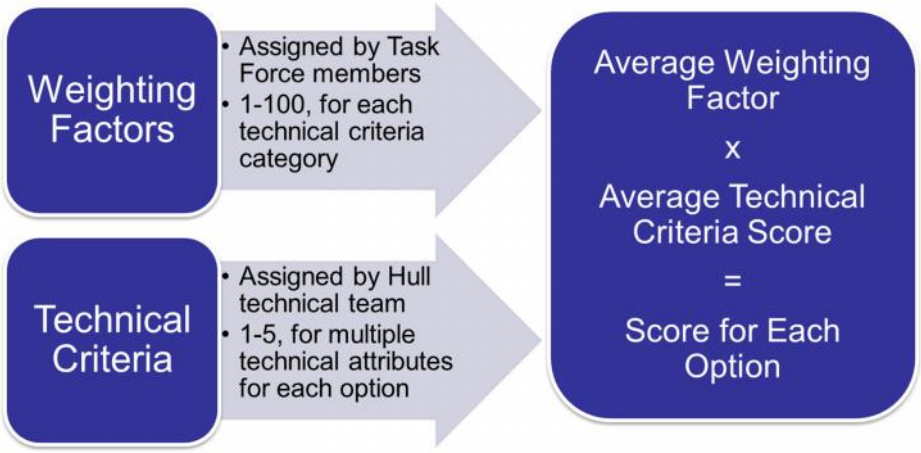
- Feasibility - criteria addressing the technical, logistical, institutional, and constructability of an option;
- Ecological Benefits/Effects - criteria addressing the impacts of an option on the natural and living environment including wetlands, aquatic and terrestrial communities, and protected species;
- Environmental Impacts/Effects - criteria addressing the impacts of an option on factors such as groundwater quality, surface water quality, land improvements, and hydro-dynamic effects (e.g. impacts on littoral drift or currents);
- Human Benefits - criteria addressing the impacts of an option on factors such as recreation opportunity, flood protection, aesthetics, human health risk, and navigational safety;
- Economic Benefits/Effects - criteria addressing the impacts of an option on factors such revenue generation, job creation, tourism, public need, and local commerce; and
- Implementation Costs - criteria addressing an option's total cost per CY.

The scoring of each sediment management and use option involved a technical score and a weighting factor for each of the six categories. Each technical criteria category was assigned a weighting factor, from 0-100, by the Task Force, as described in Section 4.3. The weighting factor represents the relative importance of each technical criteria category compared to one another. These weighting factors were multiplied by the technical score, which was based on a score of 1-5 for multiple criteria within each category, as determined by the technical team and described in Section 7.2. Figure 5 shows a graphical representation of the scoring matrix procedure.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**FIGURE 5**

**GRAPHICAL REPRESENTATION OF THE SCORING METHOD**




## 4.2 First Public Forum

The first public forum was completed on Thursday, June 16, 2011 to gather stakeholder input on potential options and relative importance of the six major categories of technical criteria, which would later be used to prioritize viable options. Task Force members shared background information and conveyed current challenges associated with sediment management in the Toledo Harbor from both economic and environmental perspectives with the attendees. The forum was jointly hosted by the GLC, Ohio LEC, and TLCPA.

The initial public forum provided stakeholders with an overview of the planning process and provided an opportunity for the Task Force members to get ideas and input regarding priorities from stakeholders. The input received from stakeholders guided the Task Force through the decision making process in prioritizing and evaluating technical alternatives for inclusion in the THSMUP.

The major objectives of the first public forum were to:

- identify all sediment management and approaches considered to date;
- identify stakeholder issues and priorities;

- solicit ideas on alternatives to assist the Task Force in establishing objective criteria that will be used to formulate alternatives that reflect stakeholder issues and priorities; and
- solicit and compile information from the public and agencies concerning potential data gaps.

Forum attendees had the opportunity to share their ideas for beneficial use of sediment for consideration, and potential incorporation into a sediment management strategy for the Toledo Harbor that is being developed by the Task Force. Ideas solicited from stakeholders comprised four major categories of alternatives. Table 4 provides a list of sediment management and use options discussed at the first public forum.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 4**

**LIST OF SEDIMENT MANAGEMENT AND USE OPTIONS DISCUSSED AT THE FIRST PUBLIC FORUM**

| Option/Alternative Category | Option/Alternative |
|---|---|
| In-Water | Submerged Aquatic Habitat Restoration Unit |
| | Emergent Habitat Restoration Unit |
| | Confined Disposal Facility |
| Nearshore | Wetland Restoration |
| | Shoreline Protection |
| Upland | Brownfields, Landfill Caps, and Mine Reclamation |
| | Agricultural Improvements |
| | Inland Monofill |
| Products | Manufactured Soil, Asphalt, Concrete, and Construction Materials, Structural Fill, and Other |

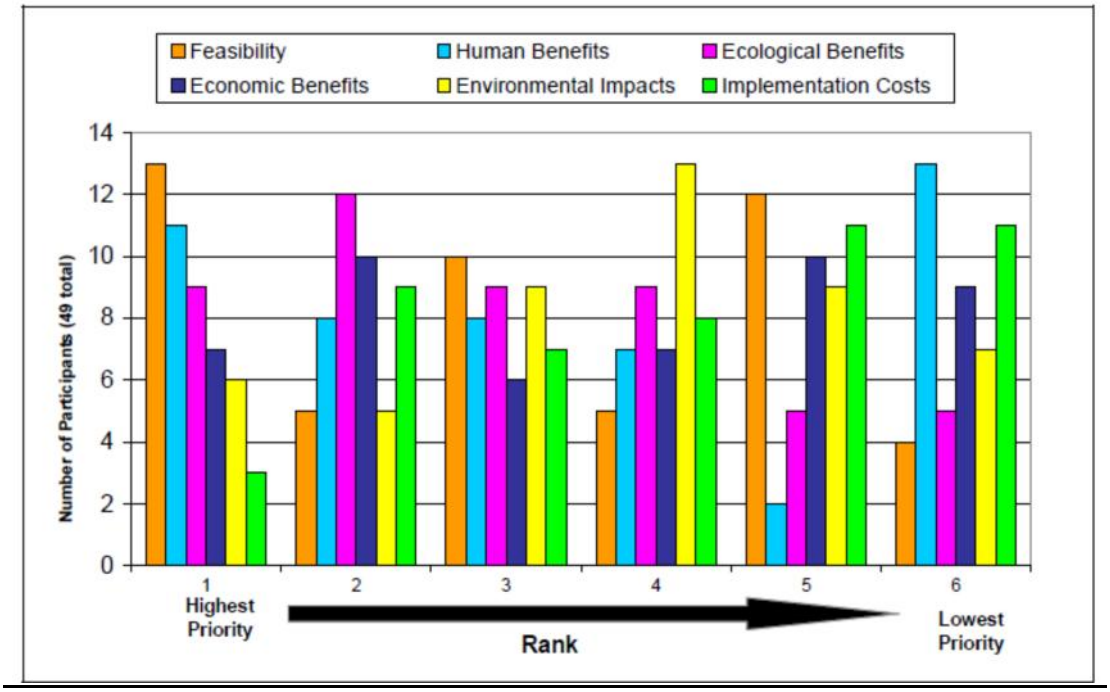
Nearly 70 stakeholders attended the first forum. Ideas suggested by stakeholders for inclusion in the THSMUP included habitat and wetland protection, creation, restoration; brownfield reclamation; engineered uses; quarry and mine reclamation; product development; agricultural enhancements; and recreational uses. The monofill option was not carried forward due to little interest from stakeholders.

Stakeholders also ranked the importance of the six criteria categories. Figure 6 provides a graph that the results of the stakeholders' prioritization of technical criteria used to identify sediment management options. In general, the graph illustrates that a dominant priority for specific criteria was not identified by stakeholders. The graph illustrates that all criteria are generally weighted equally by the stakeholders. A complete summary of the first public forum is provided in Appendix C.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**FIGURE 6**

**FIRST PUBLIC FORUM PRIORITIZATION OF TECHNICAL CRITERIA**




## 4.3 Task Force Weighting Factors

Following the June 2011 forum, the technical team presented the Task Force with a summary of sediment management and use options and prioritization of technical criteria provided by stakeholders during the first public forum. The Task Force assigned weighting factors to the six technical criteria categories. Each member organization was provided with guidance for assigning weighting factors, which included the results of the stakeholders' prioritization (see Appendix D). Representatives of participating organizations assigned values between zero (least importance) and 100 (highest importance) to each of the six criteria categories, with the

sum of the category scores not exceeding 100. Results were compiled and presented at the December 2011 Task Force meeting. During this meeting, members of the Task Force discussed their weighting factor scores and each organization was given the opportunity to reallocate points to a different category based on group discussion. The final weighting scores were averaged and used as the weighting factor for each criteria category in the matrix. A summary of the weighting factors assigned by organizational members of the Task Force is provided In Table 5. This table identifies the minimum and maximum weighting factor assigned for each technical criteria as well as the median and average calculated for each technical criteria category.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 5

## SUMMARY OF WEIGHTING FACTORS ASSIGNED BY THE TOLEDO HARBOR TASK FORCE

| Category of Technical Criteria | Final Assigned Weighting Factor | | | | | | | | | | | | Minimum | Maximum | Median | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Organization: | TLCPA | Ohio LEC | MTA | Ohio EPA | Toledo | Ohio DNR | ODOT | LECBA | NRCS | Maritime | LEW | USFWS | | | | |
| 1. Feasibility | 40 | 20 | 30 | 20 | 15 | 15 | 15 | 15 | 0 | 15 | 25 | 0 | 0 | 40 | 15 | 18 |
| 2. Ecological Benefits | 5 | 15 | 15 | 25 | 30 | 20 | 10 | 45 | 30 | 10 | 15 | 40 | 5 | 45 | 17.5 | 22 |
| 3. Environmental Impacts | 5 | 15 | 15 | 25 | 20 | 15 | 7 | 12 | 60 | 10 | 15 | 40 | 5 | 60 | 15 | 20 |
| 4. Human Benefits | 5 | 15 | 20 | 5 | 10 | 20 | 7 | 2 | 0 | 10 | 10 | 10 | 0 | 20 | 10 | 10 |
| 5. Economic Benefits | 5 | 15 | 10 | 10 | 15 | 15 | 31 | 18 | 10 | 15 | 15 | 10 | 5 | 31 | 15 | 14 |
| 6. Implementation Costs | 40 | 20 | 10 | 15 | 10 | 15 | 30 | 8 | 0 | 40 | 20 | 0 | 0 | 40 | 15 | 17 |

Notes:

1. Weighting factors were assigned by representatives of the organization that participate in the Toledo Harbor Task Force. Participating organizations include Toledo-Lucas County Port Authority (TLCPA), Ohio Lake Erie Commission (Ohio LEC), Metroparks of the Toledo Area (MTA), Ohio Environmental Protection Agency (Ohio EPA) , City of Toledo (Toledo), Ohio Department of Natural Resources (Ohio DNR), Ohio Department of Transportation (ODOT), Lake Erie Charter Boat Association (LECBA), U.S. Department of Agriculture National Resource Conservation Service (NRCS), Maritime Industry, Lake Erie Waterkeeper (LEW), and U.S. Fish and Wildlife Service (USFWS).
2. Representatives of participating organizations assigned values between zero (least importance) and 100 (highest importance) for each of the six technical categories. The weighting factors presented do not represent the opinion of the organization.
3. The sum of assigned weighting factors across all technical categories equals 100.
4. The U.S. Geological Survey (USGS) Ohio Water Science Center did not participate in assigning weighting factors
5. No response was received from representatives of the following invited organizations: Office of Congressman Bob Latta, Lucas County, Ohio Department of Development, City of Oregon, U.S. Army Corps of Engineers, Great Lakes Commission, Ohio Sea Grant Program, and Office of Senator Sherrod Brown.

# 5.0 SEDIMENT MANAGEMENT AND USE OPTIONS

Dredged sediment is increasingly being seen as a resource rather than a waste product. Dredged material from the Toledo Harbor provides several opportunities for using the material in a manner that benefits the local area. Many ideas have been identified over the years. Based on information obtained during the first public forum and the Hull Team's experience with other beneficial use opportunities, upland, nearshore, and in-water conceptual options were identified and include:

**Upland**

- beneficial use as non-structural fill
- agricultural field improvements

**Nearshore**

- wetland restoration and shoreline protection

**In-water**

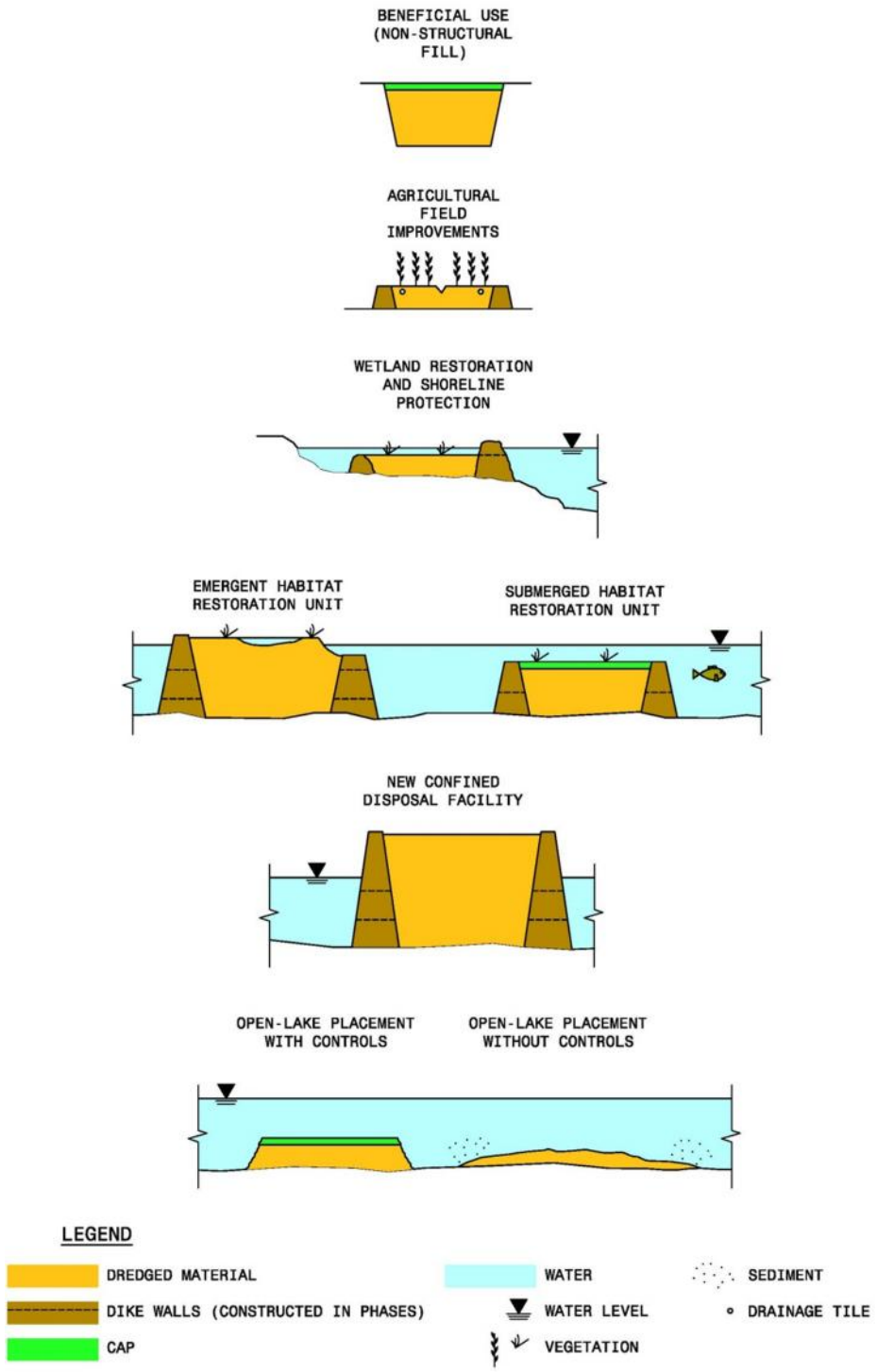
- submerged HRU
- emergent HRU
- open-lake placement with controls
- open-lake placement in a new location
- new CDF

Schematic drawings of each option are illustrated by Figure 7, Conceptual Drawings of Potential Sediment Management and Use Options. Sections 5.1 through 5.3 provide a detailed description of each option as well as the major assumptions used in the evaluation process.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## FIGURE 7

## CONCEPTUAL DRAWINGS OF POTENTIAL SEDIMENT MANAGEMENT AND USE OPTIONS



## 5.1 Upland Management and Use Options

Dredge material has been used in several upland soil related alternatives across the country, as well as locally. Upland management and use options involve the placement of dredged material on land as part of fill material, soil substitutes, or enhancements. Several upland use options were evaluated as part of this project, as discussed below.

### 5.1.1 Beneficial Use of Dredged Material as Non-Structural Fill

As part of this option, dredged material would be used as non-structural fill, both for construction and environmental projects. Some of these beneficial use options include Nu-Soil, brownfield revitalization, non-structural fill, agricultural field enhancements, etc.

For this option, it was assumed that a non-structural fill would be given away at no cost to the accepting end users. The dredged material would be hauled from the dredging operations to the existing CDF location and off-loaded from the barge into a designated re-handling area on land. This material would then be loaded into trucks and transported to a pre-determined process/dewatering site, which would be purchased, or rented, from the land owner. This site would have staging areas for the dewatering of saturated material, stockpiling of drying agent (e.g. lime) and the mixing process. Appendix G-1 contains a conceptual layout for the process/dewatering site. The saturated material would be stockpiled and dewatered. To assist in the stabilization of the material, a drying agent could be mechanically blended with the material. The final augmented product would be loaded into trucks that are contracted by the potential end users who have an appropriate end use. It is assumed that the value of the “free” material would be worth the cost to load, transport, and spread the amended material.

The following is a list of assumptions made and/or costs that were used in the evaluation of beneficial use of dredged material as non-structural fill:

- all dredged material designated to this option will be consumed;
- re-handling/off-loading area is near the existing CDF;
- process/dewatering site is within 3 miles of the off-loading site;
- an additive (lime) will be added at a ratio of 4 tons of lime per 935 CY of dry material;
- the final product would be given to the end user at no charge; and

- dredge material will be placed at off-loading site by means of a hydraulic loader.

If this option were pursued, the following evaluations are recommended in order to determine the most appropriate and cost-effective use of dredged material as non-structural fill:

- potential client markets;
- identification of locations needing non-structural fill, including a review of property use restrictions (e.g. covenant conditions);
- evaluation of potential dewatering/off-loading sites to identify the most economical location as it relates to the dredging process and the upland transportation;
- selling of the dredged material as a beneficial use would require additional testing and a detailed evaluation of distribution methods that are dependent on the proposed use;
- sediment characterization, including geotechnical and risk evaluation, to determine suitability of material that will be used for the specific non-structural fill end use; and
- determine the additional costs associated with augmentation of the material to become suitable for the end use.

### 5.1.2 Agricultural Field Improvements

The concept of this option is to use the dredged material to raise the elevation of several acres of agricultural fields where land would be rented from the land owner(s) for the timeframe required to complete the improvements. This option would improve the drainage in the agricultural fields and perhaps enrich the soil with nutrients.

For this option, dredged material would be hauled to a pump-out location near the center of gravity of the dredging work and released from the bottom of the scow or hydraulically dredged. The re-handling area would be dredged to the required size and depth, which allows the scow to have appropriate mobility. There the material would be collected by a pump-out system, which would include a series of pumps and/or manifolds to collect the dredged material as well as a sufficient amount of water to pump the slurry mix. The slurry would be pumped through an underwater pipeline conveyance system to a centralized pumping station on land. Then the material would be pumped through additional pipelines, buried within utility easements, which lead to the agricultural field location. Appendix G-2 shows the relative size of area required to place all 30M CY of material. Additional booster pumping station(s) would likely be required

depending on the pumping distance and the size of pump(s) that are chosen during the detailed design/planning phase. Dispersion points would be placed throughout the area to allow even placement of the pumped material.

A containment structure would be designed and constructed to control and divert the dredged material and associated run-off water. The majority of the containment walls would be comprised of clay berms outlining the perimeter of the area. A series of interior trenches and drainage piping would be installed to handle the dewatering process and future drainage for the completed agricultural field. Water would be collected and gravity drained by perforated drainage pipe to a header pipe prior to discharging to an appropriate ditch location.

An adequate drying process, using the aforementioned drainage system, would be implemented to decant the saturated material. After the material is evenly filled throughout the area and allowed to consolidate for approximately one year, a land cover crop would be developed for an additional year to establish an organic base. After completion, the agricultural field will be turned back over to the land owners for the continuation of agricultural use. The pumping stations and buried pipeline would remain in place for potential future irrigation activities. This option would require several detailed designs based on the projected dredging rates.

The following is a list of assumptions made and/or costs that were used in the evaluation of beneficial use of dredged material for agricultural field improvements:

- 3,000 acres of agricultural fields would be required;
- a 4 ft. improvement height would be required;
- an estimated 60% volume reduction will occur after dewatering and evapotranspiration;
- the pumping/dredging rate is 900 CY/hour;
- this option would require the purchase of additional easement land for a pipeline, estimated at $6,000 per acre;
- land rental was assumed to be $200 per acre per year for 3 years (1 year for placement, 1 year for consolidation and 1 year for land cover crop);
- land cover cost was based on initial startup costs only;
- all pumps would be purchased;

- the option would use electrical pumping operations; and
- a booster pump will be placed every 2 miles.

If this option were pursued, the following evaluations are recommended in order to determine the most appropriate and cost-effective use of agricultural field improvements:

- research potential agricultural locations in the vicinity;
- reach out to potential land owners to get feedback;
- sediment testing, including soil characteristics, potential contaminants, and nutrient values; and
- pumping and piping design.

An additional detailed study should be completed to determine potential locations that would be the most beneficial and cost-efficient depending on the projected dredging capacity. An initial review of potential agricultural property locations in the vicinity of the potential pump-out area discharge location was completed. Appendix E includes a preliminary map and summary of agricultural land owners, property size and parcel numbers within a five-mile radius of the potential discharge location of the pump-out area.

A method of sediment management similar to this option is being conducted by Ohio DNR, Division of Parks and Recreation, at East Harbor State Park, located in Lakeside-Marblehead, Ohio. Dredged material from East Harbor is being pumped onto a nearby fruit farm to raise the elevations of the farm field. Further discussion on this project is provided in Appendix F.

## 5.2 Nearshore Management and Use Options

Nearshore management and use options involve the placement of dredged material along or near the shoreline for future enhancements, protection, and restoration of the shoreline. Dredge material has been be used in many shoreline creation related options across the country. An option that restores and protects existing wetlands was evaluated, as discussed below.

### 5.2.1 Wetland Restoration and Shoreline Protection

The concept of this option is to use the dredged material to create additional wetland areas and as a protective barrier for the existing wildlife areas near the Cedar Point peninsula. An additional detailed study should be completed to determine the most beneficial and cost efficient configuration. The selected area would benefit by minimizing the erosion concerns that are

currently encountered and by the creation of controlled wetlands. A containment structure/barrier wall would be designed and constructed to withstand the wave and current impacts associated with the lake conditions. The majority of the containment structure would be comprised of local aggregate material (e.g. armor stone, underlayer stone, core stone and sand) outlining the perimeter of the proposed area. Appendix G-3 contains additional drawings and details, developed by Moffatt & Nichol, of a potential conceptual containment structure used to evaluate the option and its associated construction costs. The conceptual designs were developed using typical water levels, local storm surges, and a preliminary wind-wave hindcast. Dredged material would be transported to a pump-out location near the center of gravity of the dredging work and released from the bottom of the scow. The re-handling area would be dredged to the required size and depth to allow the scow appropriate mobility. Within the re-handling area, the material would be collected by a pump-out system, which would include a series of pumps and/or manifolds to collect the dredged material as well as a sufficient amount of water to pump the slurry mix. An alternative approach would be a hydraulic dredge hopper. The slurry would be pumped through an underwater pipeline conveyance system to a centralized pumping station on land. The material would be pumped through additional pipelines, floating nearshore or above ground on shore, which lead to the wetland areas. Dispersion points would be placed throughout the area to allow even placement of the pumped material creating a submergent/emergent surface.

Once complete, the area would be developed to establish a natural wetland habitat. Invasive species control would be included as part of a final design and O&M. Elevations within the habitat could be developed in a variety of ways to accommodate a number of different species and habitat types. If desired, a channel could remain between the restored wetland and existing wetlands. This will allow water to enter and exit the existing upland areas as it currently does and minimize impact to existing shallow shoreline habitat that is produced to pelagic wildlife. The channel will also allow navigation by small vessels and wildlife. Additional channels and swales can be further developed in the final design.

The following is a list of assumptions made and/or costs that were used in the evaluation of the wetland restoration and shoreline protection option:

- west side of Cedar Point NWR;
    - 2,650 acres would be required

  - the water depth is 2 to 5 ft. below LWD, with an average depth 3 ft. below LWD
  - a dike height 4 ft. above LWD would be required
- east of Cedar Point NWR;
  - 2,325 acres would be required
  - the water depth is 2 to 6 ft. below LWD, with an average depth 4 ft. below LWD
  - a dike height 14 ft. above LWD would be required
- the pumping/dredging rate is 900 CY/hour;
- habitat development was based on initial startup costs only;
- the pump rental was estimated per month;
- the option would use electrical pumping operations; and
- additional booster pumps would not be required.

If this option were pursued, the following evaluations are recommended in order to determine the most appropriate and cost-effective use of dredged material for wetland restoration and shoreline protection:

- evaluation of potential locations for end use;
- littoral drift patterns;
- collaboration on the targeted habitat benefits and locations; and
- structural design.

## 5.3 In-Water Management and Use Options

In-water management and use options involve the placement of dredged material within the Ohio waters near Toledo Harbor. Dredge material could be placed in a variety of HRUs or confined structures as well as into the open lake with controls or at a different location. Options evaluated included both submergent (below water) and emergent (above water) HRUs, which are options specifically designed to create aquatic and/or terrestrial habitat. The creation of a new CDF was evaluated to compare the placement of materials into a structure with minimal habitat aspects. An option that reduces the nutrient loading caused by the current open-lake

placement process by the addition of controls or relocating the placement site was also evaluated, as discussed below.

### 5.3.1 Submerged Habitat Restoration Unit

The concept of this option is to use the dredged material to assist in the development of a HRU that will provide conditions for the establishment of submergent habitat including vegetation and aquatic wildlife opportunities. An underwater containment structure would be designed and constructed to withstand the currents encountered below water as well as storm/wave energy. The majority of the containment wall would be comprised of local aggregate material (e.g. armor stone, underlayer stone, core stone and sand) outlining the perimeter of the HRU. Appendix G-4 contains additional drawings and details, developed by Moffatt & Nichol, of a potential conceptual containment structure used to evaluate the option and its associated construction costs. The conceptual designs were developed using typical water levels, local storm surges, and a preliminary wind-wave hindcast. Dredged material would be hauled to the HRU location and pumped or released into the center filling the interior until creating a submerged surface. The containment structure could be built in phases to provide adequate clearance for the scow to release the dredged material in the early stages, without the requirement of a pump. Once the structure has been filled to a specified elevation, a composite capping material would be placed on the structure, stabilizing surface areas for the desired amount of habitat development and protection against lake currents.

The following is a list of assumptions made and/or costs that were used in the evaluation of a submerged HRU:

- deep water – near Toledo Harbor Lighthouse;
  - 2,325 acres would be required
  - the water depth is 20 ft. below LWD
  - a dike height 10 ft. below LWD would be required
- shallow – near Grassy Island;
  - 9,300 acres would be required
  - the water depth is 7 ft. below LWD
  - a dike height 3 ft. below LWD would be required

- the containment structure would be completed before dredge material is placed;
- dredge material would be placed at the site by means of hydraulic unloader; and
- bentonite or similar material would be used as composite cap (surface capping areas can be decreased to reduce costs) and would also provide some habitat for benthic and fish communities.

If this option were pursued, the following evaluations are recommended in order to determine the most appropriate and cost-effective use of dredged material for a submerged HRU:

- wave climate study;
- water level fluctuation study;
- evaluate storm surge impacts;
- analyze littoral drift patterns;
- collaboration on the targeted habitat benefits and locations; and
- structural design.

### 5.3.2 Emergent Habitat Restoration Unit

The concept of this option is to use the dredged material to assist in the development of a HRU that will create island conditions for the establishment of an emergent habitat including vegetation and terrestrial wildlife opportunities. A containment structure will be designed and constructed to withstand the wave and current impacts associated with the lake conditions. The majority of the containment wall will be comprised of local aggregate material (e.g. armor stone, underlayer stone, core stone and sand) outlining the perimeter of the HRU. Appendix G-5 contains additional drawings and details, developed by Moffatt & Nichol, of a potential conceptual containment structure used to evaluate the option and its associated construction costs. The conceptual designs were developed using typical water levels, local storm surges, and a preliminary wind-wave hindcast. Dredged material will be hauled to the HRU location and pumped or released into the center filling the interior until creating an emergent surface. The containment structure could be built in phases to provide adequate clearance for the scow to release the dredged material in the early stages, without the requirement of a pump. The final surface topography could be adjusted or varied to incorporate several different habitats including emergent, wetland, submergent and aquatic. The surface would be developed by means of planting a vegetative cover, various shrubs, and small trees. After completion, the island can be further developed to include hiking trails, recreation areas and other associated

activities. Invasive species control would be included as part of a final design and O&M. During the preliminary design stages, specific areas of interest (e.g. Toledo Harbor Lighthouse) may be incorporated to determine the final location and orientation of the HRU.

The following is a list of assumptions made and/or costs that were used in the evaluation of an emergent HRU:

- deep water – near Toledo Harbor Lighthouse;
  - 405 acres would be required
  - the water depth is 20 ft. below LWD
  - a dike height 30 ft. above LWD would be required
- shallow water – near Grassy Island;
  - 1,200 acres would be required
  - the water depth is 5 ft. below LWD
  - a dike height 12.5 ft. above LWD would be required
- the containment structure would be completed before dredge material is placed;
- weir structures are included in contingency;
- dredge material would be placed at the site by means of hydraulic unloader; and
- habitat development was based on initial startup costs only.

If this option were pursued, the following evaluations are recommended in order to determine the most appropriate and cost-effective use of dredged material for an emergent HRU:

- wave climate study;
- evaluate storm surge impacts;
- collaboration on the targeted habitat benefits and locations; and
- structural design.

### 5.3.3 Open-Lake Placement

#### 5.3.3.1 New Open-Lake Placement Area (Open-Lake without Controls)

Currently, the USACE places dredged material in the northeast half of the open lake placement area, approximately located at LM-11. Stakeholders have raised concerns with open lake placement of material in the shallow western basin of Lake Erie, with average depths ranging from approximately 20-23 feet below LWD (USACE, 2009) due to potential environmental impacts that might occur through sediment re-suspension. It is also unknown the extent of which the material currently being placed in the existing open lake placement area is re-entering the Federal channel and whether "double handling" of the material is occurring. While most of the material predominately drifts to the southeast, it is possible some portion of the material could re-enter the channel due to the shallow system and when deviations from typical conditions occur. Additionally, the current open lake placement site will eventually reach capacity and will present a risk to navigational safety during scow placement. Capacity shortages may be realized in the near future if low lake levels continue.

The closest approved open-lake placement site, West Harbor, is located approximately 33 miles southeast of Toledo Harbor's current open-lake placement area. The West Harbor open-lake placement area is approximately 29 feet deep and spans approximately 160 acres. Under the current Federal Standard, costs associated with the location, including permitting, and placement of dredged material at a location other than the currently used open-lake placement site would be the responsibility of a non-federal sponsor.

Wind and wave energy significantly impacts how sediments are distributed in the western Lake Erie basin. Material placed into the existing open-lake placement area is transported south/southeast of the site and modeling suggests that potential sediment management locations further out in the western basin (e.g. open-lake placement site) are subject to more wind-wave actions compared to those closer to Maumee Bay, resulting in net erosion further out and net deposition close to the bay (LimnoTech, 2010). The new open-lake placement option evaluated under this plan would continue with the current dredging and placement methods, but re-locate the placement area approximately 15 miles from the center of gravity of the dredging work, so that the open lake placement area is in deeper water and has less potential to be re-suspended and

transported back to the Federal and non-federal channels. New open-lake placement areas should be evaluated prior to the existing open-lake placement area reaching capacity. Appendix G-7 shows the conceptual location and relative size of area required to place all 30M CY of material. It is assumed this location would have a greater depth and less current impacts than the existing location to minimize the environmental impacts and minimize sediment from re-entering the channel. A detailed evaluation of a new proposed open lake placement area would be necessary to evaluate the potential impacts to site-specific benthic and fish communities. The evaluation would need to be completed in accordance with applicable state and federal regulations (e.g. National Environmental Policy Act).

#### 5.3.3.2 Open-Lake Placement with Controls

The concept is to continue with the current dredging and placement methods of open-lake placement, but add a process that reduces the impacts of nutrient availability resulting from re-suspension. The dredged materials would be amended with aluminum sulfate (alum) or similar materials and bentonite clay or other additives prior to, or during placement in the open lake placement area. The alum solution would minimize the amount of available phosphorous that is released into the water. The addition of bentonite would act as a flocculant to minimize the potential turbidity and re-suspension issues involved with the open-lake placement. The alum solution would be applied during the dredging process as the material is placed into the scow. Once the scow is full, bentonite would be placed on top of the mixture covering the dredged material. The scow will haul to the amended material to a predetermined placement location and release the contents. Appendix G-7 shows the conceptual location and relative size of area required to place all 30M CY of material.

The following is a list of assumptions made and/or costs that were used in the evaluation of open-lake placement with controls:

- the average amount of material dredged per day is 8,000 CY;
- the unit weight of the dredged material is approximately 95 pounds per cubic foot;
- the moisture content (ratio of the weight of water to the weight of solids in a given volume of soil) of the dredged material is 145%;

- the dredged material has a dry unit weight of approximately 39 pounds per cubic foot;
- an average of 616.2 mg total phosphorus is present in 1 kg of dry sediment, all of which is assumed to be bioavailable. This is conservative, as not all of the phosphorus in the dredged material is bioavailable. However, this amount was used for rough cost purposes;
- the aluminum to phosphorus binding ration is 0.87:1;
- the quantity of bentonite required is based on 0.5%, by weight, of a scow load of dredged material;
- enough bentonite and/or alum will be hauled to the dredging operation to treat a complete a day's production of dredge material;
- the storage facility will be continually replenished with bentonite and alum solution to complete several weeks' production of dredge material; and
- the alum solution will be pumped into scow and the bentonite will be applied to the surface of the filled scow.

If this option were pursued, the following evaluations are recommended in order to determine the most appropriate and cost-effective implementation the open-lake placement with controls option:

- wave climate study;
- water level fluctuation study;
- evaluate storm surge impacts;
- analyze littoral drift patterns; and
- determine preferred treatment level (percentage of treatment will be cost-driven).

### 5.3.4 New CDF

The current CDF has a limited remaining capacity and has been restricted on what dredge material it can accept. The concept of this option is to create a new CDF for the future placement of dredged material and could accommodate material generated for both Federal and non-federal funded dredged material activities. A containment structure would be designed and constructed to withstand the wave and current impacts associated with the lake conditions. The majority of the containment wall will be comprised of local aggregate material (e.g. armor stone, underlayer stone, core stone and sand) outlining the perimeter of the CDF. Appendix G-

6 contains additional drawings and details, developed by Moffatt & Nichol, of a potential conceptual containment structure used to evaluate the option and its associated construction costs. The conceptual designs were developed using typical water levels, local storm surges, and a preliminary wind-wave hindcast. Dredged material will be hauled to the CDF location and pumped or released into the center filling the interior until the full capacity is reached. The containment structure could be built in phases to provide adequate clearance for the scow to release the dredged material in the early stages, without the requirement of a pump. Unlike the emergent HRU, this option does not include any development for habitats or wildlife although the containment structure might provide a small amount of aquatic and terrestrial habitat.

The following is a list of assumptions made and/or costs that were used in the evaluation of a new CDF:

- shallow water – near Grassy Island; and
  - 530 acres would be required
  - the water depth is 5 ft. below LWD
  - a dike height 30 ft. above LWD would be required
- a cap was not included for this option since the dredge material is not contaminated.

If this option were pursued, the following evaluations are recommended in order to determine the most appropriate and cost-effective use of dredged material for a new CDF:

- wave climate study;
- evaluate storm surge impacts; and
- structural design.

## 5.4 Other Potential Sediment Management and Use Options Not Evaluated

During the course of the grant, the Task Force agreed to several parameters to better define the scope of this grant. By following these parameters, there were some alternatives eliminated from the evaluation. However, understanding that some stakeholders were interested in better understanding the viability of these options, the project team has completed a cursory review of the major alternatives that were expressed by the parties involved.

### 5.4.1 Woodtick Peninsula/Option Located in Michigan

Woodtick Peninsula is located in Erie Township, Monroe County, Michigan and is approximately 320 acres. The location of Woodtick Peninsula is shown in Figure 1. Consumer Energy currently operates a power plant, which is scheduled to shut down in 2014. Stakeholders have expressed ideas regarding filling the existing channel on the peninsula in order to restore habitat. Given feedback from the Task Force and based on the constraints of the grant parameters, the potential options and the feasibility analyses were limited to the State of Ohio. Therefore, this project did not evaluate any options in Michigan or Canada. However, the project team estimated that approximately 1.8M CY would be required to fill the old channel at Woodtick Peninsula, or approximately two to three years capacity. The logistics of pumping the material to Woodtick Peninsula would need to be evaluated. When the selected options are chosen, it may be of value to assess locations outside of Ohio if they are available and there is sufficient community support.

### 5.4.2 Toledo Harbor Lighthouse

The Toledo Harbor Lighthouse, also referred to as the Toledo Harbor Light, is located approximately 5 miles from the shores of Maumee Bay State Park as shown in Figure 1. The lighthouse was constructed following the expansion of the Federal channel in 1901. Construction of a HRU near the Toledo Harbor Lighthouse was discussed by stakeholders at the first public forum. For the purposes of this project, no specific locations were determined for any given option. The Toledo Harbor Lighthouse was not specifically considered, but this in-water option could become part of the final project. The USACE has allocated a portion of the 2012 dredging budget toward the evaluation of a containment structure near the lighthouse, at a depth of approximately 22 feet of water. It is expected that this study of capacity and costs will be completed after this THSMUP has been finalized.

### 5.4.3 Geotubes®

Geotubes® are containers constructed of high strength, permeable textiles designed for dewatering and containment of sediment and sludge. They are used in a variety of applications including restoration, remediation, and agriculture. The use of this technology was raised during the first public forum by stakeholders. As a result, the project team evaluated the use of this technology for sediment management options at Toledo Harbor. The sediment dredged from the Federal channel is a fat clay high in silt. This type of material is not conducive for the use of Geotubes® or similar products. Geotubes® must allow water to exit and materials with high silt

content have the tendency to fill the voids of the material. The dewatering performance of Geotubes® were tested in 2009 and found to be impractical as the cost to add chemicals to stabilize the material is costly (URS/Baird, 2011).

### 5.4.4 Existing CDF and Grassy Island

Facility 3 has approximately 2M CY of USACE space available, or the capacity of about two years of dredging materials. Placement of material at the CDF is not a long-term 30-year option. Based on current USACE policy and Public Law 94-587, any dredged material determined to meet Federal guidelines (including applicable state water quality standards for open-lake placement cannot be placed in Federal CDFs. Grassy Island (Island 18) has a component that could accommodate approximately half of a years' worth of dredged sediments, but still requires more repair and replacement such as pump-out facilities. These could be used as part of the footprint for an option, not to expand but to maximize. However, there is a high capital cost of building a pump-out facility and repairing Grassy Island for the capacity, which would put it at the upper end of the cost for a new CDF. Also, the existing CDF capacity is maintained in the event of a spill response emergency in which contaminated material needs to be placed. Further, the USACE only maintains the Federal channel. The TLCPA and terminal operators cannot place material dredged from the Port terminals in the open lake placement area. This material must be placed in a CDF or used at an upland location.

Proposed sediment management and use options focused on short- and long-term options that could accept a significant amount of the 30-year dredging amount. Due to the limited capacity at the existing CDF and Grassy Island, these options were not considered.

## 5.5 Sediment Management and Use Options Summary

The primary goal of this THSMUP was to evaluate options based on the implementation of environmentally and economically accepted methods, while accommodating the placement capacity for 30 years of maintenance dredging in the Toledo Harbor. Although a combination of different options is likely a better solution than a single-option scenario, several options, including upland, nearshore, and in-water options, were carried forward to evaluate their individual suitability as short- and long-term options. The relative cost estimates for these options are discussed in Section 6.0, while the technical evaluation of each option is discussed in Sections 7.0 and 8.0. Additional data collection and detailed analyses will be required to

confirm and/or refine all of the assumptions made for this THSMUP and are discussed in Section 6.0. This information will be used to complete the final design and implementation plan.

# 6.0 SEDIMENT MANAGEMENT AND USE COST ESTIMATE AND ASSUMPTIONS

## 6.1 Projected Relative Costs

Prior to initiating the technical scoring and ranking of sediment management and use options, the technical team developed assumptions and cost estimates for major components of a sediment management and use option. The major components of these costs for each option are discussed below and include the initial construction costs of all required structures, dredging, transportation, placement, site development, mobilization/demobilization, planning, engineering, and design (PED), O&M, and a contingency cost. The conceptual plans and drawings used to develop the projected costs are provided in Appendix G.

The projected costs were determined by comparing a wide range of known methods and materials that are common to the project area and then selecting a reasonable choice in order to achieve a good comparison among all options while completing estimates at an appropriate level of detail. Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by, and reviewed under the supervision of, professionals who are competent in construction cost estimating, possess a working knowledge of construction, and capable of making professional determinations based on experience. These concepts are not detailed designs and should not be used for construction, but are of appropriate levels to fulfill the requirements of the QAPP and are suitable for relative comparison. Similarly, the prepared cost estimates are not an opinion of probable costs and should not be used for potential funding values, but they are of sufficient detail to fulfill the requirements of the QAPP and are suitable for relative comparison.

Detailed costs and associated calculations are discussed in the following sections and are provided in Tables H-1 through H-16 in Appendix H. Tables H-1 and H-2 provide the estimated total costs for each single-option evaluated and the combination option. Tables H-1 and H-2 include major cost element categories used to derive the estimated total costs and are identified by an Item Number (e.g. Item 1.0). The sub-components of each major cost element category (e.g. Item 1.1, Item 1.2) are identified in Tables H-3 through H-16, where appropriate.

The estimated relative costs were also used to perform a preliminary sensitivity analysis determining the likely relative most efficient configuration of each option and ultimately helping

to define the proposed combination of options. These configurations should not be considered final, but are representative for discussion purposes of this THSMUP. Prior to the final selection, additional sensitivity analyses should be performed in more detail to accurately determine the best configuration and combination of options. Section 6.2.1 discusses additional evaluations that should be considered in the next phase.

### 6.1.1 Dredging

The dredging process and associated costs were based on recent practices common to the dredging of the Toledo Harbor. All options that were evaluated included this initial dredging cost, as identified by Item 14.0 in Tables H-1 and H-2. During common practices, material is dredged from the channel using a mechanical clamshell dredge, which loads bottom dump scows with the dredged material. The scows haul the material to the placement area and release the material through the bottom of the vessel. The assumed cost of this practice, $6/CY, includes a one-way haul distance of 2 miles. The dredging rate for this process is approximately 900 CY per hour or 240,000 CY per month. There are many dredging alternatives, including hydraulic dredging, that can be further evaluated and which could provide a cost savings depending on the specific option chosen.

This cost was used for general estimating purposes so that a comparative analysis of options could be completed. An evaluation of alternative dredging methods should be completed to accommodate the selected option or combination of options to allow for the determination of the most efficient completion time, economical benefit, and environmental effects. The Task Force should consider completing a cost analysis and evaluation of types of dredging and material handling and transportation costs relative to the specific sediment management and use option employed at a specific geographic location.

### 6.1.2 Containment Structures

A majority of the options would require the construction of a containment structure(s) to control the dredged material. These structures define the perimeter and shape of the placement area and were based on the 30M CY of dredged material that is projected to be removed from the Toledo Harbor over the next 30 years. Unless specified, consolidation was not considered and there were no volume reductions applied. A cost-effective shape (square) was assumed for the layout. The placement area was assumed to be constructed as one cell that could handle the full amount of material and that it would be constructed before the material placement would

begin. Depending on the orientation of the final shape and orientation of the structure, the amount of material, and the final location, it might be more feasible and realistic to build multiple cells in several phases throughout the dredging process. The phased construction would increase the overall cost of the option.

The conceptual drawings and details of conceptual containment structures developed for the wetland restoration/shoreline protection option, deep water and shallow water submerged HRU options, deep water and shallow water emergent HRU options, and the new CDF option, developed by Moffatt & Nichol, are provided in Appendix G-3 through Appendix G-6. Associated construction costs for the conceptual containment structures developed for these respective options are provided in Tables H-6 through H-11 of Appendix H. The conceptual containment structures are oriented to minimize the amount of slope protection needed to accommodate typical water levels, local storm surges, and a preliminary wind-wave hindcast.

During the course of the project, it was apparent that the USACE was in progress of completing, or had completed, similar structure designs such as an HRU near the Toledo Harbor Lighthouse location. Although public presentations and conceptual designs and preliminary cost estimates were completed, the USACE elected not to share calculations and data as requested by some Task Force representatives. USACE reported that even though the level of work was sufficient to develop costs and be shared for public comment, the supporting documentation could not be released based on USACE internal guidelines and that the requested information and data would not be released until senior peer review was completed. In December 2012, USACE informed the Task Force that the project would not continue due to the lack of a non-federal sponsor. Not having the benefit to use existing USACE data and information, the Hull Team used methods, procedures, and guidelines (e.g. Costal Engineering Manual, USACE Manuals) similar to those used by USACE to develop an appropriate level of design. Wind data was obtained from the Toledo Express Airport. Fetch distances and average water depths were obtained from National Oceanic and Atmospheric Administration (NOAA) Charts 14830, 14846, and 14847. The Hull Team's preliminary wind-wave hindcast was used to establish preliminary dike heights used in the conceptual designs. The results of preliminary wind-wave hindcast were similar to those reported in the portions of USACE-managed *Toledo Harbor Habitat Restoration Unit Conceptual Design Report* (URS/Baird, 2011) that were released to the Task Force.

The preliminary design of the containment dikes consists of a core stone or sand, an underlayer stone, and an armor stone based on available local aggregate materials. The bulk of the containment dike consists of core stone at an assumed cost of $50 per ton. The design provides for the installation of underlayer stone over the core stone as a slope protection layer to prevent erosion at an assumed cost of $85 per ton. The design also includes the installation of armor stone over the underlayer stone as a slope protection layer to absorb the wave and current impacts at an assumed cost of $100 per ton.

The deep water and shallow water submerged HRU options include a composite cap, as identified by Item 3.0 in Appendix H, to provide a surface that can be developed into a habitat. A basic bentonite mixture was assumed for the cap, which would give the surface more stability to support vegetation. The entire surface, or portions of the surface, could be capped depending on the wave impacts and the required area desired for habitat development. Capping costs are estimated at $4 per square foot and consider capping 50% of the deep water habitat restoration surface.

The construction costs estimated for containment structures are based on discussions with local marine contractors and on the use of typical methods such as barge transportation and mechanical placement of the materials. Depending on the location (water depth), alternative methods such as floating conveyors might be more advantageous than the barge transportation. Although several construction methods are possible, common practices and similar methods were assumed for each option in order to keep the costs relative throughout and from becoming too aggressive or underestimated.

The construction costs estimated for containment structures (e.g. clay berms) used in the upland agricultural field improvement option are provided in Tables H-4 and H-5 of Appendix H. Costs assume clay berms are sufficient to contain the dredged material. These clay berms would be installed using typical land-based methods such as truck transportation and dozer placement.

### 6.1.3 Dredged Material Placement

In addition to the initial dredging costs discussed in Section 6.1.1, Item 10.0 of Tables H-1 and H-2 provides the estimated cost to unload or place the hauled dredged material at the placement area. No additional cost is included in Item 10.0 for options that allow for the

material to be released from the bottom of the scow at the placement area to the pump-out area described in Section 6.1.6. The beneficial use option, deep water and shallow water emergent HRU options, deep water and shallow water submerged HRU options, and new CDF option include a dredged material placement cost of $7.50/CY since placement of the dredged material within a containment structure, or at an upland location, requires the material be pumped from the scow by means of a hydraulic unloader or similar piece of equipment. Future evaluations could determine that a phased construction of the containment structure to allow the material to be released from the bottom of a scow, or through the use of a mechanical unloader, could be more feasible than the use of a hydraulic unloader to place the entire volume of the dredged material. This evaluation will be dependent on location (water depth) and the site-specific option.

### 6.1.4 Habitat/Site Development

The wetland restoration/shoreline protection option and deep water and shallow water emergent HRU options include estimated costs associated with future habitat development after the completion of dredged material placement. Item 5.0 of Tables H-6, H-9, and H-10, provided in Appendix H, includes the estimated costs to establish an indigenous vegetative cover and a good base to support wildlife at select areas of an option. The costs assume initial planting costs of $2,000 per acre and that the site would re-vegetate naturally after the initial planting. Although these initial assumptions were made to keep the costs relative, further evaluations could be performed to weigh the benefits and costs associated with additional habitat areas and further development within established areas. Invasive species control would be included as part of a final design and O&M. .

The beneficial use option and open-lake placement with controls option include estimated costs associated with initial site development prior to dredged material processing, placement, or storage activities. Item 5.0 of Tables H-3 and H-12, provided in Appendix H, includes the estimated costs for site development.

For the agricultural field improvement option, the placement site would require the implementation of infrastructure prior to releasing the material. This development cost would include land purchase/rental, pipeline installation, pump(s) purchase, pumping costs, pump station(s) construction, and other miscellaneous land improvements. Item 5.0 of Tables H-4 and H-5, provided in Appendix H, assumes a cost of $6,000 per acre for the purchase of land

used for dredged material transportation infrastructure or to house any other permanent structure required. Alternatively, landowners might lease their land to allow for site development in exchange for the benefits of owning an enhanced agricultural property. A land rental cost of $200 per acre per year was included for farmland that would not be able to produce the normal cash crop during the development, placement, dewatering and replenishing periods. The cost assumes that a pump would be purchased for a cost of $100,000 for each pumping distance of less than 2 miles and some required maintenance and pump replacement would be needed. When temporary or mobile pumps were more practical, a cost of $4,000 per month to rent the pump was assumed. A pump station was assumed at the same intervals for a cost of $50,000 including any miscellaneous access and security. In cases where the pumps would be placed permanently, an electric operating cost of $0.15 per kilowatt hour (kWh) was chosen. If the pump was predominately for temporary use, or required mobilization, a fuel cost of $4 per gallon was chosen.

The price of $6,000 per acre was used for the purchase of easement rights to install a 16-inch high-density polyethylene (HDPE) pipeline along roadsides at an assumed cost of $200 per lineal foot in order to transport the dredged material to the placement site as part of the wetland restoration/shoreline protection option and the agricultural field improvement option. After reaching the site, a discharge pipe with shut off valves at a cost of $100 per lineal foot would be used to evenly place the dredged material throughout the site. The discharge pipeline would be managed by a three-man crew whose hourly rate was assumed to be $50 per man-hour for the entire pumping duration to move the pipeline to the required areas in order to discharge the dredged material. The agricultural field improvement option includes additional site-specific development to attain the final goal. A drainage system to collect runoff water at a cost of $3 per foot would be installed for dewatering the dredged material and would remain in place for future drainage. After the material dewatered and consolidated, a cost of $100 per acre to plant a land cover crop (e.g. alfalfa) was assumed in order to introduce some organics back into the material.

### 6.1.5 Nutrient Loading Controls/Capping

The open-lake placement option is the only option that includes a cost for any type of amendment to control the nutrient loading that might be associated with the placement of dredged material. Estimated costs associated with the amendment and application are provided by Items 6.0 and 8.0 of Table H-12. An estimated cost of $1/CY is included to amend

the material with aluminum sulfate (alum) to minimize the amount of available phosphorous that is released and bentonite clay to act as a flocculant to minimize the potential turbidity and re-suspension issues associated with the placement process. Labor for alum and bentonite application is estimated at $1/CY. The controls that were assumed for this option could be applied to any option and cost could be adjusted to increase the phosphorus and turbidity reduction or decreased to reduce the cost. Additional information on this amendment method is provided in Appendix I.

### 6.1.6 Pump-Out Area Development

A relatively new concept to the dredging world involves the development of a pump-out system, which uses a system of pumps and pipelines to transport dredged material. This system would be located near the center of gravity to greatly reduce the in-water transportation costs associated with the current dredging process. This improvement would require the implementation of permanent infrastructure as part of the wetland restoration/shoreline protection option and the agricultural field improvement option. Costs associated with the pump-out area development are identified by Item 7.0 of Tables H-4 through H-6, provided in Appendix H. The development costs include the required dredging for scow mobility, pipeline installation, purchase of pumps, pumping costs, docking structures and other miscellaneous improvements. A cost of $20 per CY to dredge out the re-handling area and to bury the pipeline includes mechanical dredging, scow transportation and placement of the material. An installation cost of $500 per lineal foot for a 16-inch HDPE pipeline and an additional cost of $600 per ton for concrete ballasts using marine equipment are assumed in order to minimize any boating obstructions. The pump-out area is assumed to have three in-take locations to allow the scow to bottom release the material similar to the open-lake placement. Each in-take requires the construction of a docking structure at an estimated cost of $1,000,000 each for the 30-year project life. A jet pump or slurry pump would be attached to the docking structure and operated by a one-man crew at a rate of $50 per hour. For the pumps, an assumed rental rate of $4,000 per month per pump and an operating cost of $4 per gallon were used.

Once the pump-out system is completed, it could be used for the transport of dredged material to any upland or nearshore option. In addition, if several options use the same pump-out area, the initial infrastructure costs would be divided between the options, thus lowering the relative unit cost. For the initial evaluation of each single-option, it was assumed that each option would absorb the full infrastructure cost. This pump-out area concept was selected to avoid any

disruptions to the current dredging methods performed by the USACE. Additional dredging evaluations should be conducted to determine the most efficient dredged material transport method. The costs involved to develop the infrastructure should be compared to other concepts such as the use of a hydraulic dredge within the centralized dredging area where the bulk of dredging is routinely required.

### 6.1.7 Placement Sites Proximity to Center of Gravity

Since the initial dredging cost included a one-way haul of 2 miles, an increase or decrease was given to sites that were farther away or closer than the 2-mile range, as identified by Item 11.0 of Tables H-1 and H-2 in Appendix H. The cost of $0.16 per CY of material per mile to haul the material was determined by the average size of the current scows used and the travel time of those scows. The options that use the pump-out area would have a minimal travel time and therefore receive the greatest decrease in cost, but would incur the pump-out area development cost.

### 6.1.8 Mobilization/Demobilization

Mobilization includes all activities and associated costs for the transportation of dredging or construction equipment, and operating supplies to the site in order to commence a phase or portion of the project. Demobilization includes all activities and associated costs for transportation of dredging or construction equipment, and operating supplies from the site that are no longer required to complete a phase or portion of the project. This includes the disassembly, removal, and site clean-up. Depending on the option and the schedule of the option, there might be several mobilizations and demobilizations. For the purpose of this study, an 8% increase to the construction and development costs was assumed. Mobilization/demobilization is identified by Item 9.0 of Tables H-1 and H-2 in Appendix H.

### 6.1.9 Planning, Engineering, and Design (PED)

This cost element includes the miscellaneous PED that will be required for each site-specific option. Once an option is chosen, additional data will need to be obtained to further refine the selected option. This process will take into account the assumptions made and steps that were outside of this evaluation to determine if the assumptions apply or need to be revised. For the purpose of this study, a PED cost of 10% of the overall projected cost was assumed. PED is identified by Item 12.0 of Tables H-1 and H-2 in Appendix H.

### 6.1.10 Operation and Maintenance (O&M)

This cost element includes all of the required O&M that will be required for each option during the dredging and construction process. The options will require careful coordination between the dredging and construction activities that take place concurrently. A continual analysis of the operation will produce an optimum level of quality, efficiency, and effectiveness. For the purpose of this study, a 5% increase to the overall projected costs was assumed. O&M is identified by Item 13.0 of Tables H-1 and H-2 in Appendix H.

### 6.1.11 Contingency

The contingency cost element includes all of the unknown or unforeseen circumstances that might arise during the implementation of the option. This cost was also intended to include any of the minor intangible costs associated with the option that were not included in this evaluation. For the purpose of this study, a 25% increase to the overall projected costs on top of the mobilization/demobilization, PED, and O&M was assumed. A contingency for unidentified costs is identified by Item 15.0 of Tables H-1 and H-2 in Appendix H.

## 6.2 Major Assumptions

Major assumptions used to develop the cost estimates include the following:

- each option was evaluated to receive all of the 30-year estimated dredged material volume (30M CY) despite initial assumption that a combination option was likely a better solution;
- no regulatory/programmatic constraints were considered, especially in the long-term sense;
- not intended to anticipate every problematic cost;
- costs were used to serve as a relative comparison between options - not to be used as comprehensive cost estimate for each alternative;
- the location of each option was approximated for estimating purposes;
- not an exhaustive financial analysis;
- basic attempt to recognize major capital improvement and O&M costs; and
- current economic values without inflation.

When, and if, a specific option is selected for implementation, a site-specific design will need completed to determine whether the sediment source from a specific geographic location is

suitable for a specific end use and location. Such determinations will consist of evaluations of existing data and/or the collection of new site-, use-, or material-specific data to characterize the physical suitability (e.g. grain size, texture, plasticity, organic content, etc.) engineering suitability (e.g. compatibility, consolidation, shear strength, etc.), and environmental suitability (e.g. chemical concentrations, toxicity, leaching potential, etc.) of site-specific sources of dredged material and a final use/placement option. The completion of these evaluations will be used in the final design and implementation plan to determine the construction sequence and methods used, the structures involved, the environmental and economic benefits desired, the overall size, and the final location.

The following general items might be required:

- complete sediment testing;
- research potential client markets;
- evaluate potential locations for end use;
- complete detailed analysis on the type of end use;
- evaluate potential dewatering/off-loading sites;
- reach out to potential land owners to get feedback;
- complete pumping and piping design;
- collaborate on the targeted habitat benefits;
- complete structural designs;
- complete a wave climate study;
- complete a water level fluctuation study;
- evaluate storm surge impacts;
- analyze littoral drift patterns
- develop adaptive management strategy for invasive species control, if applicable; and
- determine preferred treatment level (percentage of treatment will be cost-driven).

# 7.0 SEDIMENT MANAGEMENT AND USE OPTION EVALUATION RESULTS

## 7.1 Introduction

As discussed previously, this THSMUP evaluates alternatives to current open-lake placement practices and provides recommendations for sediment management and use options including HRUs and other beneficial use concepts. Options presented in Section 5.0 were first evaluated as stand-alone sediment management solutions based on the major assumptions described below. These options were evaluated using a scoring matrix, which allows for an objective evaluation of a number of options based on several criteria categories, which are prioritized prior to scoring each option.

### 7.1.1 Single-Option Major Assumptions

Based on direction from the Task Force, some assumptions were incorporated into the development and evaluation of each option and include:

- Each option was initially evaluated to receive all of the 30-year estimated dredged material volume (30M CY) despite an assumption that a combination option is likely a better solution.
- No regulatory/programmatic constraints were incorporated into the evaluation, in the consideration of long-term (30-year) options. This assumption was made in part due to the unpredictable nature of regulatory/programmatic constraints, as well as the possibility to change these constraints within the next 30 years.
- The cost estimates developed as part of this project were not intended to anticipate every programmatic cost. Costs were estimated to the same level of detail and are based on very preliminary designs only. Costs were used for relative comparisons and scoring purposes and should not be considered as more than cost ranges at this point.
- When, and if, a specific option is selected for implementation, a site-specific design will need completed to determine that the sediment source from a specific geographic location is suitable for a specific end use and location. Such determinations will consist of evaluations of existing data and/or the collection of new site-, use-, or material-specific data to characterize the physical suitability (e.g. grain size, texture, plasticity, organic content, etc.) engineering suitability (e.g. compatibility, consolidation, shear strength, etc.), environmental suitability (e.g. chemical concentrations, toxicity, leaching potential, etc.), ecological suitability (e.g. species selection, invasive species management, wetland impacts, etc.) of site-specific sources of dredged material and a final use/placement option. A refined cost estimate will also need to be completed to account for site-specific design considerations.

When evaluating each single-option using the matrix approach, several assumptions were built in to the assessment and include:

- Each single-option was evaluated to receive all of the 30-year estimated dredged material volume (30M CY) despite initial assumption that a combination option is likely a better solution.
- Unit Costs were:
  - used to serve as a relative comparison between options - not to be used as comprehensive cost estimate for each option;
  - used for estimating purposes based on the approximate location of option;
  - not an exhaustive financial analysis; and
  - used for a basic attempt to recognize major capital improvement and O&M costs.
- The initial evaluation did not consider:
  - all aspects of a specific location of option;
  - current programmatic/regulatory restrictions;
  - funding availability and sources;
  - limitations on currently accepted practices; or
  - inflation of current market costs.
- The initial evaluation did consider:
  - the option location relative to center of gravity of estimated volume of material dredged between 2001-2010;
  - current lake bathymetry; and
  - current market costs.
- No programmatic constraints were considered during the evaluation of the options.
- It was assumed that a combination option is likely a better solution than a single-option approach.

### 7.1.2 Risks

The selection of any option involves a certain degree of risk. Some options involve a higher degree of risk in relationship to other options. These risks are associated with the unknown

circumstances and the assumptions made. The assumptions will be a statistical judgment based on all available information. The project life and capacity of each option must be determined in order to finalize the overall design. The actual amount of required dredging during the project life is unknown and an assumption will be made, based on historical data and projected quantities, to determine the required capacity. Using the current advancements in water quality protection, the latest technology in the dredging process and the selection of a new placement option, the overall amount of sediment that reaches the channel should be reduced. If the required quantity of dredged material is decreased over time and the projected dredging amounts are too high, then the initial designs would be oversized. For most options (e.g. HRUs, CDFs), the full predetermined amount of projected dredge material is required in order to achieve the desired environmental and economic benefits. Other options (e.g. agricultural field improvements, beneficial use) can be reduced and/or terminated and re-implemented depending on the demand for sediment placement. An evaluation of the projected reduction should be completed prior to the design and to help determine the final option or combination of options.

The actual volume of dredged material is unknown and assumptions were made based on historical data and projected consolidation rates to determine the required capacity. In order to project actual consolidation rates, additional sample collection and testing will be required. The current volume assumed is based on cut CY, which are inclusive of the buoyant forces acting on the sediment prior to removal from the lake. Once the sediment is removed from the lake, the water is removed and the overall volume is reduced. For most options (e.g. submerged portions of HRUs) when the sediment is placed into the containment area, it will be re-introduced to some buoyant forces. For other options (e.g. agricultural field improvements, beneficial use), additional consolidation will occur and the overall volume will be reduced further when the sediment is placed into the containment area or relocated to an upland location. An evaluation of the projected consolidation should be completed prior to the design and to help determine the final option or combination of options.

## 7.2 Technical Criteria and Scoring Results

Within each technical criteria category, the technical team developed a number of category-specific attributes. For example, the human benefit criteria category included attributes such as recreational benefits, flood protection, and aesthetics, among others. The technical team assigned scores to attributes within each criteria category ranging from 1 to 5, with higher

scores representing benefits and/or minimal complications, as described below. The technical team also took into consideration that although an option might result in a negative short-term impact, the overall long-term benefits outweigh short-term impacts. For example, wetland creation can result in temporary impacts to surface water during the construction. However, over the long-term, the wetland will improve overall surface water quality. A discussion of major technical criteria categories and attributes and scoring are presented below.

### 7.2.1 Feasibility Scoring Summary

Feasibility included attributes addressing the technical, logistical, institutional, and constructability factors described in this section. All options will have a degree of difficulty associated with the factors above and were evaluated and scored on the complications required to overcome the criteria listed below:

- Placement timing and sequencing - Options were scored based on their ability of the site to accept material based on timing and volume. Options that can handle a large volume of sediment and/or can be placed in a timely manner were given higher scores than options in having more complicated or difficult to overcome timing and sequencing factors.

- Capacity Expansion Capability - Options were scored based on their ability to expand the option to accommodate a larger capacity or add on additional areas. Options that can be easily expanded were scored higher than options with limited expansion capability.

- Size of Overall Footprint - Options were scored based on the projected area disturbed from initial dredging activity to final placement area. Options that have a smaller footprint were scored higher than those which have a large overall footprint.

- Implementation/Construction Complexity - Options were scored based on the complexity of design/construction activities and implementation of processing/management plans. Options that have a low implementation/construction complexity were scored higher than those which have high complexity of design/construction activities and implementation of processing/management plans.

- Construction Duration - Options were scored based on the length of construction time that is required before placement of material can begin. Options that take less time to construct were scored higher than options which have relative lengthy construction durations.

- Site Accessibility - Ease of access was scored for each option and determined by factors including route, distance, and logistics. Options that have better site accessibility were scored higher than options having relative limited site accessibility.

For each option evaluated, a score was assigned for each of the feasibility attributes according the following scale:

1- Highly complicated

2- Moderately to highly complicated

3- Moderately complicated

4- Minimally to moderately complicated

5- Minimally complicated

The technical scoring results for feasibility are presented in Table 6. The open-lake placement options resulted in the highest overall feasibility technical score due to the ease of implementation and similarities to the current dredging process. The remaining options scored relatively close, meaning that these options have a similar degree of complication involved in preparing each option for final implementation. The submerged shallow water HRU scored the lowest due to the large footprint size and required construction time period.

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## TABLE 6

## SUMMARY OF SCORING FOR FEASIBILITY

| Feasibility Criteria | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | New Open-Lake Placement Area without Controls | Open-Lake Placement with Controls | New CDF |
| Placement Timing and Sequencing | 1 | 5 | 5 | 5 | 4 | 3 | 3 | 4 | 5 | 4 | 5 |
| Capacity Expansion Capability | 5 | 5 | 4 | 5 | 3 | 2 | 5 | 5 | 5 | 5 | 4 |
| Size of Overall Footprint | 2 | 4 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 3 |
| Implementation and Construction Complexity | 4 | 1 | 2 | 2 | 2 | 3 | 4 | 3 | 5 | 4 | 3 |
| Construction Duration | 5 | 1 | 2 | 2 | 2 | 3 | 4 | 4 | 5 | 5 | 2 |
| Site Accessibility | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 4 |
| **Total Technical Score** | **21** | **20** | **19** | **20** | **16** | **17** | **22** | **21** | **25** | **25** | **21** |
| **Average Technical Score** | **3.5** | **3.3** | **3.2** | **3.3** | **2.7** | **2.8** | **3.7** | **3.5** | **4.2** | **4.2** | **3.5** |
| **Average Weighted Score (Avg. Score x 17)** | **59.5** | **56.1** | **54.4** | **56.1** | **45.9** | **47.6** | **62.9** | **59.5** | **71.4** | **71.4** | **59.5** |

### 7.2.2 Ecological Benefits/Effects Scoring Summary

Various ecological benefit attributes were selected to evaluate each option. Options can both negatively and positively impact ecological benefits and some criteria are interdependent. Thus, the net overall ecological benefit/effect was evaluated and scored for each option relative to the final placement/management location. Existing information and studies were used to evaluate the impact of each option on the ecological attributes below.

- Planktonic and Benthic Community/Habitat - Many species (e.g. aquatic worms, dipteran larvae, and midges) live on the lakebed or within the subsurface layers.

Additionally, species that are floating or weakly swimming have the potential to be impacted due to their restricted movement. Options that will create or enhance the planktonic and benthic community were given a score greater than 3 while those that remove or negatively impact this habitat type were given scores less than 3.

- Fish and Aquatic Invertebrate Species/Habitat - This criterion included conditions that support fish and invertebrate habitat including submerged aquatic vegetation and fish spawning, nursery, and refuge areas. Options that will create or enhance these types of habitats were given a higher score than those that remove or negatively impact these habitat types.

- Wetlands (Coastal and Non-coastal) - Wetlands provide many ecological benefits. Much of the wetlands in the Lake Erie watershed are gone and few coastal wetlands remain. Options were scored based on the potential impacts to existing wetlands or creation of new wetland areas that provide ecological benefits. Options that will create significant wetland areas were given high scores while options that will negatively impact wetlands were given a low score.

- Protected Species/Habitat - Each option was scored based on the impact to rare, threatened, and endangered species and their habitat. This criterion includes impacts to state listed species as well as species protected under federal acts, such as the Bald and Golden Eagle Protection Act and Endangered Species Act.

- Pelagic Birds/Habitat - This criterion rated the impact of each option on avian species that rely heavily on coastal and open water. Options that will create or improve pelagic bird habitat were scored higher than options that are likely to have no impact or an adverse impact to pelagic bird species or their associated habitat.

- Terrestrial Species/Habitat -The impact on land-based flora and fauna (e.g. forests, mammals, amphibians) was evaluated and scored for each option. Options that will benefit terrestrial species or habitat were scored high while options that will negatively impact this habitat were scored lower.

- Creation of Surface Water Features with Ecologically Beneficial Habitat - Options that will create ecologically beneficial habitat via the creation of surface water features were scored higher than options that will remove or negatively impact existing surface water bodies.

For each option evaluated, a score was assigned for each of the environmental attributes according the following scale:

1- negative overall effect, high level of effort to overcome

2- negative effect, moderate level of effort to overcome

3- minimal effect

4- positive effect, moderate degree of benefit

5- high positive effect, high degree of benefit

The technical scoring results for ecological benefits/effects are presented in Table 7. The wetland restoration and shoreline protection option resulted in the highest overall ecological benefits/effects technical score, followed by the emergent and submergent HRUs, respectively. These options are expected to create various ecological habitats, including fish and aquatic habitat, pelagic bird habitat, and terrestrial habitat. The open-lake placement options scored the lowest for ecological benefits/impacts, meaning that these options have a potentially slight negative impact on ecological benefits, with a moderate level of effort to overcome. Other options, such as beneficial use and agricultural field improvements, are expected to have minimal ecological benefits/effects.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 7

## SUMMARY OF SCORING FOR ECOLOGICAL BENEFITS/EFFECTS

| Ecological Benefits/Effects Technical Criteria | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | New Open-Lake Placement Area without Controls | Open-Lake Placement with Controls | New CDF |
| Planktonic and Benthic Community/Habitat | 3 | 2 | 2 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 2 |
| Fish and Aquatic Invertebrate Species/Habitat | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 2 |
| Wetlands (tidal, non-tidal) | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| Protected Species/Habitat | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| Pelagic Bird Species/Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 4 |
| Terrestrial Species/Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| Creation of Surface Water Features with Ecologically Beneficial Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 4 |
| **Total Technical Score** | **21** | **25** | **26** | **23** | **23** | **28** | **21** | **21** | **19** | **19** | **21** |
| **Average Technical Score** | **3.0** | **3.6** | **3.7** | **3.3** | **3.3** | **4.0** | **3.0** | **3.0** | **2.7** | **2.7** | **3.0** |
| **Average Weighted Score (Avg. Score x 22)** | **66.0** | **79.2** | **81.4** | **72.6** | **72.6** | **88.0** | **66.0** | **66.0** | **59.4** | **59.4** | **66.0** |

### 7.2.3 Environmental Impacts/Effects Scoring Summary

Various environmental impacts/effects attributes were selected to evaluate each option. It was recognized that options could both negatively and positively impact the environment and that

some criterion are interdependent. Existing information and studies were used to evaluate the impact of each option on the attributes below.

- Hydrodynamic Effects - Options were evaluated and scored based on their potential to alter erosion and re-suspension of sediment due to surface water currents or runoff. Options that will reduce sediment re-suspension or erosion were given high scores while options that will increase sediment erosion and re-suspension were given low scores.

- Land Improvements - Options were scored based on the degree to which they created, stabilized, or improved the structure of land as well as the impact of the option on existing physical conditions (e.g. grain size, existing quality). Options that will have a negative impact on land improvements were given a low score while options that are likely to improve or benefit land improvements were given a high score.

- Surface Water Quality - This criterion evaluated the impact of the option on surface water quality such as dissolved oxygen, turbidity, nutrients, and contaminants. Options that will negatively impact surface water quality were given low scores while options that benefit surface water quality were given high scores.

- Groundwater Quality - Options were scored based on their potential impact to groundwater quality (e.g. water table impacts, contaminants, nutrients).

For each option evaluated, a score was assigned for each of the environmental attributes according the following scale:

1- negative overall effect, high level of effort to overcome

2- negative effect, moderate level of effort to overcome

3- minimal effect

4- positive effect, moderate degree of benefit

5- high positive effect, high degree of benefit

The technical scoring results for environmental impacts/effects category is presented in Table 8. Most options scored above 3.0, or had some net positive environmental impact/effect. The agricultural options had the highest technical scoring for environmental impacts/effects, followed by the beneficial use option. The new open-lake placement area without controls and the new CDF options scored lowest for environmental impacts/effects with scores below 3.0.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 8

## SUMMARY OF SCORING FOR ENVIRONMENTAL IMPACTS/EFFECTS

| Environmental Impacts/Effects Technical Criteria | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | New Open-Lake Placement Area without Controls | Open-Lake Placement with Controls | New CDF |
| Hydrodynamic Effects | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 3 | 2 |
| Land Improvements | 5 | 4 | 4 | 3 | 3 | 4 | 5 | 5 | 3 | 3 | 4 |
| Surface Water Quality | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 1 | 4 | 2 |
| Groundwater Quality | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 3 |
| **Total Technical Score** | **16** | **14** | **14** | **13** | **13** | **14** | **17** | **17** | **8** | **13** | **11** |
| **Average Technical Score** | **4.0** | **3.5** | **3.5** | **3.3** | **3.3** | **3.5** | **4.3** | **4.3** | **2.0** | **3.3** | **2.8** |
| **Average Weighted Score (Avg. Score x 20)** | **80.0** | **70.0** | **70.0** | **66.0** | **66.0** | **70.0** | **86.0** | **86.0** | **40.0** | **66.0** | **56.0** |

### 7.2.4 Human Benefits/Effects Scoring Summary

Various human benefit attributes were selected to evaluate each option. It was recognized that options could both negatively and positively impact humans and that some criterion are interdependent. Existing information and studies were used to evaluate the impact of each option on the attributes below.

- Recreation Opportunity - Options were evaluated based on their likelihood to provide recreation opportunities such as fishing, boating, swimming, hiking, wildlife observation, and parks. Options that are likely to create recreational opportunities were given a high score while options that are likely to remove or negatively impact existing recreation were scored low.

- Flood Protection - The potential for each option to aid in flood storage capacity or adversely impact the existing flood regime were the basis for scoring. Options

that increase flood storage capacity were given high scores while options that negatively impact the existing flooding regime were given low scores.

- Aesthetics - Options were scored based on their perceived aesthetic impact. This included any potential noise, dust, or odors associated with the construction or final design of each option. Aesthetic impacts associated with options located closer to residential areas and high boating traffic areas were given lower scores than impacts that are likely to occur away from populated areas.

- Human Health Risk - The potential impacts of each option associated with human health risk were evaluated and scored. Options with higher potential impacts from contaminants were scored lower than options in which human health risk is minimal.

- Navigational Safety - Options were scored based on the degree to which each option is likely to impact commercial and recreational vessel traffic.

For each option evaluated, a score was assigned for each of the human benefit/effects attributes according the following scale:

1- negative overall effect, high level of effort to overcome

2- negative effect, moderate level of effort to overcome

3- minimal effect

4- positive effect, moderate degree of benefit

5- high positive effect, high degree of benefit

The technical scoring results for human benefits/effects are presented in Table 9. The wetland restoration and shoreline protection option resulted in the highest human benefits/effects score. The new CDF option, new open-lake placement area without controls option, and open-lake placement with controls option scored below 3.0, indicating a potentially negative overall human benefit/effect.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 9**

**SUMMARY OF SCORING FOR HUMAN BENEFITS/EFFECTS**

| Human Benefits/Effects Technical Criteria | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | New Open-Lake Placement Area without Controls | Open-Lake Placement with Controls | New CDF |
| Recreation Opportunity | 3 | 4 | 5 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 |
| Flood Protection | 3 | 3 | 3 | 3 | 3 | 5 | 5 | 5 | 3 | 3 | 3 |
| Aesthetics | 3 | 4 | 5 | 3 | 3 | 4 | 2 | 2 | 3 | 2 | 2 |
| Human Health Risk | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 |
| Navigational Safety | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 |
| **Total Technical Score** | **15** | **16** | **18** | **15** | **15** | **19** | **16** | **16** | **14** | **14** | **12** |
| **Average Technical Score** | **3.0** | **3.2** | **3.6** | **3.0** | **3.0** | **3.8** | **3.2** | **3.2** | **2.8** | **2.8** | **2.4** |
| **Average Weighted Score (Avg. Score x 10)** | **30.0** | **32.0** | **36.0** | **30.0** | **30.0** | **38.0** | **32.0** | **32.0** | **28.0** | **28.0** | **24.0** |

### 7.2.5 Economic Benefits/Effects Scoring Summary

Various economic benefit attributes were selected to evaluate each option. It was recognized that options could both negatively and positively impact humans and that some criterion are interdependent. Existing information and studies were used to evaluate the impact of each option on the attributes below.

- Revenue Generation (During Operation) - Each option was evaluated and scored based on the potential for revenue generation during the operation of the respective option. During operation is defined here as the time from construction to the final capacity. Revenue is assumed to come directly as a result of the option and does not include secondary revenue that may come from associated activities. Options that have the potential to generate revenue during operation were scored higher than options that do not have the potential to generate revenue.

- Revenue Generation (Post-operation) - Each option was evaluated and scored based on the potential for revenue generation post-operation. Post-operation is defined here as the time from reaching final capacity to end of the option's lifespan. Revenue is assumed to come directly as a result of the option and does not include secondary revenue that may come from associated activities. Options that have the potential to generate revenue post-operation were scored higher than options that do not have the potential to generate revenue.

- Public Need - This criterion evaluated whether each option fulfills a public need, or directly serves the citizens of the western Lake Erie basin. Options that serve a public need were scored higher than options that do not fulfill a public need.

- Job Creation - Each option was evaluated and scored based on the potential for the option to create short-term and long-term job opportunities. For example, short-term jobs would include construction and management opportunities during construction while long-term jobs might include permanent management positions associated with the O&M of an option.

- Tourism - This criterion included the potential for an option to impact tourism and includes aspects such as wildlife reserves, bird watching, fishing, boating, and parks. Options that had a high potential to enhance tourism were scored higher than options which did not.

- Local Commerce - Each option was evaluated and scored based on the potential revenue generation through commercially harvested species (e.g. crops and fish) or materials.

For each option evaluated, a score was assigned for each of the economic benefit/effect attributes according the following scale:

1- negative overall effect, high level of effort to overcome

2- negative effect, moderate level of effort to overcome

3- minimal effect

4- positive effect, moderate degree of benefit

5- high positive effect, high degree of benefit

The technical scoring results for economic benefits/effects are presented in Table 10. The beneficial use and agricultural field improvement options resulted in the highest economic benefits/effects scores, while the open-lake placement with controls option and new open-lake placement area without controls option resulted in the lowest scores. No options scored below 3.0.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 10**

**SUMMARY OF SCORING FOR ECONOMIC BENEFITS/EFFECTS**

| | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Economic Benefits/Effects Technical Criteria** | **Beneficial Use** | **Emergent HRU - Deep Water** | **Emergent HRU - Shallow Water** | **Submerged HRU - Deep Water** | **Submerged HRU - Shallow Water** | **Wetland Restoration & Shoreline Protection** | **Agricultural Field Improvements (5-mile radius)** | **Agricultural Field Improvements (10-mile radius)** | **New Open-Lake Placement Area without Controls** | **Open-Lake Placement with Controls** | **New CDF** |
| Revenue Generation (During Operation) | 5 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 5 |
| Revenue Generation (Post-operation) | 4 | 4 | 4 | 3 | 3 | 3 | 5 | 5 | 3 | 3 | 4 |
| Public Need | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 |
| Job Creation | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 |
| Tourism | 3 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 |
| Local Commerce | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 3 | 3 | 3 |
| **Total Technical Score** | **26** | **25** | **25** | **22** | **22** | **22** | **26** | **26** | **19** | **18** | **22** |
| **Average Technical Score** | **4.3** | **4.2** | **4.2** | **3.7** | **3.7** | **3.7** | **4.3** | **4.3** | **3.2** | **3.0** | **3.7** |
| **Average Weighted Score (Avg. Score x 14)** | **60.2** | **58.8** | **58.8** | **51.8** | **51.8** | **51.8** | **60.2** | **60.2** | **44.8** | **42.0** | **51.8** |

### 7.2.6 Implementation Cost Scoring Summary

One attribute was used to express the overall costs involved for each option by evaluating the unit costs of each option in comparison with one another. After determining the estimated relative costs for each option, as described in Section 6.0, the range of costs were defined to assign each option with a score based on its relationship to the highest and lowest unit cost options that were evaluated.

- Total Cost per CY - The total cost per CY was estimated based on:
  - general location of option determined by the technical team

- material dredging costs
- construction costs
- material transportation costs
- material placement costs
- maintenance costs
- monitoring costs

For each option evaluated, a score was assigned for the implementation cost attribute according the following scale:

| | |
|---|---|
| 1 - | highest relative cost |
| >1 to <5 - | intermediate score values relatively based on range of costs per CY |
| 5 - | lowest relative cost |

As a result, the highest cost option receives the lowest score (1) and the lowest cost option receives the highest score (5). All other options were scored based on their relative cost compared to the highest and lowest cost option. This resulted in some options receiving decimal scores using the following equation:

$$\text{Intermediate Technical Cost Score} = \left(\frac{\text{Highest Unit Cost - Option Unit Cost}}{\text{Average Unit Cost}}\right) + 1$$

Where:

$$\text{Average Unit Cost} = \frac{\text{Highest Unit Cost - Lowest Unit Cost}}{4} = \$12.85/\text{CY}$$

The highest unit cost was the submerged shallow water HRU at $61.70/CY, and the lowest unit cost was the agricultural field improvements (5-mile) at $10.30/CY. The option unit cost is defined as the single-option cost for each option being scored. The technical scoring result for implementation cost is presented in Table 11. The 5-mile agricultural field improvement option had the lowest unit cost, resulting in the highest implementation cost score. The submerged shallow water HRU had the highest unit cost, resulting in the lowest implementation cost score.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 11**

**SUMMARY OF SCORING FOR IMPLEMENTATION COSTS**

| Implementation Cost Technical Criteria | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | New Open-Lake Placement Area without Controls | Open-Lake Placement with Controls | New CDF |
| Total Cost per CY | 3.46 | 3.28 | 3.88 | 2.49 | 1.00 | 4.95 | 5.00 | 4.93 | 4.98 | 4.94 | 3.68 |
| **Average Technical Score** | 3.46 | 3.28 | 3.88 | 2.49 | 1.00 | 4.95 | 5.00 | 4.93 | 4.98 | 4.94 | 3.68 |
| **Weighted Score (Avg. Score x 17)** | 58.8 | 55.8 | 66.0 | 42.3 | 17.0 | 84.2 | 85.0 | 83.8 | 84.7 | 84.0 | 62.6 |

## 7.3 Sediment Management and Use Option Matrix Results

### 7.3.1 Technical Criteria Score Summary

A summary of the technical scores for each criteria category for each option is included in Table 12. The maximum score possible for an option was 30 while the lowest was zero. The technical criteria scores ranged from 17.0 (submerged shallow water HRU) to 23.5 (5-mile agricultural field improvements).

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 12

## SUMMARY OF SCORING FOR EACH TECHNICAL CRITERIA CATEGORY

| Technical Criteria Category | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | New Open-Lake Placement Area without Controls | Open-Lake Placement with Controls | New CDF |
| **Feasibility** | 3.5 | 3.3 | 3.2 | 3.3 | 2.7 | 2.8 | 3.7 | 3.5 | 4.2 | 4.2 | 3.5 |
| **Ecological Benefits/Effects** | 3.0 | 3.6 | 3.7 | 3.3 | 3.3 | 4.0 | 3.0 | 3.0 | 2.7 | 2.7 | 3.0 |
| **Environmental Impacts/Effects** | 4.0 | 3.5 | 3.5 | 3.3 | 3.3 | 3.5 | 4.3 | 4.3 | 2.0 | 3.3 | 2.8 |
| **Human Benefits/Effects** | 3.0 | 3.2 | 3.6 | 3.0 | 3.0 | 3.8 | 3.2 | 3.2 | 2.8 | 2.8 | 2.4 |
| **Economic Benefits/Effects** | 4.3 | 4.2 | 4.2 | 3.7 | 3.7 | 3.7 | 4.3 | 4.3 | 3.2 | 3.0 | 3.7 |
| **Implementation Costs** | 3.46 | 3.28 | 3.88 | 2.49 | 1.00 | 4.95 | 5.00 | 4.93 | 4.98 | 4.94 | 3.68 |
| **Total Technical Score** | **21.3** | **21.1** | **22.1** | **19.1** | **17.0** | **22.8** | **23.5** | **23.2** | **19.9** | **20.9** | **19.1** |

### 7.3.2 Weighted Criteria Score Summary

A summary of the weighted scores for each criteria category for each option is included in Table 13. The weighted criteria scores ranged from 283.3 (submerged shallow water HRU) to 392.1 (5-mile agricultural field improvements).

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 13

## SUMMARY OF WEIGHTED SCORING FOR EACH TECHNICAL CRITERIA CATEGORY

| Technical Criteria Category | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | New Open-Lake Placement Area without Controls | Open-Lake Placement with Controls | New CDF |
| **Feasibility (17)** | 59.5 | 56.1 | 54.4 | 56.1 | 45.9 | 47.6 | 62.9 | 59.5 | 71.4 | 71.4 | 59.5 |
| **Ecological Benefits/Effects (22)** | 66.0 | 79.2 | 81.4 | 72.6 | 72.6 | 88.0 | 66.0 | 66.0 | 59.4 | 59.4 | 66.0 |
| **Environmental Impacts/Effects (20)** | 80.0 | 70.0 | 70.0 | 66.0 | 66.0 | 70.0 | 86.0 | 86.0 | 40.0 | 66.0 | 56.0 |
| **Human Benefits/Effects (10)** | 30.0 | 32.0 | 36.0 | 30.0 | 30.0 | 38.0 | 32.0 | 32.0 | 28.0 | 28.0 | 24.0 |
| **Economic Benefits/Effects (14)** | 60.2 | 58.8 | 58.8 | 51.8 | 51.8 | 51.8 | 60.2 | 60.2 | 44.8 | 42.0 | 51.8 |
| **Implementation Costs (17)** | 58.8 | 55.8 | 66.0 | 42.3 | 17.0 | 84.2 | 85.0 | 83.8 | 84.7 | 84.0 | 62.6 |
| **Total Weighted Score** | **354.5** | **351.9** | **366.6** | **318.8** | **283.3** | **379.6** | **392.1** | **387.5** | **328.3** | **350.8** | **319.9** |

Note: Weighting factors for each criteria category are noted next to the technical criteria category in parentheses.

### 7.3.3 Relative Ranking of Single-Options

The relative ranking of the options based on the technical and weighted scores were very similar (Table 14). The agricultural field improvements, wetland restoration and shoreline protection, and emergent shallow water HRU options ranked in the top three options based on their average technical scores. The submerged shallow and deep water HRUs and the new CDF options ranked in the bottom three options based on their average technical scores. After applying the weighting factor, options did not change with the exception of the new CDF and deep water submerged HRU options. These options were initially tied based on the technical

score ranking. After weighting factors were applied, the new CDF had a slightly higher weighted score, which gave it a higher ranking.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 14**

**SUMMARY OF SINGLE-OPTION RANKINGS BASED ON TECHNICAL AND WEIGHTED SCORES**

| Rank | Option | Technical Score | Option | Weighted Score |
|---|---|---|---|---|
| 1 | Agricultural Field Improvements (5-mile radius) | 23.5 | Agricultural Field Improvements (5-mile radius) | 392.1 |
| 2 | Agricultural Field Improvements (10-mile radius) | 23.2 | Agricultural Field Improvements (10-mile radius) | 387.5 |
| 3 | Wetland Restoration & Shoreline Protection | 22.8 | Wetland Restoration & Shoreline Protection | 379.6 |
| 4 | Emergent HRU - Shallow Water | 22.1 | Emergent HRU - Shallow Water | 366.6 |
| 5 | Beneficial Use | 21.3 | Beneficial Use | 354.5 |
| 6 | Emergent HRU - Deep Water | 21.1 | Emergent HRU - Deep Water | 351.9 |
| 7 | Open-Lake Placement with Controls | 20.9 | Open-Lake Placement with Controls | 350.8 |
| 8 | New Open-Lake Placement Area without Controls | 19.9 | New Open-Lake Placement Area without Controls | 328.3 |
| 9 | New CDF | 19.1 | New CDF | 319.9 |
| 10 | Submerged HRU – Deep Water | 19.1 | Submerged HRU - Deep Water | 318.8 |
| 11 | Submerged HRU - Shallow Water | 17.0 | Submerged HRU - Shallow Water | 283.3 |

## 7.4 Single-Option Challenges

There are several challenges with using a single option to accommodate all 30M CY of material. First, there is a low flexibility when using a single option approach. Altering a design, location, or other logistics is difficult once a single-option has commenced. There can also be seasonal challenges associated with this approach. For example, construction of a single in-water option might be restricted to a narrow window due to several aspects such as fish spawning windows and storm events. Additionally, a single option generally has a higher capital cost and does not strike a balance between capital cost and O&M. Single options also must be sufficiently large to accommodate all 30M CY, which makes the footprint unreasonable. They also have large

structural requirements and have very site-specific impacts due to the large footprint. As a result, both short-term and long-term plans will likely consist of a combination of approaches due to the challenges of a single option.

## 7.5 Combination Approach

A combination option where the 30M CY of material is allocated across several options will help to overcome the challenges associated with using a single option to accommodate the entire volume of material. By distributing the 30M CY of material across several options, the overall "footprint," and capital cost of each option will be reduced. Construction of different options can be done concurrently, or one option can be constructed when environmental windows, or other constraints, prohibit work on a second option. Finally, a combination option maximizes the benefits associated with each option, such as adding habitat as well as creating a market for dredged material. The positive and negative impacts of each option are distributed through a combination approach. Additionally, adaptive management involving a combination option is much more feasible compared to using a single option. In the event that difficulties arise with the implementation of one option, additional sediment volume could be allocated to a different option.

# 8.0 IDENTIFICATION OF THE COMBINATION OPTION

## 8.1 Introduction

As previously discussed, a major assumption of this THSMUP is that a combination of different options is likely a better solution than a single-option scenario due to the complexity of the technical criteria identified by the Task Force as well as the difficulties of a multidisciplinary approach. A combination of options allows for more flexibility with respect to logistics (e.g. final placement site relative to specific dredging location in a given year) which provides benefits to feasibility, practicality, and costs. It also allows for opportunities to balance the environmental, ecological, human, and economic impacts and benefits.

## 8.2 Selection of Combination Option

After evaluating and screening the feasibility, ecological benefits, environmental impacts, human benefits, economic benefits, implementation costs and other factors for the different options, a combination of four options were selected as the proposed option. Generally, options selected for the combination option scored highest in at least one technical criteria category. The options selected for the combination scenario are wetland restoration and shoreline protection, agricultural field improvements, open-lake placement with controls, and beneficial use. Based on an initial evaluation, the approximate volume of sediment (total over 30 years) for each option was allocated as follows:

- wetland restoration and shoreline protection - 7M CY;
- agricultural field improvements - 7M CY;
- open-lake placement with controls - 13M CY; and
- beneficial use - 3M CY.

The volumes above are preliminary and for initial discussion purposes only. As the program is developed, the options, as well as respective volumes and locations, may be modified to adapt to possible changes in dredging operations, technology advancements, research activities, etc. Appendix G-8 shows the conceptual locations and relative size of areas required to place the above quantities.

### 8.2.1 Potential Locations of Combination Option

Discussed below are a few potential/preliminary locations for the Combination Option. These and other locations will be further evaluated during a detailed design of these options. Also, specific center of gravities can be determined for each option during a detailed design.

Shoreline Protection and Wetland Restoration

Two locations that have been identified for this option are the areas west and east of Cedar Point. These areas are relatively close to the center of gravity of dredging operations and would provide additional habitat near the Cedar Point NWR. A preliminary evaluation determined that a channel would be maintained between the existing and new habitats, which would allow for the current hydrology of the refuge to be maintained as well as provide aquatic access to the refuge area.

Agricultural Field Improvements

Several parcels of farmlands were identified by Proudfoot Associates. The parcels were located within a 5-mile radius from a potential location on the Maumee Bay shore near the center of gravity. The parcels are all in agricultural zoning and within Lucas County. This initial evaluation showed that there are a few potential areas for this option but that a larger radius might be needed during a detailed design. A review of farmlands within a 10-mile radius, which also extends into the counties of Ottawa and Wood, showed that the potential areas could double or triple in comparison to the 5-mile radius scenario. This preliminary review was based on plat maps and public information available in local Auditor's websites. Property owners were not contacted.

Open-Lake Placement with Controls

A potential location for this option would be near the current placement site, possibly northeast of the site. Deeper areas of the current placement site that have space available could also be used, which could help maintain previously disposed sediment in place as well. The selection of a new site would require detailed studies and design considerations to comply with the requirements from Ohio EPA. A new open-lake placement site would be designated and evaluated by USACE under Clean Water Act Section 404(b)(1) guidelines. This area would be coordinated with OEPA in terms of evaluating whether the proposed discharge of dredged material at the site would comply with applicable state water quality standards.

Beneficial Use

There are several locations along the section of the Federal channel within the Maumee River that could be used to install a processing facility for beneficial use of the dredge material. During a detailed design, a final location would be selected based on property ownership, access (aquatic and terrestrial), proximity to the center of gravity, and other factors.

### 8.2.2 Combination Option Matrix Scoring

During the process of selecting a combination option, the technical team scored the combination scenario to compare it with the other (individual) options. Table 15 presents the results from the combination option scoring, along with the scores of each single-option. Note that the combination option scored higher than the individual options in each category. Also, each individual option that comprises the combination option scored the highest in at a minimum of one technical criterion.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 15

## TECHNICAL AND WEIGHTED SCORING FOR SINGLE-OPTIONS AND COMBINATION OPTION

| Technical Criteria Category | Technical Criteria | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | New Open-Lake Placement Area without Controls | Open-Lake Placement with Controls | New CDF | Combination[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Feasibility | Placement Timing and Sequencing | 1 | 5 | 5 | 5 | 4 | 3 | 3 | 4 | 5 | 4 | 5 | 5 |
| | Capacity Expansion Capability | 5 | 5 | 4 | 5 | 3 | 2 | 5 | 5 | 5 | 5 | 4 | 5 |
| | Size of Overall Footprint | 2 | 4 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 |
| | Implementation/ Construction Complexity | 4 | 1 | 2 | 2 | 2 | 3 | 4 | 3 | 5 | 4 | 3 | 4 |
| | Construction Duration | 5 | 1 | 2 | 2 | 2 | 3 | 4 | 4 | 5 | 5 | 2 | 5 |
| | Site Accessibility | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 4 | 5 |
| | **Total Technical Score** | **21** | **20** | **19** | **20** | **16** | **17** | **22** | **21** | **25** | **25** | **21** | **28** |
| | **Average Technical Score** | **3.5** | **3.3** | **3.2** | **3.3** | **2.7** | **2.8** | **3.7** | **3.5** | **4.2** | **4.2** | **3.5** | **4.7** |
| | **Average Weighted Score (Avg. Score x 17)** | **59.5** | **56.1** | **54.4** | **56.1** | **45.9** | **47.6** | **62.9** | **59.5** | **71.4** | **71.4** | **59.5** | **79.9** |
| 2. Ecological Benefits/Effects | Planktonic and Benthic Community/Habitat | 3 | 2 | 2 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 3 |
| | Fish and Aquatic Invertebrate Species/habitat | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 3 |
| | Wetlands (tidal, non-tidal) | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 4 |
| | Protected Species/Habitat | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Pelagic Birds/Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 4 |
| | Terrestrial Species/Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Creation of Surface Water Features with Ecologically Beneficial Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 4 |
| | **Total Technical Score** | **21** | **25** | **26** | **23** | **23** | **28** | **21** | **21** | **19** | **19** | **21** | **24** |
| | **Average Technical Score** | **3.0** | **3.6** | **3.7** | **3.3** | **3.3** | **4.0** | **3.0** | **3.0** | **2.7** | **2.7** | **3.0** | **3.4** |
| | **Average Weighted Score (Avg. Score x 22)** | **66.0** | **79.2** | **81.4** | **72.6** | **72.6** | **88.0** | **66.0** | **66.0** | **59.4** | **59.4** | **66.0** | **74.8** |
| 3. Environmental Impacts/Effects | Hydrodynamic Effects | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 3 | 2 | 4 |
| | Land Improvements | 5 | 4 | 4 | 3 | 3 | 4 | 5 | 5 | 3 | 3 | 4 | 4 |
| | Surface Water Quality | 3 | 3 | 3 | 3 | 3 | 3 | 4 | Z 4 | 1 | 4 | 2 | 4 |
| | Groundwater Quality | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 3 | 3 |
| | **Total Technical Score** | **16** | **14** | **14** | **13** | **13** | **14** | **17** | **17** | **8** | **13** | **11** | **15** |
| | **Average Technical Score** | **4.0** | **3.5** | **3.5** | **3.3** | **3.3** | **3.5** | **4.3** | **4.3** | **2.0** | **3.3** | **2.8** | **3.8** |
| | **Average Weighted Score (Avg. Score x 20)** | **80.0** | **70.0** | **70.0** | **66.0** | **66.0** | **70.0** | **86.0** | **86.0** | **40.0** | **66.0** | **56.0** | **76.0** |
| 4. Human Benefits/Effects | Recreation Opportunity | 3 | 4 | 5 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 |
| | Flood Protection | 3 | 3 | 3 | 3 | 3 | 5 | 5 | 5 | 3 | 3 | 3 | 4 |
| | Aesthetics | 3 | 4 | 5 | 3 | 3 | 4 | 2 | 2 | 3 | 2 | 2 | 3 |
| | Human Health Risk | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| | Navigational Safety | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| | **Total Technical Score** | **15** | **16** | **18** | **15** | **15** | **19** | **16** | **16** | **14** | **14** | **10** | **16** |
| | **Average Technical Score** | **3.0** | **3.2** | **3.6** | **3.0** | **3.0** | **3.8** | **3.2** | **3.2** | **2.8** | **2.8** | **2.4** | **3.2** |
| | **Average Weighted Score (Avg. Score x 10)** | **30.0** | **32.0** | **36.0** | **30.0** | **30.0** | **38.0** | **32.0** | **32.0** | **28.0** | **28.0** | **24.0** | **32.0** |
| 5. Economic Benefits/Effects | Revenue Generation (During Operation) | 5 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 5 | 4 |
| | Revenue Generation (Post-Operation) | 4 | 4 | 4 | 3 | 3 | 3 | 5 | 5 | 3 | 3 | 4 | 4 |
| | Public Need | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 4 |
| | Job Creation | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 |
| | Tourism | 3 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 |
| | Local Commerce | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 3 | 3 | 3 | 4 |
| | **Total Technical Score** | **26** | **25** | **25** | **22** | **22** | **22** | **26** | **26** | **19** | **18** | **22** | **24** |
| | **Average Technical Score** | **4.3** | **4.2** | **4.2** | **3.7** | **3.7** | **3.7** | **4.3** | **4.3** | **3.2** | **3.0** | **3.7** | **4.0** |
| | **Average Weighted Score (Avg. Score x 14)** | **60.2** | **58.8** | **58.8** | **51.8** | **51.8** | **51.8** | **60.2** | **60.2** | **44.8** | **42.0** | **51.8** | **56.0** |
| 6. Implementation Costs | Total Cost per CY | 3.46 | 3.28 | 3.88 | 2.49 | 1.00 | 4.95 | 5.00 | 4.93 | 4.98 | 4.94 | 3.68 | 4.75 |
| | **Average Technical Score** | **3.46** | **3.28** | **3.88** | **2.49** | **1.00** | **4.95** | **5.00** | **4.93** | **4.98** | **4.94** | **3.68** | **4.75** |
| | **Average Weighted Score (Avg. Score x 17)** | **58.8** | **55.8** | **66.0** | **42.3** | **17.0** | **84.2** | **85.0** | **83.8** | **84.7** | **84.0** | **62.6** | **80.8** |
| **Total Average Score** | | ***21.3*** | ***21.1*** | ***22.1*** | ***19.1*** | ***17.0*** | ***22.8*** | ***23.5*** | ***23.2*** | ***19.9*** | ***20.9*** | ***19.1*** | ***23.9*** |
| **Total Weighted Score** | | ***354.5*** | ***351.9*** | ***366.6*** | ***318.8*** | ***283.3*** | ***379.6*** | ***392.1*** | ***387.5*** | ***328.3*** | ***350.8*** | ***319.9*** | ***399.5*** |

Notes:

1. The combination option includes beneficial use (3M CY), wetland restoration and shoreline protection (7M CY), agricultural field improvements (7M CY), and open-lake placement with controls (13M CY). These volumes are preliminary and for initial planning purposes only.

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## 9.0 SINGLE AND COMBINATION OPTION FINAL RANKING AND RELATIVE COSTS

Based on the results of the technical and weighted scores (Section 8.0), the single and combination options were ranked based on weighted score (Table 16). The combination option had the highest weighted score compared to the single-options. Additionally, the estimated unit cost for the combination option was $13.50, compared to the single-option unit costs, which ranged from $10.30 to $61.70.

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 16**

**SUMMARY OF RANKING, TECHNICAL AND WEIGHTED SCORES, AND UNIT COST FOR SINGLE-OPTIONS AND COMBINATION OPTION**

| Rank | Option | Technical Score | Weighted Score | Unit Cost ($/CY) |
|---|---|---|---|---|
| **1** | Combination[1] | 23.9 | 399.5 | $13.50 |
| **2** | Agricultural Field Improvements (5-mile Radius) | 23.5 | 392.1 | $10.30 |
| **3** | Agricultural Field Improvements (10-mile Radius) | 23.2 | 387.5 | $11.20 |
| **4** | Wetland Restoration & Shoreline Protection | 22.8 | 379.6 | $10.90 |
| **5** | Emergent HRU - Shallow Water | 22.1 | 366.6 | $24.70 |
| **6** | Beneficial Use | 21.3 | 354.5 | $30.10 |
| **7** | Emergent HRU - Deep Water | 21.1 | 351.9 | $32.40 |
| **8** | Open-Lake Placement with Controls | 20.9 | 350.8 | $11.10 |
| **9** | New Open-Lake Placement Area without Controls | 19.9 | 328.3 | $10.50 |
| **10** | New CDF | 19.1 | 319.9 | $27.30 |
| **11** | Submerged HRU - Deep Water | 19.1 | 318.8 | $42.60 |
| **12** | Submerged HRU - Shallow Water | 17.0 | 283.3 | $61.70 |

Notes:

1. The combination option includes beneficial use (3M CY), wetland restoration and shoreline protection (7M CY), agricultural field improvements (7M CY), and open-lake placement with controls (13M CY). These volumes are preliminary and for initial planning purposes only.

# 10.0 EVALUATION OF ENVIRONMENTALLY ENHANCED DREDGING TECHNIQUES

## 10.1 Hydraulic Dredging with Permanent Discharge Lines

Dredging at Toledo Harbor is typically completed using mechanical dredging. Mechanical dredging uses a clamshell, or bucket, to dredge the material. During mechanical dredging, the bucket is lowered through the water column and is used to scoop sediment from the bottom. The bucket is closed, raised up through the water column to the surface, and is swung over a bottom-dump scow where the bucket load is dropped. This process is repeated until the scow is filled. As the scow nears capacity, water that flows off of the scow often carries fine-grained sediment that can cause turbidity in the water column.

One way to minimize potential turbidity in the water column is to use hydraulic dredging and permanent discharge lines. A literature review of various dredging techniques showed that hydraulic dredges tend to re-suspend less sediment into the water column than mechanical dredges when all other factors are equivalent such as sediment size, hydrodynamic conditions, etc. (Anchor Environmental, 2003). Hydraulic dredging uses a centrifugal pump to transport the dredged material as a slurry. As part of this method, the slurry is transported through pipelines connected to the pump discharge. Booster pumps can be added to aid in the transport of material over long distances. Permanent discharge pipelines can be submerged on the bottom of the lakebed to reduce the hazards associated with floating pipelines (e.g. wave action, boat traffic, etc.). Based on historical information, a 2:1 pumping ratio of water to dredged sediment must be achieved in order to avoid clogging the pipeline. This ratio is an important factor in determining the required pump and pipeline size, pumping power, and containment volumes associated with each option.

## 10.2 Open-Lake Placement with Controls

Open-lake placement with controls would include amending material dredged from the Federal channel with aluminum sulfate (alum) or similar materials and bentonite clay and/or other coagulants prior to or during placement in the open lake placement area. Alum treatment results in the settling and removal of insoluble aluminum phosphate, reducing water column TP and chlorophyll *a* concentrations (Welsh and Cooke, 2009). The reduced phosphorus concentration limits the food source for blue-green algae, potentially reducing the generation of HABs. Additionally, alum can increase the shear strength of material post-placement. Bentonite has been demonstrated to be an effective flocculant to reduce turbidity during

placement (USACE, 2001). Use of alum and bentonite could result in positive impacts to both short- and long-term turbidity.

Bentonite and/or other coagulants will act as a flocculant during placement to reduce turbidity and increase the shear strength of the placed sediment while also helping to neutralize the alum-dosed dredged material. Bentonite, a member of the smectite family of clays, is primarily composed of montmorillonite and is one of the most cohesive common clays. It is used in a variety of areas, including construction, cat litter, food additives, foundry, and paper making. Jiang and Kim (2008) found that bentonite was highly effective as a coagulant at removing chlorophyll *a* and reducing turbidity from water dosed with *Microcystis.* In addition, bentonite has been shown to increase the shear stress of sediments, reducing erosion rates and enhancing the stability of the sediments when incorporated with capping materials. The addition of even 0.5% bentonite mixture was shown to increase shear strength and a 2% bentonite mixture increased the shear strength by up to two orders of magnitude (USACE, 2001).

It is anticipated this method could be carried out separately from the dredging operation by a separate vessel being used to treat the dredging scow, resulting in minimal disturbance to the operation. A white paper discussing this option in more detail can be found in Appendix I.

# 11.0 SEDIMENT MANAGEMENT AND USE RECOMMENDED OPTIONS

## 11.1 Recommended Options

### 11.1.1 Short-Term Options

Short-term options can be implemented within the next 1 to 5 years and have minimal delays resulting from permitting, design, etc. Short-term options can be pursued while planning, design, and permitting activities are completed for long-term options. Short-term options generally have minimal delays associated with design and permitting. Options that are favorable for short-term implementation include:

- open-lake placement with controls;
- open-lake placement without controls in a new location; and
- beneficial use as non-structural fill.

These options have varying unit costs, with the unit costs ranging $10.50/CY for open-lake placement at a new location without controls and $30.10/CY for beneficial use. These options could be implemented within the next few dredging years and would not significantly impact the federal dredging operation.

### 11.1.2 Long-Term Options

Long-term options typically undergo a more extensive planning, design, and permitting process. These options generally have a large capital cost but can accommodate a large volume of material over many years. Options that are favorable for long-term implementation include:

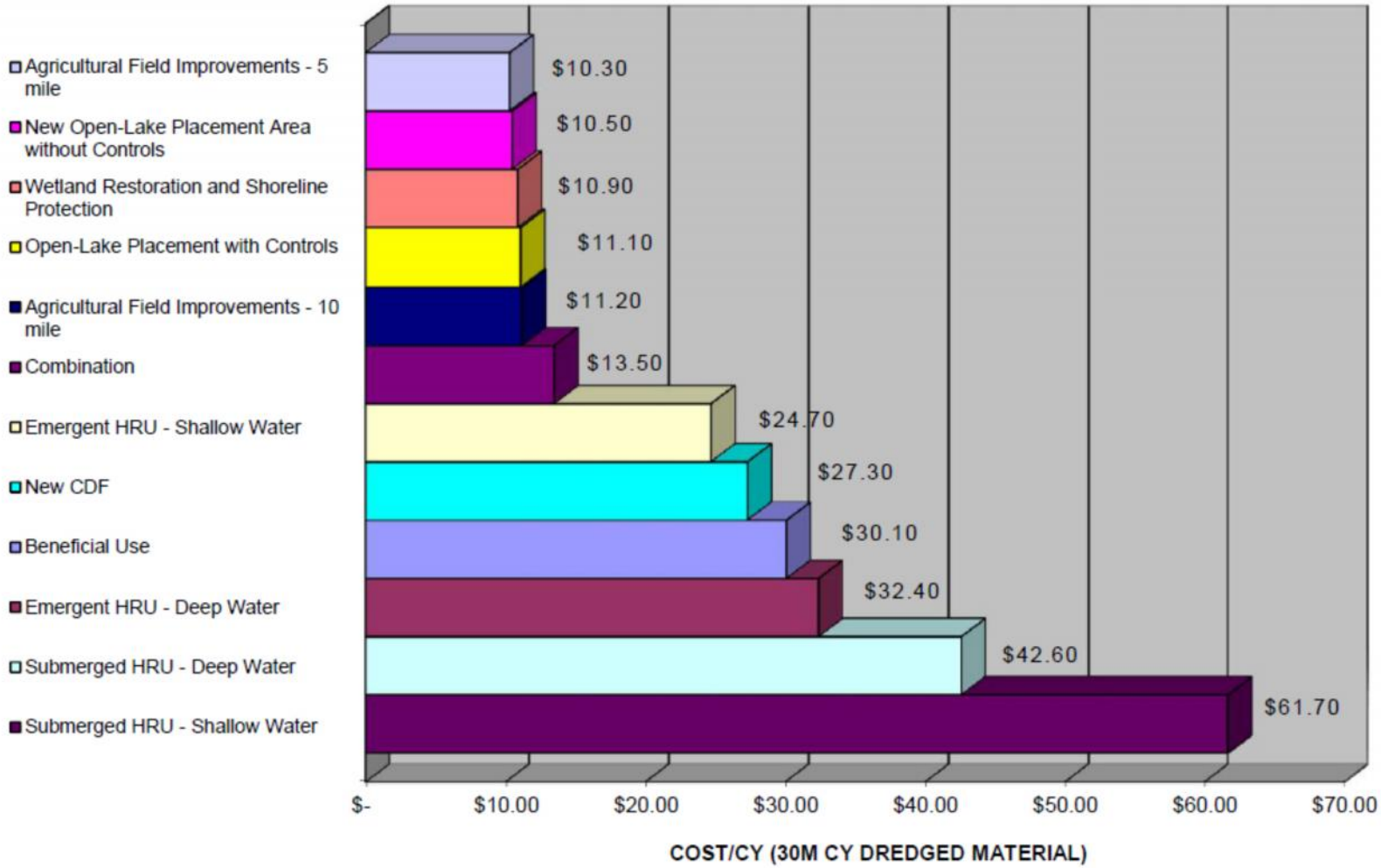
- agricultural field improvements;
- wetland restoration and shoreline protection;
- submerged HRU;
- emergent HRU; and
- new CDF.

Figure 8, Relative Unit Costs for Single-Options and Combination Option, illustrates relative unit costs for long-term options, which range from $10.30 for the 5-mile radius agricultural field improvement option to $61.70 for the submergent shallow water HRU.

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## FIGURE 8

## RELATIVE UNIT COSTS FOR SINGLE-OPTIONS AND COMBINATION OPTION



## 11.2 Second Public Forum

A second Toledo Harbor Public Forum was held on Tuesday June 19, 2012 to present stakeholders with the ranking and prioritization of sediment management and use options. Forum attendees had the opportunity to learn about proposed sediment management and use options under consideration, as well as the evaluation approach used to prioritize the options. This forum provided an opportunity for stakeholder input regarding the evaluation approach and proposed options through a question and answer session and a post-forum survey.

The major objectives of the second public forum were to:

- review potential sediment management and use options for Toledo Harbor;
- present the technical team's evaluation process for prioritizing sediment management and use options for Toledo Harbor;
- present the preliminary prioritized sediment management and use options identified for Toledo Harbor; and
- solicit feedback from stakeholders on the proposed evaluation process and preliminary sediment management and use options identified for Toledo Harbor.

A complete summary of the second public forum is provided in Appendix J.

## 11.3 Potential Funding Sources and Legislative Changes

Various sources of funding can be pursued for further study or construction of sediment management and use options. In some cases, certain funding sources might be conducive to collecting data or information required to proceed with an option or construct a pilot/demonstration project. Funds can be obtained directly through Congress or the state legislature through specifically authorized projects and/or programs. For example, the Ohio legislature passed the Healthy Lake Erie Fund, scheduled to take effect October 1, 2012, which appropriates $3M to address nutrient runoff and algae blooms in Lake Erie. Additionally, Section 217 of WRDA 1996 provides for Dredged Material Disposal Facility (DMDF) public-private partnerships in which a non-federal sponsor(s) would design, build, and operate the DMDF and the Federal government would pay a tipping fee.

Table K-1 in Appendix K presents a list of potential grants and loan programs in which funding for Toledo Harbor Sediment Management and Use options could be pursued. This list is not meant to serve as an exhaustive inventory of all possible funding sources. In addition to the

selected funding list provided by Table K-1 in Appendix K, additional funding programs can be found through the Catalog of Federal Domestic Assistance, published by the U.S. Office of Management and Budget. The website grants.gov also provides a listing of available grant programs. Longstanding efforts are underway to free up funds in the Harbor Maintenance Trust Fund (HMTF) for their original purpose of supporting dredging of navigational harbors. Should this money become available, it is possible some could be used to pursue a sediment management and use option. Additionally, special programs such as the GLRI might provide opportunities to use grant funds to pursue various options. State funds might also be a possibility to pursue construction of a sediment management and use option. In some cases, an option (i.e. beneficial use) may produce a revenue stream, which can assist in the O&M associated with the option. Other options for raising funds include special taxes or sales tax surcharges, specialty license plates, credit cards, private foundations, endowment funds, and private-public partnerships (USEPA, 2007).

Funding a sediment management and use option solely through state and federal programs and/or grants is becoming increasingly difficult. As a result, it is likely that local, state, and/or private funds might be necessary to fully plan, design, and implement a sediment management and use option. Additionally, changes to WRDA or other Congressional acts would be required for USACE to pursue any option that is currently not authorized under their existing authorities (e.g. Section 204). Stakeholders should consider ensuring that Toledo Harbor is adequately addressed in future WRDAs.

## 11.4 Recommended Implementation Approaches and Considerations

It is recognized that prior to implementing a specific sediment management and use option identified in the THSMUP, additional monitoring and/or data evaluation might be necessary to estimate costs better and to ensure the implementation of that option is feasible and protective of human health and the environment at the location for which it is being considered. Such determinations might consist of evaluations of existing data and/or the collection of new site-, use-, or material-specific data to characterize the physical suitability (e.g. grain size, texture, plasticity, organic content, etc.), engineering suitability (e.g. compatibility, consolidation, shear strength, etc.), and environmental suitability (e.g. chemical concentrations, toxicity, leaching potential, ecological inventories of existing benefits, etc.) of site-specific sources of dredged material and a final use/placement option. Additionally, the use of dredged material may likely require a material management plan, which details the logistics of using dredged material for

upland uses, including stormwater controls, record keeping, and methods to be implemented. This plan would be closely coordinated with Ohio EPA to ensure compliance with applicable regulations and standards.

Prior to actual implementation of a sediment management and use option, the Task Force should complete, as appropriate, the following site-specific characterization activities and evaluations:

1. complete more detailed design cost sensitivity analyses that will also help identify best mix (relative volume) and timing of individual components (original allocations used for evaluation/discussion purposes in the combination approach will likely change);
2. engage site-specific discussions with controlling entities and regulatory agencies;
3. establish ongoing discussions with legislators and public officials regarding project opportunities and associated legislation/funding needs;
4. initiate pilot projects (e.g. open-lake placement with controls, agricultural field improvement);
5. review findings of the USACE Section 204 study, Ohio State University beneficial use study, the Phase II Phosphorus Task Force report, and other applicable sediment management and use studies when they become available, and adjust the approach to reflect new findings, as appropriate;
6. review and incorporate future open-lake placement data monitoring phosphorus dynamics of dredged material and open-lake placement methods, as required in the 2012 Section 401 WQC;
7. complete additional laboratory and field testing to address active consolidation rates for relevant scenarios; and
8. complete more detailed evaluations of alternative dredging techniques compared to infrastructure costs associated with sediment transportation to specific sediment management and use options.

Under the current Federal dredging program, any options that exceed the cost of the federally preferred option are the responsibility of a non-federal sponsor. Since open-lake placement is currently the federally preferred option, project partners and funding sources must be identified to carry forward an option presented as part of this THSMUP.

The material placement methods considered and allocated volumes comprising the combination option were identified taking into consideration current practices and using best professional

judgment and were established to develop preliminary cost estimates so that the combination option could be compared to the single-options. Actual volumes and associated management and construction costs will be based on site-specific attributes including distance from dredging operations, available space, and timing. A sensitivity analysis should be completed to identify the most cost-effective material placement methods and to identify a more optimal volume allocated to each selected option within the combination option.

The Task Force should jointly inventory and prioritize potential sediment management options identified in this THSMUP. They may consider establishing a sub-committee to facilitate the development of an integrated decision-making framework in order to pursue and implement prioritized sediment management options identified by the Task Force. To accomplish this, a sub-committee could work with the dredging project leads to implement options identified under this THSMUP and inventory and monitor future dredging projects.

Collaboration of all dredging work, including those seeking permits, could result in a coordinated, cost-effective sediment management approach. The subcommittee could coordinate with Port terminal operators, marinas, local development agencies, and others that conduct dredging to develop a system of inventorying planned dredging projects, needs, and backlogs. Compiling the permit requirements, dredging history, sediment characteristics, and placement and use attributes into an integrated computer-hosted geographical information system (GIS) will assist the Task Force in planning for future sediment management needs. The GIS could be used to facilitate collaboration and coordination between Federal and non-federal stakeholders. The GIS could also include attributes specific to THSMUP-recommended options such as allocated capacity, remaining capacity, characteristics of placed material (e.g. source, volume, analytical/geotechnical characterization, etc.), any placement restrictions, and other attributes that will assist the Task Force in long-term planning of a sediment management strategy.

The GIS could also be used to predict future dredge needs by projecting anticipated dredge volumes based on rates of sediment accumulation, or past dredging cycles, so that multiple property owners can plan to dredge at the same time, thereby leveraging resources, and funding. Potential benefits of a coordinated system could include reduced costs by avoiding multiple mobilizations. Additionally, the Task Force can plan for the demand for dredge disposal or beneficial use.

The subcommittee would report to the Task Force during regular meetings to update members on future dredging projects. By having an established system, the Task Force will be positioned to quickly seek funding opportunities in order to implement sediment management options. If a subcommittee is formed, it is recommended, at minimum, a representative(s) from USACE (local office and regulatory), TLCPA, City of Toledo, and City of Oregon should be included to ensure future dredging projects are identified and coordinated.

In addition to securing project partners and funding, collaboration between the project partner(s) and USACE will be necessary to implement an option in coordination with the existing Federal contract. Additional work that might be required to implement an option could be added onto the existing Federal contract or as a separate contract. Project partners must work together to implement solutions, including overcoming regulatory and programmatic obstacles in a manner that remains protective of human health and the environment and that is economically sound.

## 11.5 Timelines for Options and Phasing

Timelines for implementation will be dependent on the completion of additional project-specific evaluations, as described in Section 4.0, as well as securing project funding. Short-term options presented in Section 11.1.1 can be implemented within the next five years while long-term options, which will require extensive planning and design, could take up to five years to implement. Pilot projects described in Section 11.4 to support the implementation of recommended short-term and long-term sediment management options can be immediately initiated.

Final engineering and design and permitting for short-term options are expected to take 6 to 12 months. However, this estimate could vary based on specific project conditions and programmatic restraints. Final engineering and design and permitting for long-term options are expected to take 12 to 24 months. However, this estimate could vary based on specific project conditions and programmatic restraints.

Depending on the option being pursued, the implementation committee would involve local stakeholders and the applicable regulatory organizations. Implementation of the sediment management and use approach will need to be carried out in phases. Construction of different options can be completed concurrently, or one option can be constructed when environmental windows, or other constraints, prohibit work on a second option. Finally, a combination option

maximizes the benefits associated with each option, such as adding habitat as well as creating a market for dredged material. The negative impacts of each option are mitigated by a combination approach. Additionally, a combination approach allows for adaptive management. In the event that difficulties or opportunities arise during the implementation of one option, additional sediment volume could be allocated to, or from, a different option. Short-term options can be constructed or implemented within 5 years, while long-term options will need to be constructed in phases over a longer timeframe.

Of the prioritized options presented in this THSMUP, the agricultural field improvements, the open-lake placement with controls, beneficial use, and wetland restoration/shoreline protection are most suitable for implementation based on feasibility and costs. Prior to full-scale implementation, a small-scale and short-term preliminary study (pilot project), or other preliminary evaluation, should be conducted to better assess the potential to optimize the full-scale implementation of each option and to confirm assumptions used in the development of the preliminary concept. Pilot testing can generally be completed within one year from initiation, not including any unforeseen delays in regulatory approvals/permits, contracting, or funding.

Additional evaluations and tasks that should be initiated in Year One include:

- identify public-private partnerships to pursue funding opportunities to implement portions of the THSMUP;
- completion of a comprehensive risk evaluation regarding suitability of dredged material to be beneficially used in a manner protective of human health and the environment;
- inventory of existing conditions and assessment of ecological cost and benefits of wetland restoration;
- economic analysis of alternative dredging techniques and configurations (e.g. pump-out system and hydraulic dredge);
- fluid mechanics testing to optimize infrastructure design;
- agronomic testing to support agricultural field improvements;
- ongoing search for opportunities to support beneficial use (e.g. structural fill);
- bench-scale testing to determine dosing levels for amendments to dredge material for the open-lake placement with controls option; and

- completion of a materials management plan to outline the logistics of using dredged material for upland uses, including stormwater controls, record keeping, and methods to be implemented.

The following tasks should be completed in Year Two:

- implementation of open-lake placement with controls option:
- implementation of beneficial use as non-structural fill option;
- final design activities for the agricultural field improvement option; and
- final design activities for the wetland restoration and shoreline protection option.

The following tasks should be completed in Year Three:

- continued implementation of open-lake placement with controls;
- continued implementation of beneficial use as non-structural fill;
- permitting, procurement, and pre-construction activities for agricultural field improvement option; and
- permitting, procurement, and pre-construction activities for wetland restoration and shoreline protection option.

The following tasks should be completed in Year Four:

- continued implementation of open-lake placement with controls;
- continued implementation of beneficial use as non-structural fill;
- construction of final design for agricultural field improvement components; and
- construction of final design for wetland restoration and shoreline protection components.

The following options should be implemented in Year Five:

- continued implementation of open-lake placement with controls;
- continued implementation of beneficial use as non-structural fill;
- agricultural field improvements; and
- wetland restoration and shoreline protection.

Potential funding to complete these tasks are discussed in Section 11.3. GLRI funding, GLC and Ohio LEC grants and a variety of other program funds could be pursued for both pilot project and implementation. Further, should the HMTF legislation be successful, this program

could provide a long-term source of funding the implementation of a comprehensive sediment management and use strategy.

## 11.6 Refinement of Recommended Agricultural Field Improvement Option

Based on recent discussions with Ohio EPA and other stakeholders, it appears that one of the more sustainable sediment management options identified as part of work completed for the THSMUP is the beneficial use of dredged material for agricultural field improvements. In light of the relative importance of the agricultural field improvement option to the overall program and the recognition that a pilot project would likely be appropriate to get support from the farm community, several additional tasks were completed to obtain relevant information needed to move this option forward as a potential pilot demonstration project. A pilot project could serve as a model for beneficial use of dredged materials on agricultural fields and demonstrate the implementability of full-scale implementation. Results could have significant implications and replication opportunities for the management and beneficial use of dredged material throughout the Great Lakes.

Additional activities completed to refine the agricultural field improvement option included:

- Desktop review of agronomic suitability of dredged material, including a review of available dredged sediment data, crop recommendations (e.g. alfalfa, corn), potential additives (e.g. fertilizer, lime), and review of similar projects to identify the number of growing cycles needed to obtain suitable agronomic and soil conditions for crops;
- Refinement of design and implementation methods, including project-specific specifications for the implementation of the agricultural field improvement option and a desktop review of the agricultural field improvement option currently being completed at East Harbor State Park and other similar projects;
- Refinement of preliminary cost estimates, including a more detailed pump management and maintenance cost, more detailed land rental/acquisition and easement costs, refined anticipated energy costs associated with pumping operations, and refined construction cost estimates for installation of in-water and upland infrastructure; and
- Identification of next steps (e.g. financing, permitting) that are recommended to move forward with the implementation of the agricultural field improvement option or a pilot project.

A detailed report of the work completed as part of refinement of this option is included in Appendix L. The refined costs were based on a re-evaluation of the major design components, including the most economical dredging and operational methods available, and a better defined

site-specific potential placement location. While the refined cost estimates are closer to a final opinion of probable costs, they should not be used for potential funding values.

Two options were evaluated for the transport of material to the final selected agricultural field placement site: constructing a mechanical dredge with a pump-out location or using a hydraulic dredge and pipeline system. Details on the cost and operation of several hydraulic dredge sizes are discussed in Appendix L. The use of a hydraulic dredge appears to be more economically and logistically feasible than the current mechanical methods used in conjunction with a pump-out area. However, hydraulic dredges have not been used in the Toledo Harbor since 2006, and it could be challenging to find a hydraulic dredge that meets the current federal procurement requirements (e.g. U.S. flag vessel, small business, etc.). If, during the planning/design period, it is determined that the use of a hydraulic dredge is not feasible, the pump-out area concept can be modified for the use of a mechanical dredge.

The physical characteristics of the dredged material are similar to naturally productive, fine textured agricultural soils in northwest Ohio. With the construction of proper engineered controls to facilitate dewatering and proper handling, tillage, and fertility treatments, the dredged material can develop into a productive agricultural soil. The recommended next steps for the agricultural improvement option include:

- pilot study – perform a pilot study to demonstrate the suitability of the agricultural field improvement option as a viable sediment management and use option for Toledo Harbor dredged material; and
- contact potential site property owners and secure legal agreements; determine sequencing plan for the sites.

Prior to land application of dredged material, it is expected that property owners would require a demonstration that the dredged material are as follows:

- dredged material does not pose an unacceptable risk to human health and the environment;
- nutrients and texture is compatible with current field conditions;
- traditional farming practices and equipment can be employed after material is land-applied and returned to the farmer; and
- level of effort for maintenance of ditches, tiles, and structural controls is not significantly more than current practices.

Since the comparative scoring analysis identified the agricultural field improvement option as a preferred option that can be implemented relatively quickly and used to manage dredged material over the long-term, additional refinement of the design and costs were completed to better position the option for a pilot project or for consideration for full-scale implementation. The agricultural field improvement option is a viable, cost-effective sediment management and use option for material dredged from Toledo Harbor. A pilot project of this option could serve as a model for beneficial use of dredged materials on agricultural fields and demonstrate the implementability of a full-scale project.

# 12.0 SUMMARY

The THSMUP identifies and prioritizes practicable, implementable, economically sound, and environmentally acceptable options, which could be implemented by federal, state, municipal, and private entities that must dredge areas of the Toledo Harbor to maintain safe conditions for marine commerce, recreational navigation, and other purposes.

Options were ranked and prioritized through a comparative scoring analysis, which focused on general physical attributes, logistics, geographic attributes, historic and projected dredging volumes, habitat areas, initial cost estimates, and stakeholder input on the relative importance of six major categories of technical criteria. These criteria included feasibility, ecological benefits/effects, environmental impacts/effects, human benefits/effects, economic benefits/effects, and implementation cost. The goal of the comparative scoring analysis was to complete a fair, equitable evaluation of options that can be very dissimilar in both overall design goal and implementation.

The prioritization was first completed assuming each single-option would accommodate 30M cubic yards of dredged material over 30 years. Results of the single-option evaluation indicate that agricultural field improvements, wetland restoration and shoreline protection, shallow water emergent HRU, and beneficial use options scored the highest.

Options that are favorable for short-term implementation include:

- open-lake placement with controls;
- open-lake placement in a different approved placement location; and
- beneficial use as non-structural fill.

Options that are favorable for long-term implementation include:

- agricultural field improvements;
- wetland restoration and shoreline protection;
- submerged HRU;
- emergent HRU; and
- new CDF.

Following the single-option evaluation, higher ranking single-options were evaluated for incorporation into a combination option capable of accommodating the 30M CY of dredged material over 30 years due to the complexity of the technical criteria identified by the Task Force as well as the difficulties of a multidisciplinary approach. A combination of options allows for more flexibility with respect to feasibility, practicality, and costs, and provides for opportunities to balance the environmental, ecological, human, and economic impacts and benefits. Shoreline protection and wetland restoration, agricultural field improvements, open-lake placement with controls, and beneficial use were selected for the combination scenario since they scored highest in at least one technical criteria category during the single-option evaluation. When compared to the single-options, the combination option ranked the highest, demonstrating that this combination option best balances environmental, ecological, and economic benefits and impacts while minimizing overall unit cost.

Since the comparative scoring analysis identified the agricultural field improvement option as a preferred option that can be implemented relatively quickly and used to manage dredged material over the long-term, additional refinement of the design and costs was completed to better position the option for a pilot project or for full-scale implementation. Such a strategy would require following any appropriate protocols related to environmental reviews, permits, and other processes that consider engineering and science principles as well as community concerns and issues raised by stakeholders.

The THSMUP presents a comprehensive sediment management solution for the Toledo Harbor that is practical, protective of human health and the environment, and is essential to securing implementation funding. Ultimately, the Task Force and stakeholders will be responsible for incorporating the recommendations from this THSMUP into a strategy that can be implemented. Additionally, stakeholders can assist in the development and modification of current programmatic and regulatory constraints that impede the pursuit of certain sediment management and use options.

# 13.0 TASK FORCE COMMENTS

Throughout the development of the THSMUP, Task Force members were provided status updates during Task Force meetings and public forums and were encouraged to provide feedback to the Hull Team. These meetings and forums were held to solicit feedback on the weighted matrix approach and proposed sediment management and use options. Feedback and comments during these meetings have been documented through meeting minutes. Documentation of the discussions held during Task Force meetings and public forums are hosted on Ohio LEC's website at http://lakeerie.ohio.gov/GLRI/ToledoHarbor.aspx.

During the November 2012 Task Force meeting, the Hull team provided Task Force members with an overview of the final draft THSMUP including the updated agricultural field improvement option conceptual design and estimated costs. There was significant discussion on the draft THSMUP. Task Force members provided feedback regarding their opinion of sediment management and use options presented in the THSMUP, as well as comments related to the refinement of the agricultural field improvement option. Task Force members discussed the need to develop federal and state agency and legislative support for implementation of THSMUP. Task Force members discussed pilot projects that could be implemented relatively quickly including the agricultural field improvement option and the open-lake placement with controls option.

Task Force members were given the opportunity to review draft versions of the THSMUP and to communicate informal comments verbally or through e-mail or to provide formal written comments for inclusion in the final THSMUP. On December 18, 2012, the USACE submitted written comments on the earliest version of the THSMUP released to the Task Force for review and comment. A copy of the USACE's written comments is provided in Appendix M and were considered in the preparation of the final THSMUP.

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# APPENDIX A

Toledo Harbor Dredging Quantities and Center of Gravity Memorandum

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Hull & associates, inc.

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# Memorandum

TO: John Hull, P.E. and Kelly Bensman

FROM: Fernando Camargo

DATE: September 22, 2011

RE: Toledo Harbor Dredging Quantities and Center of Gravity; TPA044.100.0010

---

This Memorandum has been prepared to provide an update on the ongoing data review and calculations regarding sediment dredging in the Toledo Harbor, as part of the Toledo-Lucas County Port Authority and the Ohio Lake Erie Commission "Great Lakes Restoration Initiative Project; EPA Grant # GL-00E00523-0".

The local office of the United States Army Corps of Engineers (USACE), which is responsible for dredging the Toledo Harbor Federal Shipping Channel, provided estimates of the locations and volumes of dredged sediment between 2001 and 2010. The numbers provided are not necessarily precise and are an attempt by the USACE to quantify the effort of work by the dredging contractor. Table 1 shows the total sediment dredged per year and per location (River or Lake).

**TABLE 1**
**VOLUME OF SEDIMENT DREDGED IN THE TOLEDO HARBOR FEDERAL CHANNEL BETWEEN 2001 AND 2010**

| YEAR | CUBIC YARDS REMOVED FROM RIVER CHANNELS | CUBIC YARDS REMOVED FROM LAKE CHANNELS | TOTAL PER YEAR |
|---|---|---|---|
| 2001 | 174,355 | 729,618 | 903,973 |
| 2002 | 133,500 | 300,000 | 433,500 |
| 2003 | 0 | 619,026 | 619,026 |
| 2004 | 0 | 689,900 | 689,900 |
| 2005 | 0 | 567,728 | 567,728 |
| 2006 | 0 | 620,852 | 620,852 |
| 2007 | 115,000 | 600,000 | 715,000 |
| 2008 | 0 | 540,000 | 540,000 |
| 2009 | 0 | 720,400 | 720,400 |
| 2010 | 50,000 | 734,052 | 784,052 |
| **TOTAL PER LOCATION** | **472,855** | **6,121,576** | **6,594,431** |

Based on the data provided by USACE, the annual average over the last 10 years is approximately 660,000 cubic yards of sediment dredged, with a minimum of approximately 433,500 cubic yards in 2002, and a maximum of approximately 904,000 cubic yards in 2001.

**CENTER OF GRAVITY**

Center of gravity calculations were performed on dredge data to arrive at a ship channel location which represented the average station from which dredge spoils were removed. Figure 1 is a location map of the portion of the Toledo Harbor showing the locations from which dredge spoils were removed. The cumulative total over the last 10 years were color-coded to show the locations where dredging occurred per the following legend:

- Green 40,000 to 300,000 cubic yards
- Yellow 300,000 to 600,000 cubic yards
- Red 600,000 to 1,040,000 cubic yards

The center of gravity was calculated separately for the River Channel and the Lake Channel. The separation between Lake and River (station 291+00) was determined based on volumes rather than physical location. Calculations were then performed on the combined data for an overall center of gravity.

Figure 2 depicts the center of gravity for dredging in the Lake Channel. The X axis shows the stationing from which the dredge material was removed. The ordinate depicts the estimated average number of cubic yards per station that was removed between 2001 and 2010.

Figure 3 depicts the center of gravity for dredging in the River Channel. Ordinate and abscissa depict the same parameters as the previous figure. Figure 4 shows the center of gravity for overall dredging operations (Lake and River Channels combined).

The Center of Gravity calculations were performed as follows. The total volume of dredge spoils within each range of stations (as provided by the USACE) was multiplied by the distance between the initial station and the middle station within the respective range. This calculation determines the “moment arm” for each dredging event. The individual moment arms were then added to determine the total moment arm. This number was then divided by total volume of material to determine the final center of gravity stationing. This represents the equivalent distance if all material were to be replaced by a point mass acting at one location.

The center of gravity for dredging within the Lake Channel was calculated to be Station 593; the center of gravity for dredging within the River Channel was calculated to be Station 146; and the center of gravity for dredging within the Overall Federal Channel was calculated to be Station 559.

# FIGURES

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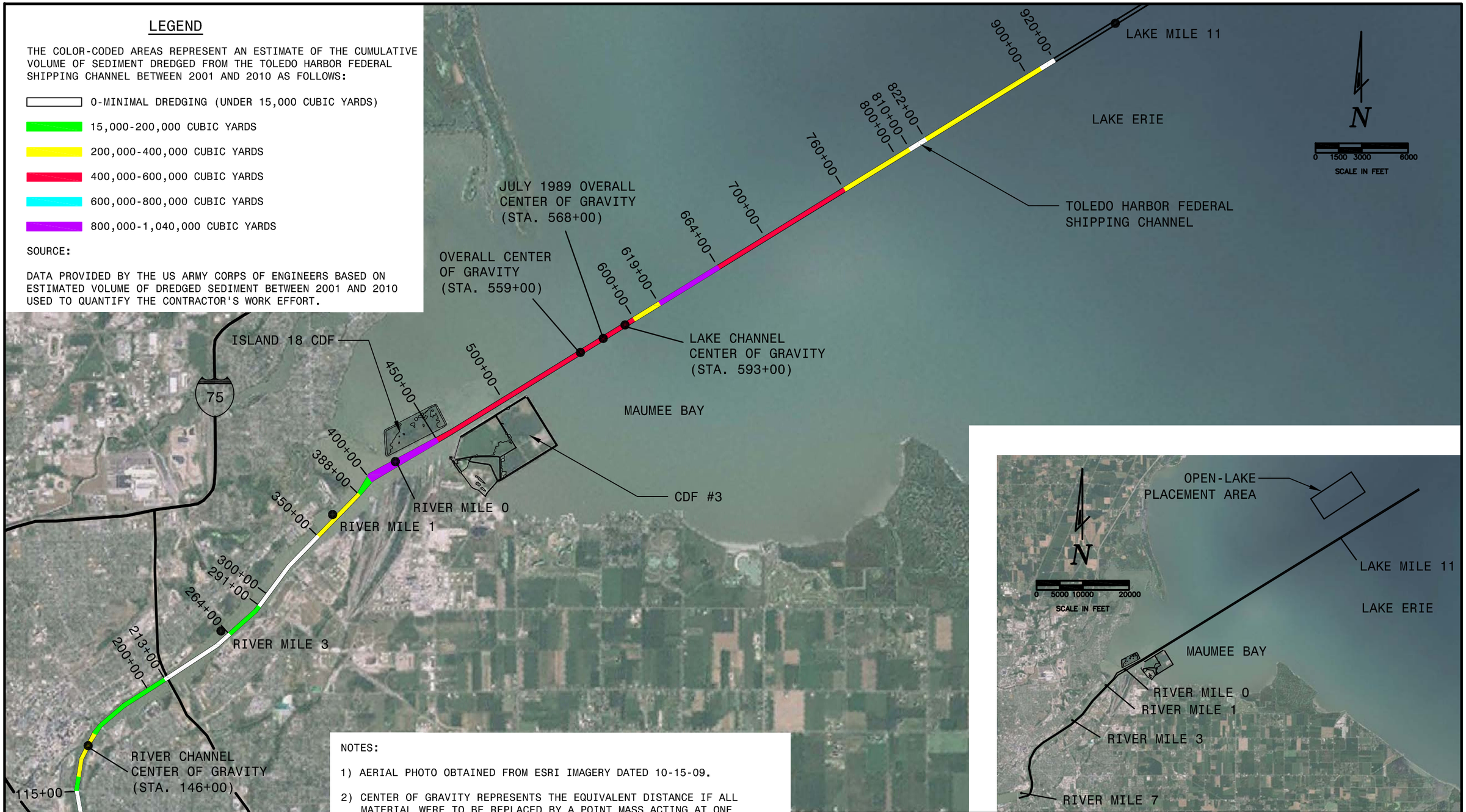
## LEGEND

THE COLOR-CODED AREAS REPRESENT AN ESTIMATE OF THE CUMULATIVE VOLUME OF SEDIMENT DREDGED FROM THE TOLEDO HARBOR FEDERAL SHIPPING CHANNEL BETWEEN 2001 AND 2010 AS FOLLOWS:

- 0-MINIMAL DREDGING (UNDER 15,000 CUBIC YARDS)
- 15,000-200,000 CUBIC YARDS
- 200,000-400,000 CUBIC YARDS
- 400,000-600,000 CUBIC YARDS
- 600,000-800,000 CUBIC YARDS
- 800,000-1,040,000 CUBIC YARDS

SOURCE:

DATA PROVIDED BY THE US ARMY CORPS OF ENGINEERS BASED ON ESTIMATED VOLUME OF DREDGED SEDIMENT BETWEEN 2001 AND 2010 USED TO QUANTIFY THE CONTRACTOR'S WORK EFFORT.




NOTES:

1) AERIAL PHOTO OBTAINED FROM ESRI IMAGERY DATED 10-15-09.

2) CENTER OF GRAVITY REPRESENTS THE EQUIVALENT DISTANCE IF ALL MATERIAL WERE TO BE REPLACED BY A POINT MASS ACTING AT ONE LOCATION. IT ESSENTIALLY REPRESENTS THE CENTER OF WHERE DREDGING HAS OCCURRED BETWEEN 2001 AND 2010 BY VOLUME OF SEDIMENT.

3) THE JULY 1989 OVERALL CENTER OF GRAVITY WAS REPORTED IN THE "EVALUATION OF WOODTICK PENINSULA RESTORATION AND RECREATIONAL HILL/UPLAND DISPOSAL ALTERNATIVES USING TOLEDO HARBOR DREDGE SPOIL MATERIAL", PREPARED BY HULL & ASSOCIATES, INC., DATED JULY 1989, USING DATA BETWEEN 1984 AND 1988.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GREAT LAKES RESTORATION INITIATIVE PROJECT
EPA GRANT #GL-00E00523-0
TOLEDO-LUCAS COUNTY PORT AUTHORITY AND THE OHIO LAKE ERIE COMMISSION


FIGURE 1
TOLEDO HARBOR 2001-2010

MAUMEE RIVER/LAKE ERIE, OHIO

| | |
|---|---|
| PROJECT NO.: TPA044 | SUBMITTAL DATE: SEPTEMBER 2011 |
| CAD DWG FILE: TPA044.100.0001 | PLOT DATE: 9/21/11 |

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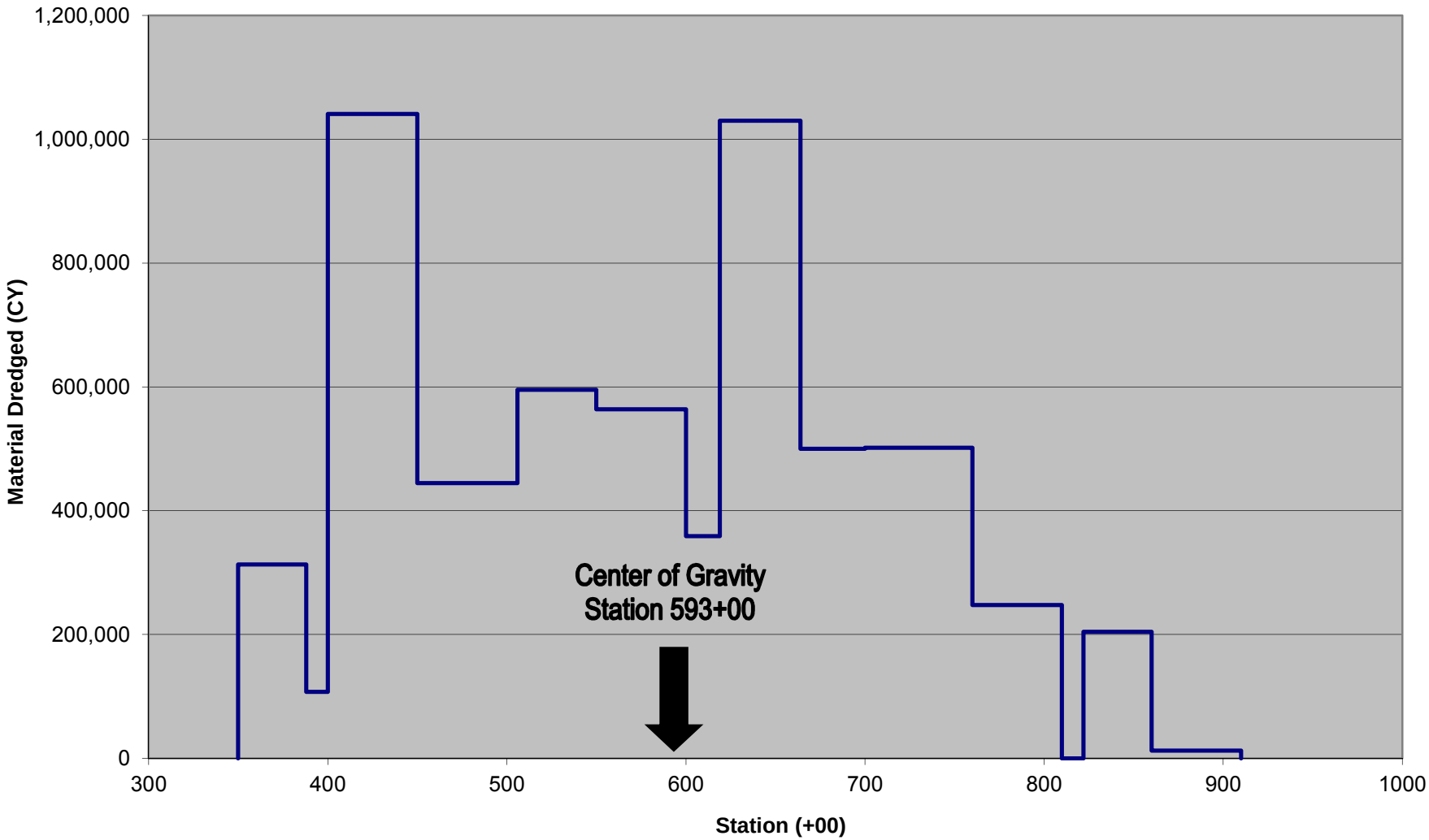
## Figure 2

## Toledo Harbor Federal Shipping Channel - 2001-2010
## Lake Channel



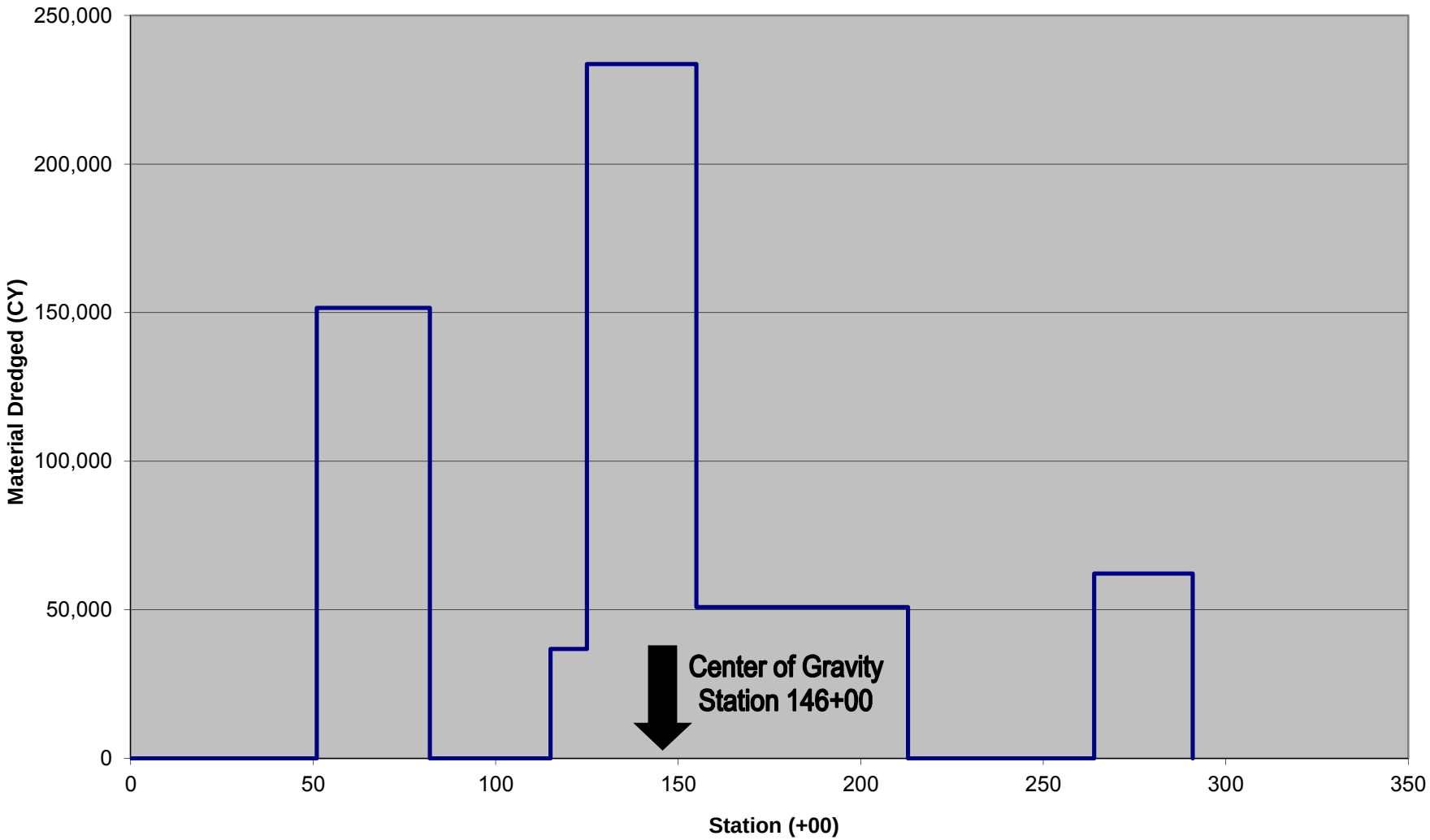

HULL & ASSOCIATES, INC.
TOLEDO, OHIO

Source: data provided by the US Army Corps of Engineers based on estimated 10-year cumulative volume of dredged sediment used to quantify the contractor's work effort.

SEPTEMBER 2011
TPA044.100.0006.XLS

**Figure 3**

**Toledo Harbor Federal Shipping Channel - 2001-2010**
**River Channel**

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TOLEDO, OHIO

Source: data provided by the US Army Corps of Engineers based on estimated 10-year cumulative volume of dredged sediment used to quantify the contractor's work effort.

SEPTEMBER 2011
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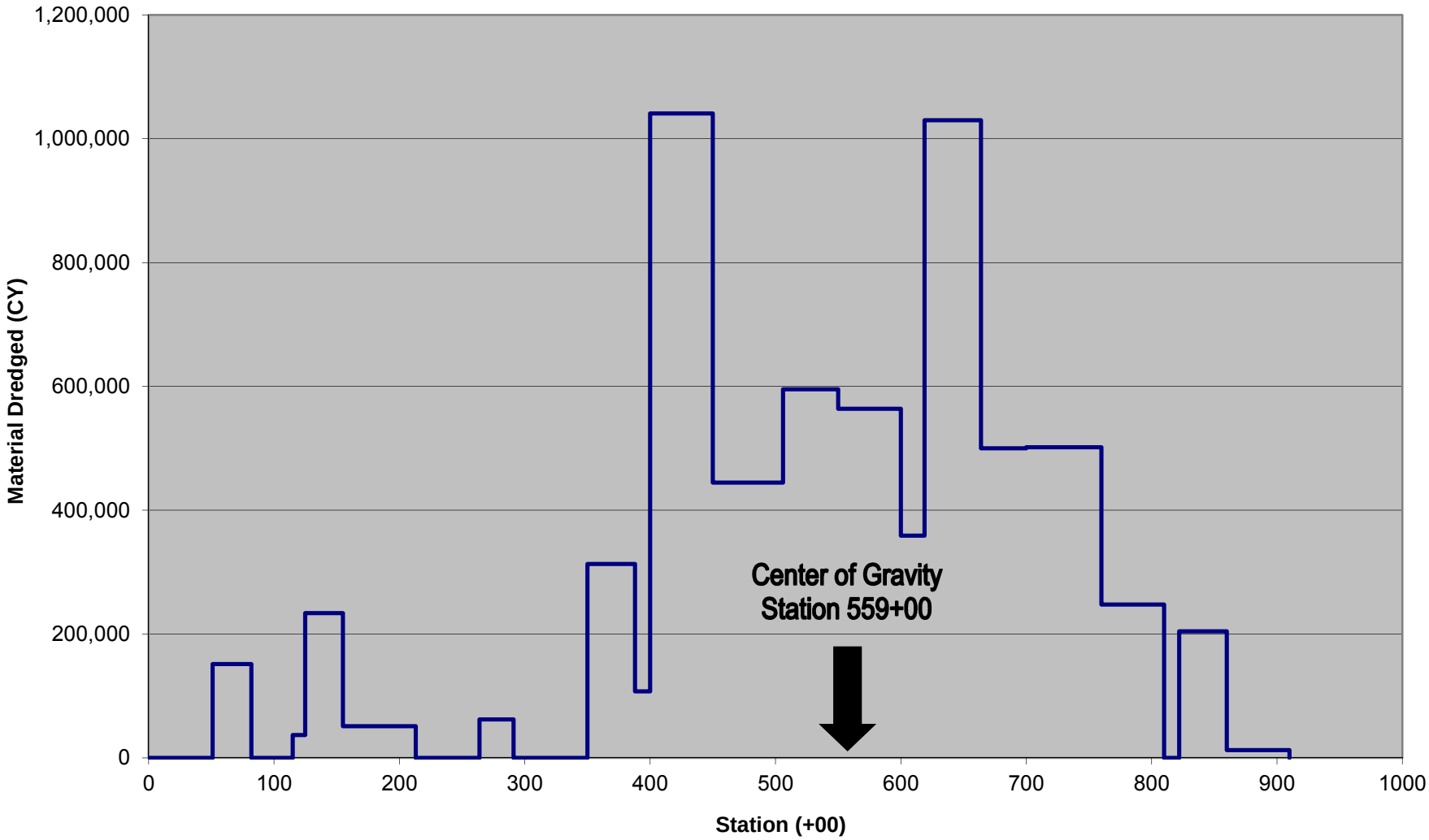
## Figure 4

## Toledo Harbor Federal Shipping Channel - 2001-2010
## Overall

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TOLEDO, OHIO

Source: data provided by the US Army Corps of Engineers based on estimated 10-year cumulative volume of dredged sediment used to quantify the contractor's work effort.

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# APPENDIX B

Physical and Chemical Characteristics for
Toledo Harbor Dredged Sediment and Risk Memorandums

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# APPENDIX B-1

Physical and Chemical Characteristics for Toledo Harbor Dredged Sediment, Geotechnical Test Results, and USACE Evaluation of Toledo Harbor Federal Navigation Channel with Respect to Suitability for Open-lake Placement

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# Memorandum

TO: John Hull, P.E., Hull & Associates, Inc.

FROM: Phil Hicks and Kristin Gardner, Hull & Associates, Inc.

DATE: August 30, 2012

RE: Summary of Physical and Chemical Characteristics of the Toledo Harbor Dredge Sediment; TPA044.100.0036

---

This memorandum provides a summary of general physical and chemical characteristics of material dredged from the Toledo Harbor federal channel.

**Physical Characteristics**

Physical characteristics of dredged material summarized below is based on historical monitoring and testing of a sample of dredged material collected by the U.S. Army Corps of Engineers (USACE) from the Federal channel in 2011. Toledo Harbor dredged material is primarily comprised of fines (a mix of silt and clay), primarily classified as CH (clay with high plasticity or fat clay) with a Plastic Index (PI) of over 50 and with a high water retention capacity. Geotechnical properties of the dredged material sample collected from the Federal channel in 2011 was determined by Hull & Associates, Inc.'s American Association of State Highway and Transportation Officials (AASHTO) accredited geotechnical/materials testing laboratory. The purpose of the geotechnical analysis was to confirm assumptions of the moisture content, specific gravity, and grain size of the material that were used in the conceptual design. The geotechnical laboratory test results are attached.

<u>Moisture Content</u>
A moisture content of 146.3% was determined using the oven dry method and a moisture content of 143.2% was determined using the air dry method. An assumed value of 145% was used to achieve the relative costs associated with the different placement options.

<u>Specific Gravity</u>
Standard test methods, American Society for Testing and Materials (ASTM) ASTM D 854/AASHTO T100, were used to determine the specific gravity of the sediment to be 2.723.

Density
The density of the dredged material was determined to be approximately 95 pounds per cubic foot. The dry unit weight was determined to be approximately 39 pounds per cubic foot. These assumptions were used to achieve the relative costs associated with the different placement options.

Particle-Size Distribution
The grain size distribution shows that the sample is approximately 1.4% sand, 20.4 % silt, and 78.1% clay. The diameter corresponding to 100% finer (D100) is 0.6 millimeters and the diameter corresponding to 60% finer (D60) is 0.002 millimeters. The sediment is classified as a Fat Clay (CH).

The laboratory testing above was performed on a single sample and should not be considered representative of the entire Federal channel. Additional samples and tests should be conducted to achieve a better understanding of the sediments characteristics and how they will act according to the selected option and placement methods.

**Chemical Characteristics**

Traditional contaminants in Toledo Harbor include heavy metals, polycyclic aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) (USACE, 2009). Sediment and water samples from the Lake Approach, River Channel, and open-lake reference and placement areas were collected by USACE in 2010. Various bulk sediment chemical testing was completed including inorganic analyses (e.g. heavy metals, total organic carbon, and inorganic parameters) and organic analyses (e.g. PAHs, PCBs, and pesticides). Elutriate testing was also completed on sediment samples. Results of the most recent evaluation of Toledo Harbor sediment with respect to open-lake placement, completed by USACE, is included as an attachment. This document summarizes sampling and completed in 2010 and the associated sediment quality evaluation results completed by the USACE. In addition, a summary of the maximum reportable concentrations of various contaminants of concern detected in 2010 bulk sediment samples from the River and Lakes channels as well as various sediment quality guidelines for sediment is provided in the Toledo Harbor Dredge Sediment Preliminary Risk Evaluation memorandum that is included in Appendix B-2 of the Toledo Harbor Sediment and Use Plan (THSMUP).

Hull & associates, inc.

# SPECIFIC GRAVITY TEST DATA SHEET
## ASTM D 854/AASHTO T100

| | |
|---|---|
| **LAB NO.** | B12-237 |
| **SAMPLE DATE** | NA |
| **PROJECT** | TOLEDO HARBOR |
| **PROJ. NO.** | TPA004 |
| **BORING #** | NA |
| **SAMPLE #** | DREDGING SCOW |
| **DEPTH** | |
| **DATE TESTED** | 3/6/2012 |

**DESCRIPTION/REMARKS** GRAY FAT CLAY

| TEST NO. | 1 | 2 | 3 |
|---|---|---|---|
| | | | |
| Volumetric flask no.l | 7 | | |
| Flask weight (g) | 58.40 | | |
| Weight of flask + water filled to mark, $W_1$ (g) | 157.66 | | |
| Weight of flask + soil + water filled to mark, $W_2$ (g) | 168.43 | | |
| Tare Number | 7 | | |
| Weight of Tare (g) | 58.4 | | |
| Weight of dry soil + Tare (g) | 75.42 | | |
| Weight of dry soil , $W_3$ (g) | 17.02 | | |
| Temperature of test, $T_1$ °C | 21.5 | | |
| $G_1$ (at $T_1$ °C) = $W_3/(W_1 -(W_2 - W_3))$ | **2.723** | | |
| Correction factor A | 0.9998 | | |
| $G_1$ (at 20°C) = G1 (at T°C)$^A$ | **2.723** | | |
| Date/Tested By | HQP | | |
| Date/Checked By | SM | | |
| Results Approved By | | | |

**RELATIVE DENSITY OF WATER AND CONVERSION FACTOR k FOR VARIOUS TEMPERATURES**

| TEMP, °C | RELATIVE DENSITY OF WATER | CORRECTION FACTOR A | TEMP, °C | RELATIVE DENSITY OF WATER | CORRECTION FACTOR A |
|---|---|---|---|---|---|
| 18 | 0.9986244 | 1.0004 | 25 | 0.9970770 | 0.9989 |
| 19 | 0.9984347 | 1.0002 | 26 | 0.9968156 | 0.9986 |
| 20 | 0.9982343 | 1.0000 | 27 | 0.9965451 | 0.9983 |
| 21 | 0.9980233 | 0.9998 | 28 | 0.9962652 | 0.9980 |
| 22 | 0.9978019 | 0.9996 | 29 | 0.9959761 | 0.9977 |
| 23 | 0.9975702 | 0.9993 | 30 | 0.9956780 | 0.9974 |
| 24 | 0.9973286 | 0.9991 | | | |

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US Army Corps
of Engineers®
Buffalo District

# EVALUATION OF TOLEDO HARBOR FEDERAL NAVIGATION CHANNEL SEDIMENTS WITH RESPECT TO SUITABILITY FOR OPEN-LAKE PLACEMENT

## I. Introduction.

This preliminary Tiered Evaluation on Toledo Harbor Federal navigation channel sediments has been performed in accordance with guidelines contained in the 1998 U.S. Environmental Protection Agency (USEPA)/U.S. Army Corps of Engineers (USACE) Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/USACE 1998a). It is based on 2004 Lake Approach Channel sediment data (Engineering and Environment, Inc. [EEI] 2004), 2006 Upper Lake Approach Channel and River Channel sediment data (EEI 2006) and 2010 data on River Channel and Lake Approach Channel sediments (USACE 2010).

## II. Sediment Quality Assessment.

*Background and Potential Sources of Sediment Contamination*

Traditional contaminants in Toledo Harbor Federal navigation channel sediments include heavy metals, phosphorous, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and pesticides. Major sources of contamination to bottom sediments in the harbor's Lake Approach Channel in Maumee Bay include sediments from Maumee River, Ottawa River and Western Basin of Lake Erie. The harbor's River Channel is situated within the Maumee River Area of Concern (AOC) http://www.epa.gov/glnpo/aoc/maumee.html. Major sources of pollution to bottom sediments in the River Channel include: (1) non-point source agricultural runoff (i.e., phosphorus, nitrogen and pesticides); (2) urban storm water runoff (i.e., heavy metals, oil and PAHs), and commercial and residential development; (3) municipal and effluent industrial point source discharges (the Lucas County Wastewater Treatment Plant is a major local source of ammonia to Toledo Harbor); (4) combined sewer overflows (CSOs) (i.e., oil, sediment and bacteria); (5) sanitary sewer overflows; and (6) chemical leachate from waste disposal sites. Swan Creek is also a known source of pollutants to Maumee River sediments.

*Evaluation Based on Existing Sediment Data*

Toledo Harbor sediments were sampled and analyzed across three events. In 2004, 11 surface grab samples were collected from the Lake Approach Channel between Lake Mile (LM) 0 and LM 10 (Sites LM-0 through LM-10), and four surface grab sediment samples were collected from both the open-lake reference area (Sites TL-1 through TL-4) and open-lake placement area (Sites TD-1 through TD-4) (Figure 1). In 2006, 16 surface grab samples were collected from the Upper Lake Approach Channel between LM 0 and 2 (Sites LM-0 through LM-2) and River Channel (Sites RM-1 through RM-7), and four and two samples were collected from the open-lake reference area (Sites TL-1 through TL-4) and open-lake placement area (Sites TD-1 and TD-2), respectively (Figure 2). All sediment samples were subject to bulk particle size analyses, and analyzed for the following: Inorganics—heavy metals, cyanide, ammonia, phosphorus, nitrogen, oil/grease and total organic carbon (TOC); and organics—PAHs, PCBs and pesticides (EEI 2004 and 2006). A standard elutriate test (SET) for the same inorganic and organic contaminants was applied to all of the Federal navigation channel sediment samples. In addition, water column acute toxicity tests (bioassays) were applied to upper Lake Approach Channel samples (U.S. Army Engineer Research and Development Center [ERDC] 2006), and short-term fate (STFATE) modeling was used to predict releases of ammonia associated with the open-lake placement of sediments dredged from throughout the Federal navigation channels (USAERDC 2007).

In 2010, 39 surface grab samples were collected from the Lake Approach Channel between LM 0 and 13 (Sites LM-0 through LM-13) and River Channel (Sites RM-1 through RM-7), and four were collected from the open-lake reference area (Sites TL-1 through TL-4) and open-lake placement area (Sites TD-1 through TD-4) (Figures 3 and 4). Sediment samples between RM 1 and LM 5 were collected for analysis at one-quarter mile intervals. All sediment samples were subject to bulk particle size analyses, and analyzed for the following: Inorganics—heavy metals, cyanide, nitrogen-ammonia, phosphorus, nitrogen-total Kjeldahl, oil/grease and TOC; and organics—PAHs, PCBs and pesticides (USACE 2010). A SET for the same inorganic and organic contaminants was applied to all of the Federal navigation channel sediment samples. In addition, solid-phase bioassays were applied to the Site RM-2 sediment sample, as well as composited open-lake reference and placement area sediments. Water column bioassays were also performed on the Site RM-2 sediment sample.

This report evaluates the 2004 and 2006 Toledo Harbor Federal navigation channel sediments individually, and then proceeds to evaluate the 2010 harbor sediment data. The toxicological assessment of these sediments is summarized as follows:

a. Lake Approach Channel sediments (EEI 2004). The sediment sampling sites for this reach of Toledo Harbor are shown in Figure 1.

1. *Bulk sediment analyses.*

(a) **Physical testing:** Table 1 presents the results of the sieve analyses performed on the sediment samples. The Lake Approach Channel material was comprised of between 79.4% (Site LM-2) and 99.3% (Site LM-4) silts and clays, with the remainder sands. Three of the four open-lake reference area sediment samples were comprised predominantly of silts and clays (81.6 to 94.1%), with some sands. Since the Site TL-4 sediment sample was composed of 62% sands, it was not considered in this evaluation because it was not physically comparable to the Lake Approach Channel sediments. Sediments at the open-lake placement area were composed of between 94.4% and 98.4% silts and clays, with the remainder sands.

(b) **Chemical testing:** Both open-lake reference and placement area sediments in the Western Basin of Lake Erie (Figure 1) were used to represent the lake environs. As such, contaminant concentrations in Lake Approach Channel and River Channel sediment samples were compared to these areas to determine if they significantly exceeded lake sediment concentrations. Contaminant concentrations in samples that exceeded the maximum lake value were then screened against Ohio Environmental Protection Agency (OEPA) sediment reference values (SRVs) for the Huron/Erie Lake Plain or Ohio (statewide) (OEPA 2008). Those which significantly exceeded both of these screening criteria were preliminarily determined to be sediment contaminants of concern (COCs) unless they were not found to be of toxicological significance.

(1) Inorganic analyses—Table 2 presents the results of inorganic analyses on the sediment samples.

•Heavy metals—Aluminum concentrations in the sediment samples ranged from 14,800 to 27,800 mg/kg at Sites LM-9 and LM-5, respectively. They were comparable to the maximum lake value of 23,200 mg/kg and less when compared to the Huron/Erie Lake plain SRV of 42,000 mg/kg. Concentrations of barium at Sites LM-0, LM-3, LM-4 and LM-5 (129 to 144 mg/kg) were comparable to the maximum lake value of 121 mg/kg and below the SRV of 210 mg/kg in Huron/Erie Lake plain of Ohio. Similarly, beryllium concentrations at Sites LM-0, LM-3, LM-4, LM-5 and LM-8 (0.95 to 1.12 mg/kg) were very comparable to the maximum lake value of 0.93 mg/kg but somewhat higher than the Ohio (statewide) SRV of 0.80 mg/kg. Concentrations of iron in the Lake Approach Channel sediment samples at Sites LM-0, LM-3, LM-4, LM-5 and LM-8 (range of 29,400 to 34,200 mg/kg) were comparable to the

maximum lake value of 28,200 mg/kg and less than the Huron/Erie Lake plain SRV of 44,000 mg/kg. Manganese concentrations at Sites LM-0, LM-3, LM-4, LM-5, LM-8 and LM-10 ranged from 471 to 563 mg/kg, all of which were comparable to the maximum lake value of 446 mg/kg and lower when compared to the Huron/Lake Erie lake plain SRV of 1,000 mg/kg. Vanadium concentrations at Sites LM-0, LM-3, LM-4 and LM-5 (range of 45.2 to 53.3 mg/kg) were comparable to the maximum lake value of 44.6 mg/kg and Ohio (statewide) SRV of 40 mg/kg.

•TOC and other inorganic parameters—TOC levels in the Lake Approach Channel sediment samples ranged from 2.68% (Site LM-0) to 3.89% (Site LM-10). At the open-lake reference and placement areas, TOC levels ranged from 2.02% to 3.03% and 2.10% to 2.73%, respectively. Ammonia concentrations were significantly higher at several Lake Approach Channel sites (Sites LM-0, LM-1, LM-3 and LM-4) relative to the open-lake reference area sediments, ranging from 203 to 422 mg/kg. Based on these data, ammonia was identified as a preliminary COC at Sites LM-0 and LM-3.

(2) Organic analyses

•PAHs—Table 3 presents the results of these analyses. Total PAHs concentrations were determined through summing the 16 USEPA priority pollutants. Total PAH concentrations in the Lake Approach Channel sediment samples ranged from 0.94 to 1.70 mg/kg. At the open-lake reference and placement areas, total PAH levels ranged from 0.34 to 3.7 mg/kg, and 0.98 to 1.4 mg/kg, respectively. Total PAH concentrations in the Lake Approach Channel sediments were very similar to those at both of the open-lake areas. Low levels of some PAH compounds were measured in the Lake Approach Channel sediment samples. Acenaphthylene at Sites LM-0 and LM-8 significantly exceeded the open-lake reference area range (27.7 and 7.01 μg/kg, respectively). In addition, the concentrations of 1-methylnaphthalene at Sites LM-4 and LM-9 were significantly higher relative to the open-lake reference area samples. However, neither of these is of toxicological concern. Therefore, PAHs were not regarded as COCs.

•PCBs—Table 4 presents the results of these analyses. PCBs were quantified as Aroclor mixtures. PCBs were measured at all of the Lake Approach Channel Sites, except for Site LM-6. Individual Aroclor mixtures that were detected ranged from 3.8 μg/kg of Aroclor 1254 at Site LM-2 to 143 μg/kg of Aroclor 1242 at Site LM-5. Total PCB concentrations (only considering the detected values) in the Lake Approach Channel sediment samples ranged from 11.6 μg/kg at Site LM-2 to 223 μg/kg at Site LM-1. Total PCB levels in sediments at Sites LM-1 (223 μg/kg) and LM-5 (174 μg/kg) were somewhat elevated relative to those at the open-lake reference (154 μg/kg) and

placement (76 μg/kg) areas.

In order to ascertain whether total PCBs would bioaccumulate from the Lake Approach Channel Site LM-1 and LM-5 sediment samples at levels higher relative to those at the open-lake reference/placement areas, a Tier 2 theoretical bioaccumulation potential (TBP) model was employed. TBP is an equilibrium theory-based algorithm used to predict the potential bioaccumulation of neutral, organic compounds, such as PCBs, in sediments (McFarland 1984). This model is expressed as:

$$TBP = BSAF\ (L)\ (C_s/TOC)$$

Where:

TBP = Predicted whole body tissue concentration of the neutral organic compound (μg/kg wet weight)
BSAF = Biota-sediment accumulation factor
L = Concentration of lipid in target animals (percent of wet weight)
$C_s$ = Concentration of neutral organic compound in sediment (μg/kg dry weight)
TOC = Total organic carbon concentration in sediment (percent of dry weight)

The target animal used in this case is an oligochaete worm. In this model, a 1% lipid content in oligochaete worms, an average that is characteristically representative (e.g., Ankley *et al.* 1992, Pickard *et al.* 2001), a BSAF of 1.48 (Lenox, unpublished Lake Erie data) and TOC data from Table 2 were used. The total PCB TBP predictions are summarized in the table below:

| Lake Approach Channel Site | Total PCB TBP, μg/kg | Open-lake reference area total PCB TBP, μg/kg | Open-lake placement area total PCB TBP, μg/kg |
|---|---|---|---|
| LM-1 | 116 | 75.2 | 50.4 |
| LM-5 | 77.3 | | |

The TBP for total PCBs at Site LM-5 was comparable to that on the open-lake reference area sample. For Site LM-1, the TBP for total PCBs was 41.8 μg/kg higher (55% increase) relative to the open-lake reference area sample, which may not show a statistical difference if the sediments were subjected to Tier 3 solid phase bioaccumulation experiments. However, based on the TBP prediction, total PCBs were retained as a preliminary COC at Site LM-1 sediments in the Lake Approach Channel.

•Pesticides—Table 5 presents the results of these analyses. Most pesticides in the Lake Approach Channel sediments samples were non-detectable at method detection limits (MDLs) ranging from 0.804 to

377 µg/kg. The sum of 4,4′-dichlorodiphenyltrichloroethane (DDT) and its metabolites/breakdown products 4,4′-dichlorodiphenyldichloroethylene (DDE) and 4,4′-dichlorodiphenyldichloroethane (DDD) (ΣDDT) at Site LM-6 was 19.2 µg/kg, which was within the range of the summation of these compounds at the open-lake reference (ΣDDT range = 14.0 to 58.2 µg/kg) and placement (ΣDDT = 19.9 to 21.9 µg/kg) areas. These three compounds were summed for comparison purposes based on the following rationale:

1—4,4′-DDT, 4,4′-DDE and 4,4′-DDD are considered highly hydrophobic, having Log $K_{ow}$s of 6.91, 6.51 and 6.02 respectively (ATSDR 2002). Hydrophobicities tend to reduce the bioavailability of sediment-associated neutral organic contaminants;

2—BSAFs in the literature for sediment-processing benthic organisms show that the bioavailability of DDT, DDE and DDD is similar (Ingersoll *et al.* 2004), or that DDT (Mulsow and Landrum 1995) can be less bioavailable than DDE (Ferraro *et al.* 1990); and

3—The sediment samples were processed through gas chromatographic analysis. This has been shown to cause a breakdown of DDT into DDE and DDD, which would tend to make the analytical differentiation of the three compounds based on these sediment data obscure (Forman and Gates 1997).

Chlordane was measured at 182 µg/kg in sediments at Site LM-0. Since the open-lake reference area sediment levels were non-detectable at limits above and below the concentration measured in the channel sediment (MDL range = 121 to 264 µg/kg), a Tier 2 TBP prediction would not provide useful information unless the censored data on the open-lake reference area sediment samples could be assigned a workable value. Therefore, chlordane was determined to be preliminary sediment COC at this site.

2. *Elutriate testing*—Tables 6 through 9 present the results of the standard elutriate test (SET) performed on the sediment samples. The results show low releases of some of the metals from the Lake Approach Channel sediment samples (Table 6). No releases of PAH compounds were indicated at or above MDLs ranging from 0.500 to 0.590 µg/L (Table 7). No releases of PCBs were shown at or above MDLs ranging from 0.100 to 0.417 µg/L (Table 8). Most pesticide releases were non-detectable at MDLs ranging from 0.200 to 10.0 µg/L (Table 9). At Site LM-0, 4,4′-DDT was estimated at a "J" value of 0.158 µg/L. In addition, a release of dieldrin at 0.4 µg/L was evidenced at Site LM-4. STFATE modeling indicated that any contaminant level that exceeded the respective Lake Erie Aquatic Life Criterion would comply with the WQS for outside the mixing zone maximum (OMZM), after consideration of mixing (USAERDC 2007).

b. River Channel and Upper Lake Approach Channel sediments (EEI 2006). The sediment sampling sites for this reach of Toledo Harbor are shown in Figure 2. (Note: In addition to the River Channel and Upper Lake Approach Channel sediments, paragraph 2[b][2] below [water column bioassays] also addresses ammonia elutriate modeling for sediments sampled from Sites LM-0, LM-1, LM-3, LM-4 of the Lake Approach Channel in 2004 [EEI 2004]).

1. *Bulk sediment analyses.*

(a) **Physical testing:** Table 10 presents the results of the sieve analyses performed on the sediment samples. The Upper Lake Approach Channel material was comprised of between 86.5% (Site LM-1.75) and 98.9% (Site LM-1.25) silts and clays, with the remainder sands. This was consistent with the 2004 data on this reach (EEI 2004). The River Channel material was comprised of between 72.9% (Site RM-7) and 98.8% (Site LM-0) silts and clays, with the remainder sands. Three of the four open-lake reference area site sediments were comprised predominantly of silts and clays (72.5% to 96%), with some sands. The sediment sample from Site TL-3 was comprised of a relatively more coarse-grain fraction (41.6% sands). Sediments at the open-lake placement area were composed of between 78.5% and 97.1% silts and clays, with the remainder sands.

(b) **Chemical testing:** As in the evaluation of the Lake Approach Channel material contamination, both open-lake reference and placement area sediments in the Western Basin of Lake Erie (Figure 1) were used to represent the lake environs. As such, contaminant concentrations in Lake Approach Channel and River Channel sediment samples were compared to these areas to determine if they significantly exceeded lake sediment concentrations. Contaminant concentrations in samples that exceeded the maximum lake value were then screened against OEPA SRVs for the Lake Erie/Huron plain (OEPA 2003). Those which significantly exceeded both of these screening criteria were preliminarily determined to be sediment COCs unless they were not found to be of toxicological significance.

To first verify that the 2004 and 2006 data showed similar levels of open-lake reference area contamination, Table 11 compares the bulk chemistry on the sediments. Some of the metals increased in concentration between 2004 and 2006. However, these increases were not toxicologically significant. All metal concentrations at the open-lake area in 2006 were comparable to the Huron/Lake Erie lake plain and/or Statewide SRV (at three sites, copper was marginally higher than the sediment reference value of 42 mg/kg) (Ohio EPA 2003). The decrease in the maximum concentration of cyanide between 2004 (1.12 mg/kg) and 2006 (0.13 mg.kg) may have been toxicologically significant. Most of the other inorganic parameters, as well as total PAHs and total PCBs,

showed a decrease in concentration. The increase in concentration of DDT (and its metabolites/breakdown products) and aldrin in 2006 was negligible.

(1) Inorganic analyses—Table 12 presents the results of inorganic analyses on the sediment samples.

•Heavy metals—Aluminum concentrations in the sediment samples ranged from 11,800 to 23,200 mg/kg at Sites RM-1 and RM-7, respectively. They were more comparable to the maximum lake value of 17,700 mg/kg and less when compared to the Huron/Erie Lake Plain SRV of 42,000 mg/kg. Concentrations of barium in the sediment samples ranged from 96.5 (Site RM-01) to 171 (Site RM-7) mg/kg and were comparable to the maximum lake value of 123 mg/kg and below the SRV of 210 mg/kg in Huron/Erie Lake Plain. Beryllium concentrations ranged from 0.70 mg/kg (Site RM-1) to 1.31 mg/kg (Site RM-7) and were comparable to the maximum lake value of 1.0 mg/kg and Ohio (statewide) SRV of 0.80 mg/kg. At Site RM-2, cadmium was measured at 2.71 mg/kg, and was significantly higher than the maximum lake value of 1.14 mg/kg, as well as the 0.96 mg/kg SRV for the Huron/Erie Lake Plain. However, a concentration of 2.71 mg/kg would not appear to be acutely toxic. Chromium was measured at 83.8 mg/kg at Site RM-2, and was significantly higher than the maximum lake value of 39 mg/kg, as well as the 51 mg/kg SRV for the Huron/Erie Lake Plain. However, a concentration of 83.8 mg/kg would not appear to be acutely toxic. At Sites RM-2 and RM-3, copper was measured at 84.6 and 77.9 mg/kg, respectively, and was significantly higher than the maximum lake value of 50 mg/kg, as well as the Huron/Erie Lake Plain of Ohio SRV of 42 mg/kg. However, such a concentration is not acutely toxic. At Sites RM-2 and RM-4, lead was measured at 61.6 and 47.3 mg/kg, respectively, and was significantly higher than the maximum lake value of 33.7 mg/kg. Such levels of lead are consistent with the Ohio (statewide) SRV of 47 mg/kg and are not toxicologically significant. The magnesium concentrations at Sites RM-3 (22,600 mg/kg) and RM-7 (19,000 mg/kg) were significantly higher than the maximum lake value of 14,400, but lower than the Huron/Erie Lake Plain SRV of 29,000 mg/kg. Manganese concentrations at Sites LM-2, LM-1.5, LM-1.25, LM-1, LM-0, RM-3 and RM-7 ranged from 614 to 913 mg/kg, all of which were greater than the maximum lake value of 584 mg/kg, but lower when compared to the Huron/Erie Lake plain SRV value of 1,000 mg/kg. The nickel concentration of 49.1 mg/kg at Site RM-2 was significantly higher than the maximum lake value of 37.7 mg/kg. This concentration also exceeds the Huron/Erie Lake Plain SRV of 33 mg/kg and may be acutely toxic. Therefore, it was identified as a preliminary COC in the Site RM-2 sediments. Vanadium concentrations at Sites LM-2, LM-1.5, LM-1.25, LM-0, RM-3 and RM-7 (range of 35.3 to 45.9 mg/kg) were somewhat higher than the maximum lake value of 34.6 mg/kg and comparable to the Ohio (statewide) SRV of 40 mg/kg.

•TOC and other inorganic parameters—TOC levels in the Upper Lake Approach Channel and River Channel sediment samples ranged from 1.7% (Site RM-3) to 7.7% (Site RM-2). At the open-lake reference and placement areas, TOC levels ranged from 1.4% to 3.4% and 3.4% to 3.6%, respectively. The cyanide concentration of 0.65 mg/kg at Site RM-2 was significantly higher than those at the open-lake reference and placement areas. It is unclear as to whether such a level in sediment is potentially toxic; cyanide appears have little environmental relevance. Therefore, it was treated as a preliminary COC at this site. Ammonia concentrations in the sediment samples were significantly higher at several of the sites (Sites LM-1, LM-0.5, LM-0.25 and RM-1 ranged from 300 to 460 mg/kg) relative to the open-lake reference area range of 63 to 93 mg/kg). Based on these data, ammonia was identified as a preliminary contaminant of concern (COC) at Sites LM-1, LM-0.5, LM-0.25 and RM-1.

(2) Organic analyses

•PAHs—Table 13 presents the results of these analyses. Total PAH concentrations in the Upper Lake Approach Channel sediment samples ranged from 0.08 to 0.28 mg/kg, which was lower than those measured in this reach of the channel in 2004 (Table 3). In the River Channel sediment samples, total PAH concentrations ranged from 0.05 (Site RM-3) to 9.6 mg/kg (Site RM-2). At the open-lake reference and placement areas, total PAH levels ranged from 0.06 to 0.80 mg/kg, and 0.06 and 0.07 mg/kg, respectively. Except for Site RM-2, total PAH concentrations in the Upper Lake Approach Channel and River Channel sediments were very comparable to those at both of the open-lake areas. The total PAH concentration of 9.6 mg/kg at Site RM-2 may be acutely toxic. Therefore, total PAHs were identified as a COC at this site in the River Channel.

•PCBs—Table 14 presents the results of these analyses. PCBs, as Aroclors, were not detected in any of the Upper Lake Approach Channel and River Channel sediment samples at MDLs ranging from 6.2 to 14 µg/kg. PCBs were non-detectable in the open-lake reference and placement area sediment samples at MDLs ranging from 6 to 10 µg/kg. Since PCBs were not detected in the Site LM-1 sediments (relative to the data from EE1 [2004]), they were eliminated as a preliminary COC at this site in the Lake Approach Channel.

•Pesticides—Table 15 presents the results of these analyses. Pesticides in the Upper Lake Approach Channel and River Channel sediments samples were non-detectable at MDLs ranging from 0.161 to 45.4 µg/kg. With few exceptions, pesticides were non-detectable in the open-lake reference and placement area sediment samples at MDLs ranging from 0.147 to

33.6 µg/kg. DDT, DDD, DDE and aldrin were measured at low levels at a single site within the open-lake reference area (Site TL-1). Based on the 2004 data (EEI 2004), chlordane was identified as a preliminary COC in sediments at Site LM-0. The 2006 data on chlordane did not show detectable concentrations of this pesticide in any of the Upper Lake Approach/River Channel sites at much lower MDLs ranging from 8.6 µg/kg to 15 µg/kg. Therefore, chlordane was not identified as a COC at this site.

2. *Elutriate testing*

(a) **SET**—Tables 16 through 19 present the results of the SET performed on the sediment samples. The results show low releases of some of the metals from the Upper Lake Approach Channel and River Channel sediment samples (Table 16). There were some releases of PAH compounds indicated at or above MDLs ranging from 0.031 to 0.064 µg/L (Table 17). Low to moderate releases of most PAH compounds were evidenced from sediments at Site RM-2. No releases of PCBs were shown at or above MDLs ranging from 0.11 to 0.21 µg/L (Table 18). No pesticide releases from the sediments were detectable at MDLs ranging from 0.00160 to 0.423 µg/L (Table 19). STFATE modeling indicated that any contaminant level that exceeded the respective Lake Erie Aquatic Life Criterion would comply with the WQS for OMZM, after consideration of mixing (USAERDC 2007).

(b) **Water column bioassays**—At Sites LM-0, LM-1, LM-3, LM-4 (2004) and LM-1.0, LM-0.5, LM-0.25, RM-1 (2006), ammonia was measured at bulk sediment concentrations that were significantly higher (range 203 to 460 mg/kg) relative to the open-lake reference and placement areas (maximum range 93 to 124 mg/kg). Therefore, it was identified as a COC at these sites. Ammonia is an atypical COC because depending on concentration, it is less toxic in sediment, but can temporarily become acutely toxic to fish when released during the open-lake placement of dredged material (invertebrates are typically not as sensitive as fish to ammonia levels [USEPA 1999]). Therefore, its toxicity is most appropriately characterized in the water column.

To assess the toxicity of ammonia releases, sediments with the highest concentration in the Lower Lake Approach Channel between LM-1 and LM-2 (340 to 460 mg/kg) were subjected to Tier 3 laboratory water column bioassays (USEPA/USACE 1998a). The following short-term toxicity tests were performed on these sediments to determine lethal responses to elutriate: (1) 2-day exposure of the cladoceran (water flea) (*Ceriodaphnia dubia*) to four elutriate treatments (100%, 50%, 10% and 0%) and a performance control, with survival as measurement endpoint; and (2) 4-day exposure of fathead minnow (*Pimephales promelas*) to four elutriate treatments (100%, 50%, 10% and 0%) and a performance control, with survival as measurement endpoint. The

bioassays were performed by USAERDC. During the experiments, total ammonia concentrations were sufficiently elevated in the LM-1 sediment 100% elutriate treatment to warrant concern that they may confound the *P. promelas* bioassay data. Therefore, a toxicity reduction evaluation (TRE) was performed for the *P. promelas* test, which involved: (1) passing of 100% elutriate through a zeolite column to remove ammonia; and (2) treatment of 100% elutriate with ethylenediamine tetraacetate acid (EDTA) to decrease the bioavailability of metals (via complexation) without altering ammonia concentrations (Hockett and Mount 1996). The results of these two bioassays, which are reported in USAERDC (2006), are summarized in Table 20 and discussed below:

(1) *C. dubia* bioassay—No statistically significant reduced survival was evidenced across all three elutriate treatments, relative to the 0% treatment (site water), for either the LM-1 or LM-2 sediment samples. Mortality data from the test were insufficient to calculate lethal concentration (LC) 50 values.

(2) *P. promelas* bioassay—Statistically significant reduced survival was not evidence in the 50% or 10% treatments, relative to the 0% treatment (site water) for either the LM-1 or LM-2 sediment samples. The 100% elutriate treatment for the LM-1 and LM-2 sediment samples showed statistically significant reduced survivals (54±17% and 66±15%, respectively; $P<0.05$) relative to the site water (86±11%). This reduced survival was prior to mixing in the water column. Mortality data from the test were insufficient to calculate LC50 values. The TRE strongly suggested that the mortality observed was due to ammonia. Since invertebrates are considered less sensitive to ammonia, the lack of observed toxicity of the 100% elutriate treatment to *C. dubia* supports the presumption that the reduced *P. promelas* survival in the same treatment was attributable to ammonia.

Subsequent Tier 2 elutriate modeling (Short-Term Fate [STFATE] model; see (USACE/USEPA 1998b) results indicated that open-lake placement of the dredged material would have no potential for violating the WQS for ammonia outside of the mixing zone at normal lake velocities (USAERDC 2007). Runs using the measured elutriate concentrations achieved the WQS within 15 minutes and 150 feet from the discharge from either a barge or hopper dredge. A very conservative run assuming a total release of ammonia from the sediment achieved the WQS within 2.1 hours and 1300 feet from the discharge from a barge, and within 2.6 hours and 1350 feet from the discharge from a hopper dredge. Based on this assessment, ammonia was eliminated as a COC in the sediments.

c. River Channel and Lake Approach Channel sediments (USACE 2010). The Lake Approach Channel and River Channel sediment sampling sites for this event are shown in Figures 3 and 4, respectively.

1. *Bulk sediment analyses.*

(a) **Physical testing:** Table 21 presents the results of the sieve analyses performed on the sediment samples. The Lake Approach Channel material was comprised of between 73% (Site LM-3.75) and 97% (Sites LM-2.25 and 2.5) silts and clays, with the remainder sands. The River Channel material was comprised of between 29% (Site RM-1) and 95% (Site RM-0.5) silts and clays, with the remainder sands and/or gravel. In comparison to the 2006 data, several of the sites in the River Channel were comprised of substantially more coarse-grain sediment, several of which contained gravel. Sediments at the open-lake reference area were comprised predominantly of silts and clays (86% to 93%), with the remainder sands. At the open-lake placement area, sediments were composed of between 79% and 83% silts and clays, with some sands.

(b) **Chemical testing:** As in the evaluation of the previous Lake Approach Channel and River Channel material contamination, both open-lake reference and placement area sediments in the Western Basin of Lake Erie (Figure 1) were used to represent the lake environs. As such, contaminant concentrations in Lake Approach Channel and River Channel sediment samples were compared to these areas to determine if they significantly exceeded lake sediment concentrations. Contaminant concentrations in samples that exceeded the maximum lake value where then screened against OEPA SRVs for the Lake Erie/Huron plain (OEPA 2008). Those which significantly exceeded both of these screening criteria were preliminarily determined to be sediment COCs unless they were not found to be of toxicological significance.

Data on the 2010 open-lake reference area (USACE 2010) did not evidence any significant degradation in lake environs sediment quality since 2004 (EEI 2004) and 2006 (EEI 2006) (see Table 11).

(1) Inorganic analyses

•Heavy metals—Table 22 presents the results of the metals analyses. While aluminum, beryllium and vanadium exceeded both lake maximum values and SRVs at some of the sites, they were comparable in all instances. Aluminum ranged from 3,000 mg/kg (LM-3.75) to 43,000 mg/kg (LM-0.25) in the Lake Approach Channel, compared to a maximum lake value of 27,000 mg/kg (TL-3) and Huron/Erie Lake Plain SRV of 42,000 mg/kg. Beryllium ranged from 0.76 mg/kg (LM-1.5) to 1.2 mg/kg (LM-0.25) in Lake Approach Channel sediments, compared to a maximum lake value of 1.0 mg/kg (TD-2) and Ohio (statewide) SRV of 0.8 mg/kg. Vanadium ranged from 4.6 mg/kg (LM-0.25) to 45 mg/kg (LM-4.5) in Lake Approach Channel sediments compared to a maximum lake value of 39 mg/kg (TL-3) and Ohio (statewide) SRV of 40 mg/kg.

Regarding the River Channel sediments, most metals in RM-2 sediments were at concentrations greater than the maximum lake values and/or Ohio SRVs. Metals which exceeded the screening values included aluminum (48,000 mg/kg), arsenic (13 mg/kg), beryllium (1.2 mg/kg), cobalt (14 mg/kg), copper (47 mg/kg), iron (47,000 mg/kg), zinc (220 mg/kg) and vanadium (55 mg/kg), with vanadium representing the largest exceedance relative to Ohio (statewide) SRV of 40 mg/kg. However, none were at levels of significant toxicological concern. Concentrations of cadmium (2.5 mg/kg), copper (61 mg/kg) and silver (0.78 mg/kg) in Site RM-4 sediments were greater than the maximum lake values and Huron/Erie Lake Plain SRVs of 0.96 mg/kg and 42 mg/kg, and Ohio (statewide) SRV of 0.43 mg/kg, respectively. Copper (61 mg/kg) represented the largest exceedance from the maximum lake value of 44 mg/kg. However, none were at levels of significant toxicological concern. Outside of these two River Channel sites, only vanadium was measured at levels that were above both screening criteria, with a maximum value of 45 mg/kg which was comparable to the Ohio (statewide) SRV of 40 mg/kg. The 2006 data on nickel at Site RM-2 showed a level of 49.1 mg/kg (EEI 2006) which was significantly higher than the maximum lake value of 37.7 mg/kg and Huron/Erie Lake Plain SRV. However, the 2010 data did not reproduce this result and a maximum of 46 mg/kg was measured in lake sediments. Therefore, nickel was eliminated as a COC in the Site RM-2 sediments.

•TOC and other inorganic parameters—The results of these analyses are summarized in Table 23. TOC levels in the Lake Approach Channel sediment samples ranged from 0.097% (LM-0.5) to 2.7% (LM-0.0); in the River Channel sediment samples, TOC levels ranged from 1.5% (RM-4.0) to 2.8%% (RM-0.25). At the open-lake reference and placement areas, TOC levels ranged from 0.82% to 1.3% and 1% to 1.5%, respectively. In comparison to the 2004 and 2006 data (Tables 2 and 12, respectively), the 2010 data showed overall substantially lower TOC levels in harbor and lake sediments. Nitrogen-ammonia concentrations in the sediment samples were significantly higher at several of the sites (Sites LM-3.25, LM-0.75, LM-0.5, LM-0.25, LM-0, RM-0.25, RM-0.5, RM-0.75, RM-3, RM-5 and RM-7 ranged from 300 to 480 mg/kg) relative to the open-lake reference area range of 110 to 230 mg/kg. This bulk sediment concentration range was very similar to those measured in sediments evaluated using water column bioassays (340 to 480 mg/kg) (USAERDC 2006) and STFATE modeling (USAERDC 2007), which indicated that open-lake placement of the dredged material would have no potential for violating the WQS for ammonia outside of the mixing zone at normal lake velocities. Therefore, nitrogen-ammonia was not identified as a COC at Sites LM-3.25, LM-0.75, LM-0.5, LM-0.25, LM-0, RM-0.25, RM-0.5, RM-0.75, RM-3, RM-5 and RM-7. Oil and grease were detected at levels above the maximum lake value of 460 mg/kg in both River Channel sediments (470 mg/kg [RM-6] and 780 mg/kg [RM-0.25]) and Lake Approach Channel sediments (690 mg/kg [LM-1.75], 540 mg/kg [LM-4.75] and

580 mg/kg [LM-6.0]). These levels were less than previous concentrations observed in the lake (EEI 2004; see Table 2). Site RM-0.75 in the River Channel showed a phosphorus level of 540 mg/kg, which is greater than the maximum lake value of 510 mg/kg. Phosphorus levels in the Lake Approach Channel sediments ranged from 170 mg/kg (LM-8) to 580 mg/L (LM-0.0), several of which exceeded the maximum lake value of 510 mg/kg. However, these concentrations were less than previously observed in the lake (EEI 2006; see Table 12). Total nitrogen was detected at a maximum concentration of 1,700 mg/kg in the lake, and several sites in the Lake Approach Channel exceeded this level (range 230 mg/kg [LM-0.75] to 2,500 mg/kg [LM-4.5]). These concentrations are within the range of levels previously observed in the lake (EEI 2004; see Table 2). Cyanide was identified as a preliminary sediment COC at Site RM-2 because it was significantly higher (0.65 mg/kg) than the maximum lake value in 2006 (EEI 2006). However, it was measured at 1.9 mg/kg in open-lake placement area sediments in 2010 and 1.12 mg/kg in open-lake reference area sediments in 2004 (EEI 2004). Cyanide appears to have limited environmental relevance. Therefore, it was eliminated as a COC at this site based on existing information.

(2) Organic analyses

•PAHs—Table 24 presents the results of these analyses. Total PAH concentrations in the Lake Approach Channel sediment samples ranged from 1.26 mg/kg (Site LM-1.75) to 4.48 mg/kg (Site LM-1.25), which was higher than those measured in harbor sediments in 2004 and 2006 (Tables 3 and 13, respectively). In the River Channel sediment samples, total PAH concentrations ranged from 3.39 mg/kg (Site RM-0.5) to 107 mg/kg (Site RM-4). In comparison to the 2004 and 2006 data, the 2010 data showed a marked increase in PAH contamination in the River Channel sediments. At the open-lake reference and placement areas, total PAH levels ranged from 2.62 to 13.1 mg/kg, and 3.3 and 5.32 mg/kg, respectively. Total PAH concentrations in sediments at Sites RM-6, RM-4, RM-2 and RM-1 (range 16.9 to 107 mg/kg) were greater than those at the open-lake reference and placement areas, and could potentially be acutely toxic. Consequently, total PAHs were identified and/or retained as a COC at these sites in the River Channel.

The potential risk of PAH mixtures in Site RM-6, RM-4, RM-2 and RM-1 sediment samples to the freshwater amphipod *Hyalella azteca* was estimated using hydrocarbon narcosis and equilibrium partitioning (EqP) models (USEPA 2003). Note that sediments typically contain a mixture of PAHs from both petrogenic and pyrogenic sources. In comparison to petrogenic PAHs, pyrogenic PAH compounds are often more persistent and less mobile and bioavailable in the environment, often resulting in lower toxicities (Gustaffsson *et al.* 1997). PAH mixtures that arise from pyrogenic sources indicate the presence of black carbon

forms that have exhibited an unusually strong partitioning behavior. Such mixtures strongly adsorb to this black carbon, thus limiting their concentration in interstitial water, and reducing mobility, bioavailability and toxicity (on a bulk sediment concentration basis) (e.g., Pastorok *et al.* 1994).

To decipher the predominant origin of PAH mixtures, PAH compound diagnostic ratios were calculated for the sediment samples collected at Sites RM=6, RM-4, RM-2, RM-1 and RM-0.75 (Table 25). Neff *et al.* (2005) recommends that fluoranthene/pyrene (FL/PY) and phenanthrene/anthracene (PH/AN) ratios both be used to aid in differentiating between sediment-associated pyrogenic and petrogenic PAHs. The FL/PY ratios for all of the sediment samples were greater than 1.0, indicating that they were of pyrogenic origin. The PH/AN ratios for Site RM-2 and RM-1 sediment samples appear to yield contradictory source results because they suggest PAHs of petrogenic origin. It should be noted, however, that anthracene concentrations in most of the samples are J-flagged, contributing uncertainty to the PH/AN diagnostic ratios. This uncertainty, when considered with the other lines of evidence, suggests that the Site RM-1 sediments possess a predominantly pyrogenic PAH assemblage. Moreover, Christensen *et al.* (1999) calculated a PH/AN ratio of 4.7 for pyrogenic highway dust sources, which is similar to the PH/AN ratio of 4.5 in the Site RM-1 sediments. With respect to Site RM-2 sediments, the high PH/AN ratio of 10 was assumed to evidence a predominantly petrogenic PAH assemblage. It should be noted that there was a significantly higher number of J-flagged PAH compound concentrations in the Site RM-1, RM-2 and RM-4 sediments, suggesting some uncertainty in the data. This was attributable to running these samples at higher dilutions (50x, 50x, and 100x, respectively), which would raise the detection and reporting limits. PAH compounds that had fairly high detection, but were still lower than the adjusted reporting limits, were flagged with a "J."

The hydrocarbon narcosis and EqP models (USEPA 2003) assume that the risk of PAH mixtures to benthic organisms is attributable to the number of PAH toxic units that are freely dissolved in sediment pore water, and is used to calculate EqP Sediment Benchmark Toxic Units, Final Acute Value ($\sum ESBTU_{FAV}$) (USEPA 2003). The presence of TOC is an important partitioning parameter as it acts to sequester PAHs in the sediment phase, thus lowering the amount of PAHs available in the water phase. $ESBTU_{FAV}$s are calculated as follows:

$$ESBTU_{FAV} = \frac{C/f_{OC}}{C_{OC\ PAHi,\ FAVi}}$$

Where:

$C_{OC,\ PAHi,\ FAVi}$ = Final acute (FAV) concentration in sediment (μg/$g_{OC}$) (see USEPA 2003)
C = Concentration of PAH compound in sediment (μg/g dry weight)
$f_{OC}$ = Decimal fraction of TOC in sediment (TOC) (μg/$g_{OC}$ dry weight)

Freshwater sediments containing $\sum ESBTU_{FAV} < 1.0$ for a mixture of 34 or more PAH compounds are predicted to be acceptable for the protection of benthic organisms. Conversely, $\sum ESBTU_{FAV} \geq 1.0$ suggest that sensitive benthic organisms may be affected by the PAH mixture. USACE guidelines (USEPA/USACE 1998) emphasize acute toxicity tests for dredged material evaluations. This model employed $C_{OC,\ PAHi,\ FAVi}$ specific to *H. azteca* (Kreitinger, personal communication; USEPA 2003), which is one of two recommended test species used for standard acute toxicity tests in dredged material toxicity evaluations (USEPA/USACE 1998), and is anticipated to be more sensitive to PAHs than most other freshwater organisms (including the midge *Chironomus dilutus*). The $C_{OC\ PAHi,FAVi}$ values for *H. azteca* are based on an acute toxicity critical body burden of 13.9 μmol/g lipid, which is the geometric mean of the acute value for fluoranthene within the genus (GMAV) based on data originally published by Spehar *et al.* (1999) (see Appendix C of USEPA 2003). Use of this single critical body burden in the model is assumed to be valid because hydrophobicity-normalized toxicity is considered to be equivalent among Type I narcotic chemicals. The 13.9 μmol/g octanol GMAV for *H. azteca* has been confirmed in the literature. Hawthorn *et al.* (2007) predicted a critical body burden of 15 μmol/g lipid (lower 95% confidence interval) for 85% or greater survival when 97 field collected sediments were evaluated in 28-day laboratory tests and the dissolved PAH concentration in sediment porewater was determined by ASTM D7363 (Hawthorne *et al.* 2007). In addition, the lethal residue ($LR_{50}$) value of 33.0 μmol/g lipid determined by Hawthorne *et al.* (2007) using these 97 field samples was in very good agreement with the $LR_{50}$ value of 32 μmol/g lipid determined in water only laboratory exposures using radio-labeled fluoranthene (Schuler *et al.* 2006).

The calculation of $C_{OC\ PAHi,FAVi}$ for individual PAH compounds was based on the following equation:

$$C_{OC\ PAHi,FAVi} = K_{oc} * MW * [10^{-0.945*\log(Kow)+\log(GMAV)}]$$

Where:
$K_{OC}$ = Organic carbon-water partition coefficient for PAH compound
$K_{OW}$ = Octanol-water partition coefficient for PAH compound
MW = Molecular weight of PAH compound, g/mol
GMAV = Geometric mean of acute toxicity (critical body burden) values for fluoranthene within the genus, 13.9 μmol/g lipid

For PAH mixtures at Sites RM-6, RM-4 and RM-1, an uncertainty factor of 3.6 with a confidence level of 95% (Hawthorne *et al.* 2006) was applied to the $\sum ESBTU_{FAV}$ because the analyses covered only the 16 USEPA priority pollutant PAH compounds, and because the PAHs were assumed to be predominantly of pyrogenic origin based on the diagnostic ratios. An uncertainty factor of 11.5 with a confidence interval of 95% (which is an imprecise estimate) (USEPA 2003) was used for Site RM-2 sediments because the diagnostic ratios were assumed to evidence that the PAH assemblage may be petrogenic in nature.

Tables 26 through 30 present the calculated sediment PAH mixture $\sum ESBTU_{FAVs}$ at Sites RM-6, RM-4, RM-2 and RM-1, as well as Site R-0.75. $\sum ESBTU_{FAV}$ among Sites RM-6, RM-4, RM-2 and RM-1 ranged from 0.65 to 5.79. All sites, except for Site RM-6, showed $\sum ESBTU_{FAV} > 1.0$ (range 1.90 to 5.79), suggesting unacceptable PAH-associated acute toxicity to *H. azteca* in these sediments. The predicted low acute toxicity resulting from the total PAH concentration in Site RM-6 sediments is also consistent with a no observed effect concentration (NOEC) of 17 mg/kg determined for Buffalo River Area of Concern (AOC) sediments based on standard 10-day solid phase bioassay data using *H. azteca* and *C. dilutus* (mayfly nymph), with survival, and survival and growth, as the biological measurement endpoints, respectively (USEPA/USACE 1998). Therefore, sediments dredged from the River Channel at Sites RM-4, RM-2 and RM-1 do not meet Federal guidelines for open-lake placement. Note that data on PAH contamination in sediments collected from Site RM-3 indicates that they would meet Federal guidelines for open-lake placement. However, absent a better delineation of the acutely toxic PAH contamination flanking this site, sediments dredged from this area should not be placed in the open-lake at this time.

•PCBs—Table 31 presents the results of these analyses. PCBs, as Aroclor mixtures, were not detected in any of the Lake Approach Channel sediments at laboratory reporting limits (LRLs) ranging from 73 to 92 µg/kg. PCBs (Aroclor 1254) were detected at only River Channel Site RM-4 (100 µg/kg) and Site RM-2 (27 µg/kg), and exceeded open-lake reference and/or placement area concentrations. PCBs (also Aroclor 1254) were detected in the open-lake reference area sediments at concentrations of up to 14 µg/kg, and were not detected in open-lake placement area sediments at LRLs ranging from 61 to 86 µg/kg. Note, however, that total PCB concentrations at Sites RM-4 and RM-2 were within the range measured in open-lake reference areas sediments in 2004 (31.7 µg/kg to 154 µg/kg; see Table 4) (EEI 2004).

Total PCB TBP values were calculated for the RM-4, RM-2, open-lake reference and placement area sediments. An oligochaete worm was used as a target animal in the model. A 1% lipid content in oligochaete worms, BSAF of 1.48 (Lenox, unpublished Lake Erie data) and TOC data from Table 2 were used in the

model. TBP predictions for total PCBs at Sites RM-4 and RM-2 are summarized in the table below (Note: non-detectable PCB concentrations in open-lake placement area sediments were valued at the lowest LRL):

| River Channel site | Total PCB TBP, µg/kg | Open-lake reference area total PCB TBP, µg/kg | Open-lake placement area total PCB TBP, µg/kg |
|---|---|---|---|
| RM-4 | 100 | 20 | 75.2 |
| RM-2 | 20 | | |

The TBP for total PCBs at Site RM-2 was comparable or lower to that for the open-lake reference and placement area sediments. For Site RM-4, the TBP for total PCBs was higher in comparison to that on the open-lake reference and placement area sediments. However, a total PCB concentration of 0.1 mg/kg in benthic organisms would likely not result in unacceptable risk in the aquatic environment. The total PCB TBP was also only about 25 µg/kg higher relative to those of the open-lake placement area and 2004 open-lake reference area (76.2 µg/kg). Such a difference relative to the open-lake reference area sample may not show a statistical difference if composited sediments from the RM-2 MU were subjected to Tier 3 solid phase bioaccumulation experiments. Further, it is likely that the benthic bioavailability of PCBs in the RM-4 sediments (lake BSAF = 1.48) is lower than what was modeled to predict bioaccumulation due to a higher fraction of black carbon in harbor vs. lake sediments. Therefore, the TBP prediction of 100 µg/kg is likely very conservative. Based on this information, total PCBs were not identified as a COC at Site RM-4 sediments in the River Channel.

•Pesticides—Table 32 presents the results of these analyses. Pesticides in the Lake Approach Channel sediments, as well as open-lake reference and placement area sediments, were non-detectable at LRLs ranging from 1.9 to 48 µg/kg. In River Channel sediments, the only detected pesticides were 4,4-DDD and 4,4-DDE at Site RM-4. The ∑DDT concentration at this site was 5.2 µg/kg, which is not of significant toxicological concern. Chlordane concentrations were non-detectable in harbor sediments at LRLs ranging from 28 µg/kg to 48 µg/kg.

(c) **Biological testing:** Standard 10-day bioassays were performed on composited RM-2, and composited open-lake reference and placement area sediment samples, using the test species *H. azteca* and *C. dilutus*. The biological measurement endpoints were survival, and survival and growth, respectively. These bioassays were applied to these sediments presumably to evaluate the potential acute toxicity associated with elevated concentrations of nickel, cyanide and total PAHs, as evidenced by EEI (2006). However, only PAHs were evidenced as a COC in these sediments based on the

2010 data, although many of the metals exceeded lake-related values but determined to not be of toxicological significance (USACE 2010). Table 33 summarizes the results of these tests.

(1) *H. azteca* bioassay—For a comparison of the mean survival associated with the RM-2 sediments versus the open-lake reference and placement area sediments, arcsine-square root transformed data were used. These data were acceptably normally distributed (Shapiro-Wilk's test on the residuals of the transformed data) and the variances were homogeneous (Levene's test). Although the global F test (an analysis of variance [ANOVA]) was not significant, the least significant difference (LSD) mean comparisons indicated that *H. azteca* survival associated with the RM-2 sediments (78±11%) was significantly reduced relative to open-lake reference area sediments (92±18%), but not the open-lake placement area sediments (90±15%).

A comparison of mean *H. azteca* survival for the RM-2 sediments to the combined open-lake reference/placement area sediment survival mean found that the arcsine-square root transformed data to not be normally distributed and have unequal variances. Therefore, rankits (normalized ranks) of the data were used. The rankits were marginally non-normally distributed, but the treatment variances of the rankits were homogeneous. The ANOVA F was significant, and the LSD test indicated that the mean survival for the RM-2 sediments was significantly lower than the combined open-lake reference/placement area sediment survival mean (91%). The *H. azteca* bioassay results suggest material dredged from Site RM-2 does not meet Federal guidelines for open-lake placement.

Note that the evidenced acute toxicity of RM-2 sediments to *H. azteca* (which may not be attributable to PAH contamination) is marginal because it was not statistically lower relative open-lake placement area sediment mean survival, which showed a mean survival similar to that of the open-lake reference area sediments.

(2) *C. dilutus* bioassay—Mean survival of *C. dilutus* for the RM-2 sediments (90±23%) was not significant different relative to the open-lake reference area sediments (97.5±8%) and open-lake placement area sediments (90±17%). Mean growth of *C. dilutus* (ash-free dry weight) for the RM-2 sediments (1.17±0.11 mg) was not significantly different in comparison to the open-lake reference area sediments (1.19±0.06 mg) and open-lake placement area sediments (1.27±0.24 mg).

2. *Elutriate testing*

(a) **SET**—Tables 34 through 38 present the results of the SET performed on the sediment samples. Releases of dissolved total phosphorus from the sediments ranged from 0.019 mg/L (Site LM 1.75) to 0.13 mg/L (Site LM-6) (Table 35), which represented less than 0.06% of total measured bulk sediment concentrations (Table 23). There were some low releases of PAH compounds (16 USEPA priority pollutants), ranging from 0.028 µg/L benzo(g,h,i)perylene (Site LM-1.25) to 1.1 µg/L fluoranthene (Site RM-6) (Table 36). Site RM-2 sediments showed the highest releases of total PAHs. No releases of PCBs (as Aroclors) from the sediments were shown at or above LRLs ranging from 0.1 µg/L to 0.3 µg/L (Table 37). No pesticide releases from the sediments were detectable at LRLs ranging from 0.01 µg/L to 2.0 µg/L (Table 38). Mercury and zinc releases were the only metals to exceed inside mixing zone maximum (IMZM) or OMZM standards for the Protection of Aquatic Life in Lake Erie. Elutriate data on RM-1.0 and RM-0.75 sediments showed mercury at concentrations of 0.013 mg/L and 0.023 mg/L respectively (Table 34), both of which exceeded the IMZM (0.0034 mg/L) and OMZM (0.0017 mg/L) standards. Previously, mercury releases that exceeded the OMZM standard were limited to the Lake Approach Channel sediments (LM-1.75 and LM-0 [see Table 16]) at lower levels [0.0017 mg/L and 0.0025 mg/L]). Elutriate samples for RM-0.5 (0.13 mg/L), RM-1.0 (0.13 mg/L) and LM-4.5 (0.14 mg/L) sediments showed zinc at concentrations greater than the OMZM standard of 0.12 mg/L. These results were consistent with the 2004 (EEI 2004) and 2006 (EEI 2006) elutriate data (Tables 6 and 16, respectively).

Because SET results represent the concentration released at the point of discharge, mixing in the water column must be considered for the contaminants that exceed the applicable water quality standard. Mixing evaluations are only necessary for the contaminant requiring the most dilution to achieve WQSs (USEPA/USACE 1998). Therefore, compliance for all parameters can be assumed if compliance for the contaminant requiring the most dilution can be demonstrated. Mixing was evaluated through the STFATE model and the dilution determination was based on the following equation (USEPA/USACE 2007):

$$D = (C_c - C_{wq})/(C_{wq} - C_{ds})$$

D = Dilution
$C_c$ = Concentration of dissolved contaminant in the standard elutriate
$C_{wq}$ = Water Quality Standard
$C_{ds}$ = Background concentration of the contaminant in placement area water

The highest release of mercury associated with Site RM-0.75 sediments requires a dilution of 14 to comply with the OMZM standard of 0.0017 mg/L, assuming a background concentration of 0.0002 mg/L valued at the LRL. This is the maximum dilution of Toledo Harbor dredged material required to comply with

WQSs. STFATE modeling indicated that after consideration of mixing at the placement area water column, mercury at an initial concentration of 0.023 mg/L would meet IMZM and OMZM WQSs. Therefore, placement of this dredged material at the open-lake area would appear to comply with applicable water quality standards for the Protection of Aquatic Life in Lake Erie.

(b) **Water column bioassays**—The Site RM-2 sediment composite was subjected the following short-term toxicity tests to determine lethal responses to elutriate: (1) 2-day exposure of *C. dubia* to five elutriate treatments (100%, 50%, 25%, 12.5% and 6.25%) and a performance control, with survival as measurement endpoint; and (2) 4-day exposure of *P. promelas* to five elutriate treatments (100%, 50%, 25%, 12.5% and 6.25%) and a performance control, with survival as measurement endpoint. The results of these two bioassays are summarized below:

(1) *C. dubia* bioassay—The results of this bioassay are summarized in Table 39. No statistically significant reduced mean survival was evidenced across all elutriate treatments relative to the control. This result indicates no acute toxicity associated with the sediment elutriates. The $EC_{50}$ (median effect concentration) was estimated to be greater than 100%.

(2) *P. promelas* bioassay—The results of this bioassay are summarized in Table 40. No statistically significant reduced mean survival was evidenced across all elutriate treatments relative to the control. This result indicates no acute toxicity associated with the sediment elutriates. The $LC_{50}$ (median lethal toxicant concentration) was estimated to be greater than 100%.

The fact that these bioassays did not evidence significant acute toxicity suggests that low releases and bioavailability of contaminants, including PAHs, to the water column, presumably due to stronger partitioning to sediment. SET data on these sediments (see Table 36) did not evidence substantial releases of contaminants, including PAHs, from Site RM-2 sediments.

d. Final COC List. Total PAHs were identified as sediment COCs at River Channel Sites RM-4, RM-2 and RM-1.

e. Quality Assurance (QA)/Quality Control (QC) Documentation. QA/QC information and records on the data contained in this evaluation are available in EEI (2004 and 2006).

*Conclusion*

This evaluation has determined that:

a. Sediments dredged from the Toledo Harbor Lake Approach Channel, as represented by Sites LM-0 through LM-13 (Figures 1 and 4), meet Federal guidelines for open-lake placement.

b. Sediments dredged from the Toledo Harbor River Channel, as represented by Sites RM-0.25, RM-0.5, RM-0.75, RM-5, RM-6 and RM-7 (Figure 3), meet Federal guidelines for open-lake placement.

c. Sediments dredged from the Toledo Harbor River Channel, as represented by Sites RM-4, RM-2 and RM-1 (Figure 3), do not meet Federal guidelines for open-lake placement.

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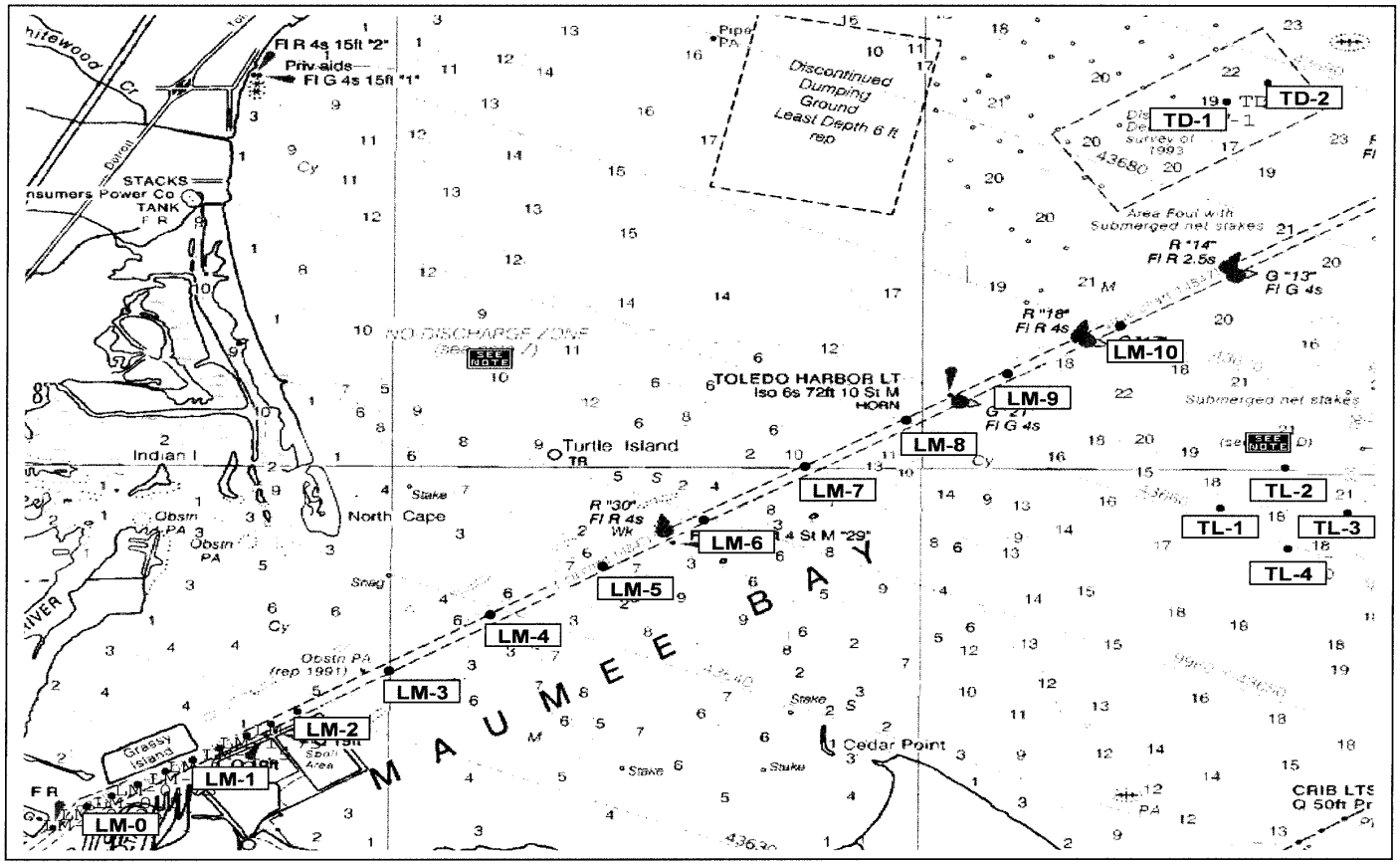


**FIGURE 1. Toledo Harbor 2004 sediment sampling sites in Lake Approach Channel, and open-lake reference and placement areas.**

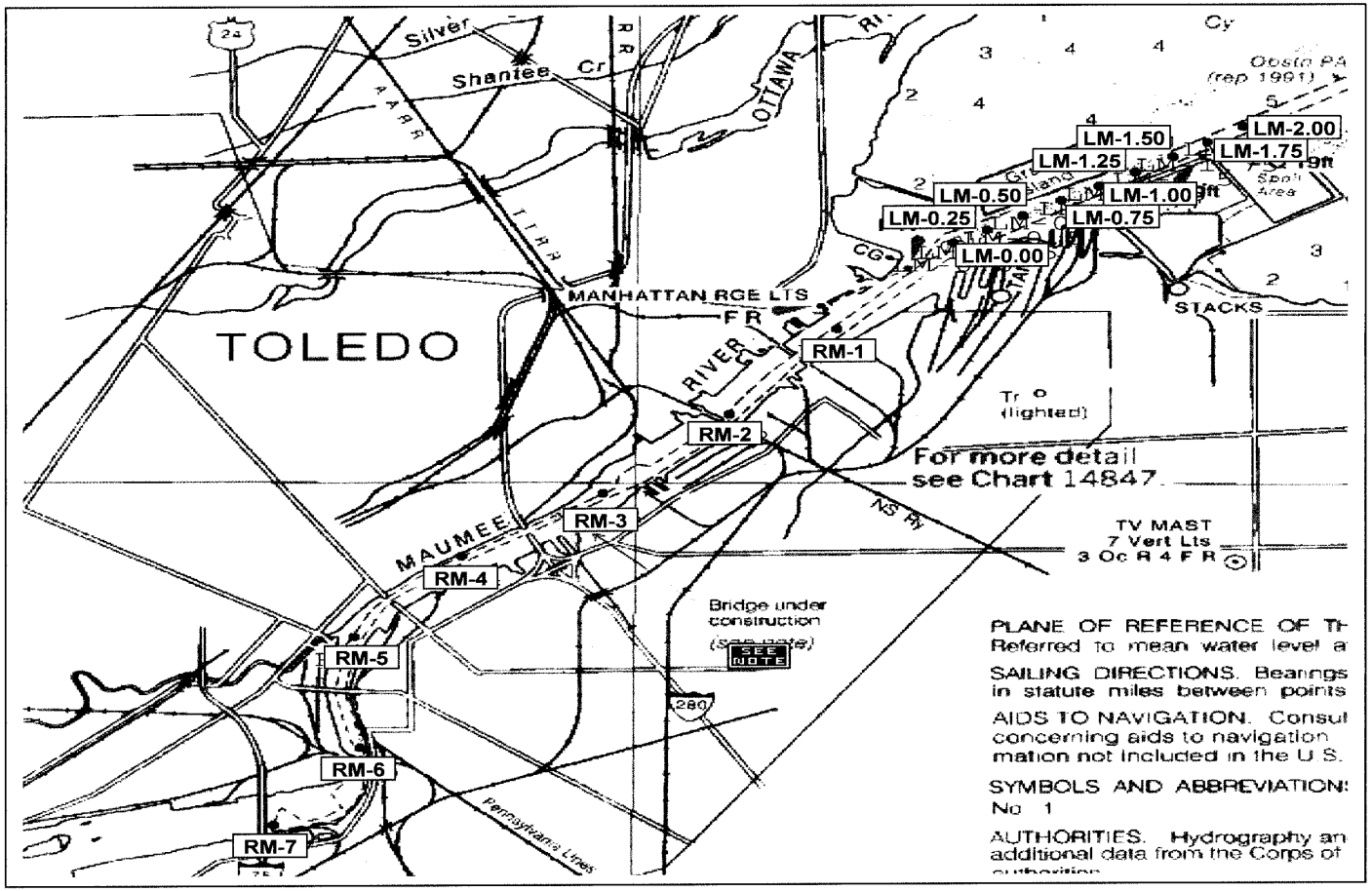


**FIGURE 2. Toledo Harbor sediment 2006 sampling sites in Maumee River Channel and Upper Lake Approach Channel.**

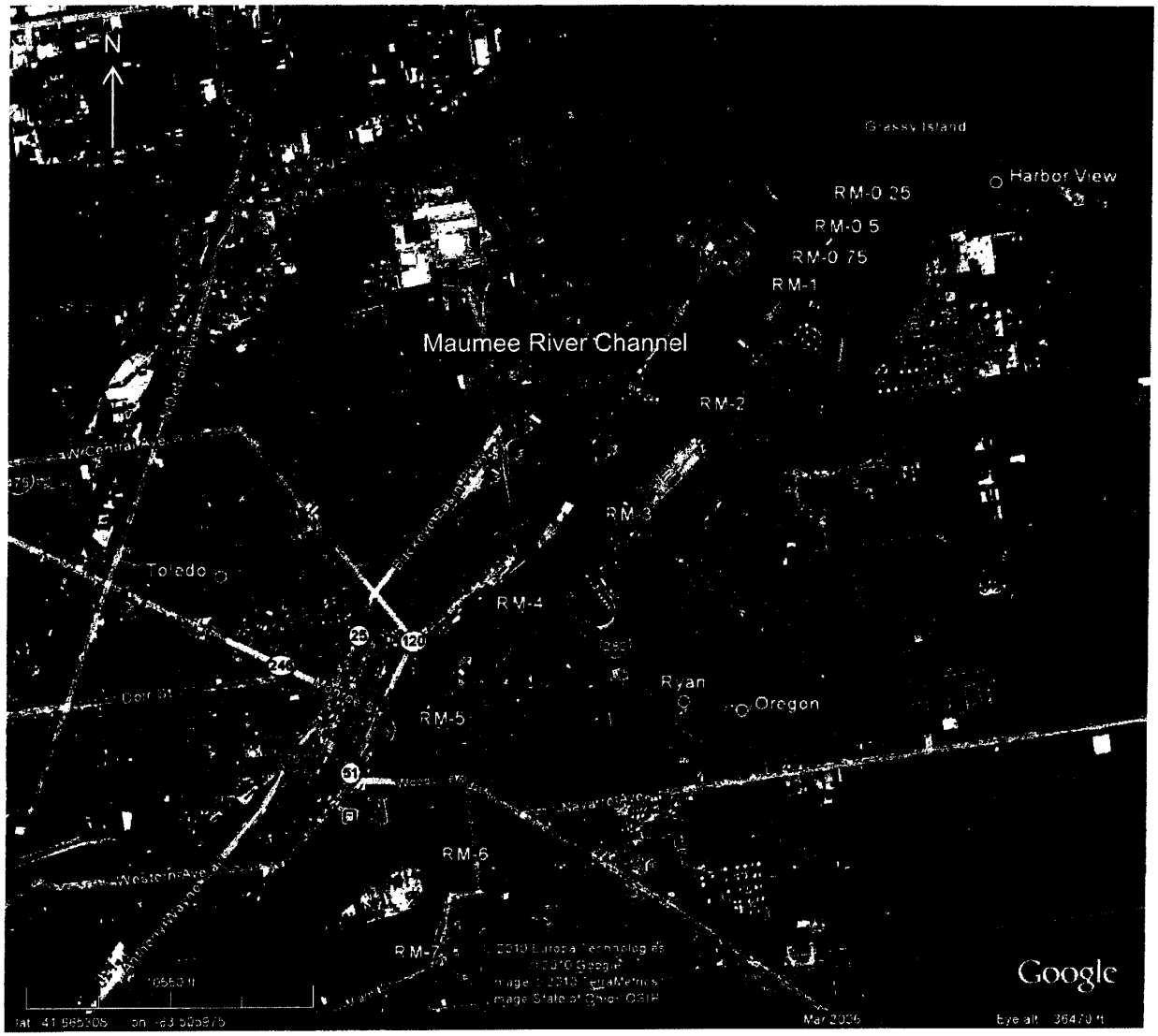


FIGURE 3. Toledo Harbor 2010 sediment sampling sites in the Maumee River Channel.

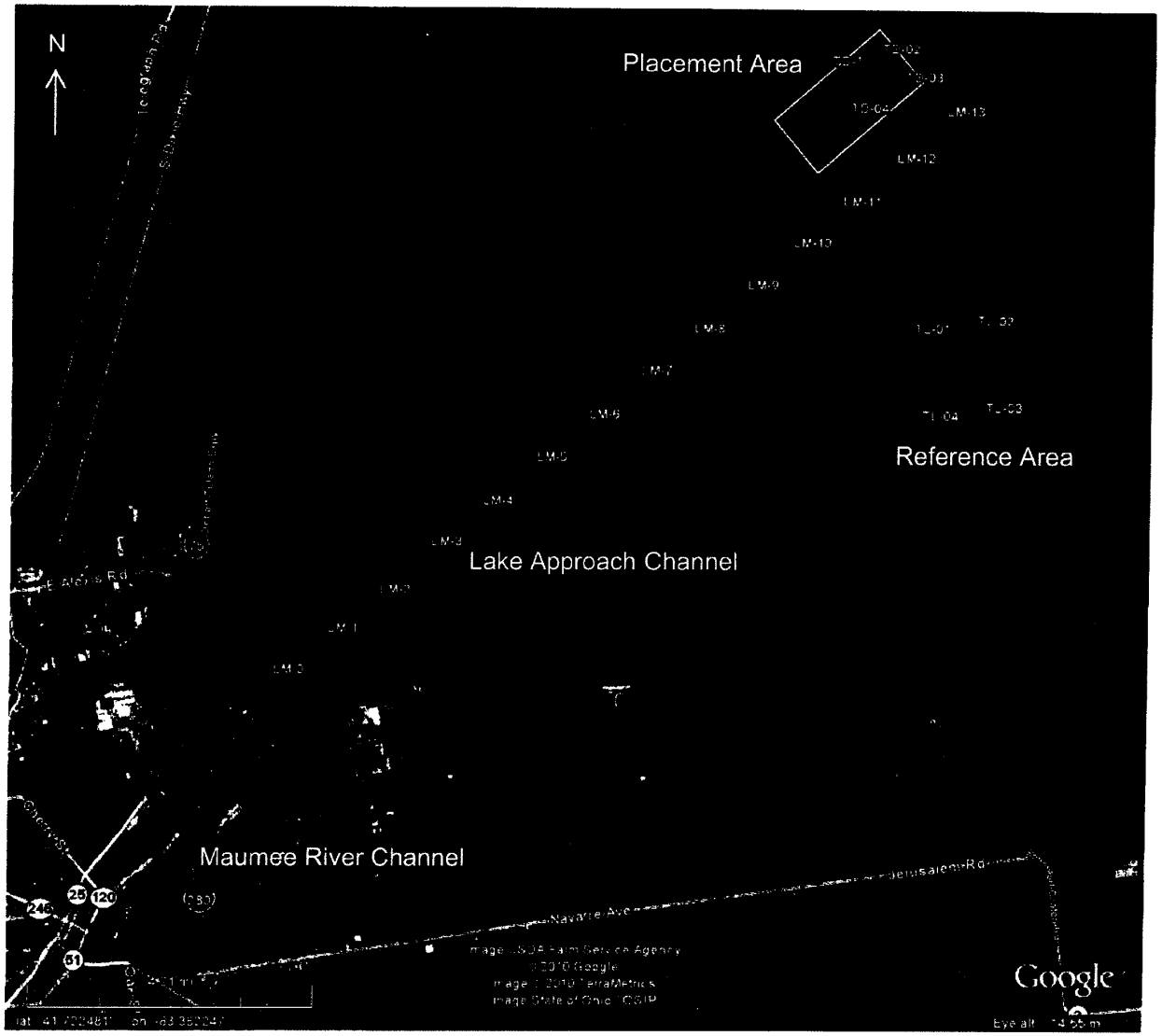


FIGURE 4. Toledo Harbor 2010 sediment sampling sites in the Lake Approach Channel and Open Lake Reference and Placement Areas.

**TABLE 1. Particle size distribution of Toledo Harbor Lake Approach Channel sediments (from EEI 2004).**

| Particle Size (%) | Lake Approach Channel | | | | | | | | | | | Open-Lake Reference Area | | | | Open-Lake Placement Area | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1 | TD-2 | TD-3 | TD-4 |
| Gravel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sand | 2.3 | 5.6 | 20.6 | 1.1 | 0.7 | 1.2 | 4.1 | 31.8 | 2.2 | 18.70 | 31.2 | 18.4 | 5.9 | 15.4 | 62 | 2 | 4.3 | 5.6 | 1.6 |
| Silt | 43.8 | 41.3 | 38.4 | 53.3 | 52.6 | 50.7 | 46.8 | 22.5 | 62 | 44.6 | 36.9 | 47 | 57.6 | 49.1 | 14.5 | 49.9 | 56.5 | 59.6 | 68.8 |
| Clay | 53.9 | 53.1 | 41 | 45.6 | 46.7 | 48.1 | 49.1 | 45.7 | 35.8 | 36.7 | 31.9 | 34.6 | 36.5 | 35.5 | 23.5 | 48.1 | 39.2 | 34.8 | 29.6 |

**TABLE 2. Bulk inorganic analyses on Toledo Harbor Lake Approach Channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placement area (from EEI 2004).**

| Metals (mg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | Open-Lake Reference Area | | | | Open-Lake Placement Area | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1 | TD-2 | TD-3 | TD-4 |
| Aluminum | **23800** | 15300 | 16400 | **25300** | **23800** | **27800** | 22800 | 15300 | 21400 | 14800 | 16600 | 2230 | 7980 | 12200 | 8170 | 17200 | 23200 | 20500 | 18500 |
| Antimony | <0.135* | <0.134 | <0.103 | <0.15 | **<0.154** | <0.141 | <0.127 | <0.098 | <0.134 | <0.109 | <0.11 | <0.097 | <0.124 | <0.098 | <0.089 | <0.142 | <0.126 | <0.128 | <0.134 |
| Arsenic | **7.67** | 4.92 | 5.93 | **7.4** | **7.62** | **8.28** | 6.7 | 4.97 | **7.28** | 5.24 | 6.86 | 0.951 | 2.87 | 6.04 | 2.63 | 6.14 | 7.15 | 6.22 | 5.91 |
| Barium | **132** | 84.5 | 106 | **129** | **130** | **144** | 116 | 77.1 | 111 | 76.5 | 81.6 | 12.2 | 44.2 | 74.1 | 80.9 | 99 | 121 | 113 | 95.7 |
| Beryllium | **0.984** | 0.646 | 0.672 | **1.05** | **0.998** | **1.12** | 0.881 | 0.656 | **0.952** | 0.68 | 0.767 | 0.118 | 0.372 | 0.6 | 0.367 | 0.858 | 0.925 | 0.85 | 0.854 |
| Cadmium | 1.09 | 0.796 | 1.62 | 1.07 | 1.23 | 1.21 | 1.1 | 0.798 | 1.27 | 1.31 | 1.54 | 0.271 | 0.825 | 2.01 | 0.711 | 1.85 | 1.21 | 1.14 | 1.73 |
| Calcium | 29400 | 18300 | 27700 | **31400** | **32000** | **31300** | 25600 | 26400 | 26000 | 25100 | 27400 | 3180 | 13800 | 29500 | 18100 | 18900 | 29800 | 27800 | 24700 |
| Chromium | 30.4 | 21.6 | 27 | 31.2 | 33.3 | 36.3 | 30.2 | 22.2 | 33.8 | 28 | 32' | 5.06 | 18.8 | 32.1 | 15.2 | 45.2 | 29.7 | 27.3 | 36.5 |
| Cobalt | **10.4** | 6.51 | 7.45 | **10.5** | **10.4** | **11.3** | 9.47 | 7.08 | **10.2** | 7.77 | 8.43 | 0.943 | 4.49 | 7.38 | 3.93 | 9.69 | 9.71 | 9.1 | 9.28 |
| Copper | 30.1 | 19.1 | 27 | 29.8 | 31.1 | 32.8 | 27.8 | 19.9 | 30.9 | 26.4 | 30.3 | 4.35 | 15.5 | 30.5 | 11.1 | 36.8 | 28.9 | 27 | 33.7 |
| Iron | **30900** | 19600 | 21200 | **31100** | **30800** | **34200** | 28000 | 20500 | **29400** | 22100 | 25100 | 2570 | 12500 | 21000 | 11700 | 26100 | 28200 | 26000 | 26300 |
| Lead | 21.5 | 15.5 | 23.2 | 21.4 | 24.3 | 26.3 | 21.5 | 16.1 | 27 | 25.2 | 31.2 | 4.59 | 17.5 | 34 | 12 | 40.7 | 22.5 | 20.4 | 33 |
| Magnesium | 9830 | 6580 | 8600 | **11200** | **12300** | **12700** | 10400 | 8660 | 10900 | 10300 | 11000 | 1120 | 6800 | 8980 | 3850 | 11700 | 11300 | 9840 | 11700 |
| Manganese | **471** | 326 | 349 | **514** | **554** | **563** | 425 | 374 | **519** | 384 | **462** | 50.3 | 246 | 371 | 157 | 446 | 442 | 418 | 407 |
| Mercury | 0.087 | 0.106 | 0.121 | 0.108 | 0.131 | 0.133 | 0.109 | 0.115 | 0.188 | 0.259 | 0.306 | 0.235 | 0.339 | 0.306 | 0.117 | 0.385 | 0.096 | 0.1 | 0.308 |
| Nickel | 32.6 | 21.7 | 27.7 | 33.3 | 34.4 | 37.8 | 31 | 23.5 | 34.6 | 27.6 | 30.7 | 3.78 | 16.7 | 27.7 | 14.9 | 38.5 | 31.5 | 29 | 34.7 |
| Potassium | **4360** | 3090 | 2760 | **4800** | **4780** | **5200** | **4350** | 3050 | 4110 | 2870 | 3140 | 564 | 1670 | 2470 | 1750 | 4030 | 4240 | 3770 | 3560 |
| Selenium | 0.466 | 0.561 | <0.267 | <0.389 | 0.615 | <0.367 | 0.604 | <0.254 | <0.349 | <0.284 | 0.771 | <0.252 | 0.451 | 0.703 | <0.231 | 0.589 | 1.72 | 0.395 | 0.378 |
| Silver | 0.289 | 0.187 | 0.354 | 0.25 | 0.246 | 0.272 | 0.232 | 0.181 | 0.31 | 0.3 | 0.356 | 0.063 | 0.201 | 0.371 | 0.122 | 0.518 | 0.258 | 0.22 | 0.375 |
| Sodium | 183 | 149 | 134 | 189 | 209 | 200 | 160 | 129 | 155 | 121 | 121 | 43.8 | 98.4 | 131 | 863 | 178 | 129 | 124 | 129 |
| Thallium | **0.552** | 0.385 | 0.404 | **0.554** | **0.543** | 0.6 | 0.505 | 0.343 | 0.481 | 0.346 | 0.378 | 0.147 | 0.366 | 0.409 | 0.201 | 0.441 | 0.523 | 0.482 | 0.438 |
| Vanadium | **45.2** | 31 | 30.4 | **47.3** | **48.4** | **53.3** | 44.2 | 29.7 | 41.5 | 29 | 31.2 | 4.16 | 17.9 | 26.8 | 18.3 | 37.8 | 44.6 | 40.5 | 36.5 |
| Zinc | 119 | 79.8 | 100 | 119 | 118 | 133 | 112 | 75.7 | 120 | 102 | 114 | 14.9 | 62.9 | 106 | 50.8 | 151 | 113 | 105 | 131 |

| Misc (mg/kg-dry weight) | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1 | TD-2 | TD-3 | TD-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOC | 26800 | 28400 | 33900 | 35500 | 35100 | 33300 | 30000 | 34500 | 30100 | 33400 | 38900 | 28500 | 27800 | 30300 | 20200 | 22300 | 25300 | 27300 | 21000 |
| Cyanide | 0.566 | 0.352 | 0.25 | 0.95 | 0.31 | 0.354 | <(-0.724 | 0.284 | 0.433 | 0.16 | 0.18 | 0.213 | 0.268 | 1.12 | 0.215 | 0.252 | 0.324 | 0.275 | 0.661 |
| Ammonia | **422** | **210** | 183 | **244** | **203** | 175 | 142 | 108 | 175 | 70.5 | 69.4 | 116 | 74.3 | 124 | 69.8 | 108 | 176 | 196 | 112 |
| Phosphorus | 497 | 581 | 593 | **949** | 552 | 546 | 444 | 383 | 599 | 328 | 458 | 571 | 580 | 585 | 457 | 836 | 691 | 639 | 619 |
| Nitrogen | **2920** | 2670 | 1870 | **3230** | 2830 | 2830 | 2120 | 1320 | 2740 | 1540 | 1820 | 1670 | 2330 | 1770 | 1270 | 2880 | 2280 | 2430 | 2360 |
| Oil & Grease | 1220 | 1060 | 938 | 559 | 530 | <321 | 878 | 880 | 815 | 717 | 974 | 1010 | 636 | 1030 | 417 | 1790 | 916 | 1630 | 1290 |

*Not detected at or above the specified minimum detection limit.

**TABLE 3. Bulk polycyclic aromatic hydrocarbon (PAH) analyses on Toledo Harbor Lake Approach Channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placement area (from EEI 2004).**

| PAHs (µg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | Open-lake Reference Area | | | | Open-lake Placement Area | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1 | TD-2 | TD-3 | TD-4 |
| 2-Methylnaphthalene | <4.18* | <4.16 | <3.24 | **<4.59** | **<4.76** | <4.33 | <3.91 | <3.06 | <4.21 | <3.34 | <3.37 | <3.03 | <3.8 | <3.06 | <2.77 | <4.34 | <3.99 | <3.94 | <4.12 |
| 1-Methylnaphthalene | 60.1 | 50.1 | <3.68 | 37 | **66.9** | 57.7 | 58.3 | <3.47 | 46.3 | **72.8** | 54.7 | <3.43 | 66.7 | <3.47 | 20.4 | 47.2 | 44.2 | 36.3 | 44.5 |
| Acenaphthene | <18.7 | <18.6 | <14.5 | <20.5 | <21.2 | <19.3 | <17.5 | <13.7 | <18.8 | <14.9 | <15.1 | 23.6 | <17 | 39.3 | <12.4 | <19.4 | <17.8 | <17.6 | <18.4 |
| Acenaphthylene | **27.7** | <2.07 | <1.61 | <2.29 | <2.37 | <2.16 | <1.95 | <1.52 | **7.01** | <1.66 | <1.68 | <1.51 | 3.58 | <1.52 | <1.38 | <2.16 | <1.99 | 14.2 | 4.15 |
| Anthracene | 26.7 | 21.6 | 51 | <12.8 | 25.1 | 22.1 | 19 | 11.1 | 22.6 | 33.2 | 20.7 | 73.5 | 29 | 142 | <7.73 | 20.4 | 45.1 | 20.2 | 24.3 |
| Benz(a)Antracene | 114 | 97.7 | 161 | 72.3 | 120 | 129 | 122 | 54.6 | 97.6 | 139 | 96.5 | 245 | 126 | 355 | 30.1 | 87.8 | 124 | 117 | 89.1 |
| Benzo(a)Pyrene | 116 | 85.6 | 161 | 74.8 | 100 | 106 | 104 | 53.9 | 104 | 127 | 107 | 207 | 149 | 330 | 33.3 | 120 | 125 | 110 | 102 |
| Benzo(b)Flouranthene | 162 | 114 | 186 | 106 | 144 | 142 | 137 | 69.5 | 120 | 152 | 109 | 285 | 155 | 391 | 38.6 | 136 | 170 | 138 | 117 |
| Benzo(ghi)Perylene | 97.4 | 72.7 | 103 | 70 | 98.7 | 87.7 | 83.7 | 43.7 | 67.9 | 81.3 | 66.1 | 128 | 80.7 | 194 | 27 | 79 | 86.4 | 75 | 69.3 |
| Benzo(k)Floranthene | <1.8 | <1.79 | <1.4 | **<1.98** | **<2.05** | **<1.87** | <1.69 | <1.32 | <1.81 | <1.44 | <1.45 | <1.3 | <1.64 | <1.32 | <1.2 | <1.87 | <1.72 | <1.7 | <1.78 |
| Chrysene | 125 | 97.4 | 136 | 67.8 | 101 | 114 | 113 | 48.5 | 90.1 | 107 | 79.6 | 191 | 90.7 | 288 | 25.4 | 77.2 | 120 | 112 | 70.3 |
| Dibenz(a,h)Anthracene | 11.1 | 8.58 | 31.4 | 14.2 | <3.34 | 9.45 | <2.74 | 9.66 | 20 | 20.2 | 15.2 | 39.6 | 21.4 | 59.2 | 5.93 | 3.04 | 11.1 | 32.1 | <2.89 |
| Fluoranthene | 243 | 167 | 265 | 165 | 206 | 198 | 191 | 94.1 | 146 | 187 | 120 | 313 | 165 | 510 | 43.1 | 147 | 257 | 193 | 143 |
| Fluorene | 31.1 | <17.2 | <13.5 | <19.1 | <19.7 | <18 | <16.2 | <12.7 | <17.5 | <13.9 | <14 | <12.6 | <15.8 | 134 | <11.5 | <18 | <16.5 | <16.4 | <17.1 |
| Indeno(1,2,3-cd)Pyrene | <2.47 | <2.45 | <1.91 | **<2.71** | **<2.81** | **<2.56** | <2.31 | <1.81 | <2.48 | <1.97 | <1.99 | <1.79 | <2.24 | <1.8 | <1.64 | <2.56 | <2.35 | <2.33 | <2.43 |
| Naphthalene | 38.3 | 38.6 | <1.93 | <2.73 | <2.82 | <2.57 | <2.32 | <1.82 | <2.5 | 28.9 | <2 | 173 | <2.26 | 173 | <1.64 | 28.8 | <2.37 | <2.34 | 24.7 |
| Phenanthrene | 128 | 94.7 | 186 | 76.9 | 90.8 | 91.9 | 88.8 | 49.6 | 75.6 | 103 | 68.8 | 174 | 85.7 | 409 | 21.4 | 70.9 | 125 | 94.7 | 72.3 |
| Pyrene | 226 | 190 | 377 | 159 | 194 | 198 | 198 | 117 | 173 | 241 | 163 | 447 | 197 | 665 | 55.1 | 175 | 246 | 197 | 171 |
| Total PAHs | 1433.6 | 1084.3 | 1699.2 | 909.7 | 1205.6 | 1206.6 | 1163.4 | 591.06 | 1017.4 | 1329.6 | 940.19 | 2323.4 | 1212.5 | 3700.7 | 340.59 | 1040.7 | 1400.5 | 1183.8 | 978.37 |

*Not detected at or above the specified minimum detection limit.

**TABLE 4. Bulk polychlorinated biphenyl (PCB) analyses on Toledo Harbor Lake Approach Channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placement area (from EEI 2004).**

| PCBs (µg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | Open-lake Reference Area | | | | Open-lake Placement Area | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1 | TD-2 | TD-3 | TD-4 |
| PCB-1016 | <8.69* | **<27.3** | <2.13 | <3.01 | <3.12 | <6.94 | <8.15 | <2.01 | 2.76 | <2.19 | <2.21 | <6.5 | <2.49 | <6.6 | <6.2 | <9.7 | <8.6 | <8.3 | <8.4 |
| PCB-1221 | **<24.5** | **<76.9** | <6 | <8.49 | <8.79 | **<19.6** | **<23** | <5.66 | 7.78 | <6.17 | <6.24 | <6.5 | <7.02 | <6.6 | <6.2 | <9.7 | <8.6 | <8.3 | <8.4 |
| PCB-1232 | **<14.5** | **<45.4** | <3.54 | <5.02 | <5.2 | **<11.6** | **<13.6** | <3.34 | <4.6 | <3.65 | <3.69 | <6.5 | <4.15 | <6.6 | <6.2 | <9.7 | <8.6 | <8.3 | <8.4 |
| PCB-1242 | <14.5 | <45.4 | 7.8 | 14.2 | 18.3 | **143** | <13.6 | 13 | 14.4 | 14.9 | 34.1 | 43 | 49.9 | 61 | 14 | 35 | 24 | 30 | 24 |
| PCB-1248 | <8.69 | **<27.3** | <2.13 | <3.01 | <3.12 | <6.94 | <8.15 | <2.01 | <2.76 | <2.19 | <2.21 | <6.5 | <2.49 | <6.6 | <6.2 | <9.7 | <8.6 | <8.3 | <8.4 |
| PCB-1254 | 17.8 | **182** | 3.8 | 5.2 | 5.8 | 31.4 | <4.07 | 4.8 | 5.4 | 7 | 13.6 | 65 | 26.7 | 77 | 11 | 26 | 8.8 | 25 | 10 |
| PCB-1260 | <8.69 | **40.6** | <2.13 | <3.01 | <3.12 | <6.94 | <8.15 | <2.01 | <2.76 | 2.5 | 5.5 | 19 | 11.3 | 16 | 6.7 | 15 | 6.7 | 15 | 4.2 |
| TOTAL PCBs | 17.8 | **223** | 11.6 | 19.4 | 24.1 | **174** | ND | 17.8 | 30.3 | 24.4 | 53.2 | 127 | 87.9 | 154 | 31.7 | 76 | 39.5 | 70 | 38.2 |

*Not detected at or above the specified minimum detection limit.

**TABLE 5. Bulk pesticide analyses on Toledo Harbor Lake Approach Channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placement area (from EEI 2004).**

| Pesticides (µg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | Open-lake Reference Area | | | | Open-lake Placement Area | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1 | TD-2 | TD-3 | TD-4 |
| 4,4-DDD | <5.76* | <2.86 | <2.23 | <6.33 | <3.27 | <2.98 | <2.69 | <2.11 | <5.79 | <2.3 | <2.32 | <8.33 | <5.23 | <4.21 | <3.82 | <5.97 | <5.49 | <5.43 | <5.68 |
| 4,4-DDE | <4.94 | <2.45 | 7.55 | <5.42 | <2.81 | <2.56 | <2.31 | <1.81 | <4.97 | <1.97 | <1.99 | 35.5 | <4.48 | 14.8 | <3.27 | <5.12 | <4.71 | <4.66 | <4.87 |
| 4,4-DDT | <10.4 | <5.18 | <4.04 | <11.4 | <5.92 | <5.4 | 14.2 | <3.81 | <10.5 | <4.16 | <4.2 | <15.1 | <9.46 | <7.62 | <6.91 | <10.8 | <9.94 | <9.83 | <10.3 |
| Aldrin | <4.71 | <2.34 | <1.83 | <5.17 | <2.68 | <2.44 | <2.2 | <1.72 | <4.74 | <1.88 | <1.9 | <6.81 | <4.27 | <3.44 | <3.12 | <4.88 | <4.49 | <4.44 | <4.64 |
| Alpha-BHC | <3.17 | <1.57 | <1.23 | <3.48 | <1.8 | <1.64 | <1.48 | <1.16 | <3.19 | <1.26 | <1.28 | <4.58 | <2.88 | <2.32 | <2.1 | <3.28 | <3.02 | <2.99 | <3.12 |
| Beta-BHC | <2.6 | <1.29 | <1.01 | <2.86 | <1.48 | <1.35 | <1.22 | <0.951 | <2.62 | <1.04 | <1.05 | <3.76 | <2.36 | <1.9 | <1.72 | <2.7 | <2.48 | <2.45 | <2.56 |
| Chlordane | 182 | <90.6 | <70.7 | <200 | <104 | <94.5 | <85.3 | <66.7 | <183 | <72.8 | <73.5 | <264 | <166 | <133 | <121 | <189 | <174 | <172 | <180 |
| Delta-BHC | <2.9 | <1.29 | <1.01 | <2.89 | <1.48 | <1.35 | <1.22 | <0.954 | <2.65 | <1.04 | <1.05 | <3.79 | <2.39 | <1.9 | <1.72 | <2.7 | <2.48 | <2.45 | <2.56 |
| Dieldrin | <4.71 | <2.34 | <1.83 | <5.17 | <2.68 | <2.44 | <2.2 | <1.72 | <4.74 | <1.88 | <1.9 | <6.81 | <4.27 | <3.44 | <3.12 | <4.88 | <4.49 | <4.44 | <4.64 |
| Endosulfan 1 | <2.2 | <1.09 | <0.853 | <2.41 | <1.25 | <1.14 | <1.03 | <0.804 | <2.21 | <0.878 | <0.887 | <3.18 | <2 | <1.61 | <1.46 | <2.28 | <2.1 | <2.07 | <2.17 |
| Endosulfan 2 | <4.24 | <2.11 | <1.64 | <4.66 | <2.41 | <2.2 | <1.98 | <1.55 | <4.27 | <1.69 | <1.71 | <6.14 | <3.85 | <3.1 | <2.81 | <4.4 | <4.05 | <4 | <4.18 |
| Endrosulfan Sulfate | <5.03 | <2.5 | <1.95 | <5.52 | <2.86 | <2.6 | <2.35 | <1.84 | <5.06 | <2.01 | <2.03 | <7.28 | <4.57 | <3.68 | <3.33 | <5.21 | <4.8 | <4.74 | <4.96 |
| Endrin | <5.53 | <2.75 | <2.14 | <6.07 | <3.14 | <2.87 | <2.59 | <2.02 | <5.56 | <2.21 | <2.23 | <8 | <5.02 | <4.04 | <3.67 | <5.74 | <5.27 | <5.22 | <5.45 |
| Endrin Aldehyde | <5.53 | <2.75 | <2.14 | <6.07 | <3.14 | <2.87 | <2.59 | <2.02 | <5.56 | <2.21 | <2.23 | <8 | <5.02 | <4.04 | <3.67 | <5.74 | <5.27 | <5.22 | <5.45 |
| Endrin Ketone | <5.94 | <2.95 | <2.3 | <6.53 | <3.38 | <3.08 | <2.78 | <2.17 | <5.98 | <2.37 | <2.4 | <8.6 | <5.4 | <4.34 | <3.94 | <6.16 | <5.67 | <5.6 | <5.86 |
| Gamma-BHC | <2.28 | <1.13 | <0.884 | <2.51 | <1.3 | <1.18 | <1.07 | <0.834 | <2.29 | <0.91 | <0.92 | <3.3 | <2.07 | <1.67 | <1.51 | <2.37 | <2.18 | <2.15 | <2.25 |
| Heptachlor | <2.91 | <1.44 | <1.13 | <3.19 | <1.65 | <1.51 | <1.36 | <1.06 | <2.92 | <1.16 | <1.17 | <4.21 | <2.64 | <2.13 | <1.93 | <3.01 | <2.77 | <2.74 | <2.87 |
| Heptachlor Epoxide | <2.46 | <1.22 | <0.955 | <2.71 | <1.4 | <1.28 | <1.15 | <0.901 | <2.48 | <0.983 | <0.993 | <3.56 | <2.24 | <1.8 | <1.63 | <2.55 | <2.35 | <2.32 | <2.43 |
| Methoxychlor | <36.8 | <18.3 | <14.3 | <40.4 | <20.9 | <19 | <17.2 | <13.4 | <37 | <14.7 | <14.8 | <53.2 | <33.4 | <26.9 | <24.4 | <38.1 | <35 | <34.7 | <36.2 |
| Toxaphene | <343 | <170 | <133 | <377 | <195 | <178 | <160 | <125 | <345 | <137 | <138 | <496 | <311 | <251 | <227 | <356 | <327 | <323 | <338 |

*Not detected at or above the specified minimum detection limit.

## TABLE 6. Inorganic standard elutriate test (SET) results on Toledo Harbor Lake Approach Channel sediments (from EEI 2004).

| Metals (mg/L) | Lake Approach Channel | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 |
| Aluminum | 31.4 | 26.1 | 83.3 | 3.57 | 1.72 | 7.31 | 36.9 | 40.5 | 18.3 | 24.4 | 18 |
| Antimony | 0.0003U* | 0.0003U | 0.0004 | 0.0003U | 0.0003U | 0.0003U | 0.0003U | 0.0004 | 0.0003U | 0.0004 | 0.0004 |
| Arsenic | 0.023 | 0.011 | 0.023 | 0.014 | 0.021 | 0.021 | 0.014 | 0.02 | 0.01 | 0.008 | 0.007 |
| Barium | 0.23 | 0.188 | 0.552 | 0.06 | 0.052 | 0.07 | 0.235 | 0.269 | 0.143 | 0.172 | 0.132 |
| Beryllium | 0.001 | 0.001 | 0.003 | 0.0002 | 0.00008U | 0.0003 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 |
| Cadmium | 0.001 | 0.005 | 0.002 | 0.0002 | 0.0001 | 0.0002 | 0.001 | 0.001 | 0.0004 | 0.001 | 0.001 |
| Calcium | 45.2 | 32 | 31.5 | 44.1 | 54.9 | 35.7 | 29.6 | 30.4 | 27.5 | 23.1 | 23 |
| Chromium | 0.039 | 0.033 | 0.118 | 0.005 | 0.002 | 0.009 | 0.044 | 0.053 | 0.025 | 0.039 | 0.031 |
| Cobalt | 0.012 | 0.009 | 0.027 | 0.002 | 0.001 | 0.003 | 0.011 | 0.013 | 0.006 | 0.008 | 0.006 |
| Copper | 0.032 | 0.026 | 0.083 | 0.009 | 0.005 | 0.011 | 0.034 | 0.041 | 0.022 | 0.028 | 0.024 |
| Iron | 32.1 | 24.3 | 73.6 | 4.29 | 2.16 | 7.8 | 32.3 | 38 | 18.3 | 21.2 | 16.6 |
| Lead | 0.022 | 0.019 | 0.071 | 0.004 | 0.002 | 0.007 | 0.028 | 0.035 | 0.018 | 0.025 | 0.022 |
| Magnesium | 16.8 | 12.5 | 21.2 | 11.3 | 15.4 | 10.1 | 11.7 | 12.8 | 8.9 | 8.61 | 7.38 |
| Manganese | 1.07 | 0.731 | 0.891 | 1.04 | 1.41 | 1 | 0.723 | 1.03 | 0.761 | 0.406 | 0.393 |
| Mercury | 0.0002 | 0.0002 | 0.0003 | 0.0002 | 0.0001 | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 |
| Nickel | 0.04 | 0.033 | 0.101 | 0.008 | 0.009 | 0.014 | 0.043 | 0.05 | 0.025 | 0.033 | 0.026 |
| Potassium | 10.3 | 8.52 | 18.9 | 4.73 | 3.79 | 3.87 | 9.62 | 11.2 | 6.59 | 7.96 | 6.45 |
| Selenium | 0.002 | 0.001U | 0.002 | 0.001U | 0.002 | 0.001U | 0.001 | 0.001 | 0.001U | 0.001U | 0.001 |
| Silver | 0.0002 | 0.0002 | 0.001 | 0.0001 | 0.00004 | 0.0001 | 0.0002 | 0.0003 | 0.0002 | 0.0003 | 0.0002 |
| Sodium | 7.45 | 7.51 | 5.19 | 7.74 | 7.65 | 7.26 | 5.85 | 5.56 | 5.49 | 4.63 | 4 |
| Thallium | 0.001 | 0.001 | 0.002 | 0.0001 | 0.00005 | 0.0001 | 0.001 | 0.001 | 0.0003 | 0.0004 | 0.0003 |
| Vanadium | 0.061 | 0.047 | 0.148 | 0.01 | 0.006 | 0.017 | 0.068 | 0.082 | 0.036 | 0.044 | 0.033 |
| Zinc | 0.144 | 0.111 | 0.377 | 0.019 | 0.009 | 0.032 | 0.154 | 0.18 | 0.082 | 0.117 | 0.086 |

| Misc (mg/L) | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ammonia | 10.1 | 4.33 | 2.99 | 6.85 | 2.96 | 2.17 | 1.76 | 1.58 | 1.45 | 0.573 | 0.765 |
| Cyanide | 0.00237J** | 0.00279J | 0.00227J | 0.00227J | 0.00601 | 0.00176J | 0.00172U | 0.00172U | 0.00203J | 0.00172U | 0.00172U |
| Phosphorus | 0.582 | 1.72 | 0.653 | 0.621 | 0.485 | 1.23 | 1.17 | 1.05 | 0.757 | 0.752 | 0.669 |
| Oil & Grease | 2.26U | 1.53U | 1.44U | 1.83U | 1.88U | 1.51U | 1.53U | 1.55U | 2.62J | 1.46U | 1.53U |

*Not detected at or above the specified minimum detection limit.
**Estimated value between the minimum detection limit and reporting limit.

## TABLE 7. PAH SET results on Toledo Harbor Lake Approach Channel sediments (from EEI 2004).

| | Lake Approach Channel | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PAHs (µg/L) | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 |
| 1-Methylnaphalene | 0.500U* | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| 2-Methylnaphthalene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Acenaphthene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Acenaphthylene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Anthracene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Benzo(a)Antracene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Benzo(a)Pyrene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Benzo(b)Flouranthene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Benzo(ghi)Perylene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Benzo(k)Floranthene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Chrysene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Dibenzo(a,h)Anthracene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Fluoranthene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Fluorene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Indeno(1,2,3-cd)Pyrene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Naphthalene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Phenanthrene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |
| Pyrene | 0.500U | 0.500U | 0.500U | 0.500U | 0.590U | 0.570U | 0.500U | 0.500U | 0.570U | 0.500U | 0.500U |

*Not detected at or above the specified minimum detection limit.

## TABLE 8. PCB SET results on Toledo Harbor Lake Approach Channel sediments (from EEI 2004).

| PCBs (µg/L) | Lake Approach Channel | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 |
| PCB-1016 | 0.100U* | 0.100U | 0.100U | 0.100U | 0.250U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U |
| PCB-1221 | 0.100U | 0.100U | 0.100U | 0.100U | 0.417U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U |
| PCB-1232 | 0.100U | 0.100U | 0.100U | 0.100U | 0.250U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U |
| PCB-1242 | 0.100U | 0.100U | 0.100U | 0.100U | 0.300U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U |
| PCB-1248 | 0.100U | 0.100U | 0.100U | 0.100U | 0.250U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U |
| PCB-1254 | 0.100U | 0.100U | 0.100U | 0.100U | 0.250U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U |
| PCB-1260 | 0.100U | 0.100U | 0.100U | 0.100U | 0.250U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U | 0.100U |

*Not detected at or above the specified minimum detection limit.

## TABLE 9. Pesticide SET results on Toledo Harbor Lake Approach Channel sediments (from EEI 2004).

| Pesticides (µg/L) | Lake Approach Channel | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-1 | LM-2 | LM-3 | LM-4 | LM-5 | LM-6 | LM-7 | LM-8 | LM-9 | LM-10 |
| 4,4-DDD | 0.400U* | 0.400U | 0.400U | 0.400U | 0.0400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| 4,4-DDE | 0.400U | 0.400U | 0.400U | 0.400U | 0.0191J** | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| 4,4-DDT | 0.158J | 0.400U | 0.400U | 0.400U | 0.0177J | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| Aldrin | 0.200U | 0.200U | 0.200U | 0.200U | 0.0200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U |
| Alpha-BHC | 0.200U | 0.200U | 0.200U | 0.200U | 0.0200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U |
| Beta-BHC | 0.200U | 0.200U | 0.200U | 0.200U | 0.0200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U |
| Delta-BHC | 0.200U | 0.200U | 0.200U | 0.200U | 0.0200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U |
| Chlordane | 2.50U | 2.50U | 2.50U | 2.50U | 2.50U | 2.50U | 2.50U | 2.50U | 2.50U | 2.50U | 2.50U |
| Dieldrin | 0.400U | 0.400U | 0.400U | 0.400U | 0.4 | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| Endosulfan I | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U |
| Endosulfan II | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| Endosulfan Sulfate | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| Endrin | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| Endrin Aldehyde | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| Endrin Ketone | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U | 0.400U |
| Gamma-BHC | 0.200U | 0.200U | 0.200U | 0.200U | 0.0200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U |
| Heptachlor | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U |
| Heptachlor Epoxide | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U |
| Methoxychlor | 2.00U | 2.00U | 2.00U | 2.00U | 0.200U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U |
| Toxaphene | 10.0U | 10.0U | 10.0U | 10.0U | 1.00U | 10.0U | 10.0U | 10.0U | 10.0U | 10.0U | 10.0U |

*Not detected at or above the minimum detection limit.
**Estimated value between the minimum detection limit and reporting limit.

**TABLE 10. Particle size distribution of Toledo Harbor Upper Lake Approach Channel and River Channel sediments (from EEI 2006).**

| Particle Size | Upper Lake Approach and River Channels | | | | | | | | | | | | | | | | Open-Lake Reference Area | | | | Open-Lake Placement Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (%) | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1(06) | TD-2(06) |
| Gravel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sand | 5.8 | 13.4 | 1.4 | 1.1 | 2.8 | 4.1 | 2.4 | 2.2 | 1.2 | 13.9 | 8.8 | 48.5 | 14.4 | 3.2 | 16.4 | 27.1 | 27.5 | 4 | 41.6 | 5.4 | 21.5 | 2.9 |
| Silt | 46 | 44.4 | 48 | 52.1 | 44.8 | 54.5 | 42.6 | 45.6 | 55.7 | 34.7 | 44.8 | 21.7 | 36.1 | 48.8 | 43.7 | 35.4 | 41.7 | 61 | 28.1 | 70.8 | 33.9 | 45.4 |
| Clay | 48.2 | 42.2 | 50.6 | 46.8 | 52.3 | 41.4 | 55 | 52.2 | 43.1 | 51.4 | 46.4 | 29.8 | 49.5 | 48 | 39.9 | 37.5 | 30.8 | 35 | 30.3 | 23.8 | 44.6 | 51.7 |

# TABLE 11. Comparison of Toledo Harbor open-lake reference area bulk sediment chemistry - 2004, 2006 and 2010.

| Parameter | Open-Lake Reference Area Concentration Range (mg/kg) | | | Difference, 2004 vs. 2006 | | Difference, 2006 vs. 2010 | |
|---|---|---|---|---|---|---|---|
| | 2004 | 2006 | 2010 | Significance Y/N (+/-) | Toxicogenic (Y/N) | Significance Y/N (+/-) | Toxicogenic (Y/N) |
| Aluminum | 8170-12200 | 9410-13000 | 20000-27000 | N | N | Y (+) | N |
| Antimony | <0.09-<0.12 | <0.39-<0.70 | <0.1-0.13 | Y (+) | N | Y (-) | N |
| Arsenic | 0.95-6.04 | 3.92-6.98 | 6-7.4 | N | N | N | N |
| Barium | 12.2-80.9 | 81.3-100 | 96-130 | N | N | N | N |
| Beryllium | 0.12-0.60 | 0.64-0.87 | 0.76-0.92 | N | N | N | N |
| Cadmium | 0.27-2.01 | 0.28-1.14 | 1.4-2.3 | N | N | Y (+) | N |
| Calcium | 3180-29500 | 28700-39900 | 28000-33000 | Y (+) | N | N | N |
| Chromium | 5.06-32.1 | 27.5-36.6 | 35-53 | N | N | Y | N |
| Cobalt | 0.94-7.38 | 7-8.99 | 8.98-11 | N | N | N | N |
| Copper | 4.35-30.5 | 34.3-50 | 32-44 | Y (+) | N | N | N |
| Iron | 2570-21000 | 21500-27700 | 24000-29000 | Y (+) | N | N | N |
| Lead | 4.59-34.0 | 22.7-33.7 | 36-55 | N | N | Y | N |
| Magnesium | 1120-8980 | 7980-14400 | 12000-15000 | Y (+) | N | N | N |
| Manganese | 50.3-371 | 365-562 | 520-640 | N | N | N | N |
| Mercury | 0.18-0.34 | 0.21-0.36 | 0.24-0.38 | N | N | N | N |
| Nickel | 3.78-27.7 | 25.6-37.7 | 34-46 | N | N | N | N |
| Potassium | 564-2470 | 1600-2270 | 2500-3500 | N | N | Y | N |
| Selenium | <0.23-0.70 | <0.55-<0.0.99 | 0.74-1 | N | N | N | N |
| Silver | 0.06-0.37 | 0.24-0.48 | 0.4-0.64 | N | N | N | N |
| Sodium | 43.8-863 | <24.7-<62.1 | 93-100 | Y (-) | N | N | N |
| Thallium | 0.15-0.41 | 2.47-2.92 | 0.4-0.51 | Y (+) | N | Y (-) | N |
| Vanadium | 4.16-26.8 | 22-28 | 29-39 | N | N | Y | N |
| Zinc | 14.9-106 | 105-139 | 140-190 | Y (+) | N | Y (+) | N |
| Total Organic Carbon | 20200-28500 | 14000-34000 | 8200-13000 | N | N | Y (-) | N |
| Cyanide | 0.21-1.12 | 0.05-0.13 | <2.1-<2.8 | Y (-) | Y | N | N |
| Ammonia | 69.8-116 | 63-90 | | N | N | | N |
| Phosphorus | 457-585 | 453-606 | 350-490 | N | N | Y (-) | N |
| Nitrogen | 1670-2330 | 310-1100 | | Y (-) | N | | N |
| Oil & Grease | 636-1030 | <160-598 | <210-<280 | Y (-) | N | N | N |
| Total PAHs | 0.34-3.7 | 0.06-0.8 | 2.62-13.1 | Y (-) | N | Y (+) | N |
| Total PCBs | 0.03-0.15 | <0.009 | 0.013-0.014 | Y (-) | N | N | N |
| Pesticides | * | ** | ** | Y (+) | N | N | N |

*All non-detectable at method detection limits ranging from 2.07 to 356 µg/kg.

**All non-detectable at method detection limits ranging from 0.147 to 31.3 µg/kg, except for DDT (4.02 µg/kg), DDD (1.41 µg/kg), DDE (1.95 µg/kg) and aldrin (1.53 µg/kg).

**TABLE 12. Bulk inorganic analyses on Toledo Harbor Upper Lake Approach Channel and River Channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placement area (from EEI 2006).**

| Metals | Lower Lake Approach and River Channels | | | | | | | | | | | | | | | | Open-lake Reference Area | | | | Open-lake Placement Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (mg/kg-dry | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1(06) | TD-2(06) |
| Aluminum | **19400** | 15600 | **22400** | **18300** | **17700** | 15500 | **18500** | **18600** | **19000** | 11800 | 17500 | **22400** | **18000** | **18000** | **18200** | **23200** | 9410 | 13000 | 10900 | 12800 | 14800 | 17700 |
| Antimony | **<1.15*** | <0.686 | **<1.29** | **<0.971** | <0.745 | **<0.992** | <0.714 | **<0.826** | **<0.871** | <0.600 | **<0.873** | <0.705 | <0.562 | **<72.5** | <0.776 | **<0.837** | <0.391 | <0.699 | <0.455 | <0.626 | <0.798 | <0.509 |
| Arsenic | **10.4** | 6.88 | **10.8** | **9.07** | **8.12** | 6.53 | 6.43 | 5.77 | **7.88** | 4.29 | **10.6** | **10.8** | **9.04** | **7.62** | **7.23** | **14** | 6.44 | 6.98 | 3.92 | 4.95 | 5.64 | 7.11 |
| Barium | **149** | 118 | **162** | **139** | **141** | **167** | **142** | **146** | **153** | 96.5 | **169** | **163** | **147** | **140** | **144** | **171** | 81.3 | 97.8 | 82.4 | 100 | 107 | 123 |
| Beryllium | **1.07J**** | 0.87 | **1.19J** | **1.04J** | **1.02** | 0.943J | **1.11** | **1.05** | **1.08** | 0.703J | **1.06** | **1.22** | **1.01** | 0.995 | 0.984 | **1.31** | 0.639 | 0.87 | 0.689 | 0.824 | 0.817J | 1 |
| Cadmium | 0.168J | 0.268J | <0.188 | 0.166J | <0.109 | <0.145 | <0.105 | <0.121 | <0.127 | <0.0879 | **2.71** | 0.275J | **1.49** | 0.159J | 0.114J | 0.367J | 1.14 | 0.665J | 0.278J | 0.458J | 0.681J | 0.546J |
| Calcium | 43000 | 35900 | 36200 | 33000 | 35300 | **51400** | 36000 | 39100 | **44000** | 26400 | 38900 | **81400** | 39900 | **46200** | **43700** | **69900** | 39900 | 30100 | 38300 | 28700 | 43100 | 31800 |
| Chromium | 32.7 | 26.3 | 37.4 | 31.7 | 28.1 | 24.2 | 28.5 | 29.5 | 31.1 | 21 | **83.8** | 38 | 38.5 | 27 | 27.4 | **42.2** | 30.8 | 36.6 | 27.5 | 33.1 | 39 | 36.5 |
| Cobalt | **12.9** | 10.1 | **14.4** | **12.2** | 10.1 | 9.26 | 11 | 10 | 10.4 | 6.85 | 9.8 | **15.1** | 11.2 | 10.7 | 10.9 | **15.7** | 7.13 | 8.99 | 7 | 8.26 | 10.6 | 11.9 |
| Copper | **56.3** | 43.9 | **57.2** | 49.2 | 46.6 | 49.7 | 47.1 | 48.1 | **51.1** | 32.7 | **84.6** | **77.9** | **57.9** | 47.9 | 46.9 | **60.7** | 49.7 | 50 | 34.3 | 45 | 46.5 | 49.8 |
| Iron | **31600** | 25300 | **35200** | **30300** | **30200** | 27100 | **30100** | **30600** | **31800** | 19900 | **33700** | **36400** | 28300 | 27400 | 28000 | **37100** | 25300 | 27700 | 21500 | 25600 | 25400 | 29400 |
| Lead | 21.7 | 15.8 | 21.9 | 20.3 | 19.1 | 17.5 | 16.7 | 19.4 | 21.2 | 13.4 | **61.6** | 26.8 | **47.3** | 17.4 | 15.4 | 21.5 | 30.7 | 33.7 | 22.7 | 30.3 | 28.7 | 25.3 |
| Magnesium | 11800 | 10600 | 12100 | 10500 | 10300 | 11700 | 10500 | 9950 | 10700 | 7350 | 9790 | **22600** | 10700 | 10200 | 10300 | **19000** | 11700 | 14400 | 7980 | 12900 | 11000 | 12400 |
| Manganese | **834** | 487 | **913** | **795** | **671** | 567 | 510 | 546 | **614** | 320 | 570 | **790** | 527 | 523 | 493 | **629** | 436 | 562 | 365 | 493 | 523 | 584 |
| Mercury | 0.081J | 0.068J | 0.044J | 0.079J | 0.057J | 0.065J | 0.076J | 0.095J | 0.088J | 0.11J | **0.4** | 0.049J | 0.12J | 0.066J | 0.046J | 0.049J | 0.21 | 0.36 | 0.21J | 0.32 | 0.22J | 0.17J |
| Nickel | 37.2 | 29.9 | **41.9** | 36.6 | 36.6 | **38** | 35.2 | 36.3 | **37.8** | 23.1 | **49.1** | **40.9** | 36.7 | 30.6 | 30.7 | **41.5** | 25.6 | 37.7 | 29.8 | 35.3 | 36.5 | 37.7 |
| Potassium | **3640** | 2770 | **4190** | **3200** | **3080** | 2880 | **3210** | **3270** | **3440** | 2110 | 2940 | **4060** | **3050** | **3340** | **3330** | **4240** | 1600 | 2270 | 1920 | 2180 | 2730 | 2980 |
| Selenium | **<1.63** | <0.97 | **<1.82** | **<1.37** | <1.05 | **<1.40** | <1.01 | **<1.17** | **<1.23** | <0.849 | **<1.24** | <0.997 | <0.794 | <1.03 | <1.1 | **<1.18** | <0.553 | <0.987 | <0.644 | <0.885 | <1.13 | <0.719 |
| Silver | <0.28 | <0.167 | <0.314 | <0.237 | 0.182J | 0.266J | 0.348J | <0.202 | 0.225J | 0.293J | **1.77** | <0.172 | **0.562** | <0.177 | <0.189 | 0.265J | 0.419J | 0.478J | 0.244J | 0.336J | 0.214J | 0.26J |
| Sodium | **<102** | <60.9 | **<114** | <86.2 | <66.1 | <88.1 | <63.4 | <73.4 | <77.3 | <53.3 | <77.4 | <62.6 | <49.9 | <64.4 | <68.9 | <74.3 | <24.7 | <62.1 | <40.4 | <55.6 | 90.3J | <45.1 |
| Thallium | 1.35J | 1.14J | 1.51J | 1.02J | **3.27J** | **3.24J** | **2.96J** | **3.95J** | **3.95J** | 1.52J | **3.58J** | 2.58J | 1.68J | 1.54J | 2.22J | **3.37J** | 2.75 | 2.47J | 2.82 | 2.92J | 0.992J | 1.66 |
| Vanadium | **39.2** | 31.4 | **43.9** | **35.3** | 33.3 | 31.4 | 33.1 | 33.9 | **35.3** | 21.4 | 33.7 | **42.9** | 33.8 | 34 | 33.9 | **45.9** | 22 | 28 | 23.3 | 27.1 | 29.7 | 34.6 |
| Zinc | 147 | 120 | **160** | 138 | 130 | **148** | 131 | 136 | 144 | 97.5 | **245** | **169** | **171** | 133 | 128 | **171** | 116 | 139 | 105 | 126 | 148 | 147 |

| Misc (mg/kg-dry weight) | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1 | TD-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOC | **67000** | **46000** | **61000** | **69000** | **71000** | **62000** | **52000** | **68000** | **69000** | **54000** | **77000** | 17000 | **46000** | **62000** | **41000** | 29000 | 25000 | 14000 | 26000 | 34000 | 34000 | 36000 |
| Cyanide | 0.07U | 0.06U | **0.076J** | **0.090J** | 0.068J | **0.08U** | 0.06U | **0.072J** | 0.08U | 0.06U | **0.65** | 0.04U | 0.05U | 0.06U | **0.07J** | 0.05U | 0.05U | 0.07U | 0.06U | 0.06J | 0.07U | 0.13J |
| Ammonia | 52 | 57 | 27 | 53 | **340** | 65 | **460** | **300** | 76 | **360** | 55 | 43 | 56 | 37 | 16 | 49 | 90 | 63 | 87 | 93 | 22 | 24 |
| Phosphorus | **780** | 574 | **762** | **732** | **713** | **728** | **659** | **670** | **826** | **724** | **638** | 479 | **1010** | **701** | 600 | 497 | 453 | 603 | 537 | 606 | 577 | 556 |
| Nitrogen | **1300** | 750 | 760 | **1300** | 930 | **1100** | 600 | **1100** | 890 | **1200** | 1000 | 840 | 770 | **1400** | 520 | 730 | 350 | 310 | 850 | 1100 | 1600 | 780 |
| Oil & Grease | **709** | 308 | <232 | 528 | <212 | 435 | 420 | <200 | 509 | 261 | **1140** | <133 | 489 | 569 | 250 | 49 | 598 | 319 | 229 | <160 | <171 | <160 |

*Not detected at or above the specified minimum detection limit.
**Estimated value between the minimum detection limit and reporting limit.

**TABLE 13. Bulk PAH analyses on Toledo Harbor Upper Lake Approach Channel and River Channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placement area (from EEI 2006).**

| PAHs (µg/kg-dry weight) | Upper Lake Approach and River Channels | | | | | | | | | | | | | | | | Open-lake Reference Area | | | | Open-lake Placement Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1(06) | TD-2(06) |
| 2-Methylnaphthalene | 3.8J* | 3.1J | <2.8** | <2.6 | 7.7J | 2.5J | <2.1 | 2.6J | 4.2J | <2.3 | **46** | <1.6 | <2 | <2.3 | **6.2J** | <1.8 | 5.9J | 2.1J | <1.9 | 2.1J | <2.1 | <2 |
| 1-Methylnaphthalene | 7.4J | 6.1J | 3.6J | 3.3J | 17J | 4.3J | <2.1 | 4.7J | 8.6J | <2.3 | **120** | <1.6 | 2.1J | 2.4J | 13J | <1.8 | 15 | 4J | 1.9J | 3.9J | <2.1 | <2 |
| Acenaphthene | <2.4 | 2.9J | <2.6 | <2.4 | <2.4 | 3.1J | <2 | <2.2 | 3.2J | <2.1 | **340** | <1.5 | 5J | <2.1 | **13J** | <1.6 | 8.8J | <1.7 | <1.7 | <1.8 | <1.9 | <1.8 |
| Acenaphthylene | 3J | 4J | <2.6 | <2.4 | 3.9J | 3.4J | <2 | <2.2 | 5.2J | 2.4J | **190** | <1.5 | 2.6J | <2.1 | 4.6J | <1.6 | 27 | 5.4J | <1.7 | 4J | 2.6J | <1.8 |
| Anthracene | 5.1J | 6.2J | <4 | <3.6 | 3.9J | 14J | <3 | <3.4 | 5.8J | <3.2 | **500** | <2.3 | 4.7J | <3.2 | 13J | <2.5 | 25 | 4.1J | <2.6 | 3J | <2.9 | <2.7 |
| Benz(a)Anthracene | 11J | 19 | <3.6 | 7.1J | 12J | 20 | 5.5J | 6.4J | 16J | 6.2J | **700** | <2 | 9.9J | 10J | 34 | 2.4J | 72 | 13J | 3.5J | 9.2J | 4.6J | 2.5J |
| Benzo(a)Pyrene | 11J | 17 | <6.3 | 6.6J | 13J | 18 | 6.4J | 6.7J | 16J | 5.7J | **550** | <3.6 | 8.2J | 11J | 19 | <4 | 63 | 14J | <4.1 | 9.8J | 5.3J | <4.3 |
| Benzo(b)Flouranthene | 9J | 15J | <6.1 | 5.7J | 13J | 17 | 6.8J | 6.8J | 15J | 5.2J | **400** | <3.5 | 7.6J | 10J | 20 | <3.8 | 42 | 10J | <4 | 7.7J | <4.5 | <4.2 |
| Benzo(ghi)Perylene | 7.7J | 12J | <3.4 | 5.1J | 11J | 13J | 5.8J | 6.2J | 12J | 3.8J | **280** | <1.9 | 5.6J | 9.2J | 11J | <2.1 | 38 | 8.9J | 3.2J | 6.8J | 4.1J | <2.3 |
| Benzo(k)Floranthene | 9.1J | 15J | <5.7 | 6.3J | 12J | 17 | 5.5J | 6.5J | 11J | 5.4J | **440** | <3.3 | 7.7J | 11J | 19 | <3.6 | 46 | 12J | <3.7 | 8J | 4.6J | <3.9 |
| Chrysene | 14J | 24 | <5.7 | 8.2J | 20 | 31 | 8.7J | 9.9J | 20J | 8.7J | **730** | <3.3 | 11J | 14J | 40 | <3.6 | 80 | 16 | 5.3J | 11J | 6.1J | <3.9 |
| Dibenz(a,h)Anthracene | 3.4J | 4.6J | <3 | <2.7 | 4.2J | 4.9J | 2.4J | <2.5 | 5.3 | <2.3 | **120** | <1.7 | 2.3J | 3.5J | 4.4J | <1.9 | 19 | 3.7J | <1.9 | 2.9J | <2.2 | <2 |
| Fluoranthene | 29 | 35 | 9.7J | 13J | 32 | 49 | 16J | 20 | 39 | 19 | **1400** | 7.7J | 31 | 30 | 88 | 8.2J | 96 | 25 | 7.8J | 15 | 9J | 6.5J |
| Fluorene | <4.1 | 6J | <4.3 | <3.9 | <3.9 | 5.6J | <3.3 | <3.7 | 5.8J | <3.4 | **590** | <2.5 | 5.5J | <3.5 | 17J | <2.7 | 24 | 3.1J | <2.9 | <3 | <3.2 | <3 |
| Indeno(1,2,3-cd)Pyrene | 7.3J | 11J | <3 | 5J | 10J | 12J | 4.7J | 5.3J | 11J | 3.7J | **290** | <1.7 | 5.3J | 8.8J | 11J | 1.9J | 37 | 8.6J | 2.7J | 6.5 | 3.7J | <2 |
| Naphthalene | 20J | 11J | 3.7J | 4J | 15J | 9.4J | 5.4J | 8.2J | 13J | 7.3J | **500** | <1.7 | 3.5J | 2.9J | 15J | <1.9 | 77 | 18J | 3.6J | 14J | 3.9J | 2.8J |
| Phenanthrene | 15J | 20 | 4.7J | 5.1J | 12J | 25 | 6.4J | 9.2J | 19J | 8.7J | **1400** | 4.2J | 15 | 12J | **67** | 3.3J | 38 | 9.8J | 3.5J | 6.7J | 3.9J | 3.3J |
| Pyrene | 24 | 27 | 7.9J | 10J | 26 | 35 | 11J | 15J | 31 | 13J | **1000** | 5.4J | 21 | 21 | 53 | 5.4J | 90 | 20 | 6.9J | 13J | 7.2J | 4.7J |
| Total PAHs | 186.3 | 238.9 | 82.7 | 97 | 219 | 284.2 | 99.1 | 121.5 | 241.1 | 104.7 | **9596** | 51 | 150 | 159 | 448.2 | 54.1 | 803.7 | 179.4 | 62.9 | 128.4 | 73.9 | 55.7 |

*Estimated value between the minimum detection limit and reporting limit.
**Not detected at or above the specified minimum detection limit.

**TABLE 14. Bulk PCB analyses on Toledo Harbor Upper Lake Approach Channel and River Channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placemenent area (from EEI 2006).**

| PCBs (ug/kg-dry weight) | Upper Lake Approach and River Channels | | | | | | | | | | | | | | | | Open-lake Reference Area | | | | Open-lake Placement Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-2 | LM-1.7 | LM-1.5 | LM-1.3 | LM-1.0 | LM-0.7 | LM-0.5 | LM-0.25 | LM-0 | AM-1 | RM-1 | RM-2 | RM-3 | RM-5 | RM-6 | RM-7 | TL-1 | TL-2 | TL-3 | TL-4 | TD-1(06) | TD-2(06) |
| PCB-1016 | **<11*** | **<8.9** | **<12** | **<11** | **<11** | **<9.3** | **<9.1** | **<10** | **<11** | **<9.6** | **<9.8** | <6.9 | <8.3 | **<9.8** | **<9.3** | <7.6 | <6.3 | <8.1 | <7.9 | <8.4 | <8.9 | <8.3 |
| PCB-1221 | **<10** | **<8.2** | **<11** | **<10** | **<10** | **<8.6** | **<8.4** | **<9.6** | **<10** | **<8.9** | **<9.1** | <6.4 | <7.7 | **<9.1** | **<8.6** | <7.1 | <5.9 | <7.5 | <7.3 | <7.7 | <8.2 | <7.7 |
| PCB-1232 | **<10** | **<8** | **<11** | **<9.9** | **<9.9** | **<8.4** | **<8.2** | **<9.3** | **<10** | **<8.6** | **<8.8** | <6.2 | <7.5 | **<8.8** | **<8.4** | <6.9 | <5.7 | <7.3 | <7.1 | <7.5 | <8 | <7.5 |
| PCB-1242 | **<11** | **<8.8** | **<12** | **<11** | **<11** | **<9.2** | **<9** | **<10** | **<11** | **<9.4** | **<9.7** | <6.8 | <8.2 | **<9.7** | **<9.2** | <7.5 | <6.2 | <8 | <7.8 | <8.2 | <8.8 | <8.2 |
| PCB-1248 | **<11** | **<8.4** | **<11** | **<10** | **<10** | **<8.8** | **<8.6** | **<9.8** | **<11** | **<9** | **<9.3** | <6.5 | <7.8 | **<9.2** | **<8.8** | <7.2 | <6 | <7.6 | <7.5 | <7.8 | <8.4 | <7.8 |
| PCB-1254 | **<11** | **<9** | **<12** | **<11** | **<11** | **<9.5** | **<9.2** | **<11** | **<11** | **<9.7** | **<10** | <7 | <8.4 | **<10** | **<9.5** | <7.7 | <6.4 | <8.2 | <8 | <8.4 | <9 | <8.4 |
| PCB-1260 | **<13** | **<10** | **<14** | **<12** | **<12** | **<11** | **<10** | **<12** | **<13** | **<11** | **<11** | <7.8 | <9.4 | **<11** | **<11** | <8.6 | <7.1 | <9.2 | <9 | <9.4 | <10 | <9.4 |
| Total PCBs | 77 | 61.3 | 83 | 74.9 | 74.9 | 64.8 | 62.5 | 71.7 | 77 | 66.2 | 67.7 | 47.6 | 57.3 | 67.6 | 64.8 | 52.6 | 43.6 | 55.9 | 54.6 | 57.4 | 61.3 | 57.3 |

*Not detected at or above the specified minimum detection limit.

**TABLE 15. Bulk pesticide analyses on Toledo Harbor Lake Approach and River Channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placement area (from EEI 2006).**

| Pesticides (µg/kg-dry weight) | Upper Lake Approach and River Channels | | | | | | | | | | | | | | | | Open-lake Reference Area | | | | Open-lake Placement Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 | TL-1 | TL-2 | TL-3 | TL-4 | TO-3(08) | TO-2(08) |
| 4,4-DDD | <0.555* | <0.436 | <0.591 | <0.539 | <0.537 | <0.458 | <0.447 | <0.509 | <0.554 | <0.470 | <0.482 | <0.339 | <0.470 | <0.482 | <0.458 | <0.374 | 1.41 | <0.398 | <0.389 | <0.407 | <0.437 | <0.407 |
| 4,4-DDE | <0.549 | <0.431 | <0.584 | <0.533 | <0.531 | <0.453 | <0.442 | <0.504 | <0.548 | <0.465 | <0.477 | <0.336 | <0.403 | <0.477 | <0.453 | <0.370 | 1.95 | <0.394 | <0.385 | <0.403 | <0.432 | <0.402 |
| 4,4-DDT | <0.897 | <0.705 | <0.955 | <0.871 | <0.868 | <0.741 | <0.722 | <0.823 | <0.896 | <0.760 | <0.780 | <0.549 | <0.659 | <0.779 | <0.740 | <0.605 | 4.02 | <0.643 | <0.629 | <0.659 | <0.706 | <0.657 |
| Aldrin | <0.317 | <0.249 | <0.338 | <0.308 | <0.307 | <0.262 | <0.255 | <0.291 | <0.317 | <0.269 | <0.276 | <0.194 | <0.233 | <0.276 | <0.262 | <0.214 | 1.53 | <0.227 | <0.222 | <0.233 | <0.249 | <0.232 |
| Alpha-BHC | **<0.264** | **<0.207** | **<0.281** | **<0.256** | **<0.255** | **<0.218** | **<0.212** | **<0.242** | **<0.263** | **<0.223** | **<0.229** | <0.161 | <0.193 | **<0.229** | **<0.217** | <0.178 | <0.147 | <0.189 | <0.185 | <0.193 | <0.207 | <0.193 |
| Beta-BHC | **<0.523** | <0.411 | **<0.557** | **<0.508** | **<0.506** | **<0.432** | **<0.421** | **<0.480** | **<0.523** | **<0.443** | **<0.455** | <0.320 | <0.384 | **<0.455** | **<0.432** | <0.353 | <0.293 | <0.375 | <0.367 | <0.384 | <0.412 | <0.384 |
| Chlordane | **<14.1** | <11 | **<15** | **<13.6** | **<13.6** | **<11.6** | **<11.3** | **<12.9** | **<14.0** | **<11.9** | **<12.2** | <8.6 | <10.3 | **<12.2** | **<11.6** | <9.48 | <7.87 | <10.1 | <9.87 | <10.3 | <11.1 | <10.3 |
| Delta-BHC | **<0.585** | <0.460 | **<0.623** | **<0.568** | **<0.566** | **<0.484** | **<0.471** | **<0.537** | **<0.585** | **<0.496** | **<0.509** | <0.358 | <0.430 | **<0.509** | **<0.483** | <0.395 | <0.327 | <0.420 | <0.411 | <0.430 | <0.461 | <0.429 |
| Dieldrin | **<0.507** | <0.398 | **<0.540** | **<0.492** | **<0.491** | **<0.419** | **<0.408** | **<0.465** | **<0.507** | **<0.429** | **<0.441** | <0.310 | <0.372 | **<0.441** | **<0.418** | <0.342 | <0.284 | <0.364 | <0.356 | <0.372 | <0.399 | <0.372 |
| Endosulfan I | **<0.411** | **<0.323** | **<0.438** | **<0.399** | **<0.398** | **<0.340** | **<0.331** | **<0.377** | **<0.411** | **<0.348** | **<0.358** | <0.251 | <0.302 | **<0.357** | **<0.339** | <0.277 | <0.230 | <0.295 | <0.288 | <0.302 | <0.323 | <0.301 |
| Endosulfan II | **<0.513** | <0.403 | **<0.546** | **<0.498** | **<0.497** | **<0.424** | **<0.413** | **<0.471** | **<0.513** | **<0.435** | **<0.446** | <0.314 | <0.377 | **<0.446** | **<0.423** | <0.346 | <0.287 | <0.368 | <0.360 | <0.377 | <0.404 | <0.376 |
| Endosulfan Sulfate | **<0.670** | **<0.527** | **<0.714** | **<0.651** | **<0.649** | **<0.554** | **<0.540** | **<0.615** | **<0.670** | **<0.568** | **<0.583** | <0.410 | <0.492 | **<0.583** | **<0.553** | <0.452 | <0.375 | <0.481 | <0.470 | <0.492 | <0.527 | <0.491 |
| Endrin | **<0.508** | <0.399 | **<0.541** | **<0.493** | **<0.492** | **<0.420** | **<0.409** | **<0.467** | **<0.508** | **<0.430** | **<0.442** | <0.311 | <0.373 | **<0.442** | **<0.419** | <0.343 | <0.284 | <0.365 | <0.357 | <0.373 | <0.400 | <0.372 |
| Endrin Aldehyde | **<0.702** | **<0.552** | **<0.747** | **<0.682** | **<0.679** | **<0.580** | **<0.565** | **<0.645** | **<0.701** | **<0.595** | **<0.611** | <0.429 | <0.516 | **<0.610** | **<0.579** | <0.474 | <0.393 | <0.504 | <0.493 | <0.516 | <0.552 | <0.515 |
| Endrin Ketone | **<0.569** | **<0.447** | **<0.605** | **<0.552** | **<0.550** | **<0.470** | **<0.458** | **<0.522** | **<0.568** | **<0.482** | **<0.495** | <0.348 | <0.418 | **<0.494** | **<0.469** | <0.384 | <0.318 | <0.408 | <0.399 | <0.418 | <0.447 | <0.417 |
| Gamma-BHC | **<0.281** | **<0.221** | **<0.299** | **<0.273** | **<0.272** | **<0.232** | **<0.226** | **<0.258** | **<0.281** | **<0.238** | **<0.244** | <0.172 | <0.206 | **<0.244** | **<0.232** | <0.190 | <0.157 | <0.202 | <0.197 | <0.206 | <0.221 | <0.206 |
| Heptachlor | **<0.580** | <0.456 | **<0.618** | **<0.563** | **<0.561** | **<0.479** | **<0.467** | **<0.533** | **<0.580** | **<0.491** | **<0.505** | <0.355 | <0.426 | **<0.505** | **<0.479** | <0.391 | <0.325 | <0.416 | <0.407 | <0.426 | <0.457 | <0.425 |
| Heptachlor Epoxide | **<0.280** | <0.220 | **<0.299** | **<0.272** | **<0.271** | **<0.232** | **<0.226** | **<0.257** | **<0.280** | **<0.238** | **<0.244** | <0.171 | <0.206 | **<0.244** | **<0.231** | <0.189 | <0.157 | <0.201 | <0.197 | <0.206 | <0.221 | <0.206 |
| Methoxychlor | **<3.42** | **<2.69** | **<3.64** | **<3.32** | **<3.31** | **<2.82** | **<2.75** | **<3.14** | **<3.41** | **<2.89** | **<2.97** | <2.09 | <2.51 | **<2.97** | **<2.82** | <2.30 | <1.91 | <2.45 | <2.40 | <2.51 | <2.69 | <2.50 |
| Toxaphene | **<42.7** | <33.5 | **<45.4** | **<41.4** | **<41.3** | **<35.3** | **<34.4** | **<39.2** | **<42.6** | **<35.2** | **<37.1** | <26.1 | <31.3 | **<37.1** | **<35.2** | <28.8 | <23.9 | <30.6 | <29.9 | <31.3 | <33.6 | <31.3 |

*Not detected at or above the specified minimum detection limit.

## TABLE 16. Inorganic SET results on Toledo Harbor Upper Lake Approach and River Channel sediments (from EEI 2006).

| | Upper Lake Approach and River Channels | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metals (µg/L) | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 |
| Aluminum | 20.8J* | 65.9J | 15.9J | 19.6J | 26.3J | 106J | 64.2J | 49.6J | 79.9J | 78.4J | 114 | 68 | 116 | 15.8J | 93.6 | 60.6 |
| Antimony | 0.880U** | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U | 0.880U |
| Arsenic | 8.88J | 7.08J | 7.44J | 18.4J | 6.12J | 7.12J | 4.32J | 7.56J | 2.8J | 3.64J | 8.76J | 3.2J | 6.44J | 5.44J | 9.88J | 5J |
| Barium | 184J | 164J | 179J | 183J | 178J | 201 | 682 | 225 | 142J | 299 | 470 | 186J | 244 | 179J | 303 | 194J |
| Beryllium | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U |
| Cadmium | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U | 0.240U |
| Calcium | 51200 | 43400 | 49700 | 57800 | 46200 | 44200 | 41600 | 46100 | 38000 | 40500 | 35700 | 35900 | 37400 | 51600 | 39000 | 42700 |
| Chromium | 0.520U | 0.520U | 0.520U | 0.520U | 0.520U | 0.520U | 0.88J | 0.520U | 0.520U | 0.64J | 1.00J | 0.520U | 0.520U | 0.520U | 0.76J | 0.6J |
| Cobalt | 0.32J | 0.200U | 0.28J | 0.200U | 0.200U | 0.36J | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.200U | 0.76J | 0.200U | 0.200U |
| Copper | 1.08J | 0.960U | 0.960U | 1.96J | 1.6J | 0.960U | 1.72J | 0.960U | 7.96J | 2.48J | 1.64J | 0.960U | 0.960U | 0.960U | 5.92J | 0.960U |
| Iron | 39.5J | 33.6J | 17.7J | 49.4J | 58.7J | 48.6J | 46.6J | 10.7J | 86.4J | 315J | 55.6J | 35J | 49.6J | 38.4J | 81.8J | 39.9J |
| Lead | 1.56U | 1.56U | 1.56U | 1.56U | 2.08J | 1.56U | 1.56U | 1.56U | 1.56U | 1.56U | 1.56U | 1.56U | 1.56U | 1.56U | 1.56U | 1.56U |
| Magnesium | 15900 | 11300 | 15500 | 17800 | 13300 | 10900 | 9480 | 11000 | 10800 | 10000 | 9990 | 9460 | 10300 | 14000 | 11400 | 11300 |
| Manganese | 1780 | 848 | 2070 | 2260 | 1630 | 755 | 382 | 800 | 531 | 394 | 453 | 543 | 524 | 1230 | 782 | 515 |
| Mercury | 0.47 | 1.7 | 0.32 | 0.29 | 0.24 | 0.13J | 0.11J | 0.23 | 2.5 | 0.10U | 0.68 | 0.12J | 0.27 | 0.12J | 0.11J | 0.22 |
| Nickel | 3.96J | 2.28J | 4.48J | 5.84J | 3.88J | 12.5 | 2.76J | 3.6J | 2.56J | 2.16J | 3.76J | 1.6J | 1.84J | 15.4 | 1.32J | 2.28J |
| Potassium | 4560 | 5110 | 4790 | 4500 | 4530 | 6890 | 6730 | 6010 | 5400 | 5980 | 5110 | 4990 | 5400 | 6860 | 5360 | 5320 |
| Selenium | 5.48J | 3.96J | 4.76J | 6.8J | 4.84J | 3.52J | 2.6J | 4.08J | 3.00J | 2.28J | 3.48J | 2.64J | 2.68J | 5.08J | 2.48J | 3.24J |
| Silver | 0.6J | 0.24 | 0.16J | 0.16U | 0.16U | 0.28J | 0.32J | 0.16U | 0.16U | 0.16U | 0.28J | 0.16U | 0.36J | 0.64J | 0.16U | 0.16U |
| Sodium | 12000 | 11500 | 11900 | 12300 | 10900 | 11800 | 19500 | 13400 | 13200 | 13700 | 10000 | 11500 | 12300 | 10000 | 13100 | 11200 |
| Thallium | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U | 2.00U |
| Vanadium | 3.56J | 2.84J | 3.04J | 3.88J | 2.36J | 2.68J | 4.64J | 2.88J | 2.80J | 3.28J | 3.48J | 2.88J | 3.04J | 2.12J | 2.96J | 2.8J |
| Zinc | 41J | 50.1J | 40.6J | 47.5J | 187 | 58.7J | 34.5J | 49.4J | 26.8J | 51.2J | 30.8J | 40J | 46.8J | 51.4J | 46.2J | 39.8J |

| Misc (mg/L) | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cyanide | 0.0032 | 0.0029J | 0.0029J | 0.0026J | 0.0029J | 0.0029J | 0.0032J | 0.0046J | 0.0038J | 0.0055J | 0.0063J | 0.0026 | 0.0026J | 0.0026J | 0.0026J | 0.0026J |
| Ammonia | 1.93 | 1.93 | 2.45 | 3.5 | 4.55 | 7 | 7.35 | 2.8 | 1.75 | 4.55 | 2.45 | 2.28 | 4.55 | 4.55 | 4.38 | 4.38 |
| Phosphorus | 0.08 | 0.11 | 0.068 | 0.13 | 0.055 | 0.058 | 0.09 | 0.09 | 0.1 | 0.069 | 0.064 | 0.06 | 0.083 | 0.036 | 0.069 | 0.069 |
| Nitrogen | 2.1 | 4.4 | 0.28U | 2.6 | 4.7 | 9.8 | 8.1 | 5.3 | 3.2 | 7.2 | 4.2 | 3.3 | 6.7 | 4.9 | 5.1 | 5.1 |
| Oil & Grease | 1.3 | 0.85U | 0.85U | 5 | 0.85U | 0.85U | 0.96J | 0.85U | 0.85U | 1.3J | 0.85U | 1 | 1.7J | 5 | 5 | 0.85U |

*Estimated value between the minimum detection limit and reporting limit.
**Not detected at or above the specified minimum detection limit.

## TABLE 17. PAH SET results on Toledo Harbor Upper Lake Approach and River Channel sediments (from EEI 2006).

| PAH (µg/L) | Upper Lake Approach and River Channels | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 |
| 2-Methylnaphthalene | 0.050U* | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U |
| 1-Methylnaphthalene | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.24 |
| Acenaphthene | 0.036U | 0.036U | 0.036U | 0.036U | 0.036U | 0.036U | 0.036U | 0.036U | 0.036U | 0.036U | 1 | 0.036U | 0.091 | 0.036U | 0.087 | 0.14 |
| Acenaphthylene | 0.035U | 0.035U | 0.035U | 0.035U | 0.035U | 0.035U | 0.035U | 0.035U | 0.035U | 0.035U | 0.1 | 0.035U | 0.035U | 0.035U | 0.035U | 0.16 |
| Anthracene | 0.064U | 0.064U | 0.064U | 0.064U | 0.064U | 0.064U | 0.064U | 0.064U | 0.064U | 0.064U | 0.27 | 0.064U | 0.064U | 0.064U | 0.064U | 0.064U |
| Benzo(a)Anthracene | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.51 | 0.031U | 0.037 | 0.031U | 0.031U | 0.031U |
| Benzo(a)Pyrene | 0.054U | 0.054U | 0.054U | 0.054U | 0.054U | 0.054U | 0.054U | 0.054U | 0.054U | 0.054U | 0.25 | 0.054U | 0.054U | 0.054U | 0.054U | 0.054U |
| Benzo(b)Flouranthene | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.23 | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U |
| Benzo(ghi)Perylene | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.1 | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U |
| Benzo(k)Fluoranthene | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U | 0.16 | 0.050U | 0.050U | 0.050U | 0.050U | 0.050U |
| Chrysene | 0.030U | 0.030U | 0.030U | 0.030U | 0.030U | 0.030U | 0.030U | 0.030U | 0.030U | 0.030U | 0.44 | 0.030U | 0.046 | 0.030U | 0.030U | 0.030U |
| Dibenz(a,h)Anthracene | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U | 0.046 | 0.039U | 0.039U | 0.039U | 0.039U | 0.039U |
| Fluoranthene | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 0.044U | 1.4 | 0.044U | 0.17 | 0.044U | 0.076 | 0.044U |
| Fluorene | 0.057U | 0.057U | 0.057U | 0.057U | 0.057U | 0.057U | 0.057U | 0.057U | 0.057U | 0.057U | 0.74 | 0.057U | 0.057U | 0.057U | 0.062 | 0.062 |
| Indeno(1,2,3-cd)Pyrene | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.078 | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U |
| Naphthalene | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.086 | 0.031U | 0.031U | 0.031U | 0.1 | 0.17 |
| Phenanthrene | 0.048U | 0.048U | 0.048U | 0.048U | 0.048U | 0.048U | 0.048U | 0.048U | 0.048U | 0.048U | 0.58 | 0.048U | 0.1 | 0.048U | 0.14 | 0.048U |
| Pyrene | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 0.031U | 1.2 | 0.031U | 0.16 | 0.031U | 0.057 | 0.031U |

*Not detected at or above the specified minimum detection limit.

## TABLE 18. PCB SET results on Toledo Harbor Upper Lake Approach and River Channel sediments (from EEI 2006).

| PCB (µg/L) | Upper Lake Approach and River Channels | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 |
| PCB-1016 | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U | 0.18U |
| PCB-1221 | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U | 0.20U |
| PCB-1232 | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U | 0.15U |
| PCB-1242 | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U | 0.11U |
| PCB-1248 | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U | 0.21U |
| PCB-1254 | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 2.6 | 0.17U | 0.59 | 0.17U | 0.17U | 0.17U |
| PCB-1260 | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U | 0.17U |

*Not detected at or above the minimum detection limit.

## TABLE 19. Pesticide SET results on Toledo Harbor Upper Lake Approach and River Channel sediments (from EEI 2006).

| Pesticide (µg/L) | Upper Lake Approach and River Channels | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-2 | LM-1.75 | LM-1.5 | LM-1.25 | LM-1.0 | LM-0.75 | LM-0.5 | LM-0.25 | LM-0 | RM-1 | RM-2 | RM-3 | RM-4 | RM-5 | RM-6 | RM-7 |
| 4,4-DDD | 0.00370U* | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U | 0.00370U |
| 4,4-DDE | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U | 0.00350U |
| 4,4-DDT | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U | 0.00490U |
| Aldrin | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U | 0.00260U |
| Alpha-BHC | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U | 0.0101U |
| Beta-BHC | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U | 0.00230U |
| Delta-BHC | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U | 0.00200U |
| Chlordane | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U | 0.00180U |
| Dieldrin | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U | 0.00430U |
| Endosulfan I | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U | 0.00240U |
| Endosulfan II | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U |
| Endosulfan Sulfate | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U | 0.00700U |
| Endrin | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U | 0.00460U |
| Endrin Aldehyde | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U | 0.00860U |
| Endrin Ketone | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U | 0.00450U |
| Gamma-BHC | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U | 0.00160U |
| Heptachlor | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U | 0.00290U |
| Heptachlor Epoxide | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U | 0.00280U |
| Methoxychlor | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U | 0.0288U |
| Toxaphene | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U | 0.423U |

*Not detected at or above the specified minimum detection limit.

**TABLE 20. Results of water column elutriate bioassays on Toledo Harbor Upper Lake Approach Channel sediments (from USAERDC 2007). Boldface/shaded values indicate statistically reduced survival relative to 0% treatment.**

| Sample | Treatment | Test Species | | | |
|---|---|---|---|---|---|
| | | *Pimephales promelas* | | *Ceriodaphnia dubia* | |
| | | Survival (%) | $LC_{50}$ | Survival (%) | $LC_{50}$ |
| Performance Control (Dechlorinated Tap) | NA | 96±9 | NA | 92±11 | NA |
| LRM-1 | 0%<br>10%<br>50%<br>100% | 86±11<br>76±11<br>76±9<br>**54±17*** | >100% | 84±26<br>#<br>88±18<br>96±9 | >100% |
| LRM-1 Toxicity Reduction Evaluation | 100% (Zeolite)<br>100% (EDTA) | 83±13†<br>41±17 | NA | NA | |
| LRM-2 | 0%<br>10%<br>50%<br>100% | 86±11<br>98±5<br>82±11<br>**66±15*** | >100% | 84±26<br>100±0<br>96±9<br>96±9 | >100% |

# Treatment lost due to laboratory error
* Statistically reduced survival compared to site water (0% treatment)
† Statistically increased survival in the zeolite-treated 100% elutriate compared to untreated 100% elutriate
>100% = LC50 could not be calculated due to insufficient mortality in test concentrations

**TABLE 21. Physical size analyses on Toledo Harbor Federal navigation channel sediments (from USACE 2010).**

| Particle Size Distribution (%) | Open-Lake Placement Area | | | | Open-Lake Reference Area | | | | River Channel | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TD-1 | TD-2 | TD-3 | TD-4 | TL-1 | TL-2 | TL-3 | TL-4 | RM-7.0 | RM-6.0 | RM-5.0 | RM-4.0 | RM-3.0 | RM-2.0 | RM-1.0 | RM-0.75 | RM-0.5 | RM-0.25 |
| Clay | 38 | 42 | 39 | 40 | 46 | 52 | 54 | 53 | 22 | 21 | 51 | 45 | 49 | 30 | 5 | 24 | 55 | 46 |
| Silt | 41 | 40 | 44 | 39 | 45 | 34 | 36 | 40 | 37 | 33 | 30 | 20 | 33 | 36 | 24 | 27 | 40 | 35 |
| Fine Sand | 11 | 5 | 10 | 7 | 4 | 2 | 2 | 2 | 31 | 8 | 2 | 9 | 11 | 11 | 24 | 33 | 0 | 1 |
| Medium Sand | 3 | 4 | 6 | 9 | 3 | 1 | 6 | 3 | 3 | 9 | 2 | 8 | 4 | 7 | 22 | 3 | 2 | 0 |
| Coarse Sand | 7 | 9 | 1 | 5 | 2 | 11 | 2 | 2 | 7 | 21 | 9 | 6 | 3 | 5 | 13 | 13 | 3 | 18 |
| Gravel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 6 | 12 | 0 | 11 | 12 | 0 | 0 | 0 |
| Total Silt/Clay | 79 | 82 | 83 | 79 | 91 | 86 | 90 | 93 | 59 | 54 | 81 | 65 | 82 | 66 | 29 | 51 | 95 | 81 |
| Total Sand/Gravel | 21 | 18 | 17 | 21 | 9 | 14 | 10 | 7 | 41 | 46 | 19 | 35 | 18 | 34 | 71 | 49 | 5 | 19 |

| Particle Size Distribution (%) | Lake Approach Channel | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | LM-0.25 | LM-0.5 | LM-0.75 | LM-1.0 | LM-1.25 | LM-1.5 | LM-1.75 | LM-2.0 | LM-2.25 | LM-2.5 | LM-2.75 | LM-3.0 | LM-3.25 | LM-3.5 |
| Clay | 49 | 58 | 54 | 55 | 58 | 56 | 49 | 56 | 60 | 68 | 68 | 57 | 62 | 31 | 42 |
| Silt | 38 | 30 | 40 | 26 | 33 | 34 | 30 | 37 | 26 | 29 | 29 | 31 | 33 | 38 | 41 |
| Fine Sand | 3 | 1 | 2 | 9 | 2 | 1 | 5 | 2 | 4 | 2 | 2 | 1 | 1 | 18 | 8 |
| Medium Sand | 3 | 7 | 1 | 2 | 1 | 1 | 5 | 1 | 5 | 0 | 0 | 1 | 2 | 9 | 2 |
| Coarse Sand | 7 | 4 | 3 | 8 | 6 | 8 | 10 | 4 | 5 | 1 | 1 | 10 | 2 | 4 | 7 |
| Gravel | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Silt/Clay | 87 | 88 | 94 | 81 | 91 | 90 | 79 | 93 | 86 | 97 | 97 | 88 | 95 | 69 | 83 |
| Total Sand/Gravel | 13 | 12 | 6 | 19 | 9 | 10 | 21 | 7 | 14 | 3 | 3 | 12 | 5 | 31 | 17 |

| Particle Size Distribution (%) | Lake Approach Channel | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | LM-4.0 | LM-4.25 | LM-4.5 | LM-4.75 | LM-5.0 | LM-6.0 | LM-7.0 | LM-8.0 | LM-9.0 | LM-10.0 | LM-11.0 | LM-12.0 | LM-13.0 |
| Clay | 43 | 38 | 37 | 46 | 42 | 46 | 56 | 36 | 52 | 45 | 55 | 50 | 57 | 56 |
| Silt | 30 | 31 | 41 | 31 | 34 | 36 | 30 | 50 | 35 | 38 | 39 | 30 | 34 | 28 |
| Fine Sand | 12 | 17 | 14 | 10 | 11 | 11 | 8 | 11 | 7 | 3 | 1 | 1 | 2 | 7 |
| Medium Sand | 4 | 4 | 6 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 |
| Coarse Sand | 11 | 10 | 2 | 9 | 10 | 5 | 4 | 1 | 4 | 12 | 3 | 17 | 5 | 5 |
| Gravel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Silt/Clay | 73 | 69 | 78 | 77 | 76 | 82 | 86 | 86 | 87 | 83 | 94 | 80 | 91 | 84 |
| Total Sand/Gravel | 27 | 31 | 22 | 23 | 24 | 18 | 14 | 14 | 13 | 17 | 6 | 20 | 9 | 16 |

## TABLE 22. Bulk metals analyses on Toledo Harbor Federal navigation channel sediments (from USACE 2010).

| Metal (mg/kg-dry weight) | Open Lake Placement Area | | | | Open Lake Reference Area | | | | Maumee River Channel | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TD-1 | TD-2 | TD-3 | TD-4 | TR-1 | TR-2 | TR-3 | TR-4 | RM-0.0 | RM-0.5 | RM-1.0 | RM-1.5 | RM-2.0 | RM-2.5 | RM-3.0 | RM-3.5 | RM-4.0 | RM-4.5 |
| Aluminum | 20,000 | 25,000 | 26,000 | 25,000 | 20,000 | 24,000 | 27,000 | 20,000 | 28,000 | 26,000 | 39,000 | 24,000 | 33,000 | 48,000 | 20,000 | 20,000 | 40,000 | 34,000 |
| Antimony | 0.087 | 0.14 | 0.096 | 0.12 U* | 0.100 U | 0.12 | 0.13 | 0.1 | 0.089 U | 0.099 U | 0.11 | 0.21 | 0.12 U | 0.21 | 0.26 | 0.1 | 0.14 U | 0.12 |
| Arsenic | 6.6 | 7.9 | 8.7 | 8.1 | 6.2 | 7.0 | 7.4 | 6.0 | 7.7 | 8.8 | 8.5 | 8.6 | 8.4 | 13.0 | 6.7 | 6.6 | 8.4 | 8.7 |
| Barium | 87 | 120 | 130 | 130 | 100 | 120 | 130 | 96 | 110 | 98 | 130 | 110 | 130 | 190 | 91 | 85 | 160 | 160 |
| Beryllium | 0.68 | 1.0 | 0.93 | 0.90 | 0.76 | 0.91 | 0.82 | 0.8 | 0.72 | 0.71 | 1.0 | 0.64 | 0.87 J** | 1.2 J | 0.61 | 0.7 | 1.0 | 1.0 |
| Cadmium | 1.3 | 1.3 | 1.1 | 1.4 | 1.6 | 2.3 | 1.4 | 1.7 | 1.0 | 0.61 | 0.81 | 2.5 | 1.3 | 1.9 | 0.63 | 0.95 | 0.81 | 0.88 |
| Calcium | 70,000 | 39,000 | 44,000 | 37,000 | 33,000 | 28,000 | 28,000 | 33,000 | 45,000 | 88,000 | 38,000 | 35,000 | 36,000 | 56,000 | 97,000 | 46,000 | 41,000 | 47,000 |
| Chromium | 27 | 30 | 32 | 39 | 36 | 53 | 40 | 35 | 24 | 23 | 31 | 32 | 32 | 52 | 21 | 21 | 32 | 33 |
| Cobalt | 7.9 | 9.1 | 10 | 10 | 9.0 | 11 | 11 | 8.9 | 8.4 | 7.9 | 11 | 7.2 | 9.1 | 14 | 7.4 | 7.1 | 11 | 11 |
| Copper | 27 | 29 | 33 | 35 | 32 | 44 | 33 | 32 | 23 | 22 | 28 | 61 | 29 | 47 | 22 | 27 | 29 | 32 |
| Iron | 24,000 | 26,000 | 29,000 | 28,000 | 25,000 | 35,000 | 29,000 | 24,000 | 26,000 | 27,000 | 36,000 | 24,000 | 31,000 | 47,000 | 22,000 | 21,000 | 37,000 | 34,000 |
| Lead | 29 | 27 | 30 | 39 | 37 | 55 | 36 | 37 | 19 | 17 | 21 | 51 | 30 | 50 | 21 | 35 | 23 | 24 |
| Magnesium | 17,000 | 13,000 | 13,000 | 14,000 | 15,000 | 14,000 | 12,000 | 14,000 | 12,000 | 23,000 | 13,000 | 9,600 | 9,100 | 14,000 | 12,000 | 12,000 | 12,000 | 9,600 |
| Manganese | 560 | 610 | 710 | 700 | 550 | 580 | 640 | 520 | 510 | 610 | 770 | 450 | 590 | 870 | 440 | 430 | 770 | 800 |
| Mercury | 0.19 | 0.13 | 0.16 | 0.26 | 0.26 | 0.38 | 0.24 | 0.27 | 0.052 J | 0.031 J | 0.05 J | 0.16 | 0.083 | 0.087 | 0.077 | 0.069 | 0.076 J | 0.06 J |
| Nickel | 28 | 31 | 34 | 36 | 33 | 46 | 38 | 34 | 25 | 25 | 33 | 28 | 30 | 48 | 23 | 21 | 33 | 34 |
| Potassium | 2,100 | 3,100 | 3,100 | 3,200 | 2,600 | 3,100 | 3,500 | 2,500 | 3,000 | 3,100 | 4,100 | 2,300 | 3,700 | 5,300 | 2,400 | 2,300 | 4,300 | 4,400 |
| Selenium | 0.53 | 0.89 | 0.98 | 1.0 | 0.85 | 1.0 | 0.92 | 0.74 | 0.69 J | 0.73 | 0.99 | 0.58 | 0.84 J | 1.2 J | 0.67 | 0.86 | 0.84 | 0.99 |
| Silver | 0.3 | 0.29 | 0.32 | 0.47 | 0.47 | 0.64 | 0.40 | 0.45 | 0.2 | 0.12 | 0.18 | 0.78 | 0.39 | 0.53 | 0.32 | 0.27 | 0.22 | 0.21 |
| Sodium | 140 | 95 J | 96 J | 100 J | 93 J | 100 J | 140 U | 93 J | 90 | 98 J | 87 J | 71 U | 110 | 160 J | 240 | 100 | 110 J | 120 |
| Thallium | 0.41 | 0.6 | 0.5 | 0.5 | 0.42 | 0.48 | 0.51 | 0.4 | 0.45 J | 0.49 | 0.56 | 0.41 | 0.52 J | 0.76 J | 0.45 | 0.51 | 0.58 | 0.61 |
| Vanadium | 27 | 34 | 37 | 36 | 30 | 36 | 39 | 29 | 32 | 31 | 43 | 26 | 37 | 55 | 24 | 26 | 42 | 45 |
| Zinc | 110 | 120 | 140 | 160 | 140 | 190 | 150 | 140 | 99 | 88 | 130 | 130 | 130 | 220 | 93 | 130 | 130 | 140 |

| Metal (mg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0 | LM-0.25 | LM-0.5 | LM-0.75 | LM-1.0 | LM-1.25 | LM-1.5 | LM-1.75 | LM-2.0 | LM-2.25 | LM-2.5 | LM-2.75 | LM-3.0 | LM-3.25 | LM-3.5 |
| Aluminum | 37,000 | 43,000 | 33,000 | 31,000 | 34,000 | 36,000 | 33,000 | 26,000 | 27,000 | 32,000 | 3,500 | 37,000 | 35,000 | 32,000 | 28,000 |
| Antimony | 0.11 U | 0.13 U | 0.13 U | 0.097 U | 0.12 U | 0.12 U | 0.14 | 0.11 U | 0.51 | 0.11 U | 0.14 | 0.18 | 0.11 U | 0.28 | 0.15 |
| Arsenic | 8.8 | 8.4 | 8.3 | 7.0 | 7.9 | 8.2 | 7.4 | 8.9 | 6.7 | 9.2 | 8.0 | 7.9 | 7.8 | 8.9 | 11 |
| Barium | 150 | 150 | 130 | 120 | 130 | 140 | 120 | 130 | 130 | 150 | 140 | 130 | 130 | 150 | 140 |
| Beryllium | 0.98 | 1.2 | 0.87 | 0.78 | 0.89 | 0.92 | 0.76 | 0.92 | 1.1 | 1.1 | 0.9 | 0.89 | 0.93 | 1.1 | 1.0 |
| Cadmium | 0.9 | 0.82 | 0.84 | 0.81 | 0.78 | 0.85 | 0.77 | 0.87 | 0.98 | 0.82 | 0.71 | 0.68 | 0.66 | 0.76 | 0.82 |
| Calcium | 50,000 | 35,000 | 46,000 | 48,000 | 46,000 | 46,000 | 46,000 | 45,000 | 47,000 | 42,000 | 42,000 | 47,000 | 47,000 | 42,000 | 44,000 |
| Chromium | 32 | 32 | 31 | 26 | 29 | 33 | 27 | 28 | 29 | 33 | 30 | 29 | 29 | 31 | 28 |
| Cobalt | 10 | 10 | 10 | 9 | 10 | 10 | 9 | 10 | 10 | 11 | 10 | 9 | 10 | 11 | 10 |
| Copper | 31 | 29 | 31 | 26 | 29 | 31 | 26 | 29 | 30 | 30 | 27 | 26 | 27 | 29 | 26 |
| Iron | 34,000 | 37,000 | 31,000 | 30,000 | 32,000 | 34,000 | 32,000 | 29,000 | 29,000 | 33,000 | 33,000 | 34,000 | 35,000 | 33,000 | 32,000 |
| Lead | 25 | 20 | 23 | 20 | 23 | 24 | 21 | 24 | 25 | 24 | 21 | 21 | 20 | 23 | 22 |
| Magnesium | 13,000 | 9,500 | 13,000 | 13,000 | 12,000 | 13,000 | 13,000 | 14,000 | 14,000 | 12,000 | 13,000 | 13,000 | 10,000 | 11,000 | 14,000 |
| Manganese | 730 | 680 | 680 | 600 | 750 | 760 | 680 | 870 | 660 | 690 | 710 | 810 | 830 | 660 | 690 |
| Mercury | 0.069 J | 0.063 J | 0.18 | 0.062 J | 0.078 J | 0.09 | 0.11 | 0.089 | 0.095 | 0.071 J | 0.065 J | 0.063 J | 0.07 J | 0.085 | 0.081 |
| Nickel | 33 | 32 | 32 | 28 | 30 | 33 | 28 | 30 | 32 | 34 | 30 | 29 | 30 | 34 | 30 |
| Potassium | 4,300 | 4,800 | 4,100 | 3,300 | 3,700 | 4,200 | 3,400 | 2,900 | 3,200 | 4,100 | 4,100 | 3,900 | 4,200 | 3,800 | 3,400 |
| Selenium | 0.97 | 1.2 | 0.89 | 0.8 | 0.86 | 0.96 | 0.7 | 0.66 | 0.7 | 0.73 | 0.79 | 0.8 | 0.94 | 0.79 | 0.81 |
| Silver | 0.26 | 0.17 | 0.25 | 0.22 | 0.27 | 0.25 | 0.33 | 0.22 | 0.36 | 0.2 | 0.19 | 0.19 | 0.19 | 0.2 | 0.18 |
| Sodium | 120 J | 110 J | 120 J | 92 J | 110 | 110 J | 92 J | 110 J | 120 J | 120 J | 92 J | 94 J | 96 J | 110 J | 100 J |
| Thallium | 0.59 | 0.83 | 0.53 | 0.48 | 0.50 | 0.56 | 0.47 | 0.47 | 0.63 | 0.60 | 0.53 | 0.51 | 0.51 | 0.55 | 0.53 |
| Vanadium | 43 | 5 | 41 | 35 | 38 | 42 | 35 | 34 | 36 | 43 | 41 | 40 | 41 | 41 | 37 |
| Zinc | 130 | 130 | 130 | 110 | 120 | 130 | 110 | 120 | 130 | 140 | 120 | 120 | 110 | 130 | 110 |

| Metal (mg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | LM-4.0 | LM-4.25 | LM-4.5 | LM-4.75 | LM-5.0 | LM-5.5 | LM-6.0 | LM-8.0 | LM-9.0 | LM-10.0 | LM-11.0 | LM-12.0 | LM-13.0 |
| Aluminum | 3,000 | 25,000 | 29,000 | 27,000 | 28,000 | 26,000 | 25,000 | 31,000 | 30,000 | 31,000 | 26,000 | 31,000 | 27,000 | 26,000 |
| Antimony | 0.14 | 0.14 | 0.12 | 0.2 | 0.13 | 0.17 | 0.13 | 0.11 | 0.11 | 0.12 U | 0.17 | 0.13 | 0.17 | 0.19 |
| Arsenic | 8.2 | 8.6 | 8.9 | 7.8 | 8.0 | 7.9 | 8.0 | 8.7 | 8.5 | 8.9 | 8.3 | 8.3 | 7.9 | 6.7 |
| Barium | 140 | 130 | 150 | 120 | 130 | 120 | 110 | 130 | 130 | 130 | 130 | 140 | 120 | 110 |
| Beryllium | 0.97 | 0.95 | 1.0 | 0.86 | 0.97 | 0.92 | 0.85 | 1.0 | 0.99 | 0.99 | 1.0 | 1.0 | 1.1 | 1.0 |
| Cadmium | 0.76 | 0.82 | 0.81 | 0.73 | 0.77 | 0.84 | 0.76 | 1.0 | 1.1 | 1.3 | 1.4 | 1.5 | 1.6 | 1.8 |
| Calcium | 42,000 | 46,000 | 41,000 | 42,000 | 47,000 | 48,000 | 42,000 | 49,000 | 37,000 | 36,000 | 30,000 | 30,000 | 29,000 | 28,000 |
| Chromium | 28 | 27 | 30 | 36 | 28 | 27 | 26 | 32 | 32 | 40 | 40 | 42 | 45 | 49 |
| Cobalt | 9 | 10 | 10 | 12 | 9 | 9 | 9 | 10 | 10 | 11 | 11 | 11 | 11 | 11 |
| Copper | 26 | 27 | 28 | 34 | 27 | 27 | 24 | 30 | 30 | 37 | 35 | 35 | 37 | 38 |
| Iron | 31,000 | 28,000 | 30,000 | 28,000 | 30,000 | 28,000 | 27,000 | 33,000 | 32,000 | 34,000 | 30,000 | 37,000 | 32,000 | 32,000 |
| Lead | 23 | 24 | 24 | 23 | 23 | 24 | 23 | 29 | 28 | 37 | 37 | 42 | 45 | 51 |
| Magnesium | 13,000 | 14,000 | 14,000 | 13,000 | 15,000 | 15,000 | 15,000 | 18,000 | 15,000 | 15,000 | 14,000 | 16,000 | 16,000 | 17,000 |
| Manganese | 630 | 600 | 590 | 570 | 620 | 580 | 600 | 680 | 570 | 780 | 650 | 720 | 710 | 660 |
| Mercury | 0.074 | 0.082 | 0.170 | 0.082 | 0.099 | 0.093 | 0.098 | 0.140 | 0.13 | 0.23 | 0.25 | 0.3 | 0.31 | 0.37 |
| Nickel | 29 | 30 | 32 | 38 | 30 | 30 | 28 | 33 | 34 | 40 | 39 | 40 | 42 | 43 |
| Potassium | 3,300 | 3,000 | 3,500 | 4,300 | 3,200 | 3,200 | 3,000 | 3,700 | 3,300 | 3,700 | 3,400 | 3,300 | 3,300 | 3,200 |
| Selenium | 0.74 | 0.84 | 0.66 | 0.63 | 0.77 | 0.65 | 0.67 | 0.89 | 0.85 | 0.85 | 0.78 | 0.89 | 0.73 | 0.79 |
| Silver | 0.17 | 0.2 | 0.2 | 0.26 | 0.21 | 0.21 | 0.21 | 0.24 | 0.27 | 0.37 | 0.4 | 0.44 | 0.45 | 0.56 |
| Sodium | 96 J | 100 J | 97 J | 440 U | 95 J | 99 J | 91 J | 110 | 91 J | 110 J | 100 J | 94 J | 100 J | 98 J |
| Thallium | 0.51 | 0.49 | 0.55 | 0.48 | 0.50 | 0.50 | 0.44 | 0.56 | 0.53 | 0.53 | 0.53 | 0.46 | 0.43 | 0.44 |
| Vanadium | 36 | 35 | 39 | 45 | 36 | 35 | 33 | 40 | 38 | 41 | 39 | 38 | 38 | 36 |
| Zinc | 120 | 120 | 130 | 110 | 120 | 120 | 110 | 130 | 130 | 150 | 160 | 170 | 170 | 180 |

*Not detected at or above the specified reporting limit.
**Estimated value between the minimum detection limit and reporting limit.

**TABLE 23. Bulk general chemistry analyses on Toledo Harbor Federal navigation channel sediments (from USACE 2010).**

| Parameter (mg/kg-dry weight) | Open-Lake Placement Area | | | | Open-Lake Reference Area | | | | River Channel | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TD-1 | TD-2 | TD-3 | TD-4 | TL-1 | TL-2 | TL-3 | TL-4 | RM-7.0 | RM-6.0 | RM-5.0 | RM-4.0 | RM-3.0 | RM-2.0 | RM-1.0 | RM-0.75 | RM-0.5 | RM-0.25 |
| Oil and Grease | 200 U* | 190 U | 460 | 260 U | 210 U | 250 U | 280 U | 210 U | 200 U | 470 | 270 U | 170 U | 230 U | 210 U | 200 U | 190 U | 270 U | 780 |
| Nitrogen, Ammonia | 160 | 240 | 240 | 220 | 110 | 180 | 230 | 120 | 340 | 210 | 350 | 270 | 320 | 140 | 100 | 300 | 480 | 410 |
| Phosphorus, Total as P | 180 | 350 | 260 | 510 | 350 | 440 | 490 | 420 | 220 | 380 | 440 | 470 | 340 | 490 | 410 | 540 | 470 | 350 |
| Nitrogen, Total Kjeldahl | 750 | 1,100 | 1,000 | 1,700 | 1,200 | 1,500 | 1,700 | 1,200 | 900 | 870 | 1,300 | 620 | 1,100 | 820 | 970 | 900 | 1,500 | 1,300 |
| Cyanide, Total | 2.0 U | 1.9 | 2.5 U | 2.6 U | 2.1 U | 2.5 U | 2.8 U | 2.1 U | 2.0 U | 2.3 U | 2.7 U | 1.7 U | 2.3 U | 2.1 U | 2.0 U | 1.9 U | 2.7 U | 2.6 |
| Total Organic Carbon | 12,000 | 15,000 | 10,000 | 12,000 | 9,800 | 9,600 | 8,200 | 13,000 | 16,000 | 22,000 | 24,000 | 15,000 | 22,000 | 20,000 | 18,000 | 17,000 | 27,000 | 28,000 |

| Parameter (mg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | LM-0.25 | LM-0.5 | LM-0.75 | LM-1.0 | LM-1.25 | LM-1.5 | LM-1.75 | LM-2.0 | LM-2.25 | LM-2.5 | LM-2.75 | LM-3.0 | LM-3.25 | LM-3.5 |
| Oil and Grease | 250 U | 270 U | 270 U | 240 U | 270 U | 270 U | 260 U | 690 | 260 U | 650 | 270 U | 260 U | 270 U | 270 U | 250 U |
| Nitrogen, Ammonia | 460 | 300 | 330 | 390 | 120 | 140 | 280 | 200 | 140 | 240 | 150 | 230 | 230 | 300 | 270 |
| Phosphorus, Total as P | 580 | 380 | 550 | 490 | 500 | 500 | 560 | 510 | 540 | 420 | 430 | 440 | 500 | 430 | 460 |
| Nitrogen, Total Kjeldahl | 1,200 | 390 | 400 | 230 | 300 | 310 | 360 | 380 | 370 | 290 | 380 | 340 | 320 | 1,500 | 2,400 |
| Cyanide, Total | 2.5 U | 2.7 U | 2.7 U | 2.4 U | 2.7 U | 2.7 U | 2.6 U | 2.7 U | 2.6 U | 2.7 U | 2.7 U | 2.6 U | 2.7 U | 2.7 U | 2.5 U |
| Total Organic Carbon | 27,000 | 9,300 | 970 J** | 9,500 | 10,000 | 9,700 | 9,600 | 10,000 | 11,000 | 12,000 | 9,300 J | 8,800 J | 8,000 J | 12,000 | 20,000 |

| Parameter (mg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | LM-4.0 | LM-4.25 | LM-4.5 | LM-4.75 | LM-5.0 | LM-6.0 | LM-7.0 | LM-8.0 | LM-9.0 | LM-10.0 | LM-11.0 | LM-12.0 | LM-13.0 |
| Oil and Grease | 260 U | 260 U | 260 U | 230 U | 540 | 430 | 580 | 230 U | 230 U | 290 U | 280 U | 280 U | 250 U | 250 U |
| Nitrogen, Ammonia | 240 | 260 | 260 | 250 | 210 | 220 | 120 | 110 | 170 | 190 | 180 | 150 | 120 | 190 |
| Phosphorus, Total as P | 460 | 540 | 490 | 390 | 410 | 460 | 210 | 200 | 170 | 210 | 220 | 210 | 190 | 170 |
| Nitrogen, Total Kjeldahl | 2,300 | 900 | 1,400 | 2,500 | 1,400 | 1,500 | 1,100 | 1,200 | 1,900 | 2,200 | 2,100 | 1,600 | 1,400 | 810 |
| Cyanide, Total | 2.6 U | 2.6 U | 2.6 U | 2.3 U | 2.5 U | 2.2 U | 2.4 U | 2.3 U | 2.3 U | 2.9 U | 2.8 U | 2.8 U | 2.5 U | 2.5 U |
| Total Organic Carbon | 14,000 | 13,000 | 13,000 | 9,600 | 9,900 | 12,000 | 8,800 | 12,000 | 11,000 | 9,500 | 8,400 | 8,900 | 10,000 | 11,000 |

## TABLE 24. Bulk PAH analyses on Toledo Harbor Federal navigation channel sediments (from USACE 2010).

| PAH (µg/kg-dry weight) | Open-Lake Placement Area | | | | Open-Lake Mitigation Area | | | | Maumee River Channel | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TD-1 | TD-2 | TD-3 | TD-4 | TL-1 | TL-2 | TL-3 | TL-4 | RM-7.0 | RM-6.0 | RM-5.0 | RM-4.0 | RM-3.0 | RM-2.0 | RM-1.0 | RM-0.5 | RM-0.5 | RM-0.25 |
| 2-Methylnaphthalene | 50 U | 32 JM | 55 JM | 53 JM | 47 JM | 59 JM | 120 M | 42 JM | 50 U | 850 | 490 | 4,200 U | 59 U | 2,600 U | 2,400 U | 47 U | 68 U | 65 U |
| Acenaphthene | 58 | 32 J | 120 | 46 J | 56 | 53 J | 130 | 30 J | 38 J | 1,800 | 68 U | 6,800 | 41 J | 650 J | 1,900 J | 110 | 68 U | 65 U |
| Acenaphthylene | 200 | 220 | 180 | 220 | 200 | 250 | 310 | 210 | 100 | 560 U | 180 | 4,200 U | 120 M | 2,600 U | 2,400 U | 99 | 82 M | 110 M |
| Anthracene | 36 J | 29 J | 50 J | 32 J | 37 J | 25 J | 68 J | 29 J | 34 J | 620 | 38 J | 2,100 J | 70 | 460 J | 1,400 J | 120 | 31 J | 37 J |
| Benzo(a) anthracene | 190 | 160 | 420 | 160 | 210 | 150 | 540 | 170 | 180 | 1,300 | 210 | 6,500 | 310 | 1,400 J | 2,100 J | 360 | 160 | 220 |
| Benzo(a) pyrene | 230 | 190 M | 470 M | 170 M | 280 | 220 | 710 M | 230 | 160 | 650 | 230 | 10,000 | 240 | 1,400 J | 2,500 | 350 | 110 | 240 |
| Benzo(b) fluoranthene | 490 | 410 J | 550 J | 390 | 410 J | 370 | 4700 | 390 | 540 | 970 | 400 | 6,600 | 450 J | 1,700 J | 1,900 J | 440 J | 370 | 520 |
| Benzo(g,h,i) perylene | 170 | 190 | 290 | 180 | 240 | 16 J | 500 | 260 | 250 | 280 | 260 | 3,800 J | 380 | 760 J | 1,100 J | 360 | 140 | 390 |
| Benzo(k) fluoranthene | 120 | 82 | 420 M | 440 M | 150 | 120 | 230 M | 120 | 110 | 510 | 120 | 3,500 J | 190 | 650 J | 1,100 J | 220 | 140 | 180 |
| Chrysene | 210 M | 180 | 540 | 240 | 200 | 150 | 880 | 170 | 220 | 1,600 | 300 | 6,400 | 330 M | 1,400 J | 2,100 J | 410 | 290 | 380 |
| Dibenzo(a,h) anthracene | 50 U | 47 U | 63 U | 65 U | 53 U | 63 U | 70 U | 54 U | 50 U | 560 U | 68 U | 4,200 U | 59 U | 2,600 U | 2,400 U | 420 | 68 U | 65 U |
| Fluoranthene | 760 M | 700 M | 1,200 M | 720 M | 770 M | 650 M | 2400 M | 640 M | 860 | 4,200 M | 890 M | 23,000 M | 920 M | 6,700 M | 10,000 M | 1,300 M | 820 | 1,200 |
| Fluorene | 34 J | 14 J | 8.9 J | 5 J | 22 J | 9.1 J | 130 | 9 J | 47 J | 420 J | 16 J | 930 J | 110 | 1,100 J | 950 J | 210 | 170 | 210 |
| Indeno(1,2,3-cd) pyrene | 170 | 150 | 310 | 200 | 210 | 180 | 510 | 170 | 170 | 300 J | 200 | 4,600 | 300 | 770 J | 1,400 J | 330 | 300 | 370 |
| Naphthalene | 170 M | 19 J | 38 JM | 32 JM | 43 J | 42 J | 70 U | 46 J | 73 M | 560 UM | 15 J | 4,200 U | 170 M | 2,600 U | 320 JM | 110 M | 150 M | 150 M |
| Phenanthrene | 130 | 150 | 200 | 150 | 130 | 110 | 680 M | 110 | 260 | 1,200 | 250 | 4,500 | 350 | 4,600 | 6,300 | 480 | 200 | 280 |
| Pyrene | 310 M | 230 | 460 | 250 | 240 | 210 | 1200 | 210 | 300 | 1,400 | 580 | 16,000 | 420 | 3,000 | 3,700 | 590 | 290 | 390 |
| Total PAHs | 3,328 | 2,803 | 5,320 | 3,300 | 3,251 | 2,618 | 13,128 | 2,848 | 3,392 | 16,930 | 3,825 | 107,330 | 4,460 | 32,390 | 41,570 | 5,909 | 3,389 | 4,807 |

| PAH (µg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | LM-0.25 | LM-0.5 | LM-0.75 | LM-1.0 | LM-1.25 | LM-1.5 | LM-1.75 | LM-2.0 | LM-2.25 | LM-2.5 | LM-2.75 | LM-3.0 | LM-3.25 | LM-3.5 |
| 2-Methylnaphthalene | 610 | 68 U | 67 U | 59 U | 68 U | 68 U | 64 U | 68 U | 64 U | 67 U | 45 JM | 19 JM | 68 U | 68 U | 63 U |
| Acenaphthene | 64 U | 68 U | 67 U | 59 U | 68 U | 43 J | 64 U | 60 JM | 46 J | 60 JM | 67 U | 66 U | 68 U | 57 J | 47 J |
| Acenaphthylene | 94 M | 100 M | 82 M | 75 M | 190 M | 79 M | 80 M | 120 | 150 | 120 M | 300 | 130 | 190 M | 120 | 120 M |
| Anthracene | 45 J | 18 J | 45 J | 51 J | 45 J | 47 J | 45 J | 11 J | 28 J | 18 J | 24 J | 19 J | 44 J | 30 J | 35 J |
| Benzo(a) anthracene | 210 | 120 | 220 | 200 | 230 | 270 | 220 | 79 | 150 | 110 | 150 | 120 | 220 | 160 | 140 |
| Benzo(a) pyrene | 210 | 130 | 240 | 200 | 420 | 330 | 250 | 120 | 180 | 140 | 210 | 180 | 360 | 190 | 120 |
| Benzo(b) fluoranthene | 340 J | 290 | 490 | 290 J | 480 | 510 | 460 J | 99 | 250 | 160 | 350 | 260 | 450 | 340 | 280 |
| Benzo(g,h,i) perylene | 320 | 300 | 540 | 400 | 190 | 380 M | 540 | 53 J | 94 | 69 | 280 | 220 | 160 | 110 | 76 |
| Benzo(k) fluoranthene | 160 | 110 | 160 | 150 | 270 | 210 | 160 | 46 J | 98 | 70 | 120 | 93 | 240 | 120 | 86 |
| Chrysene | 290 | 210 | 280 | 300 | 310 | 400 | 290 | 100 | 240 | 170 | 280 | 220 | 300 | 220 M | 180 M |
| Dibenzo(a,h) anthracene | 64 U | 68 U | 67 U | 59 U | 68 U | 68 U | 280 | 68 U | 64 U | 67 U | 67 U | 66 U | 68 U | 68 U | 63 U |
| Fluoranthene | 960 | 650 | 950 | 980 | 990 | 1,000 | 940 | 200 M | 500 M | 390 M | 810 M | 530 M | 960 | 720 M | 620 M |
| Fluorene | 160 | 95 | 140 | 110 | 150 | 100 | 86 | 10 J | 44 J | 41 J | 67 U | 66 U | 140 | 67 J | 72 |
| Indeno(1,2,3-cd) pyrene | 300 | 180 | 270 | 220 | 260 | 320 | 250 | 70 | 180 | 130 | 230 | 170 | 250 | 270 | 210 |
| Naphthalene | 100 M | 130 M | 140 M | 130 M | 130 M | 130 M | 100 M | 70 M | 150 M | 110 M | 33 JM | 33 JM | 110 M | 93 M | 99 M |
| Phenanthrene | 230 | 150 | 240 | 280 | 260 | 220 | 210 | 47 J | 120 | 93 | 180 | 130 | 240 | 160 | 150 |
| Pyrene | 340 | 200 | 330 | 340 | 380 | 370 | 310 | 110 M | 230 M | 210 M | 430 | 330 | 390 | 320 M | 280 M |
| Total PAHs | 3,887 | 2,819 | 4,261 | 3,844 | 4,441 | 4,477 | 4,285 | 1,263 | 2,524 | 1,958 | 3,598 | 2,633 | 4,190 | 3,045 | 2,578 |

| PAH (µg/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | LM-4.0 | LM-4.25 | LM-4.5 | LM-4.75 | LM-5.0 | LM-5.0 | LM-7.0 | LM-8.0 | LM-9.0 | LM-10.0 | LM-11.0 | LM-12.0 | LM-13.0 |
| 2-Methylnaphthalene | 65 U | 66 U | 65 U | 58 U | 63 U | 55 U | 59 U | 58 U | 57 U | 72 U | 70 U | 70 U | 62 U | 62 U |
| Acenaphthene | 54 J | 52 J | 43 J | 80 | 56 J | 34 J | 71 | 49 J | 56 J | 41 J | 46 J | 67 J | 37 J | 33 J |
| Acenaphthylene | 150 M | 170 M | 99 | 140 M | 120 M | 100 M | 61 M | 240 | 150 | 170 | 160 M | 130 | 150 M | 120 M |
| Anthracene | 24 J | 58 J | 24 J | 48 J | 25 J | 33 J | 33 J | 32 J | 30 J | 28 J | 24 J | 25 J | 21 J | 19 J |
| Benzo(a) anthracene | 140 | 210 | 130 | 130 | 140 | 160 | 180 | 170 | 170 | 160 | 160 | 150 | 140 | 120 |
| Benzo(a) pyrene | 160 | 200 | 140 | 160 | 140 | 150 | 220 | 210 | 160 | 160 | 160 | 200 | 220 | 200 |
| Benzo(b) fluoranthene | 310 | 400 | 260 | 280 | 290 | 330 | 340 | 340 | 340 | 360 | 360 | 380 | 370 | 320 |
| Benzo(g,h,i) perylene | 90 | 140 | 77 | 100 | 85 | 140 M | 110 | 90 M | 84 | 67 J | 67 J | 100 | 120 | 100 |
| Benzo(k) fluoranthene | 100 | 140 | 87 | 99 | 97 | 100 | 130 | 180 | 110 | 170 | 180 | 130 | 120 | 110 |
| Chrysene | 210 M | 260 M | 170 M | 190 M | 180 M | 200 M | 250 M | 200 M | 190 M | 200 M | 180 M | 170 M | 170 M | 140 M |
| Dibenzo(a,h) anthracene | 65 U | 66 U | 65 U | 58 U | 63 U | 55 U | 59 U | 58 U | 57 U | 72 U | 70 U | 70 U | 62 U | 62 U |
| Fluoranthene | 580 M | 950 M | 560 M | 590 M | 540 M | 670 M | 680 M | 690 M | 710 M | 630 M | 590 M | 620 M | 590 M | 530 M |
| Fluorene | 53 J | 86 | 59 J | 61 | 57 J | 61 | 42 J | 40 J | 54 J | 43 J | 32 J | 36 J | 31 J | 29 J |
| Indeno(1,2,3-cd) pyrene | 230 | 280 | 200 | 210 | 210 | 200 | 200 | 200 | 200 | 210 | 190 | 240 | 220 | 200 |
| Naphthalene | 87 M | 180 M | 65 M | 81 M | 90 M | 100 M | 68 M | 130 M | 90 M | 130 M | 99 M | 110 M | 83 M | 120 M |
| Phenanthrene | 120 | 240 | 120 | 120 | 110 | 150 | 130 | 130 | 130 | 120 | 120 | 110 | 92 | 85 |
| Pyrene | 260 M | 420 M | 270 M | 270 M | 270 M | 280 M | 310 M | 290 M | 290 M | 260 M | 240 M | 240 M | 240 M | 210 M |
| Total PAHs | 2,633 | 3,852 | 2,369 | 2,617 | 2,473 | 2,763 | 2,884 | 3,049 | 2,821 | 2,821 | 2,678 | 2,778 | 2,666 | 2,398 |

*Not detected at or above the specified reporting limit.
**Estimated value between the minimum detection limit and reporting limit.
***Manual integration was used to determine area response.

## TABLE 25. PAH compound diagnostic ratios used to evaluate pyrogenic versus petrogenic assemblages in select Maumee River Channel sediment samples.

| Site | Diagnostic ratio | Threshold/reference | Dominant assemblage |
|---|---|---|---|
| **RM-6** | Phenanthrene/anthracene = 1.94 | >5, petrogenic (Neff *et al.* 2005) | **Pyrogenic*** |
| | | 3-26, petrogenic (Colombo *et al.* 1989) | **Pyrogenic*** |
| | | <4.11, pyrogenic (Iqbal *et al.* 2008) | **Pyrogenic*** |
| | Fluoranthene/pyrene = 3.0 | >1, pyrogenic (Neff *et al.* 2005) | **Pyrogenic*** |
| **RM-4** | Phenanthrene/anthracene = 2.14 | >5, petrogenic (Neff *et al.* 2005) | **Pyrogenic*** |
| | | 3-26, petrogenic (Colombo *et al.* 1989) | **Pyrogenic*** |
| | | <4.11, pyrogenic (Iqbal *et al.* 2008) | **Pyrogenic*** |
| | Fluoranthene/pyrene = 3 | >1, pyrogenic (Neff *et al.* 2005) | **Pyrogenic*** |
| **RM-2** | Phenanthrene/anthracene = 10 | >5, petrogenic (Neff *et al.* 2005) | **Petrogenic*** |
| | | 3-26, petrogenic (Colombo *et al.* 1989) | **Petrogenic*** |
| | | <4.11, pyrogenic (Iqbal *et al.* 2008) | **Petrogenic*** |
| | Fluoranthene/pyrene = 2.23 | >1, pyrogenic (Neff *et al.* 2005) | **Pyrogenic*** |
| **RM-1** | Phenanthrene/anthracene = 4.5 | >5, petrogenic (Neff *et al.* 2005) | **Pyrogenic*** |
| | | 3-26, petrogenic (Colombo *et al.* 1989) | **Petrogenic* **** |
| | | <4.11, pyrogenic (Iqbal *et al.* 2008) | **Petrogenic* **** |
| | Fluoranthene/pyrene = 2.7 | >1, pyrogenic (Neff *et al.* 2005) | **Pyrogenic*** |
| **RM-0.75** | Phenanthrene/anthracene = 4 | >5, petrogenic (Neff *et al.* 2005) | **Pyrogenic** |
| | | 3-26, petrogenic (Colombo *et al.* 1989) | **Petrogenic** |
| | | <4.11, pyrogenic (Iqbal *et al.* 2008) | **Pyrogenic** |
| | Fluoranthene/pyrene = 2.2 | >1, pyrogenic (Neff *et al.* 2005) | **Pyrogenic*** |

*Ratios based J- and/or M- flagged values for anthracene and/or fluoranthene.

**Borderline determination without consideration of data qualifier uncertainties; weight-of-the-evidence is the PAH mixture at Site R-1 is more pyrogenic.

## TABLE 26. Acute equilibrium partitioning-based sediment benchmark toxic units (ESBTUs) specific to *H. azteca* for PAH compound mixture in Site RM-6 sediments in the Maumee River Channel (from USACE 2010).

| PAH compound | $C_{oc,\ PAHi,\ FAVi}$ ($\mu g/g_{oc}$)* | Concentration | | $C_{oc}$ ($\mu g/g_{oc}$) | $ESBTU_{FAVi}$ |
|---|---|---|---|---|---|
| | | PAH ($\mu g/g$) | TOC (% dec) | | |
| Acenaphthene | 3047 | 1.80 | 0.022 | 81.81818182 | 0.026852045 |
| Acenaphthylene | 2807 | 0.56 | 0.022 | 25.45454545 | 0.009068238 |
| Anthracene | 3684 | 0.62 | 0.022 | 28.18181818 | 0.007649788 |
| Benzo(a)Anthracene | 5216 | 1.30 | 0.022 | 59.09090909 | 0.011328779 |
| Benzo(a)Pyrene | 5988 | 0.65 | 0.022 | 29.54545455 | 0.004934111 |
| Benzo(b)Fluoranthene | 6023 | 0.97 | 0.022 | 44.09090909 | 0.007320423 |
| Benzo(ghi)Perylene | 6081 | 0.28 | 0.022 | 12.72727273 | 0.002092957 |
| Benzo(k)Fluoranthene | 6789 | 0.51 | 0.022 | 23.18181818 | 0.003414615 |
| Chrysene | 5235 | 1.60 | 0.022 | 72.72727273 | 0.013892507 |
| Dibenzo(a,h)Anthracene | 6966 | 0.56 | 0.022 | 25.45454545 | 0.003654112 |
| Fluoranthene | 4389 | 4.20 | 0.022 | 190.9090909 | 0.043497173 |
| Fluorene | 3341 | 0.42 | 0.022 | 19.09090909 | 0.00571413 |
| Indeno(1,2,3-cd)Pyrene | 6918 | 0.30 | 0.022 | 13.63636364 | 0.001971142 |
| Naphthalene | 2391 | 0.56 | 0.022 | 25.45454545 | 0.010645983 |
| Phenanthrene | 3698 | 1.20 | 0.022 | 54.54545455 | 0.014749988 |
| Pyrene | 4328 | 1.40 | 0.022 | 63.63636364 | 0.014703411 |
| **Total PAHs (16)** | | 16.9 | | | |
| **$\sum ESBTU_{FAV,16}$** | | | | | 0.181489402 |
| **Uncertainty factor**** | | | | | 3.6 |
| **$\sum ESBTU_{FAV,34}$** | | | | | **0.653361847** |

*Based on acute critical body burden of 13.9 µmol/g lipid for *Hyalalla azteca* (Kreitinger, personal communication; USEPA 2003).

**Based on conservative value for PAHs at 95% confidence interval (Hawthorne *et al.* 2006).

## TABLE 27. Acute ESBTUs specific to *H. azteca* for PAH compound mixture in Site RM-4 sediments in the Maumee River Channel (from USACE 2010).

| PAH compound | $C_{oc,\ PAHi,\ FAVI}$ ($\mu g/g_{OC}$)* | Concentration | | $C_{oc}$ ($\mu g/g_{OC}$) | $ESBTU_{FAVI}$ |
|---|---|---|---|---|---|
| | | PAH ($\mu g/g$) | TOC (% dec) | | |
| Acenaphthene | 3047 | 6.80 | 0.015 | 453.3333333 | 0.148780221 |
| Acenaphthylene | 2807 | 4.20 | 0.015 | 280 | 0.099750623 |
| Anthracene | 3684 | 2.10 | 0.015 | 140 | 0.038002172 |
| Benzo(a)Anthracene | 5216 | 6.50 | 0.015 | 433.3333333 | 0.08307771 |
| Benzo(a)Pyrene | 5988 | 10.00 | 0.015 | 666.6666667 | 0.111333779 |
| Benzo(b)Fluoranthene | 6023 | 6.60 | 0.015 | 440 | 0.073053296 |
| Benzo(ghi)Perylene | 6081 | 3.80 | 0.015 | 253.3333333 | 0.041659815 |
| Benzo(k)Fluoranthene | 6789 | 3.50 | 0.015 | 233.3333333 | 0.034369323 |
| Chrysene | 5235 | 6.40 | 0.015 | 426.6666667 | 0.081502706 |
| Dibenzo(a,h)Anthracene | 6966 | 4.20 | 0.015 | 280 | 0.040195234 |
| Fluoranthene | 4389 | 23.00 | 0.015 | 1533.333333 | 0.349358244 |
| Fluorene | 3341 | 0.93 | 0.015 | 62 | 0.018557318 |
| Indeno(1,2,3-cd)Pyrene | 6918 | 4.60 | 0.015 | 306.6666667 | 0.044328804 |
| Naphthalene | 2391 | 4.20 | 0.015 | 280 | 0.117105813 |
| Phenanthrene | 3698 | 4.50 | 0.015 | 300 | 0.081124932 |
| Pyrene | 4328 | 16.00 | 0.015 | 1066.666667 | 0.246457178 |
| **Total PAHs (16)** | | 107.3 | | | |
| **$\sum ESBTU_{FAV,16}$** | | | | | 1.608657168 |
| **Uncertainty factor**** | | | | | 3.6 |
| **$\sum ESBTU_{FAV,34}$** | | | | | **5.791165805** |

*Based on acute critical body burden of 13.9 µmol/g lipid for *Hyalalla azteca* (Kreitinger, personal communication; USEPA 2003).

**Based on conservative value for PAHs at 95% confidence interval (Hawthorne *et al.* 2006).

## TABLE 28. Acute ESBTUs specific to *H. azteca* for PAH compound mixture in Site RM-2 sediments in the Maumee River Channel (from USACE 2010).

| PAH compound | $C_{oc,\ PAHi,\ FAVI}$ ($\mu g/g_{oc}$)* | Concentration | | $C_{oc}$ ($\mu g/g_{oc}$) | $ESBTU_{FAVi}$ |
|---|---|---|---|---|---|
| | | PAH ($\mu g/g$) | TOC (% dec) | | |
| Acenaphthene | 3047 | 0.65 | 0.02 | 32.5000000 | 0.010666229 |
| Acenaphthylene | 2807 | 2.60 | 0.02 | 130.0000000 | 0.046312789 |
| Anthracene | 3684 | 0.46 | 0.02 | 23.0000000 | 0.006243214 |
| Benzo(a)Anthracene | 5216 | 1.40 | 0.02 | 70.0000000 | 0.013420245 |
| Benzo(a)Pyrene | 5988 | 1.40 | 0.02 | 70.0000000 | 0.011690047 |
| Benzo(b)Fluoranthene | 6023 | 1.70 | 0.02 | 85.0000000 | 0.014112568 |
| Benzo(ghi)Perylene | 6081 | 0.76 | 0.02 | 38.0000000 | 0.006248972 |
| Benzo(k)Fluoranthene | 6789 | 0.65 | 0.02 | 32.5000000 | 0.004787156 |
| Chrysene | 5235 | 1.40 | 0.02 | 70.0000000 | 0.013371538 |
| Dibenzo(a,h)Anthracene | 6966 | 2.60 | 0.02 | 130.0000000 | 0.018662073 |
| Fluoranthene | 4389 | 6.70 | 0.02 | 335.0000000 | 0.076327182 |
| Fluorene | 3341 | 1.10 | 0.02 | 55.0000000 | 0.016462137 |
| Indeno(1,2,3-cd)Pyrene | 6918 | 0.77 | 0.02 | 38.5000000 | 0.005565192 |
| Naphthalene | 2391 | 2.60 | 0.02 | 130.0000000 | 0.054370556 |
| Phenanthrene | 3698 | 4.60 | 0.02 | 230.0000000 | 0.062195782 |
| Pyrene | 4328 | 3.00 | 0.02 | 150.0000000 | 0.034658041 |
| **Total PAHs (16)** | | 32.4 | | | |
| **$\sum ESBTU_{FAV,16}$** | | | | | 0.395093721 |
| **Uncertainty factor**** | | | | | 11.5 |
| **$\sum ESBTU_{FAV,34}$** | | | | | **4.543577791** |

*Based on acute critical body burden of 13.9 µmol/g lipid for *Hyalalla azteca* (Kreitinger, personal communication; USEPA 2003).

**Based on conservative value for PAHs at 95% confidence interval (USEPA 2003).

## TABLE 29. Acute ESBTUs specific to *H. azteca* for PAH compound mixture in Site RM-1 sediments in the Maumee River Channel (from USACE 2010).

| PAH compound | $C_{oc, PAHi, FAVi}$ ($\mu g/g_{oc}$)* | Concentration | | $C_{oc}$ ($\mu g/g_{oc}$) | $ESBTU_{FAVi}$ |
|---|---|---|---|---|---|
| | | PAH ($\mu g/g$) | TOC (% dec) | | |
| Acenaphthene | 3047 | 1.90 | 0.018 | 105.5555556 | 0.034642453 |
| Acenaphthylene | 2807 | 2.40 | 0.018 | 133.3333333 | 0.047500297 |
| Anthracene | 3684 | 1.40 | 0.018 | 77.77777778 | 0.021112318 |
| Benzo(a)Anthracene | 5216 | 2.10 | 0.018 | 116.6666667 | 0.022367076 |
| Benzo(a)Pyrene | 5988 | 2.50 | 0.018 | 138.8888889 | 0.023194537 |
| Benzo(b)Fluoranthene | 6023 | 1.90 | 0.018 | 105.5555556 | 0.017525412 |
| Benzo(ghi)Perylene | 6081 | 1.10 | 0.018 | 61.11111111 | 0.010049517 |
| Benzo(k)Fluoranthene | 6789 | 1.10 | 0.018 | 61.11111111 | 0.009001489 |
| Chrysene | 5235 | 2.10 | 0.018 | 116.6666667 | 0.022285896 |
| Dibenzo(a,h)Anthracene | 6966 | 2.40 | 0.018 | 133.3333333 | 0.019140588 |
| Fluoranthene | 4389 | 10.00 | 0.018 | 555.5555556 | 0.126579074 |
| Fluorene | 3341 | 0.95 | 0.018 | 52.77777778 | 0.015797 |
| Indeno(1,2,3-cd)Pyrene | 6918 | 1.40 | 0.018 | 77.77777778 | 0.011242813 |
| Naphthalene | 2391 | 0.32 | 0.018 | 17.77777778 | 0.00743529 |
| Phenanthrene | 3698 | 6.30 | 0.018 | 350 | 0.094645754 |
| Pyrene | 4328 | 3.70 | 0.018 | 205.5555556 | 0.047494352 |
| **Total PAHs (16)** | | 41.6 | | | |
| **$\sum ESBTU_{FAV,16}$** | | | | | 0.530013865 |
| **Uncertainty factor**** | | | | | 3.6 |
| **$\sum ESBTU_{FAV,34}$** | | | | | **1.908049916** |

*Based on acute critical body burden of 13.9 µmol/g lipid for *Hyalalla azteca* (Kreitinger, personal communication; USEPA 2003).

**Base on conservative value for PAHs at 95% confidence interval (Hawthorne *et al.* 2006).

## TABLE 30. Acute ESBTUs specific to *H. azteca* for PAH compound mixture in Site RM-0.75 sediments in the Maumee River Channel (from USACE 2010).

| PAH compound | $C_{oc, PAHi, FAVi}$ ($\mu g/g_{oc}$)* | Concentration | | $C_{oc}$ ($\mu g/g_{oc}$) | $ESBTU_{FAVi}$ |
|---|---|---|---|---|---|
| | | PAH ($\mu g/g$) | TOC (% dec) | | |
| Acenaphthene | 3047 | 0.11 | 0.017 | 6.470588235 | 0.002123593 |
| Acenaphthylene | 2807 | 0.10 | 0.017 | 5.823529412 | 0.002074645 |
| Anthracene | 3684 | 0.12 | 0.017 | 7.058823529 | 0.001916076 |
| Benzo(a)Anthracene | 5216 | 0.36 | 0.017 | 21.17647059 | 0.004059906 |
| Benzo(a)Pyrene | 5988 | 0.35 | 0.017 | 20.58823529 | 0.003438249 |
| Benzo(b)Fluoranthene | 6023 | 0.44 | 0.017 | 25.88235294 | 0.004297253 |
| Benzo(ghi)Perylene | 6081 | 0.36 | 0.017 | 21.17647059 | 0.003482399 |
| Benzo(k)Fluoranthene | 6789 | 0.22 | 0.017 | 12.94117647 | 0.001906198 |
| Chrysene | 5235 | 0.41 | 0.017 | 24.11764706 | 0.004607 |
| Dibenzo(a,h)Anthracene | 6966 | 0.42 | 0.017 | 24.70588235 | 0.003546638 |
| Fluoranthene | 4389 | 1.30 | 0.017 | 76.47058824 | 0.017423237 |
| Fluorene | 3341 | 0.21 | 0.017 | 12.35294118 | 0.003697378 |
| Indeno(1,2,3-cd)Pyrene | 6918 | 0.33 | 0.017 | 19.41176471 | 0.002805979 |
| Naphthalene | 2391 | 0.11 | 0.017 | 6.470588235 | 0.002706227 |
| Phenanthrene | 3698 | 0.48 | 0.017 | 28.23529412 | 0.007635288 |
| Pyrene | 4328 | 0.59 | 0.017 | 34.70588235 | 0.008018919 |
| **Total PAHs (16)** | | 5.9 | | | |
| **$\sum ESBTU_{FAV,16}$** | | | | | 0.073738987 |
| **Uncertainty factor**** | | | | | 3.6 |
| **$\sum ESBTU_{FAV,34}$** | | | | | **0.265460352** |

*Based on an ACR of 4.16 (USEPA 2003).

**Based on conservative value for PAHs at 95% confidence interval (Hawthorne *et al.* 2006).

## TABLE 31. Bulk PCB analyses on Toledo Harbor Federal navigation channel sediments (from USACE 2010).

| PCB (ug/kg-dry weight) | Open-Lake Placement Area | | | | | | | | Open-Lake Reference Area | | | | | | | | River Channel | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TD-1 | | TD-2 | | TD-3 | | TD-4 | | TL-1 | | TL-2 | | TL-3 | | TL-4 | | RM-7.0 | | RM-5.0 | | RM-4.0 | | RM-3.0 | | RM-2.0 | | RM-1.0 | | RM-0.75 | | RM-0.5 | | RM-0.25 | |
| Aroclor-1016 | 66 | U | 61 | U | 83 | U | 86 | U | 70 | U | 83 | U | 92 | U | 71 | U | 66 | U | 74 | U | 89 | U | 55 | U | 77 | U | 69 | U | 65 | U | 62 | U | 90 | U | 86 | U |
| Aroclor-1221 | 66 | U | 61 | U | 83 | U | 86 | U | 70 | U | 83 | U | 92 | U | 71 | U | 66 | U | 74 | U | 89 | U | 55 | U | 77 | U | 69 | U | 65 | U | 62 | U | 90 | U | 86 | U |
| Aroclor-1232 | 66 | U | 61 | U | 83 | U | 86 | U | 70 | U | 83 | U | 92 | U | 71 | U | 66 | U | 74 | U | 89 | U | 55 | U | 77 | U | 69 | U | 65 | U | 62 | U | 90 | U | 86 | U |
| Aroclor-1242 | 66 | U | 61 | U | 83 | U | 86 | U | 70 | U | 83 | U | 92 | U | 71 | U | 66 | U | 74 | U | 89 | U | 55 | U | 77 | U | 69 | U | 65 | U | 62 | U | 90 | U | 86 | U |
| Aroclor-1248 | 66 | U | 61 | U | 83 | U | 86 | U | 70 | U | 83 | U | 92 | U | 71 | U | 66 | U | 74 | U | 89 | U | 55 | U | 77 | U | 69 | U | 65 | U | 62 | U | 90 | U | 86 | U |
| Aroclor-1254 | 66 | U | 61 | U | 83 | U | 86 | U | 14 | J | 13 | J | 92 | U | 71 | U | 66 | U | 74 | U | 89 | U | 100 | | 77 | U | 27 | J | 65 | U | 62 | U | 90 | U | 86 | U |
| Aroclor-1260 | 66 | U | 61 | U | 83 | U | 86 | U | 70 | U | 83 | U | 92 | U | 71 | U | 66 | U | 74 | U | 89 | U | 55 | U | 77 | U | 69 | U | 65 | U | 62 | U | 90 | U | 86 | U |
| Aroclor-1262 | 66 | U | 61 | U | 83 | U | 86 | U | 70 | U | 83 | U | 92 | U | 71 | U | 66 | U | 74 | U | 89 | U | 55 | U | 77 | U | 69 | U | 65 | U | 62 | U | 90 | U | 86 | U |

| PCB (ug/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | | LM-0.25 | | LM-0.5 | | LM-0.75 | | LM-1.0 | | LM-1.25 | | LM-1.5 | | LM-1.75 | | LM-2.0 | | LM-2.25 | | LM-2.5 | | LM-2.75 | | LM-3.0 | | LM-3.25 | | LM-3.5 | |
| Aroclor-1016 | 84 | U | 90 | U | 89 | U | 78 | U | 89 | U | 90 | U | 85 | U | 90 | U | 85 | U | 89 | U | 88 | U | 87 | U | 90 | U | 90 | U | 83 | U | | |
| Aroclor-1221 | 84 | U | 90 | U | 89 | U | 78 | U | 89 | U | 90 | U | 85 | U | 90 | U | 85 | U | 89 | U | 88 | U | 87 | U | 90 | U | 90 | U | 83 | U | | |
| Aroclor-1232 | 84 | U | 90 | U | 89 | U | 78 | U | 89 | U | 90 | U | 85 | U | 90 | U | 85 | U | 89 | U | 88 | U | 87 | U | 90 | U | 90 | U | 83 | U | | |
| Aroclor-1242 | 84 | U | 90 | U | 89 | U | 78 | U | 89 | U | 90 | U | 85 | U | 90 | U | 85 | U | 89 | U | 88 | U | 87 | U | 90 | U | 90 | U | 83 | U | | |
| Aroclor-1248 | 84 | U | 90 | U | 89 | U | 78 | U | 89 | U | 90 | U | 85 | U | 90 | U | 85 | U | 89 | U | 88 | U | 87 | U | 90 | U | 90 | U | 83 | U | | |
| Aroclor-1254 | 84 | U | 90 | U | 89 | U | 78 | U | 89 | U | 90 | U | 85 | U | 90 | U | 85 | U | 89 | U | 88 | U | 87 | U | 90 | U | 90 | U | 83 | U | | |
| Aroclor-1260 | 84 | U | 90 | U | 89 | U | 78 | U | 89 | U | 90 | U | 85 | U | 90 | U | 85 | U | 89 | U | 88 | U | 87 | U | 90 | U | 90 | U | 83 | U | | |
| Aroclor-1262 | 84 | U | 90 | U | 89 | U | 78 | U | 89 | U | 90 | U | 85 | U | 90 | U | 85 | U | 89 | U | 88 | U | 87 | U | 90 | U | 90 | U | 83 | U | | |

| PCB (ug/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | | LM-4.0 | | LM-4.25 | | LM-4.5 | | LM-4.75 | | LM-5.0 | | LM-6.0 | | LM-7.0 | | LM-8.0 | | LM-9.0 | | LM-10.0 | | LM-11.0 | | LM-12.0 | | LM-13.0 | |
| Aroclor-1016 | 86 | U* | 87 | U | 86 | U | 76 | U | 83 | U | 73 | U | 78 | U | 77 | U | 75 | U | 95 | U | 92 | U | 92 | U | 82 | U | 82 | U | | |
| Aroclor-1221 | 86 | U | 87 | U | 86 | U | 76 | U | 83 | U | 73 | U | 78 | U | 77 | U | 75 | U | 95 | U | 92 | U | 92 | U | 82 | U | 82 | U | | |
| Aroclor-1232 | 86 | U | 87 | U | 86 | U | 76 | U | 83 | U | 73 | U | 78 | U | 77 | U | 75 | U | 95 | U | 92 | U | 92 | U | 82 | U | 82 | U | | |
| Aroclor-1242 | 86 | U | 87 | U | 86 | U | 76 | U | 83 | U | 73 | U | 78 | U | 77 | U | 75 | U | 95 | U | 92 | U | 92 | U | 82 | U | 82 | U | | |
| Aroclor-1248 | 86 | U | 87 | U | 86 | U | 76 | U | 83 | U | 73 | U | 78 | U | 77 | U | 75 | U | 95 | U | 92 | U | 92 | U | 82 | U | 82 | U | | |
| Aroclor-1254 | 86 | U | 87 | U | 86 | U | 76 | U | 83 | U | 73 | U | 78 | U | 77 | U | 75 | U | 95 | U | 92 | U | 92 | U | 82 | U | 82 | U | | |
| Aroclor-1260 | 86 | U | 87 | U | 86 | U | 76 | U | 83 | U | 73 | U | 78 | U | 77 | U | 75 | U | 95 | U | 92 | U | 92 | U | 82 | U | 82 | U | | |
| Aroclor-1262 | 86 | U | 87 | U | 86 | U | 76 | U | 83 | U | 73 | U | 78 | U | 77 | U | 75 | U | 95 | U | 92 | U | 92 | U | 82 | U | 82 | U | | |

*Not detected at or above the specified reporting limit.

**TABLE 32. Bulk pesticide analyses on Toledo Harbor Federal navigation channel sediments (from USACE 2010).**

| Pesticide (ug/kg-dry weight) | Open-Lake Placement Area | | | | Open-Lake Reference Area | | | | River Channel | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TD-1 | TD-2 | TD-3 | TD-4 | TL-1 | TL-2 | TL-3 | TL-4 | RM-7.0 | RM-8.0 | RM-9.0 | RM-9.0 | RM-9.0 | RM-10 | RM-0.75 | RM-0.5 | RM-0.25 |
| 4,4-DDD | 3.4 U* | 3.2 U | 4.3 U | 4.4 U | 3.6 U | 4.3 U | 4.7 U | 3.6 U | 3.4 U | 3.8 U | 4.6 U | **1.3** J** | 4.0 U | 3.5 U | 3.3 U | 3.2 U | 4.6 U | 4.4 U |
| 4,4-DDE | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | **2.5** | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| 4,4-DDT | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Aldrin | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| alpha-BHC | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| alpha-Chlordane | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Beta-BHC | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Chlordane, total | 33.0 U | 31.0 U | 42.0 U | 44.0 U | 36.0 U | 42.0 U | 47.0 U | 36.0 U | 33.0 U | 38.0 U | 45.0 U | 28.0 U | 39.0 U | 35.0 U | 33.0 U | 31.0 U | 45.0 U | 43.0 U |
| delta-BHC | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Dieldrin | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Endosulfan I | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Endosulfan II | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Endosulfan sulfate | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Endrin | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Endrin aldehyde | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Endrin ketone | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| gamma-BHC (Lindane) | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| gamma-Chlordane | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Heptachlor | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Heptachlor epoxide | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Methoxychlor | 1.7 U | 1.5 U | 2.1 U | 2.2 U | 1.8 U | 2.1 U | 2.3 U | 1.8 U | 1.7 U | 1.9 U | 2.2 U | 1.4 U | 1.9 U | 1.7 U | 1.6 U | 1.5 U | 2.3 U | 2.2 U |
| Toxaphene | 33.0 U | 31.0 U | 42.0 U | 44.0 U | 36.0 U | 42.0 U | 47.0 U | 36.0 U | 33.0 U | 38.0 U | 45.0 U | 28.0 U | 39.0 U | 35.0 U | 33.0 U | 31.0 U | 45.0 U | 43.0 U |

| Pesticide (ug/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | LM-0.25 | LM-0.5 | LM-0.75 | LM-1.0 | LM-1.25 | LM-1.5 | LM-1.75 | LM-2.0 | LM-2.25 | LM-2.5 | LM-2.75 | LM-3.0 | LM-3.25 | LM-3.5 |
| 4,4-DDD | 4.3 U | 4.6 U | 4.6 U | 4.0 U | 4.6 U | 4.6 U | 4.4 U | 4.6 U | 4.4 U | 4.6 U | 4.5 U | 4.5 U | 4.6 U | 4.6 U | 4.3 U |
| 4,4-DDE | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| 4,4-DDT | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Aldrin | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| alpha-BHC | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| alpha-Chlordane | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Beta-BHC | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Chlordane, total | 42.0 U | 45.0 U | 45.0 U | 39.0 U | 45.0 U | 45.0 U | 43.0 U | 45.0 U | 43.0 U | 45.0 U | 45.0 U | 44.0 U | 46.0 U | 45.0 U | 42.0 U |
| delta-BHC | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Dieldrin | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Endosulfan I | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Endosulfan II | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Endosulfan sulfate | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Endrin | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Endrin aldehyde | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Endrin ketone | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| gamma-BHC (Lindane) | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| gamma-Chlordane | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Heptachlor | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Heptachlor epoxide | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Methoxychlor | 2.1 U | 2.3 U | 2.2 U | 2.0 U | 2.2 U | 2.3 U | 2.1 U | 2.3 U | 2.1 U | 2.2 U | 2.2 U | 2.2 U | 2.3 U | 2.3 U | 2.1 U |
| Toxaphene | 42.0 U | 45.0 U | 45.0 U | 39.0 U | 45.0 U | 45.0 U | 43.0 U | 45.0 U | 43.0 U | 45.0 U | 45.0 U | 44.0 U | 46.0 U | 45.0 U | 42.0 U |

| Pesticide (ug/kg-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | LM-4.0 | LM-4.25 | LM-4.5 | LM-4.75 | LM-5.0 | LM-6.0 | LM-7.0 | LM-8.0 | LM-9.0 | LM-10.0 | LM-11.0 | LM-12.0 | LM-13.0 |
| 4,4-DDD | 4.5 U | 4.5 U | 4.4 U | 3.9 U | 4.3 U | 3.7 U | 4.0 U | 4.0 U | 3.9 U | 4.9 U | 4.8 U | 4.7 U | 4.2 U | 4.2 U |
| 4,4-DDE | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| 4,4-DDT | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Aldrin | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| alpha-BHC | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| alpha-Chlordane | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Beta-BHC | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Chlordane, total | 44.0 U | 44.0 U | 43.0 U | 39.0 U | 42.0 U | 37.0 U | 39.0 U | 39.0 U | 38.0 U | 48.0 U | 47.0 U | 47.0 U | 42.0 U | 41.0 U |
| delta-BHC | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Dieldrin | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Endosulfan I | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Endosulfan II | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Endosulfan sulfate | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Endrin | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Endrin aldehyde | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Endrin ketone | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| gamma-BHC (Lindane) | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| gamma-Chlordane | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Heptachlor | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Heptachlor epoxide | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Methoxychlor | 2.2 U | 2.2 U | 2.2 U | 1.9 U | 2.1 U | 1.8 U | 2.0 U | 1.9 U | 1.9 U | 2.4 U | 2.3 U | 2.3 U | 2.1 U | 2.1 U |
| Toxaphene | 44.0 U | 44.0 U | 43.0 U | 39.0 U | 42.0 U | 37.0 U | 39.0 U | 39.0 U | 38.0 U | 48.0 U | 47.0 U | 47.0 U | 42.0 U | 41.0 U |

**TABLE 33. Results of 10-day toxicity tests (bioassays) on Toledo Harbor Federal navigation channel management unit RM-2 sediments, and open-lake reference and placement area sediments (from USACE 2010).**

| Sample | Test species | | | |
|---|---|---|---|---|
| | *Hyalella azteca* | *Chironomus dilutus* | | |
| | Percent Survival (%) | Percent Survival (%) | AFDW Average (mg)[1] | Biomass Average (mg)[2] |
| Laboratory Control | 94 | 92 | 1.19 | 0.99 |
| Open-lake Placement Area | 90±15 | 90±17 | 1.27±0.24 | 1.11±0.22 |
| Open-lake Reference Area | 92±18 | 97.5±8 | 1.19±0.06 | 1.13±0.07 |
| RM-2 | **78±11**[a] | 90±23 | 1.17±0.11 | 1.05±0.23 |

[1]Average ash-free-dry weight (AFDW) is total AFDW of the surviving organisms; average AFDW of C. dilutus at test initiation was 0.22 mg.
[2]Biomass weight is the total AFDW of surviving organisms divided by the initial number of organisms.
[a]Significantly different ($p<0.05$) from open-lake reference area sediment.

## TABLE 34. Metal SET data on Toledo Harbor Federal navigation channel sediments (from USACE 2010).

| Metal (mg/L) | Site Water | RM Channel | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RM:0.5 | | RM:0.0 | | RM:5.0 | | RM:3.0 | | RM:3.0 | | RM:2.0 | | RM:1.0 | | RM:0.75 | | RM:0.5 | | RM:0.25 | |
| Aluminum | 0.100000 | B* | 0.210000 | B | 0.130000 | B | 0.012000 | J** | 0.880000 | B | 0.360000 | B | 1.000000 | B | 0.190000 | B | 0.093000 | B | 0.028000 | B | 0.009700 | J |
| Antimony | 0.002500 | U*** | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.000730 | J | 0.002500 | U | 0.002500 | U | 0.000740 | J | 0.002500 | U | 0.000730 | J | 0.002500 | U |
| Arsenic | 0.001300 | B | 0.004600 | B | 0.002600 | B | 0.003200 | B | 0.007400 | B | 0.003600 | B | 0.004800 | B | 0.002700 | B | 0.003300 | B | 0.005100 | B | 0.005300 | B |
| Barium | 0.029000 | B | 0.320000 | B | 0.240000 | B | 0.280000 | B | 0.370000 | B | 0.350000 | B | 0.350000 | B | 0.260000 | B | 0.280000 | B | 0.320000 | B | 0.250000 | B |
| Beryllium | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U |
| Cadmium | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000330 | J | 0.000400 | U | 0.000098 | J | 0.000420 | | 0.000400 | U | 0.000400 | U | 0.000400 | U |
| Calcium | 37.000000 | B | 41.000000 | B | 41.000000 | B | 81.000000 | B | 42.000000 | B | 41.000000 | B | 35.000000 | B | 43.000000 | B | 44.000000 | B | 77.000000 | B | 73.000000 | B |
| Chromium | 0.000450 | J | 0.000810 | | 0.000300 | J | 0.000270 | J | 0.001900 | | 0.000740 | J | 0.001600 | | 0.000570 | J | 0.000400 | J | 0.000480 | J | 0.000280 | J |
| Cobalt | 0.002000 | U | 0.000290 | J | 0.000240 | J | 0.001500 | J | 0.000570 | J | 0.000490 | J | 0.000430 | J | 0.000290 | J | 0.000320 | J | 0.001300 | J | 0.001200 | J |
| Copper | 0.003000 | B | 0.001300 | J | 0.000950 | J | 0.001500 | J | 0.004100 | B | 0.001500 | J | 0.002200 | B | 0.002600 | B | 0.001800 | J | 0.001500 | J | 0.001500 | J |
| Iron | 0.250000 | B | 0.350000 | B | 0.230000 | B | 1.100000 | B | 0.660000 | B | 0.730000 | B | 0.720000 | B | 0.290000 | B | 0.350000 | B | 2.200000 | B | 4.200000 | B |
| Lead | 0.000250 | J | 0.000790 | | 0.000190 | J | 0.000120 | J | 0.003000 | | 0.001800 | | 0.001300 | | 0.000350 | J | 0.000600 | | 0.000210 | J | 0.000140 | J |
| Magnesium | 9.200000 | B | 11.000000 | B | 11.000000 | B | 19.000000 | B | 10.000000 | B | 11.000000 | B | 9.200000 | B | 9.300000 | B | 11.000000 | B | 18.000000 | B | 17.000000 | B |
| Manganese | 0.003600 | B | 0.890000 | | 0.710000 | | 2.900000 | | 0.440000 | | 0.950000 | | 0.550000 | | 0.420000 | | 0.560000 | | 2.500000 | | 2.500000 | |
| Mercury | 0.000200 | U | 0.000200 | J | 0.000057 | J | 0.000290 | | 0.000210 | | 0.000110 | J | 0.000063 | J | 0.013000 | | 0.023000 | | 0.000200 | U | 0.000200 | U |
| Nickel | 0.002600 | J | 0.002800 | J | 0.002600 | J | 0.005200 | | 0.004000 | J | 0.004500 | | 0.005200 | | 0.003500 | J | 0.002900 | J | 0.005300 | | 0.004100 | |
| Potassium | 2.500000 | B | 4.900000 | B | 4.700000 | B | 5.500000 | B | 4.400000 | B | 4.900000 | B | 4.600000 | B | 4.200000 | B | 5.300000 | B | 5.900000 | B | 5.100000 | B |
| Selenium | 0.000670 | J | 0.000860 | J | 0.000770 | J | 0.001100 | J | 0.000810 | J | 0.000750 | J | 0.000890 | J | 0.000700 | J | 0.000950 | J | 0.001500 | J | 0.001400 | J |
| Silver | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U |
| Sodium | 9.800000 | B | 14.000000 | B | 12.000000 | B | 13.000000 | B | 17.000000 | B | 16.000000 | B | 15.000000 | B | 13.000000 | B | 15.000000 | B | 14.000000 | B | 18.000000 | B |
| Thallium | 0.000042 | J | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U |
| Vanadium | 0.001300 | B | 0.000820 | B | 0.000880 | B | 0.000350 | J | 0.001600 | B | 0.000830 | B | 0.001800 | B | 0.001100 | B | 0.000560 | J | 0.000670 | J | 0.000750 | J |
| Zinc | 0.010000 | J | 0.083000 | | 0.060000 | | 0.110000 | | 0.080000 | | 0.100000 | | 0.076000 | | 0.076000 | | 0.086000 | | 0.140000 | | 0.083000 | |

| Metal (mg/L) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM:0.0 | | LM:0.25 | | LM:0.5 | | LM:0.75 | | LM:1.0 | | LM:1.25 | | LM:1.5 | | LM:1.75 | | LM:2.0 | | LM:2.25 | | LM:2.5 | |
| Aluminum | 0.006600 | J | 0.013000 | J | 0.013000 | J | 0.046000 | B | 0.019000 | J | 0.028000 | B | 0.030000 | B | 0.025000 | B | 0.038000 | B | 0.046000 | B | 0.007900 | J |
| Antimony | 0.002500 | U | 0.001200 | | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U |
| Arsenic | 0.004700 | B | 0.004000 | B | 0.001800 | B | 0.003800 | B | 0.002800 | B | 0.001900 | B | 0.003000 | B | 0.002800 | B | 0.003900 | B | 0.003900 | B | 0.002600 | B |
| Barium | 0.200000 | B | 0.330000 | B | 0.270000 | B | 0.310000 | B | 0.076000 | B | 0.300000 | B | 0.320000 | B | 0.340000 | B | 0.370000 | B | 0.280000 | B | 0.270000 | B |
| Beryllium | 0.000400 | U | 0.000170 | J | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U |
| Cadmium | 0.000400 | U | 0.000190 | J | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000250 | J | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U |
| Calcium | 64.000000 | B | 78.000000 | B | 56.000000 | B | 47.000000 | B | 59.000000 | B | 61.000000 | B | 58.000000 | B | 56.000000 | B | 56.000000 | B | 71.000000 | B | 64.000000 | B |
| Chromium | 0.000220 | J | 0.000440 | J | 0.000250 | J | 0.000220 | J | 0.000800 | U | 0.000250 | J | 0.000280 | J | 0.000370 | J | 0.000260 | J | 0.000380 | J | 0.000330 | J |
| Cobalt | 0.000950 | J | 0.001400 | J | 0.000740 | J | 0.000550 | J | 0.000740 | J | 0.000750 | J | 0.000790 | J | 0.000700 | J | 0.000740 | J | 0.000900 | J | 0.000800 | J |
| Copper | 0.001800 | J | 0.001500 | J | 0.001100 | J | 0.000820 | J | 0.001200 | J | 0.001200 | J | 0.004100 | B | 0.001100 | J | 0.001500 | J | 0.001300 | J | 0.002600 | B |
| Iron | 3.100000 | B | 1.600000 | B | 0.240000 | B | 0.410000 | B | 1.300000 | B | 0.290000 | B | 0.590000 | B | 0.360000 | B | 0.890000 | B | 0.320000 | B | 0.760000 | B |
| Lead | 0.000100 | J | 0.000250 | J | 0.000054 | J | 0.000130 | J | 0.000062 | J | 0.000096 | J | 0.000170 | J | 0.000110 | J | 0.000180 | J | 0.000100 | J | 0.000120 | J |
| Magnesium | 15.000000 | B | 18.000000 | B | 14.000000 | B | 12.000000 | B | 14.000000 | B | 14.000000 | B | 14.000000 | B | 14.000000 | B | 13.000000 | B | 16.000000 | B | 15.000000 | B |
| Manganese | 1.900000 | | 2.500000 | | 1.700000 | | 1.200000 | | 1.900000 | | 2.200000 | | 1.600000 | | 2.100000 | B | 2.200000 | B | 2.500000 | B | 2.300000 | |
| Mercury | 0.000200 | U | 0.000200 | U | 0.000053 | J | 0.000097 | J | 0.000200 | U | 0.000200 | U | 0.000087 | J | 0.000062 | J | 0.000031 | J | 0.000042 | J | 0.000200 | U |
| Nickel | 0.004200 | | 0.005400 | | 0.003700 | J | 0.003700 | J | 0.003900 | J | 0.004200 | | 0.004600 | | 0.003900 | J | 0.004100 | | 0.006000 | | 0.004600 | |
| Potassium | 5.400000 | B | 4.700000 | B | 5.400000 | B | 5.200000 | B | 5.000000 | B | 4.700000 | B | 4.700000 | B | 4.700000 | B | 4.100000 | B | 5.600000 | B | 4.200000 | B |
| Selenium | 0.001100 | J | 0.001300 | J | 0.001000 | J | 0.001100 | J | 0.001200 | J | 0.001300 | J | 0.001200 | J | 0.001300 | J | 0.000840 | J | 0.001400 | J | 0.001400 | J |
| Silver | 0.001500 | U | 0.000310 | J | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U |
| Sodium | 16.000000 | B | 15.000000 | B | 14.000000 | B | 14.000000 | B | 12.000000 | B | 14.000000 | B | 17.000000 | B | 13.000000 | B | 16.000000 | B | 14.000000 | B | 15.000000 | B |
| Thallium | 0.000800 | U | 0.000036 | J | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | |
| Vanadium | 0.000620 | J | 0.000640 | J | 0.000270 | J | 0.000270 | J | 0.000500 | J | 0.000380 | J | 0.000420 | J | 0.000600 | J | 0.000880 | B | 0.000920 | B | 0.000660 | J |
| Zinc | 0.067000 | | 0.096000 | | 0.099000 | | 0.110000 | | 0.018000 | J | 0.100000 | | 0.091000 | | 0.130000 | | 0.090000 | | 0.100000 | | 0.090000 | |

| Metal (mg/L) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM:2.75 | | LM:3.0 | | LM:3.25 | | LM:3.5 | | LM:3.75 | | LM:4.0 | | LM:4.25 | | LM:4.5 | | LM:4.75 | | LM:5.0 | | LM:5.25 | |
| Aluminum | 0.017000 | J | 0.027000 | B | 0.029000 | B | 0.008600 | J | 0.051000 | B | 0.100000 | B | 0.140000 | B | 0.075000 | B | 0.100000 | B | 0.015000 | J | 0.079000 | B |
| Antimony | 0.002500 | U | 0.002500 | U | 0.001300 | J | 0.002500 | U | 0.001300 | | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U |
| Arsenic | 0.001400 | B | 0.001800 | B | 0.002400 | B | 0.001800 | B | 0.002600 | B | 0.003800 | B | 0.007900 | B | 0.005700 | B | 0.002300 | B | 0.001800 | B | 0.001900 | B |
| Barium | 0.280000 | B | 0.290000 | B | 0.290000 | B | 0.310000 | B | 0.260000 | B | 0.250000 | B | 0.330000 | B | 0.350000 | B | 0.270000 | B | 0.200000 | B | 0.210000 | B |
| Beryllium | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.001200 | | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U |
| Cadmium | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.001100 | | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U |
| Calcium | 69.000000 | B | 57.000000 | B | 56.000000 | B | 64.000000 | B | 46.000000 | B | 46.000000 | B | 43.000000 | B | 46.000000 | B | 45.000000 | B | 63.000000 | B | 40.000000 | B |
| Chromium | 0.000290 | J | 0.000290 | J | 0.000370 | J | 0.000520 | J | 0.000420 | J | 0.000350 | J | 0.001200 | B | 0.000290 | J | 0.000240 | J | 0.000330 | J | 0.000310 | J |
| Cobalt | 0.000780 | J | 0.000590 | J | 0.000810 | J | 0.000860 | J | 0.000510 | J | 0.000480 | J | 0.001400 | J | 0.000380 | J | 0.000380 | J | 0.000500 | J | 0.000370 | J |
| Copper | 0.001300 | J | 0.002100 | B | 0.003700 | B | 0.002000 | B | 0.001500 | J | 0.003000 | B | 0.005900 | B | 0.002400 | B | 0.001800 | J | 0.001700 | J | 0.001400 | J |
| Iron | 0.310000 | B | 0.330000 | B | 0.610000 | B | 0.350000 | B | 0.260000 | B | 0.250000 | B | 0.330000 | B | 0.250000 | B | 0.200000 | B | 0.260000 | B | 0.200000 | B |
| Lead | 0.000062 | J | 0.000120 | J | 0.000150 | J | 0.004300 | B | 0.000220 | J | 0.000290 | J | 0.003300 | B | 0.000270 | J | 0.000520 | B | 0.000076 | J | 0.000180 | J |
| Magnesium | 16.000000 | B | 13.000000 | B | 13.000000 | B | 14.000000 | B | 11.000000 | B | 10.000000 | B | 9.500000 | B | 10.000000 | B | 9.500000 | B | 15.000000 | B | 9.000000 | B |
| Manganese | 2.300000 | B | 1.900000 | B | 2.300000 | B | 2.600000 | B | 1.500000 | B | 1.400000 | B | 1.300000 | B | 1.400000 | B | 1.200000 | B | 2.100000 | B | 1.500000 | B |
| Mercury | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U |
| Nickel | 0.004400 | | 0.003500 | J | 0.004100 | | 0.008000 | | 0.003100 | J | 0.003300 | J | 0.006300 | | 0.003600 | J | 0.003100 | J | 0.004700 | | 0.003000 | J |
| Potassium | 4.200000 | B | 4.300000 | B | 4.100000 | B | 4.200000 | B | 3.800000 | B | 3.500000 | B | 2.500000 | B | 2.500000 | B | 2.500000 | B | 2.700000 | B | 2.300000 | B |
| Selenium | 0.000950 | J | 0.000920 | J | 0.000880 | J | 0.001100 | J | 0.000760 | J | 0.000840 | J | 0.003500 | B | 0.000650 | J | 0.000820 | J | 0.001200 | J | 0.000740 | J |
| Silver | 0.001500 | U | 0.001500 | U | 0.000520 | J | 0.001500 | U | 0.000800 | | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U |
| Sodium | 13.000000 | B | 13.000000 | B | 13.000000 | B | 13.000000 | B | 13.000000 | B | 13.000000 | B | 13.000000 | B | 13.000000 | B | 12.000000 | B | 1.300000 | B | 12.000000 | B |
| Thallium | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000032 | J | 0.000800 | U | 0.001200 | | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U |
| Vanadium | 0.000510 | J | 0.000460 | J | 0.000500 | J | 0.000470 | J | 0.000770 | J | 0.001100 | B | 0.002300 | B | 0.001400 | B | 0.000970 | B | 0.000570 | J | 0.000620 | J |
| Zinc | 0.087000 | | 0.086000 | | 0.098000 | | 0.140000 | | 0.070000 | | 0.067000 | | 0.068000 | | 0.068000 | | 0.057000 | | 0.055000 | | 0.049000 | |

| Metal (mg/L) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM:5.5 | | LM:5.75 | | LM:6.0 | | LM:6.25 | | LM:6.5 | | LM:6.75 | | LM:7.0 | | LM:8.0 | | LM:9.0 | | LM:10.0 | | LM:11.0 | |
| Aluminum | 0.140000 | B | 0.075000 | B | 0.100000 | B | 0.015000 | J | 0.079000 | B | 0.093000 | B | 0.140000 | B | 0.200000 | B | 0.017000 | J | 0.027000 | B | 0.029000 | B |
| Antimony | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.002500 | U | 0.001300 | J |
| Arsenic | 0.007900 | B | 0.005700 | B | 0.002300 | B | 0.001800 | B | 0.001900 | B | 0.001800 | B | 0.001600 | B | 0.000790 | B | 0.001400 | B | 0.001800 | B | 0.002400 | B |
| Barium | 0.330000 | B | 0.350000 | B | 0.270000 | B | 0.200000 | B | 0.210000 | B | 0.200000 | B | 0.190000 | B | 0.210000 | B | 0.280000 | B | 0.290000 | B | 0.290000 | B |
| Beryllium | 0.001200 | | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U |
| Cadmium | 0.001100 | | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U | 0.000400 | U |
| Calcium | 43.000000 | B | 46.000000 | B | 45.000000 | B | 63.000000 | B | 40.000000 | B | 40.000000 | B | 39.000000 | B | 41.000000 | B | 69.000000 | B | 57.000000 | B | 56.000000 | B |
| Chromium | 0.001200 | B | 0.000290 | J | 0.000240 | J | 0.000330 | J | 0.000310 | J | 0.000360 | J | 0.000520 | J | 0.000250 | J | 0.000290 | J | 0.000290 | J | 0.000370 | J |
| Cobalt | 0.001400 | J | 0.000380 | J | 0.000380 | J | 0.000500 | J | 0.000370 | J | 0.000380 | J | 0.000300 | J | 0.000250 | J | 0.000780 | J | 0.000590 | J | 0.000810 | J |
| Copper | 0.005900 | B | 0.002400 | B | 0.001800 | J | 0.001700 | J | 0.001400 | J | 0.002500 | B | 0.001900 | J | 0.002100 | B | 0.001300 | J | 0.002100 | B | 0.003700 | B |
| Iron | 0.330000 | B | 0.250000 | B | 0.200000 | B | 0.260000 | B | 0.200000 | B | 0.210000 | B | 0.220000 | B | 0.220000 | B | 0.310000 | B | 0.330000 | B | 0.610000 | B |
| Lead | 0.003300 | B | 0.000270 | J | 0.000520 | B | 0.000076 | J | 0.000340 | J | 0.000180 | J | 0.000210 | J | 0.000260 | J | 0.000062 | J | 0.000120 | J | 0.000150 | J |
| Magnesium | 9.500000 | B | 10.000000 | B | 9.500000 | B | 15.000000 | B | 9.000000 | B | 8.600000 | B | 8.600000 | B | 8.900000 | B | 16.000000 | B | 13.000000 | B | 13.000000 | B |
| Manganese | 1.300000 | B | 1.400000 | B | 1.200000 | B | 2.100000 | B | 1.500000 | B | 1.300000 | B | 0.950000 | B | 0.670000 | B | 2.300000 | B | 1.900000 | B | 2.300000 | B |
| Mercury | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U | 0.000200 | U |
| Nickel | 0.006300 | | 0.003600 | J | 0.003100 | J | 0.004700 | | 0.003000 | J | 0.003200 | J | 0.003200 | J | 0.003200 | J | 0.004400 | | 0.003500 | J | 0.004100 | |
| Potassium | 2.500000 | B | 2.500000 | B | 2.500000 | B | 2.700000 | B | 2.300000 | B | 2.300000 | B | 2.200000 | B | 2.300000 | B | 4.200000 | B | 4.300000 | B | 4.100000 | B |
| Selenium | 0.003500 | B | 0.000650 | J | 0.000820 | J | 0.001200 | J | 0.000740 | J | 0.000530 | J | 0.002000 | U | 0.000590 | J | 0.000950 | J | 0.000920 | J | 0.000880 | J |
| Silver | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.001500 | U | 0.000520 | J |
| Sodium | 13.000000 | B | 13.000000 | B | 12.000000 | B | 1.300000 | B | 12.000000 | B | 11.000000 | B | 11.000000 | B | 11.000000 | B | 13.000000 | B | 13.000000 | B | 13.000000 | B |
| Thallium | 0.001200 | | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U | 0.000800 | U |
| Vanadium | 0.002300 | B | 0.001400 | B | 0.000970 | B | 0.000570 | J | 0.000620 | J | 0.000860 | B | 0.001000 | B | 0.000990 | B | 0.000510 | J | 0.000460 | J | 0.000500 | J |
| Zinc | 0.067000 | | 0.068000 | | 0.057000 | | 0.055000 | | 0.049000 | | 0.045000 | | 0.040000 | | 0.042000 | | 0.087000 | | 0.086000 | | 0.098000 | |

## TABLE 35. General chemistry SET data on Toledo Harbor Federal Navigation channel sediments (from USACE 2010).

| Parameter (mg/L) | Site Water | | River Channel | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RM-7.0 | | RM-6.0 | | RM-5.0 | | RM-4.0 | | RM-3.0 | | RM-2.0 | | RM-1.0 | | RM-0.75 | | RM-0.5 | | RM-0.25 | |
| Oil and Grease | 5 | U* | 5 | U | 5 | U | 5 | U | 5 | U | 0.79 | J** | 1.4 | J | 5 | U | 5 | U | 5 | U | 5 | U |
| Nitrogen, Ammonia | 0.062 | J | 6 | | 4 | | 7.2 | | 5.8 | | 7.1 | | 5.7 | | 4.4 | | 7.8 | | 9.6 | | 9.9 | |
| Phosphorus, Total as P | 0.039 | B*** | 0.049 | | 0.051 | | 0.043 | | 0.099 | | 0.067 | | 0.094 | | 0.064 | | 0.05 | | 0.071 | | 0.12 | |
| Nitrogen, Total Kjeldahl | 0.79 | | 6 | | 5.1 | | 7.2 | | 6.5 | | 6.9 | | 5.3 | | 4.8 | | 6.7 | | 9.7 | | 10 | |
| Cyanide, Total | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U |

| Parameter (mg/L) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | | LM-0.25 | | LM-0.5 | | LM-0.75 | | LM-1.0 | | LM-1.25 | | LM-1.5 | | LM-1.75 | | LM-2.0 | | LM-2.25 | | LM-2.5 | | LM-2.75 | | LM-3.0 | | LM-3.25 | | LM-3.5 | |
| Oil and Grease | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U |
| Nitrogen, Ammonia | 13 | | 6.1 | | 7.5 | | 10 | | 6.7 | | 6 | | 5.3 | | 5.9 | | 4.3 | | 7.6 | | 4.5 | | 5.4 | | 5.1 | | 4.1 | | 3.7 | |
| Phosphorus, Total as P | 0.052 | | 0.05 | | 0.032 | | 0.029 | | 0.053 | | 0.047 | | 0.028 | | 0.019 | B | 0.037 | | 0.052 | B | 0.043 | | 0.057 | | 0.056 | | 0.027 | B | 0.026 | B |
| Nitrogen, Total Kjeldahl | 8.6 | | 7.2 | | 7.8 | | 11 | | 7.4 | | 6.4 | | 6.4 | | 5 | | 4.1 | | 7.8 | | 4.6 | | 5.7 | | 4.6 | | 5.1 | | 4.6 | |
| Cyanide, Total | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.0033 | J | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U |

| Parameter (mg/L) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | | LM-4.0 | | LM-4.25 | | LM-4.5 | | LM-4.75 | | LM-5.0 | | LM-6.0 | | LM-7.0 | | LM-8.0 | | LM-9.0 | | LM-10.0 | | LM-11.0 | | LM-12.0 | | LM-13.0 | | | |
| Oil and Grease | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U | | |
| Nitrogen, Ammonia | 4.4 | | 3.4 | | 4.2 | | 4.5 | | 2.4 | | 2 | | 0.56 | | 0.65 | | 0.62 | | 0.88 | | 1.2 | | 1 | | 0.61 | | 0.39 | | | |
| Phosphorus, Total as P | 0.023 | B | 0.023 | B | 0.025 | B | 0.023 | B | 0.031 | B | 0.046 | B | 0.13 | B | 0.072 | B | 0.04 | B | 0.021 | B | 0.022 | B | 0.023 | B | 0.03 | B | 0.024 | B | | |
| Nitrogen, Total Kjeldahl | 4.5 | | 4.3 | | 4.5 | | 4.2 | | 2.8 | | 2.7 | | 1.6 | | 1.4 | | 1.3 | | 1.9 | | 1.8 | | 1.4 | | 1.2 | | 3.8 | | | |
| Cyanide, Total | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | U | 0.01 | | 0.0059 | J | 0.0026 | J | 0.0044 | J | 0.028 | J | 0.01 | U | 0.01 | U | 0.01 | U | | |

*Analyte was detected in the associated Method Blank.
**Estimated value between the minimum detection limit and reporting limit.
***Not detected at or above the specified reporting limit.

## TABLE 36. PAH SET data on Toledo Harbor Federal Navigation channel sediments (from USACE 2010).

| PAH (ug/L) | Site Water | | River Channel | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RM-7.0 | | RM-6.0 | | RM-5.0 | | RM-4.0 | | RM-3.0 | | RM-2.0 | | RM-1.0 | | RM-0.75 | | RM-0.5 | | RM-0.25 | |
| 2-Methylnaphthalene | 0.320 | B* | 0.230 | U** | 0.190 | J***,M**** | 0.210 | J | 0.440 | J | 0.710 | | 0.640 | M | 0.120 | J | 0.150 | J | 0.290 | | 0.940 | | | |
| Acenaphthene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 1.200 | U | 0.230 | U | 0.520 | | 0.210 | U | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Acenaphthylene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 1.200 | U | 0.230 | U | 0.220 | U | 0.210 | U | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Anthracene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 1.200 | U | 0.230 | U | 0.220 | U | 0.210 | MU | 0.240 | UM | 0.210 | UM | 0.210 | U | | |
| Benzo(a)anthracene | 0.200 | U | 0.230 | U | 0.280 | JM | 0.250 | U | 0.067 | J | 0.230 | U | 0.079 | J | 0.210 | MU | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Benzo(a) pyrene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 0.120 | J | 0.029 | J | 0.044 | J | 0.210 | U | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Benzo(b) fluoranthene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 0.067 | J | 0.230 | U | 0.055 | J | 0.210 | U | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Benzo(g,h,i) perylene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 0.100 | J | 0.230 | U | 0.220 | U | 0.210 | U | 0.240 | U | 0.044 | JM | 0.210 | U | | |
| Benzo(k) fluoranthene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 0.045 | J | 0.230 | U | 0.220 | U | 0.210 | U | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Chrysene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 0.085 | J | 0.230 | U | 0.055 | JM | 0.210 | U | 0.240 | U | 0.210 | M | 0.210 | U | | |
| Dibenzo(a,h) anthracene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 0.092 | J | 0.230 | U | 0.220 | U | 0.210 | U | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Fluoranthene | 0.056 | J | 0.060 | J | 1.100 | | 0.250 | U | 0.230 | J | 0.074 | JM | 0.610 | | 0.071 | JM | 0.240 | UM | 0.210 | U | 0.210 | U | | |
| Fluorene | 0.200 | U | 0.230 | U | 0.070 | J | 0.250 | U | 0.088 | J | 0.092 | J | 0.510 | | 0.045 | J | 0.240 | U | 0.043 | JM | 0.210 | UM | | |
| Indeno(1,2,3-cd) pyrene | 0.200 | U | 0.230 | U | 0.250 | U | 0.250 | U | 0.037 | J | 0.230 | U | 0.220 | U | 0.210 | U | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Naphthalene | 0.200 | U | 0.120 | J | 0.250 | U | 0.250 | U | 0.069 | JM | 0.230 | U | 0.220 | U | 0.210 | U | 0.350 | | 0.210 | U | 0.210 | | | |
| Phenanthrene | 0.200 | U | 0.230 | U | 0.230 | J | 0.250 | U | 0.110 | J | 0.230 | M | 0.890 | | 0.056 | J | 0.240 | U | 0.210 | U | 0.210 | U | | |
| Pyrene | 0.200 | U | 0.230 | U | 0.360 | M | 0.250 | U | 0.180 | J | 0.230 | M | 0.280 | M | 0.064 | J | 0.240 | U | 0.210 | U | 0.210 | U | | |

| PAH (ug/L) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | | LM-0.25 | | LM-0.5 | | LM-0.75 | | LM-1.0 | | LM-1.25 | | LM-1.5 | | LM-1.75 | | LM-2.0 | | LM-2.25 | | LM-2.5 | | LM-2.75 | | LM-3.0 | | LM-3.25 | | LM-3.5 | |
| 2-Methylnaphthalene | 0.420 | | 0.320 | J | 0.490 | J | 0.380 | J | 0.320 | J | 0.240 | J | 0.590 | J | 1.100 | B | 0.720 | B | 1.100 | B | 0.510 | J | 0.440 | J | 0.640 | J | 0.710 | B | 0.640 | B | | |
| Acenaphthene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Acenaphthylene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Anthracene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Benzo(a)anthracene | 0.033 | J | 1.000 | U | 1.500 | U | 1.200 | U | 0.052 | J | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 0.023 | J | 1.400 | U | 0.038 | J | 0.210 | U | 0.210 | U | | |
| Benzo(a) pyrene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Benzo(b) fluoranthene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Benzo(g,h,i) perylene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 0.028 | J | 0.043 | J | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Benzo(k) fluoranthene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Chrysene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 0.040 | J | 0.036 | J | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Dibenzo(a,h) anthracene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Fluoranthene | 0.051 | JM | 1.000 | U | 0.059 | J | 0.059 | J | 0.038 | J | 1.200 | U | 1.000 | U | 0.100 | J | 0.100 | J | 0.240 | U | 1.000 | U | 1.400 | U | 0.060 | J | 0.210 | U | 0.043 | J | | |
| Fluorene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 0.041 | J | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.044 | J | 0.210 | UM | | |
| Indeno(1,2,3-cd) pyrene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | U | 0.210 | U | 0.210 | U | | |
| Naphthalene | 0.230 | U | 0.310 | J | 1.500 | U | 0.260 | J | 1.100 | U | 1.200 | U | 0.230 | J | 0.220 | U | 0.210 | U | 0.240 | U | 0.230 | J | 0.290 | J | 0.150 | J | 0.210 | U | 0.210 | U | | |
| Phenanthrene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 1.100 | U | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 1.000 | UM | 0.210 | U | 0.210 | U | | |
| Pyrene | 0.230 | U | 1.000 | U | 1.500 | U | 1.200 | U | 0.040 | J | 1.200 | U | 1.000 | U | 0.220 | U | 0.210 | U | 0.240 | U | 1.000 | U | 1.400 | U | 0.074 | J | 0.210 | U | 0.210 | U | | |

| PAH (ug/L) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | | LM-4.0 | | LM-4.25 | | LM-4.5 | | LM-4.75 | | LM-5.0 | | LM-6.0 | | LM-7.0 | | LM-8.0 | | LM-9.0 | | LM-10.0 | | LM-11.0 | | LM-12.0 | | LM-13.0 | |
| 2-Methylnaphthalene | 1.400 | B | 0.610 | B | 1.600 | B | 0.960 | B | 0.810 | B | 1.000 | B | 0.910 | B | 0.910 | B | 0.830 | B | 0.690 | B | 0.770 | B | 0.760 | B | 1.000 | B | 1.000 | B |
| Acenaphthene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Acenaphthylene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Anthracene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Benzo(a)anthracene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Benzo(a) pyrene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Benzo(b) fluoranthene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Benzo(g,h,i) perylene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Benzo(k) fluoranthene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Chrysene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Dibenzo(a,h) anthracene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Fluoranthene | 0.200 | U | 0.200 | U | 0.038 | J | 0.210 | U | 0.064 | J | 0.061 | J | 0.220 | U | 0.057 | J | 0.067 | J | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Fluorene | 0.200 | U | 0.200 | U | 0.060 | J | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Indeno(1,2,3-cd) pyrene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Naphthalene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Phenanthrene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |
| Pyrene | 0.200 | U | 0.200 | U | 0.220 | U | 0.210 | U | 0.250 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.240 | U | 0.210 | U | 0.210 | U | 0.230 | U | 0.220 | U | 0.210 | U |

*Analyte was detected in the associated Method Blank.
**Not detected at or above the specified reporting limit.
***Estimated value between the minimum detection limit and reporting limit.
****Indicates that manual integration was used to determine area response.

## TABLE 37. PCB SET data on Toledo Harbor Federal navigation channel sediments (from USACE 2010).

| PCB (µg/L-dry weight) | Site Water | | River Channel | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RM-7.0 | | RM-6.0 | | RM-5.0 | | RM-4.0 | | RM-3.0 | | RM-2.0 | | RM-1.0 | | RM-0.75 | | RM-0.5 | | RM-0.25 | |
| Aroclor-1016 | 0.1 | U* | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1221 | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1232 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1242 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1248 | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1254 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1260 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1262 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |

| PCB (µg/L-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | | LM-0.25 | | LM-0.5 | | LM-0.75 | | LM-1.0 | | LM-1.25 | | LM-1.5 | | LM-1.75 | | LM-2.0 | | LM-2.25 | | LM-2.5 | | LM-2.75 | | LM-3.0 | | LM-3.25 | | LM-3.5 | |
| Aroclor-1016 | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1221 | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1232 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1242 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1248 | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1254 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1260 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1262 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |

| PCB (µg/L-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.75 | | LM-4.0 | | LM-4.25 | | LM-4.5 | | LM-4.75 | | LM-5.0 | | LM-6.0 | | LM-7.0 | | LM-8.0 | | LM-9.0 | | LM-10.0 | | LM-11.0 | | LM-12.0 | | LM-13.0 | |
| Aroclor-1016 | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1221 | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1232 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.3 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1242 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.3 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1248 | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Aroclor-1254 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.3 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1260 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.3 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |
| Aroclor-1262 | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.3 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U |

*Not detected at or above the specified reporting limit.

## TABLE 38. Pesticide SET data on Toledo Harbor Federal Navigation channel sediments (from USACE 2010).

| Pesticide (ug/L-dry weight) | Site Prior | | River Channel | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RM-7.0 | | RM-6.0 | | RM-5.0 | | RM-4.0 | | RM-3.0 | | RM-2.0 | | RM-1.0 | | RM-0.75 | | RM-0.5 | | RM-0.25 | |
| 4,4-DDD | 0.010 | U* | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| 4,4-DDE | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| 4,4-DDT | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Aldrin | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| alpha-BHC | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| alpha-Chlordane | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Beta-BHC | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Chlordane, total | 0.200 | U | 0.230 | U | 0.230 | U | 0.200 | U | 0.210 | U | 0.210 | U | 0.240 | U | 0.210 | U | 0.220 | U | 0.200 | U | 0.210 | U |
| delta-BHC | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Dieldrin | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Endosulfan I | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Endosulfan II | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Endosulfan sulfate | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Endrin | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Endrin aldehyde | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Endrin ketone | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| gamma-BHC (Lindane | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| gamma-Chlordane | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Heptachlor | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Heptachlor epoxide | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Methoxychlor | 0.010 | U | 0.012 | U | 0.011 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.012 | U | 0.010 | U | 0.011 | U | 0.010 | U | 0.011 | U |
| Toxaphene | 0.200 | U | 0.230 | U | 0.230 | U | 0.200 | U | 0.210 | U | 0.210 | U | 0.240 | U | 0.210 | U | 0.220 | U | 0.200 | U | 0.210 | U |

| Pesticide (ug/L-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-0.0 | | LM-0.25 | | LM-0.5 | | LM-0.75 | | LM-1.0 | | LM-1.25 | | LM-1.5 | | LM-1.75 | | LM-2.0 | | LM-2.25 | | LM-2.5 | | LM-2.75 | |
| 4,4-DDD | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| 4,4-DDE | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| 4,4-DDT | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Aldrin | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| alpha-BHC | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| alpha-Chlordane | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Beta-BHC | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 2.000 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Chlordane, total | 0.210 | U | 0.220 | U | 0.230 | U | 0.240 | U | 0.210 | U | 0.240 | U | 0.230 | U | 0.210 | U | 0.099 | U | 0.230 | U | 0.200 | U | 0.240 | U |
| delta-BHC | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Dieldrin | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Endosulfan I | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Endosulfan II | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Endosulfan sulfate | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Endrin | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Endrin aldehyde | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Endrin ketone | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| gamma-BHC (Linda | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| gamma-Chlordane | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Heptachlor | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Heptachlor epoxide | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Methoxychlor | 0.011 | U | 0.011 | U | 0.012 | U | 0.012 | U | 0.011 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.099 | U | 0.012 | U | 0.010 | U | 0.012 | U |
| Toxaphene | 0.210 | U | 0.220 | U | 0.023 | U | 0.240 | U | 0.210 | U | 0.240 | U | 0.230 | U | 0.210 | U | 2.000 | U | 0.230 | U | 0.200 | U | 0.240 | U |

| Pesticide (ug/L-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-3.0 | | LM-3.25 | | LM-3.5 | | LM-3.75 | | LM-4.0 | | LM-4.25 | | LM-4.5 | | LM-4.75 | | LM-5.0 | | LM-5.5 | | LM-6.0 | | LM-7.0 | |
| 4,4-DDD | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| 4,4-DDE | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| 4,4-DDT | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Aldrin | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| alpha-BHC | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| alpha-Chlordane | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Beta-BHC | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Chlordane, total | 0.200 | U | 0.200 | U | 0.220 | U | 0.220 | U | 0.220 | U | 0.220 | U | 0.210 | U | 0.210 | U | 0.270 | U | 0.200 | U | 0.240 | U | 0.220 | U |
| delta-BHC | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Dieldrin | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Endosulfan I | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Endosulfan II | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Endosulfan sulfate | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Endrin | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Endrin aldehyde | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Endrin ketone | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| gamma-BHC (Linda | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| gamma-Chlordane | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Heptachlor | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Heptachlor epoxide | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Methoxychlor | 0.010 | U | 0.010 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U |
| Toxaphene | 0.200 | U | 0.200 | U | 0.220 | U | 0.220 | U | 0.220 | U | 0.220 | U | 0.210 | U | 0.210 | U | 0.270 | U | 0.200 | U | 0.240 | U | 0.220 | U |

| Pesticide (ug/L-dry weight) | Lake Approach Channel | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LM-8.0 | | LM-9.0 | | LM-9.5 | | LM-10.0 | | LM-11.0 | | LM-12.0 | | LM-13.0 | | | | | | | | | | | |
| 4,4-DDD | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| 4,4-DDE | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| 4,4-DDT | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Aldrin | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| alpha-BHC | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| alpha-Chlordane | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Beta-BHC | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Chlordane, total | 0.220 | U | 0.270 | U | 0.200 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.220 | U | | | | | | | | | | |
| delta-BHC | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Dieldrin | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Endosulfan I | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Endosulfan II | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Endosulfan sulfate | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Endrin | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Endrin aldehyde | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Endrin ketone | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| gamma-BHC (Linda | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| gamma-Chlordane | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Heptachlor | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Heptachlor epoxide | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Methoxychlor | 0.011 | U | 0.014 | U | 0.010 | U | 0.012 | U | 0.011 | U | 0.011 | U | 0.011 | U | | | | | | | | | | |
| Toxaphene | 0.220 | U | 0.270 | U | 0.200 | U | 0.240 | U | 0.220 | U | 0.220 | U | 0.220 | U | | | | | | | | | | |

*Not detected at or above the specified reporting limit.

**TABLE 39. Results of *Ceriodaphnia dubia* 48-hour static acute elutriate toxicity test on RM-2 sediments (from USACE 2010).**

| Treatment/Control | Solution Concentration (%) | Cumulative Percent Mortality (Cumulative Percent Affected)[a] | |
|---|---|---|---|
| | | 24-hour | 48-hour |
| Control/Dilution Water | 0 | 0 (0) | 0 (0) |
| Elutriate | 6.25 | 0 (0) | 0 (0) |
| | 12.5 | 0 (0) | 0 (0) |
| | 25 | 0 (0) | 0 (0) |
| | 50 | 0 (0) | 0 (0) |
| | 100 | 0 (0) | 0 (0) |

[a]Cumulative Percent Affected is the total percentage of test organisms observed being dead, immobile, exhibiting loss of equilibrium or other defined endpoints.

**TABLE 40. Results of *Pimephales promelas* 96-hour static acute with 48-hour renewal elutriate toxicity test on RM-2 sediments (from USACE 2010).**

| Treatment/Control | Solution Concentration (%) | Cumulative Percent Mortality (Cumulative Percent Affected)[a] | | | |
|---|---|---|---|---|---|
| | | 24-hour | 48-hour | 72-hour | 96-hour |
| Control/Dilution Water | 0 | 2 (2) | 2 (2) | 4 (4) | 4 (4) |
| Elutriate | 6.25 | 0 (0) | 0 (0) | 0 (0) | 0 (2) |
| | 12.5 | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| | 25 | 0 (0) | 0 (0) | 2 (2) | 2 (2) |
| | 50 | 0 (0) | 0 (0) | 2 (2) | 2 (2) |
| | 100 | 0 (0) | 0 (0) | 0 (0) | 0 (0) |

[a]Cumulative Percent Affected is the total percentage of test organisms observed being dead, immobile, exhibiting loss of equilibrium or other defined endpoints.

US Army Corps of Engineers®
Buffalo District

# ADDENDUM TO THE EVALUATION OF TOLEDO HARBOR FEDERAL NAVIGATION CHANNEL SEDIMENTS WITH RESPECT TO SUITABILITY FOR OPEN-LAKE PLACEMENT

## I. Introduction.

This addendum to the Tiered Evaluation on Toledo Harbor Federal navigation channel sediments (2010) presents supplemental information as requested by the Ohio Environmental Protection Agency (OEPA), including definitions as well as expanded discussion. It will be addressed in future revisions to the Tiered Evaluation.

## II. Sediment Quality Assessment.

*Evaluation Based on Existing Sediment Data*

*The following has been added to this section:*

Guidance in the 1998 USEPA/USACE Great Lakes Dredged Material Testing and Evaluation Manual provides that existing information be reviewed under Tier 1. Note that sampling sites, test contaminants and test methodologies can differ among sampling/analysis events. This Tiered Evaluation includes data collected in 2004, 2006, and 2010; in this case, the 2010 data is considered the most comprehensive and current. Each investigation is built on previous data and is thus included in the evaluation. The 2010 sampling/analysis event was performed across the entire harbor at one point in time and the sampling frequency is substantially higher. The 2004 investigation focused on the Lake Approach Channel by collecting samples every mile between Lake Mile (LM)-0 to LM-10. The 2006 investigation focused on the first two miles of the Lake Approach Channel by sampling every quarter mile, and sampled the River Channel every mile from River Mile (RM)-1 to RM-7. The 2010 investigation sampled the Lake Approach Channel every mile from LM-0 to LM-13, with sampling every quarter mile from LM-0 to LM-5 and every mile from LM-5 to LM-13, and the River Channel from RM-0.25 to RM-7, with sampling every quarter mile from RM-0.25 to RM-1 and every mile from RM-1 to RM-7. Preliminary contaminants of concern (COCs) identified in 2004 and 2006 were not retained, mostly because the 2010 sampling at increased intervals did not substantiate the results.

This evaluation primarily compares discrete harbor bulk sediment contaminant concentrations to the maximum discrete lake value (both open-lake reference and placement areas) for the year analyzed on a bulk sediment concentration basis as well as for theoretical bioaccumulation potential (TBP) evaluations. In the evaluation, "maximum lake value" refers to the maximum discrete result observed in the lake, including both the open-lake reference and placement areas, and OEPA SRVs (i.e., Huron/Erie Lake Plain or statewide). The term "acutely toxic" is applied to sediment based on varying lines of evidence for a specific contaminant that suggest acute toxicity to aquatic organisms (e.g., sediment quality guidelines [as a simple screen], bioassay data, modeling). The term "toxicologically significant" suggest that existing and relevant lines of evidence suggest unacceptable adverse toxicity to aquatic organisms, including acute effects (e.g., survival and/or growth) and/or bioaccumulation. If any maximum lake bulk concentration appears high in terms of potential toxicity (potentially including an OEPA sediment reference value [SRV]), another lower (and acceptable) lake value is used for comparison to the dredged material.

c. River Channel and Lake Approach Channel sediments (USACE 2010).

1. *Bulk sediment analyses.*

(b) **Chemical testing:**

(2) Organic analyses

•PCBs

*The following has been added to this section:*

The predicted bioaccumulation from site RM-4 sediments is 33% higher than the bioaccumulation predicted for open lake sediments. Based on 28-day *L. variegatus* PCB bioaccumulation experiment data on Eighteenmile Creek Area of Concern (AOC) (New York State tributary to Lake Ontario) sediments (USAERDC 2004), it is not believed that this represents a substantial difference. The Toledo Harbor TBP evaluation uses a total PCB BSAF of 1.48 and shows a predicted bioaccumulation difference of 25 ug/kg, or 33%, between the RM-4 and lake reference area sediments (the TOC-normalized concentrations were 6700 ug/kg-TOC and 5100 ug/kg-TOC, respectively). An Eighteenmile Creek AOC composite sediment sample from a treatment similar to the RM-4 sediment with total PCB and TOC concentrations of 198 ug/kg and 3.3% respectively (6000 ug/kg-TOC) yielded PCB tissue residues in five tissue replicates ranging from 90.7 to 154 ug/kg, with a resulting mean BSAF of 1.43. The difference among the highest and lowest replicates was 70%. Across all of the five treatments, the average

total difference in PCB bioaccumulation among replicates was 37% (range 20% to 70%). These empirical bioaccumulation data show that a bioaccumulation difference of 33% is not uncommon for the variability encountered among biological replicates with similar bulk sediment PCB exposures. Given this variability, it is not believed that Tier 3 bioaccumulation testing would show a significant difference between open-lake and RM-4 sediments.

## REFERENCE

USAERDC. 2004. Sediment Sampling, Chemical and Biological Analyses for the Eighteenmile Creek AOC, Olcott, New York. Technical Report prepared by Environmental Laboratory.

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# APPENDIX B-2

Toledo Harbor Sediment Preliminary Risk Evaluation

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Hull & associates, inc.

3401 Glendale Avenue, Suite 300 ◆ Toledo, Ohio 43614 ◆ (419) 385-2018 ◆ (419) 385-5487 fax

# Memorandum

TO: John Hull, P.E., Hull & Associates, Inc.

FROM: Ed Pfau, Hull & Associates, Inc.

DATE: August 30, 2012

RE: Toledo Harbor Dredge Sediment Preliminary Risk Evaluation; TPA044.100.0035

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Dredged sediments from Toledo Harbor have been evaluated with respect to several proposed beneficial uses. The potential beneficial uses of dredged sediments include in-water uses (e.g. open-lake placement), near-shore uses (e.g. wetland restoration and shoreline protection), and upland uses (e.g. agricultural field improvement, non-structural fill). The accumulation of chemicals in the sediment from sources such as storm run-off, point discharges and atmospheric deposition, affects the sediment quality and therefore affects the appropriateness of dredged sediment material for a given beneficial use. Therefore, reported concentrations of select chemicals in the sediments may be compared to appropriate sediment screening criteria, so that decisions may be made regarding beneficial use options.

Toledo Harbor bulk sediment samples were collected by the U.S. Army Corps of Engineers (USACE) from the Lake Approach Channel and River Channel areas in 2010. These samples were analyzed for bulk polycyclic aromatic hydrocarbons (PAHs), total polychlorinated biphenyls (PCBs) and inorganics. Theses sampling results have been summarized in the attached Table B-1. For each analyte, the maximum reported concentration for the 2010 sampling event is reported, along with the sampling location at which the maximum concentration was detected. Table B-1 also provides seven sets of screening criteria, as available, for some or most of the reported analytes.

The seven sets of screening criteria include the following:

- U.S. EPA Regional Screening Levels (RSLs) for industrial soil;
- RSLs for residential soil;
- Ohio EPA Voluntary Action Program (VAP) direct contact soil standards for commercial/industrial land use;
- VAP direct contact soil standards for residential land use;
- Ohio EPA sediment reference values (SRVs);
- U.S. EPA Region 5 Ecological Screening Levels (ESLs) for sediments; and
- Threshold Effects Concentrations (TECs) from MacDonald, Ingersoll and Berger (2000).

The SRVs developed by Ohio EPA are "representative background sediment conditions in lotic (flowing) water bodies"[1]. The sediment reference values are developed on either a statewide basis or are specific to the Huron Erie Lake Plain (HELP) eco-region within Ohio. Concentrations of any analyte in dredged sediment at or below an SRV are indicative of naturally-occurring concentrations and may be considered acceptable for any proposed beneficial use.

The RSLs were developed for U.S. EPA and are maintained by the Oak Ridge National Laboratory (ORNL)[2]. The RSLs for industrial soil and residential soil are two sets of human health risk-based concentrations, each based on default assumptions regarding industrial (i.e. occupational) and residential direct contact soil exposures (i.e. soil ingestion, dermal contact with soil, and inhalation of particulate and volatile emissions from soil to outdoor air). As their name implies, the RSLs are intended as screening levels to determine whether concentrations of a chemical in soil require further evaluation in a risk assessment; therefore, the RSLs are based on a series of conservative assumptions regarding exposure, toxicity, and target risk (*i.e.* a target excess lifetime cancer risk of $1 \times 10^{-6}$). Dredged sediments with concentrations below the industrial soil RSLs may be suitable for upland placement at industrial sites.

[1] Ohio EPA. 2008. *Guidance for Conducting Ecological Risk Assessments*. Attachment H. Division of Emergency and Remedial Response, Columbus, Ohio. . April 2008. May be accessed at: http://www.epa.state.oh.us/portals/30/rules/RR-031.pdf

Dredged sediments with concentrations below the residential soil RSLs may be suitable for upland placement at residential sites. In general, Ohio EPA considers residential soil RSLs to adequately encompass human direct contact exposures in most applications[3], potentially including recreational land use, mixed land use and unrestricted land uses. It may be assumed that agricultural land use falls within the category of land uses encompassed by residential soil RSLs. However, the residential soil RSLs do not incorporate assumptions about human consumption and contaminant uptake from soil into food crops, milk and eggs, and livestock; therefore, human exposures based on agricultural use of dredged sediments are not specifically evaluated by comparison to residential soil RSLs. Generic screening levels based on agricultural use have not been developed by Ohio EPA or U.S. EPA, perhaps attributable to the difficulty of generically evaluating contaminant uptake into crop plants, the differential distribution of contaminants in the edible and non-edible parts of the plant, and intake rate of produce by consumers. However, the Canadian Council of Ministers of the Environment (CCME) has developed agricultural screening levels for soils[4]; the CCME guidance states that assessment of human food consumption is relevant "where consumption of backyard garden food is or is likely to be significant"[5]; the CCME generic scenario assumes that based on an assumption that 50% of the meat and produce and 100% of the milk consumed by persons is produced on-site[6]. Thus, the CCME soil quality guidelines for the protection of environmental and human health based on agricultural land use may not be relevant for the evaluation of the beneficial use of dredged sediments for agricultural field improvements.

The VAP direct contact soil standards were promulgated by Ohio EPA to represent acceptable soil concentrations associated with a specific land use (residential, or unrestricted, land use, commercial land use or industrial land use requiring an institutional control to restrict the land

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[2] USEPA Regional Screening Levels. Regularly-updated (most recent updated May 2012) on-line recourse available through several EPA regional web pages, including http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/

[3] Ohio EPA. 2010. *Guidance on evaluating sediment contaminant results*. Division of Surface Water. pp. 9-10. January 2010.

[4] Canadian Environmental Quality Guidelines Summary Table, on-line resource of the Canadian Council of Ministers of the Environment, available at: http://st-ts.ccme.ca/

[5] Canadian Council of Ministers of the Environment. 1999. Guidance manual for developing site-specific soil quality remediation objectives for contaminated sites in Canada, p. 23. Available on line at: http://ceqg-rcqe.ccme.ca/

[6] *Ibid*., p. 25.

use)[7]. Similar to the RSLs, the VAP direct contact soil standards for commercial/industrial land use and residential land use are two sets of human health risk-based concentrations, each based on default assumptions regarding commercial/industrial (i.e. occupational) and residential direct contact soil exposures (i.e. soil ingestion, dermal contact with soil, and inhalation of particulate and volatile emissions from soil to outdoor air). The VAP direct contact soil standards are based on a series of exposure value distributions that are, in general, somewhat less conservative than the U.S. EPA default values, and a target excess lifetime cancer risk of $1 \times 10^{-5}$); therefore the VAP direct contact standards are, on a chemical-specific basis, similar to or somewhat higher than the corresponding RSLs. Furthermore, the VAP direct contact standards require that the non-cancer hazards and excess lifetime cancer risks at a property be evaluated on the basis of aggregate (i.e. multiple exposure pathway) and cumulative (i.e. multiple chemical) exposures. Therefore, the actual acceptable concentration of a chemical at a VAP property may be lower than the direct contact standard, sometimes substantially lower, depending upon the number of chemicals of concern and the number and type of exposure pathways.

The Region 5 ESLs represent screening concentrations in sediment based on the protection of benthic biota[8]. The sediment ESLs are based on existing sediment criteria, as available on a chemical-specific basis, or specifically derived as sediment ESLs from the final chronic value (the FCV from the development of water quality criteria) and equilibrium partitioning for both non-polar and polar organic compounds.

The TECs represent sediment concentrations considered to be representative of the "absence of sediment toxicity", based upon the geometric mean of six existing sediment quality guidelines determined to be appropriate.[9]

Dredged sediments which meet the sediment screening criteria based on ecological receptors may be considered to be acceptable for in-water beneficial use. As shown in Table B-1, the ESL

[7] Ohio Administrative Code 3745-300-08(C)(3). Generic numerical standards rule. Effective 03/01/2009. May be accessed at: http://www.epa.ohio.gov/portals/30/SABR/docs/Rules/3745-300-08.pdf
[8] U.S. EPA. Region 5 Ecological Screening Levels. August 22, 2003. May be accessed at: http://epa.gov/region05/waste/cars/pdfs/ecological-screening-levels-200308.pdf
[9] MacDonald, D.D., Ingersoll, C.G., and Berger, T.A. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol*. **39**:20-31.

and TEC values are generally concordant for those chemicals which have both sediment screening criteria. To alleviate any confusion, Ohio EPA has developed a hierarchy of sediment guidelines for ecological receptors, placing the TEC above the ESL for any chemical with both criteria, after an initial comparison to the SRVs[10.11]. The SRVs, TECs, and ESLs may be used to evaluate dredged sediments with respect to proposed near-shore uses (i.e. wetland restoration and shoreline protection). Ohio EPA has stated that "(i)f aquatic life will be exposed to the sediment, such as in a contaminated stream, or dredged material to be redistributed in water, risk to aquatic life should be taken into account."[12] Additionally, Ohio EPA has defined sediments to include "materials within the federal and state jurisdictional boundaries of wetlands" and "materials found below the ordinary high water mark of Lake Erie"[13].

As shown in Table B-1, maximum reported concentrations from the 2010 sampling of Toledo Harbor sediments indicate that of one or more of thirty analytes exceed the SRV, TEC, or sediment ESL at sixteen locations. However, Table B-1 also shows that the exceedance of the residential soil RSL for several PAHs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene and indeno[1,2,3-cd]pyrene) is limited to the results reported the results reported from the 2010 sampling at RM-4. Dibenz(a.h)anthracene slightly exceeded the residential soil RSL at LM-1.5. The maximum reported arsenic concentrations from the 2010 sampling event (11 mg/kg), while exceeding the residential RSL of 0.39 mg/kg, falls at the background concentration represented by the HELP SRV of 11 mg/kg and is therefore consistent with naturally-occurring arsenic levels. Therefore, most Toledo Harbor sediments may also be appropriately used for upland uses (e.g. agricultural field improvement, non-structural fill), with the exception of sediments dredged from RM-4 and LM-1.5. Prior to implementing an upland beneficial use option for sediments dredged from RM-4 and LM-1.5, additional Tier 2 through Tier 4 sediment characterization testing might be necessary to evaluate site-specific biological and toxicity testing.

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[10] Ohio Administrative Code 3745-300-08(H)(2). Generic numerical standards rule. Effective 03/01/2009. May be accessed at: http://www.epa.ohio.gov/portals/30/SABR/docs/Rules/3745-300-08.pdf
[11] Ohio EPA. 2010. *Guidance on evaluating sediment contaminant results*. Division of Surface Water. pp. 9-10. January 2010.
[12] *Ibid*.
[13] Ohio Administrative Code 3745-300-01(A)(126), effective April 23, 2012.

The USACE has determined that the sediments at RM-2 are unsuitable for open-lake placement and require this material to be placed into Cell 2 of the USACE portion of Facility 3. The USACE has determined that dredged material from all other locations, while some exceed one or more screening criteria, are suitable for open-lake placement based on site-specific biological and toxicity testing.

TABLE B-1

SUMMARY OF BULK PAHS AND INORGANIC ANALYSES ON TOLEDO HARBOR BULK SEDIMENT SAMPLES FROM THE FEDERAL NAVIGATION CHANNEL IN 2010 [n]

| Chemical of Concern | 2010 Sediment Analyses[a] | | Region 9 Soil Regional Screening Level[b] | | Ohio Voluntary Action Program[c] | | Sediment Reference Value[d] (mg/kg) | Region 5 Ecological Screening Level[e] (mg/kg) | Threshold Effect Concentration[f] (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | Maximum Detected Concentration (mg/kg) | Location of Maximum Detected Concentration | Industrial Soil (mg/kg) | Residential Soil (mg/kg) | Commercial and Industrial Land Use (mg/kg) | Residential Land Use (mg/kg) | | | |
| **SVOCs/Bulk PAHs** | | | | | | | | | |
| Acenaphthene | 6.8 | RM-4 | 33,000 | 3,400 | 56,000 | 3,500 | N/A | 0.00671[g] | N/A |
| Acenaphthylene | 0.3 | LM-2.5 | N/A | N/A | 56,000[h] | 3,500[i] | N/A | 0.00587[g] | N/A |
| Anthracene | 0.62 | RM-6 | 170,000 | 17,000 | 280,000 | 18,000 | N/A | 0.0572 | 0.0572 |
| Benz(a)anthracene | 6.5 | RM-4[o] | 2.1 | 0.15 | 76 | 11 | N/A | 0.108 | 0.108 |
| Benzo(a)pyrene | 10 | RM-4 | 0.21 | 0.02 | 7.7 | 1.1 | N/A | 0.15 | 0.15 |
| Benzo(b)fluoranthene | 6.6 | RM-4 | 2.1 | 0.15 | 77 | 11 | N/A | 10.4 | N/A |
| Benzo(g,h,i)perylene | 0.54 | LM-0.5 | NA | N/A | 28,000[h] | 1,800[i] | N/A | 0.17[j] | N/A |
| Benzo(k)fluoranthene | 6.6 | RM-4 | 21 | 1.5 | 770 | 110 | N/A | 0.24[j] | N/A |
| Chrysene | 0.41 | RM-0.75 | 210 | 15 | 7,600 | 1,100 | N/A | 0.166 | 0.166 |
| Dibenz(a,h)anthracene | 0.28 | LM-1.5 | 0.21 | 0.2 | 7.7 | 1.1 | N/A | 0.033 | 0.033 |
| Fluoranthene | 23[k] | RM-4 | 22,000 | 2,300 | 37,000 | 2,400 | N/A | 0.423 | 0.423 |
| Fluorene | 0.21 | RM-0.25 and RM-0.75 | 22,000 | 2,300 | 37,000 | 2,400 | N/A | 0.0774 | 0.0774 |
| Indeno(1,2,3-cd)pyrene | 4.6 | RM-4 | 2.1 | 0.15 | 77 | 11 | N/A | 0.2[j] | N/A |
| 1-Methylnaphthalene | NM | NM | 53 | 16 | 360 | 360 | N/A | N/A | N/A |
| 2-Methylnaphthalene | 0.85 | RM-6 | 2,200 | 230 | 3,700[h] | 1,300[i] | N/A | 0.0202[j] | N/A |
| Naphthalene | 0.18[k] | LM-4 | 18 | 3.6 | 150 | 69 | N/A | 0.176 | 0.176 |
| Phenanthrene | 6.3 | RM-1.0[o] | N/A | N/A | 280,000[h] | 99,000[i] | N/A | 0.204 | 0.204 |
| Pyrene | 16 | RM-4 | 17,000 | 1,700 | 28,000 | 1,800 | N/A | 0.195 | 0.195 |
| **Total PAHs** | 107.33 | RM-4 | N/A | N/A | N/A | N/A | N/A | N/A | 1.61 |
| **Total PCBs** | ND | ND | 0.74 | 0.22 | 18 | 1.2 | N/A | 0.0598 | 0.0598 |
| **Metals and Misc.** | | | | | | | | | |
| Aluminum | 48,000 | LM-2 | 990,000 | 770,000 | N/A | N/A | 42,000 | N/A | N/A |
| Antimony | 0.51 | LM-2 | 410 | 31 | 1,200 | 30 | 8.4 | N/A | N/A |
| Arsenic | 11 | LM-3.5 and RM 2.0 | 1.6 | 0.39 | 82 | 6.7 | 11 | 9.79 | 9.79 |
| Barium | 190 | RM-2 | 190,000 | 15,000 | 370,000 | 15,000 | 210 | N/A | N/A |
| Beryllium | 1.2 | RM-2 | 2,000 | 160 | 5,100 | 150 | 0.8 | N/A | N/A |
| Cadmium | 2.5 | RM-4 | 800 | 70 | 2,300 | 72 | 0.96 | 0.99 | 0.99 |
| Calcium[l] | 97,000 | RM-1 | N/A | N/A | N/A | N/A | 110,000 | N/A | N/A |
| Chromium (III)[m] | 52 | RM-2 | 1,500,000 | 120,000 | 1,000,000 | 110,000 | 51 | 43.4 | 43.4 |
| Cobalt | 14 | RM-2 | 300 | 23 | 23,000 | 1,400 | 12 | 50[j] | N/A |
| Copper | 61 | RM-4 | 41,000 | 3,100 | 120,000[h] | 3,000[i] | 42 | 31.6 | 31.6 |

## TABLE B-1

## SUMMARY OF BULK PAHS AND INORGANIC ANALYSES ON TOLEDO HARBOR BULK SEDIMENT SAMPLES FROM THE FEDERAL NAVIGATION CHANNEL IN 2010 [n]

| Chemical of Concern | 2010 Sediment Analyses[a] | | Region 9 Soil Regional Screening Level[b] | | Ohio Voluntary Action Program[c] | | Sediment Reference Value[d] (mg/kg) | Region 5 Ecological Screening Level[e] (mg/kg) | Threshold Effect Concentration[f] (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | Maximum Detected Concentration (mg/kg) | Location of Maximum Detected Concentration | Industrial Soil (mg/kg) | Residential Soil (mg/kg) | Commercial and Industrial Land Use (mg/kg) | Residential Land Use (mg/kg) | | | |
| Cyanide | 2.6 | RM-0.25 | 20,000 | 47 | 59,000 | 1,500 | N/A | 0.0001[j] | N/A |
| Iron | 47,000 | RM-2 | 720,000 | 55,000 | N/A | N/A | 44,000 | N/A | N/A |
| Lead | 51 | RM-4 and LM 13 | 800 | 400 | 1800 | 400 | 47 | 35.8 | 35.8 |
| Magnesium[l] | 23,000 | RM-6 | N/A | N/A | N/A | N/A | 29,000 | N/A | N/A |
| Manganese | 830 | LM-3 | 23,000 | 1,800 | N/A | N/A | 1,000 | N/A | N/A |
| Mercury | 0.37 | LM-13 | 43 | 10 | 290 | 7.6 | 0.12 | 0.174 | 0.18 |
| Nickel | 48 | RM-2 | 20,000 | 44,000 | 44,000 | N/A | 36 | 22.7 | 22.7 |
| Phosphorus | 580 | LM-0 | NA | N/A | N/A | 1,500 | N/A | N/A | N/A |
| Potassium | 5,300 | RM-2 | NA | N/A | N/A | N/A | 1,200 | N/A | N/A |
| Selenium | 1.2 | LM-0.25 and RM-2 | 5,100 | 15,000 | 15,000 | 380 | 1.4 | N/A | N/A |
| Silver | 0.78 | RM-4 | 5,100 | 15,000 | 15,000 | 380 | 0.4 | 0.5[j] | N/A |
| Sodium | 240 | LM-1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Thallium | 0.83 | LM-0.25 | 10 | 230 | 230 | 6.1 | 4.7 | NA | N/A |
| Vanadium | 55 | RM-2 | 5,200 | 26,000 | 26,000 | 680 | 40 | NA | N/A |
| Zinc | 220 | RM-2 | 310,000 | 880,000 | 880,000 | 23,000 | 190 | 121 | 121 |

Notes:

a. 2010 USACE sampling included 39 surface grab samples collected from the Lake Approach Channel (LM-0 through LM-13) and River Channel (RM-1 through RM-7).

b. "Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites." June 2011.

c. Ohio Administrative Code 3745-300-08(C)(3)

d. Sediment Reference Values based on Ohio EPA Sediment Reference Values for the Huron Erie Lake Plain Region, http://www.epa.ohio.gov/portals/30/rules/RR-031.pdf#page=70 Attachment H.

e. Region 5 RCRA Ecological Screening Levels (ESLs). August 22, 2003. http://epa.gov/region05/waste/cars/pdfs/ecological-screening-levels-200308.pdf. The ESLs represent a protective benchmark (e.g., water quality criteria, sediment quality guidelines/criteria, and chronic no adverse effect levels) for 223 contaminants (based on the RCRA 40 CFR 264 Appendix IX list of hazardous substances). Sediment ESLs were derived using equilibrium partitioning (EqP) equation and the corresponding water ESL unless otherwise noted. Note: Sediment ESL = Koc x Water ESL x 0.01.

f. ESLs represent consensus-based threshold effect concentrations (TEC) as presented in MacDonald et. al. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch Environ Contam Toxicol 39:20-31 (see Table 2). The TEC represents the concentration below which harmful effects on sediment-dwelling organisms are not expected. These values do not consider bioaccumulation or biomagnification.

g. ESLs represent Interim Sediment Quality Assessment Values identified by the Ecosystem Conservation Directorate - Evaluation and Interpretation Branch. Environment Canada. September 1994.

h. VAP Program Chemical Information Database and Applicable Regulatory Standards (CIDARS) database

i. VAP Program Chemical Information Database and Applicable Regulatory Standards (CIDARS) database for Residential Child Soil Standard

j. ESLs represent concentrations identified by the Ontario Ministry of the Environment in "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario." August 1993.

k. Manual integration was used to determine area response.

l. Not a listed Hazardous Substance.

m. Reported concentrations of total chromium are assumed to represent trivalent chromium; analysis of samples for hexavalent chromium was each reported as non-detected.

n. Only actual measured values are reported for 2010 sediment data. Values reported as not detected at or above the specified minimum detection limit and estimated values between the minimum detection limit and reporting limit are not reported. NM=Not Measured; ND=Not detected at or above the specified minimum detection limit and reporting limit; EV=Estimated value; N/A - Not Applicable

o. Sediments dredged from River Mile 1, River Mile 2, and River Mile 4 were identified as not meeting Federal guidelines for open-lake placement in the latest Sediment Sampling Analysis (USACE, 2012). Total PAHs were identified as sediment COCs at these sites. All other dredged material was evaluated and determined to be suitable for open-lake placement.

# APPENDIX C

First Public Forum Report

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# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS
# INITIAL PUBLIC FORUM

## Purpose

[illegible]

## Notification

[illegible]

## Participation

[illegible]

**Activities**

[illegible]

9 [illegible] 1 [illegible]

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

### TABLE 1

### SEDIMENT MANANGEMENT CATEGORY, TYPE, AND NUMBER OF PARTICIPANTS FOR BREAK OUT SESSION GROUPS

| Alternative Category | Alternative Break Out Session Table | Number of Participants |
|---|---|---|
| [illegible] | [illegible] | 5 |
| | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| | [illegible] | 5 |
| | [illegible] | 0 |
| [illegible] | [illegible] | [illegible] |

[illegible]

[illegible]

1. [illegible]

2. [illegible]

3. [illegible]

[illegible]

5. [illegible]

[illegible]

[illegible]

**Results of Stakeholder Discussion Held during Break Out Session**

*Submerged Aquatic Habitat Restoration Unit*

[illegible]

# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 2

## SUBMERGED AQUATIC HABITAT RESTORATION UNIT: STAKEHOLDER IDENTIFICATION OF IDEAS AND LOCATIONS

[illegible]

| IDEA/CONCEPT | LOCATION |
|---|---|
| M[illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

*Note: Table only provides specific locations for submerged aquatic habitat restoration units identified by stakeholders.*

[illegible]

# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 3

## SUBMERGED AQUATIC HABITAT RESTORATION UNIT: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR ALTERNATIVE EVALUATION

| CATEGORY | TECHNICAL CRITERIA "x" | STAKEHOLDER COMMENTS |
|---|---|---|
| Ecological Benefits | x | |
| | x | |
| | x | |
| | | |
| | | |
| Feasibility | x | |
| | x | |
| | x | |
| | x | |
| | | |
| | | |
| Human Benefits | x | |
| | | |
| | x | |
| | x | |
| | x | |
| | | |
| | | |
| Economic Benefits | x | |
| | x | |
| | x | |
| | | |
| | | |
| | | |
| | | |
| Environmental Impacts | x | |
| | x | |
| | x | |
| | | |
| | x | |
| | x | |
| Implementation Costs | | |
| | | |
| | | |
| | | |
| | | |
| | x | |
| | x | |
| | x | |
| | | |
| | | |

*Emergent Habitat Restoration Unit*

[illegible]

**TOLEDO HARBOR SEDIMENT MANAGEMENT**
**AND USE SOLUTIONS INITIAL PUBLIC FORUM**

**TABLE 4**

**EMERGENT HABITAT RESTORATION UNIT:**
**STAKEHOLDER IDENTIFICATION OF IDEAS AND LOCATIONS**

| IDEA/CONCEPT | LOCATION |
|---|---|
| [illegible] | [illegible] 500 [illegible] 22 [illegible] |
| [illegible] | [illegible] 1 [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

*Note: Table only provides specific locations for emergent habitat restoration units identified by stakeholders.*

[illegible]

# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 5

## EMERGENT HABITAT RESTORATION UNIT: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR EVALUATION OF ALTERNATIVE

| CATEGORY | TECHNICAL CRITERIA "x" | STAKEHOLDER COMMENTS |
|---|---|---|
| Ecological Benefits | x | |
| | x | |
| | x | |
| | x | |
| | | |
| Feasibility | x | |
| | x | |
| | x | |
| | x | |
| | x | |
| | x | |
| Human Benefits | x | |
| | x | |
| | x | |
| | | |
| | x | |
| | x | |
| | | |
| Economic Benefits | x | |
| | x | |
| | x | |
| | x | |
| | x | |
| | x | |
| | | |
| Environmental Impacts | x | |
| | x | |
| | | |
| | x | |
| | | |
| | | |
| Implementation Costs | x | |
| | x | |
| | x | |
| | x | |
| | x | |
| | | |
| | | |
| | | |
| | | |
| | | |

*Confined Disposal Facility*

[illegible]

**TOLEDO HARBOR SEDIMENT MANAGEMENT**
**AND USE SOLUTIONS INITIAL PUBLIC FORUM**

**TABLE 6**

**CONFINED DISPOSAL FACILITY:**
**STAKEHOLDER IDENTIFICATION OF IDEAS AND LOCATIONS**

| IDEA/CONCEPT | LOCATION |
|---|---|
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] 1200 [illegible] | [illegible] |
| [illegible] | [illegible] |

*Note: Table only provides specific locations for a confined disposal facility option identified by stakeholders.*

[illegible]

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 7

## CONFINED DISPOSAL FACILITY: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR ALTERNATIVE EVALUATION

| CATEGORY | TECHNICAL CRITERIA "x" [illegible] | STAKEHOLDER COMMENTS |
|---|---|---|
| **Ecological Benefits** | [illegible] | |
| | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | |
| | [illegible] | |
| **Feasibility** | [illegible] | [illegible] |
| | [illegible] | |
| | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | |
| | [illegible] | |
| **Human Benefits** | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | |
| | [illegible] | |
| **Economic Benefits** | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | |
| | [illegible] | |
| | [illegible] | |
| | [illegible] | |
| **Environmental Impacts** | [illegible] | |
| | [illegible] | |
| | [illegible] | [illegible] |
| | [illegible] | |
| | [illegible] | |
| | [illegible] | |
| **Implementation Costs** | [illegible] | [illegible] |
| | [illegible] | [illegible] |
| | [illegible] | |
| | [illegible] | [illegible] |
| | [illegible] | |
| | [illegible] | |
| | [illegible] | |
| | [illegible] | |
| | [illegible] | |
| | [illegible] | |

*Wetland Restoration*

[illegible]

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 8

## WETLAND RESTORATION: STAKEHOLDER IDENTIFICATION OF IDEAS AND LOCATIONS

| IDEA/CONCEPT | LOCATION |
|---|---|
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

*Note: Table only provides specific locations wetland restoration options identified by stakeholders.*

[illegible]

# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 9

## WETLAND RESTORATION: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR ALTERNATIVE EVALUATION

| CATEGORY | TECHNICAL CRITERIA<br>"x" [illegible] | STAKEHOLDER COMMENTS |
|---|---|---|
| Ecological Benefits | Improved Hydrologic Functions | [illegible] |
| | Habitat Enhancements | [illegible] |
| | Improved Water Quality | [illegible] |
| | Diversification of Harbor | [illegible] |
| | Habitat Restoration | [illegible] |
| Feasibility | Technical | [illegible] |
| | Logistical | [illegible] |
| | Institutional | [illegible] |
| | Constructability | [illegible] |
| | Depth of Water | [illegible] |
| | Research Advancements | [illegible] |
| Human Benefits | Recreation | [illegible] |
| | Flood protection | [illegible] |
| | Aesthetics | [illegible] |
| | Economic Development | [illegible] |
| | Navigational Safety | [illegible] |
| | Tourism | [illegible] |
| | Site Safety | [illegible] |
| Economic Benefits | Revenue Generating Activity | [illegible] |
| | Job Creation | [illegible] |
| | Cost Savings | [illegible] |
| | Recreation | [illegible] |
| | Tourism | [illegible] |
| | Boating | [illegible] |
| | Land Value Improvement | [illegible] |
| Environmental Impacts | Location | [illegible] |
| | Construction | [illegible] |
| | Post-Construction | [illegible] |
| | Spawning Area | [illegible] |
| | Invasive Species | [illegible] |
| | Mobilization of Contaminants | [illegible] |
| Implementation Costs | Dredging | [illegible] |
| | Transportation | [illegible] |
| | Maintenance | [illegible] |
| | Monitoring | 5-10 [illegible] |
| | Ownership | [illegible] |
| | Design/Research/Studying | [illegible] |
| | Public Relations/Marketing | [illegible] |
| | Programmatic Modification/ Legislative | [illegible] |
| | Material Handling | [illegible] |
| | Characterization | [illegible] |

*Shoreline Protection*

[illegible]

**TOLEDO HARBOR SEDIMENT MANAGEMENT**
**AND USE SOLUTIONS INITIAL PUBLIC FORUM**

**TABLE 10**

**SHORELINE PROTECTION:**
**STAKEHOLDER IDENTIFICATION OF IDEAS AND LOCATIONS**

| IDEA/CONCEPT | LOCATION |
|---|---|
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

*Note: Table only provides specific locations shoreline protection options identified by stakeholders.*

[illegible]

# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 11

## SHORELINE PROTECTION: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR ALTERNATIVE EVALUATION

| CATEGORY | TECHNICAL CRITERIA<br>"x" [illegible] | STAKEHOLDER COMMENTS |
|---|---|---|
| Ecological Benefits | Improved Hydrologic Functions | [illegible] |
| | Habitat Enhancements | [illegible] |
| | Improved Water Quality | [illegible] |
| | Diversification of Harbor | [illegible] |
| | Habitat Restoration | [illegible] |
| Feasibility | Technical | [illegible] |
| | Logistical | [illegible] |
| | Institutional | [illegible] |
| | Constructability | [illegible] |
| | Depth of Water | [illegible] |
| | Research Advancements | [illegible] |
| Human Benefits | Recreation | [illegible] |
| | Flood protection | [illegible] |
| | Aesthetics | [illegible] |
| | Economic Development | [illegible] |
| | Navigational Safety | [illegible] |
| | Tourism | [illegible] |
| | Site Safety | [illegible] |
| Economic Benefits | Revenue Generating Activity | [illegible] |
| | Job Creation | [illegible] |
| | Cost Savings | [illegible] |
| | Recreation | [illegible] |
| | Tourism | [illegible] |
| | Boating | [illegible] |
| | Land Value Improvement | [illegible] |
| Environmental Impacts | Location | [illegible] |
| | Construction | [illegible] |
| | Post-Construction | [illegible] |
| | Spawning Area | [illegible] |
| | Invasive Species | [illegible] |
| | Mobilization of Contaminants | [illegible] |
| Implementation Costs | Dredging | [illegible] |
| | Transportation | [illegible] |
| | Maintenance | [illegible] |
| | Monitoring | [illegible] |
| | Ownership | [illegible] |
| | Design/Research/Studying | [illegible] |
| | Public Relations/Marketing | [illegible] |
| | Programmatic Modification/ Legislative | [illegible] |
| | Material Handling | [illegible] |
| | Characterization | [illegible] |

[illegible]

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 12

## BROWNFIELDS, LANDFILL CAPS, AND MINE RECLAMATION: STAKEHOLDER IDENTIFICATION OF IDEAS AND LOCATIONS

| IDEA/CONCEPT | LOCATION |
|---|---|
| [illegible] | [illegible] |
| M[illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

*Note: Table only provides locations specifically identified by stakeholders for brownfield, landfill cap, or mine reclamation options.*

[illegible]

# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 13

## BROWNFIELDS, LANDFILL CAPS, AND MINE RECLAMATION: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR ALTERNATIVE EVALUATION

| CATEGORY | TECHNICAL CRITERIA "x" [illegible] | STAKEHOLDER COMMENTS |
|---|---|---|
| Ecological Benefits | Improved Hydrologic Functions | [illegible] |
| | Habitat Enhancements | [illegible] |
| | Improved Water Quality | [illegible] |
| | Diversification of Harbor | [illegible] |
| | Habitat Restoration | [illegible] |
| Feasibility | Technical | [illegible] |
| | Logistical | [illegible] |
| | Institutional | [illegible] |
| | Constructability | [illegible] |
| | Depth of Water | [illegible] |
| | Research Advancements | [illegible] |
| Human Benefits | Recreation | [illegible] |
| | Flood protection | [illegible] |
| | Aesthetics | [illegible] |
| | Economic Development | [illegible] |
| | Navigational Safety | [illegible] |
| | Tourism | [illegible] |
| | Site Safety | [illegible] |
| Economic Benefits | Revenue Generating Activity | [illegible] |
| | Job Creation | [illegible] |
| | Cost Savings | [illegible] |
| | Recreation | [illegible] |
| | Tourism | [illegible] |
| | Boating | [illegible] |
| | Land Value Improvement | [illegible] |
| Environmental Impacts | Location | [illegible] |
| | Construction | [illegible] |
| | Post-Construction | [illegible] |
| | Spawning Area | [illegible] |
| | Invasive Species | [illegible] |
| | Mobilization of Contaminants | [illegible] |
| Implementation Costs | Dredging | [illegible] |
| | Transportation | [illegible] |
| | Maintenance | [illegible] |
| | Monitoring | [illegible] |
| | Ownership | [illegible] |
| | Design/Research/Studying | [illegible] |
| | Public Relations/Marketing | [illegible] |
| | Programmatic Modification/ Legislative | [illegible] |
| | Material Handling | [illegible] |
| | Characterization | [illegible] |

*Agricultural Improvements*

[illegible]

**TOLEDO HARBOR SEDIMENT MANAGEMENT**
**AND USE SOLUTIONS INITIAL PUBLIC FORUM**

**TABLE 14**

**AGRICULTURAL IMPROVEMENTS:**
**STAKEHOLDER IDENTIFICATION OF IDEAS AND LOCATIONS**

| IDEA/CONCEPT | LOCATION |
|---|---|
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

*Note: Table only provides locations specifically identified by stakeholders for agricultural improvement options.*

[illegible]

# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 15

## AGRICULTURAL IMPROVEMENTS: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR ALTERNATIVE EVALUATION

| CATEGORY | TECHNICAL CRITERIA<br>"x" [illegible] | STAKEHOLDER COMMENTS |
|---|---|---|
| Ecological Benefits | Improved Hydrologic Functions | [illegible] |
| | Habitat Enhancements | M[illegible] |
| | Improved Water Quality | [illegible] |
| | Diversification of Harbor | [illegible] |
| | Habitat Restoration | [illegible] |
| Feasibility | Technical | [illegible] |
| | Logistical | [illegible] |
| | Institutional | [illegible] |
| | Constructability | [illegible] |
| | Depth of Water | [illegible] |
| | Research Advancements | [illegible] |
| Human Benefits | Recreation | [illegible] |
| | Flood protection | [illegible] |
| | Aesthetics | [illegible] |
| | Economic Development | [illegible] |
| | Navigational Safety | [illegible] |
| | Tourism | [illegible] |
| | Site Safety | [illegible] |
| Economic Benefits | Revenue Generating Activity | [illegible] |
| | Job Creation | [illegible] |
| | Cost Savings | [illegible] |
| | Recreation | [illegible] |
| | Tourism | [illegible] |
| | Boating | [illegible] |
| | Land Value Improvement | [illegible] |
| Environmental Impacts | Location | [illegible] |
| | Construction | [illegible] |
| | Post-Construction | [illegible] |
| | Spawning Area | [illegible] |
| | Invasive Species | [illegible] |
| | Mobilization of Contaminants | [illegible] |
| Implementation Costs | Dredging | [illegible] |
| | Transportation | [illegible] |
| | Maintenance | [illegible] |
| | Monitoring | [illegible] |
| | Ownership | [illegible] |
| | Design/Research/Studying | M[illegible] |
| | Public Relations/Marketing | [illegible] |
| | Programmatic Modification/ Legislative | [illegible] |
| | Material Handling | [illegible] |
| | Characterization | [illegible] |

*Manufactured Soil, Asphalt, Concrete, Construction Materials, Structural Fill, and Other*

[illegible]

**TOLEDO HARBOR SEDIMENT MANAGEMENT**
**AND USE SOLUTIONS INITIAL PUBLIC FORUM**

**TABLE 16**

**MANUFACTURED SOIL, ASPHALT, CONCRETE, CONSTRUCTION MATERIALS, STRUCTURAL FILL, AND OTHER: STAKEHOLDER IDENTIFICATION OF IDEAS AND LOCATIONS**

| IDEA/CONCEPT | LOCATION |
|---|---|
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

*Note: Table only provides locations specifically identified by stakeholders for manufactured soil, asphalt, concrete, construction materials, structural fill, and other options.*

[illegible]

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 17

## MANUFACTURED SOIL, ASPHALT, CONCRETE, CONSTRUCTION MATERIALS, STRUCTURAL FILL, AND OTHER: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR ALTERNATIVE EVALUATION

| CATEGORY | TECHNICAL CRITERIA<br>"x" [illegible] | STAKEHOLDER COMMENTS |
|---|---|---|
| Ecological Benefits | [illegible] Improved Hydrologic Functions | [illegible] |
| | [illegible] Habitat Enhancements | [illegible] |
| | [illegible] Improved Water Quality | [illegible] |
| | [illegible] Diversification of Harbor | [illegible] |
| | [illegible] Habitat Restoration | [illegible] |
| Feasibility | [illegible] Technical | [illegible] |
| | [illegible] Logistical | [illegible] |
| | [illegible] Institutional | [illegible] |
| | [illegible] Constructability | [illegible] |
| | [illegible] Depth of Water | [illegible] |
| | [illegible] Research Advancements | [illegible] |
| Human Benefits | [illegible] Recreation | [illegible] |
| | [illegible] Flood protection | [illegible] |
| | [illegible] Aesthetics | [illegible] |
| | [illegible] Economic Development | [illegible] |
| | [illegible] Navigational Safety | [illegible] |
| | [illegible] Tourism | [illegible] |
| | [illegible] Site Safety | [illegible] |
| Economic Benefits | [illegible] Revenue Generating Activity | [illegible] |
| | [illegible] Job Creation | [illegible] |
| | [illegible] Cost Savings | [illegible] |
| | [illegible] Recreation | [illegible] |
| | [illegible] Tourism | [illegible] |
| | [illegible] Boating | [illegible] |
| | [illegible] Land Value Improvement | [illegible] |
| Environmental Impacts | [illegible] Location | [illegible] |
| | [illegible] Construction | [illegible] |
| | [illegible] Post-Construction | [illegible] |
| | [illegible] Spawning Area | [illegible] |
| | [illegible] Invasive Species | [illegible] |
| | [illegible] Mobilization of Contaminants | [illegible] |

# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

## TABLE 17 (cont.)

## MANUFACTURED SOIL, ASPHALT, CONCRETE, CONSTRUCTION MATERIALS, STRUCTURAL FILL, AND OTHER: STAKEHOLDER IDENTIFICATION OF IMPORTANT TECHNICAL CRITERIA FOR ALTERNATIVE EVALUATION

| CATEGORY | TECHNICAL CRITERIA<br>"x" [illegible] | STAKEHOLDER COMMENTS |
|---|---|---|
| Implementation Costs | [illegible] **Dredging** | [illegible] |
| | [illegible] **Transportation** | [illegible] |
| | [illegible] **Maintenance** | [illegible] |
| | [illegible] **Monitoring** | [illegible] |
| | [illegible] **Ownership** | [illegible] |
| | [illegible] **Design/Research/Studying** | [illegible] |
| | [illegible] **Public Relations/Marketing** | [illegible] |
| | [illegible] **Programmatic Modification/ Legislative** | [illegible] |
| | [illegible] **Material Handling** | [illegible] |
| | [illegible] **Characterization** | [illegible] |

## Summary of Observations

[illegible]

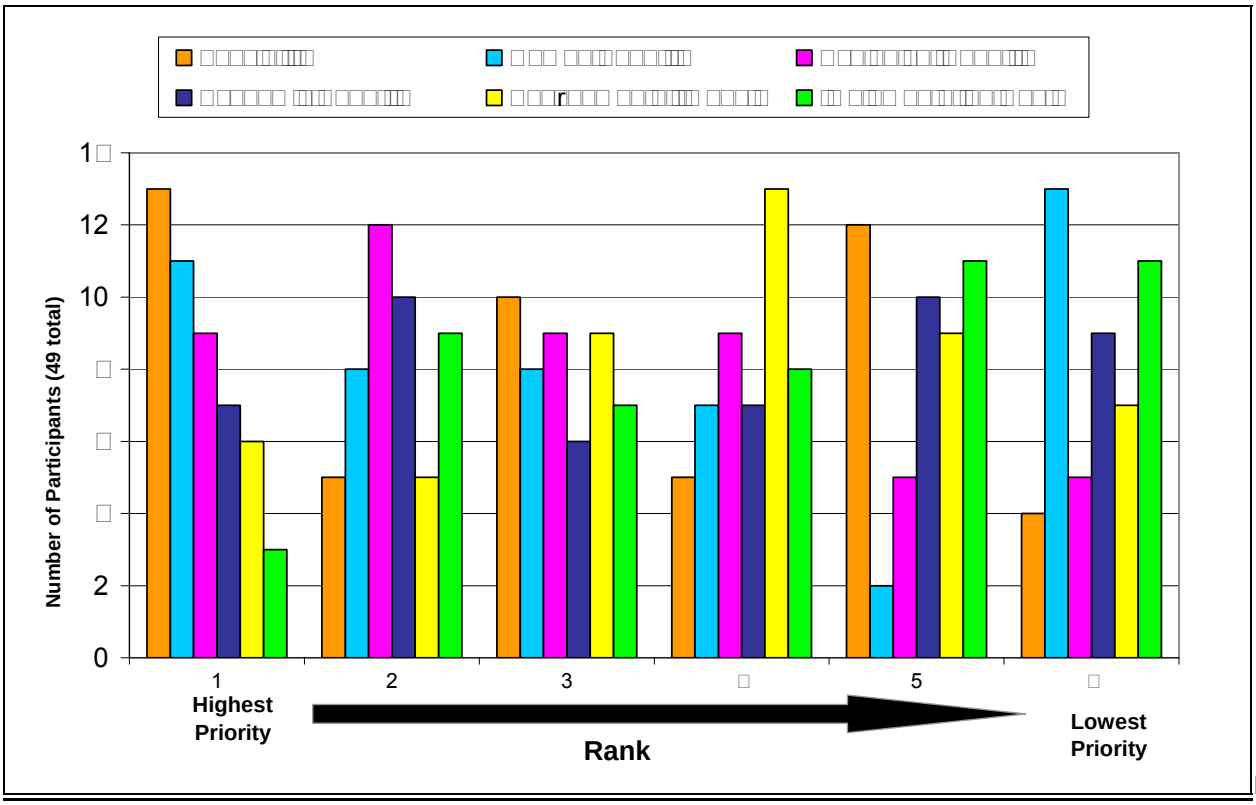
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

[illegible]

[illegible]

## FIGURE 9

## PUBLIC FORUM PRIORITIZATION OF TECHNICAL CRITERIA




[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

- [illegible]

## Next Steps

[illegible]

- [illegible]

- [illegible]

- [illegible]

# FIGURES 1-8

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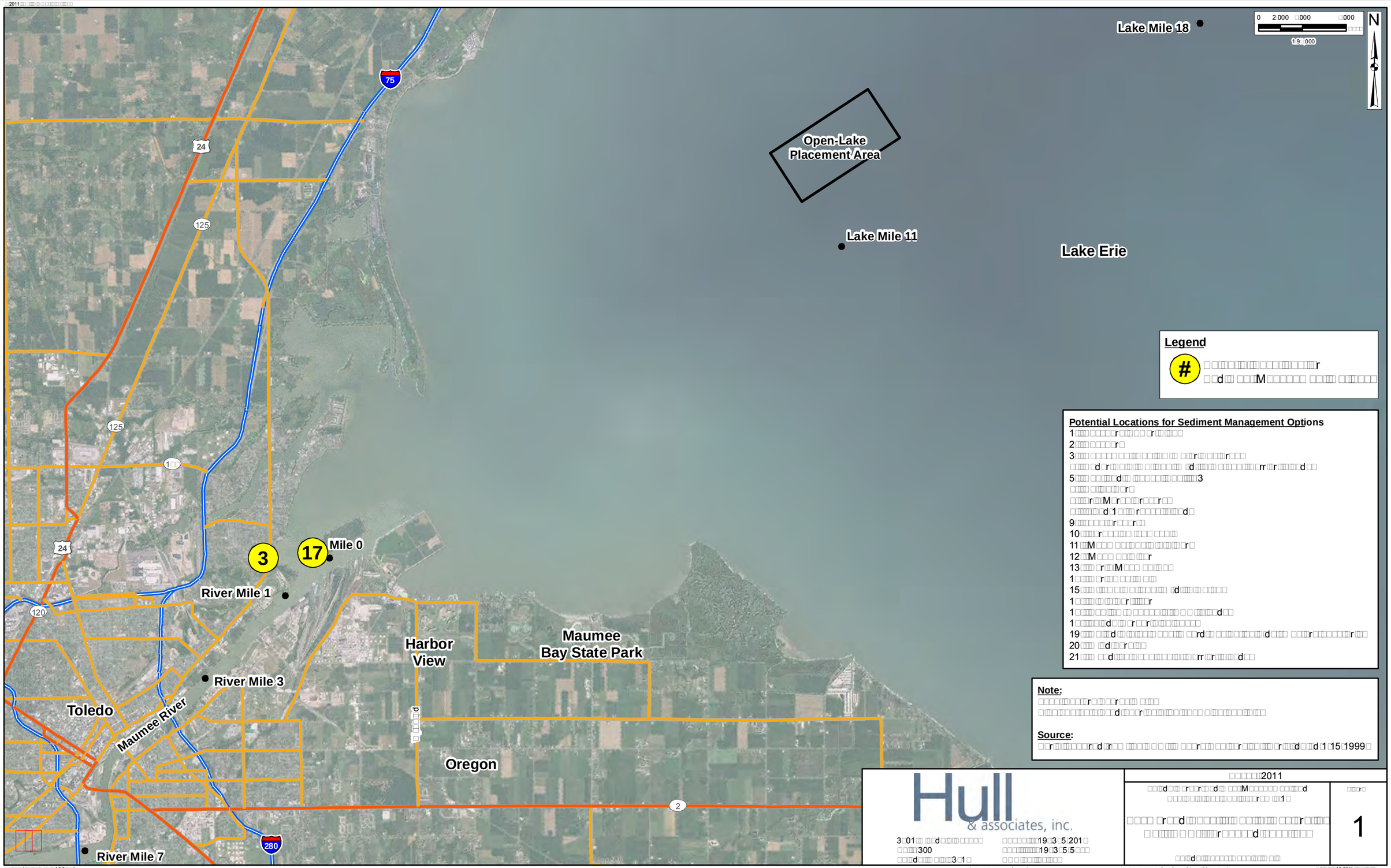
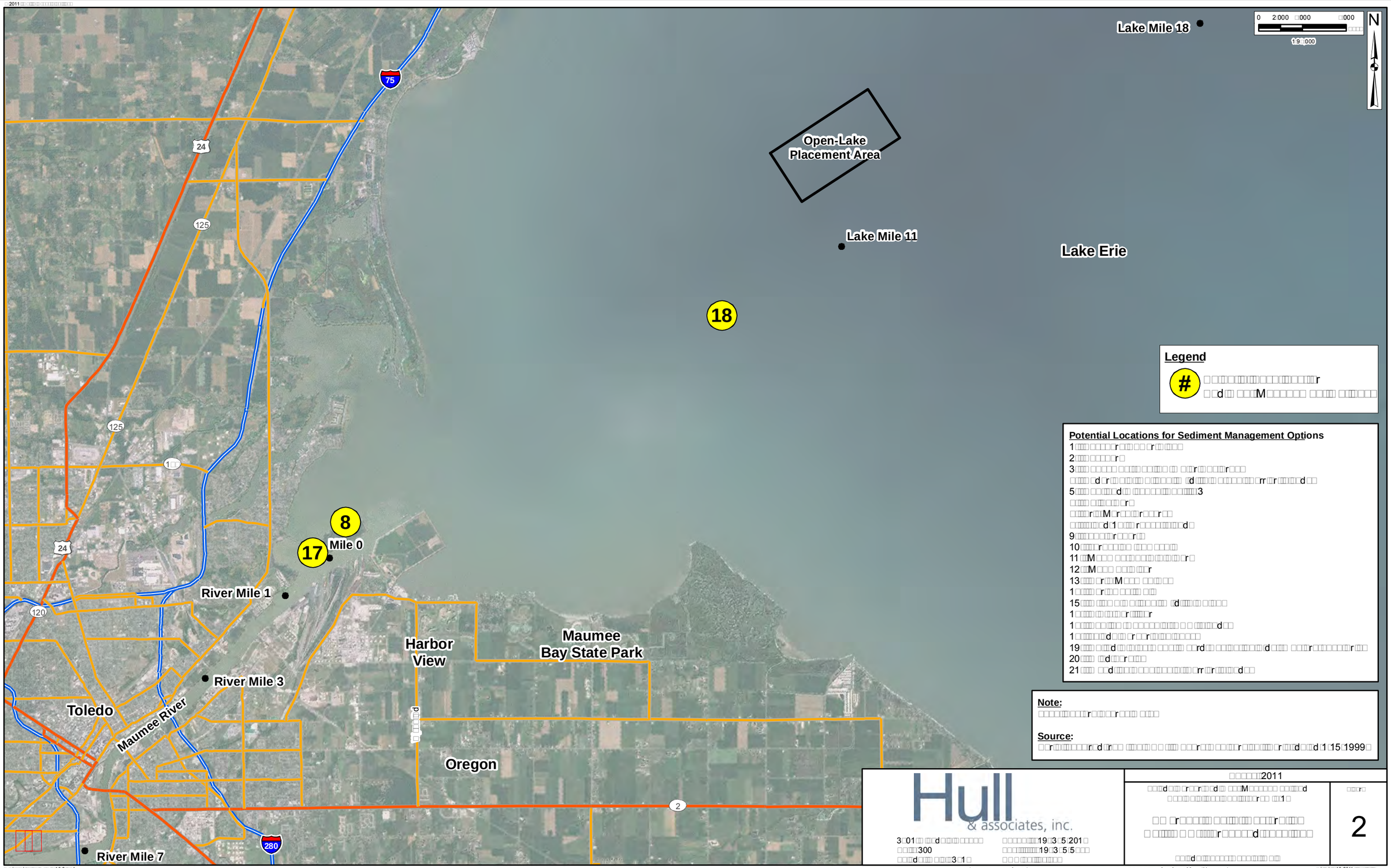
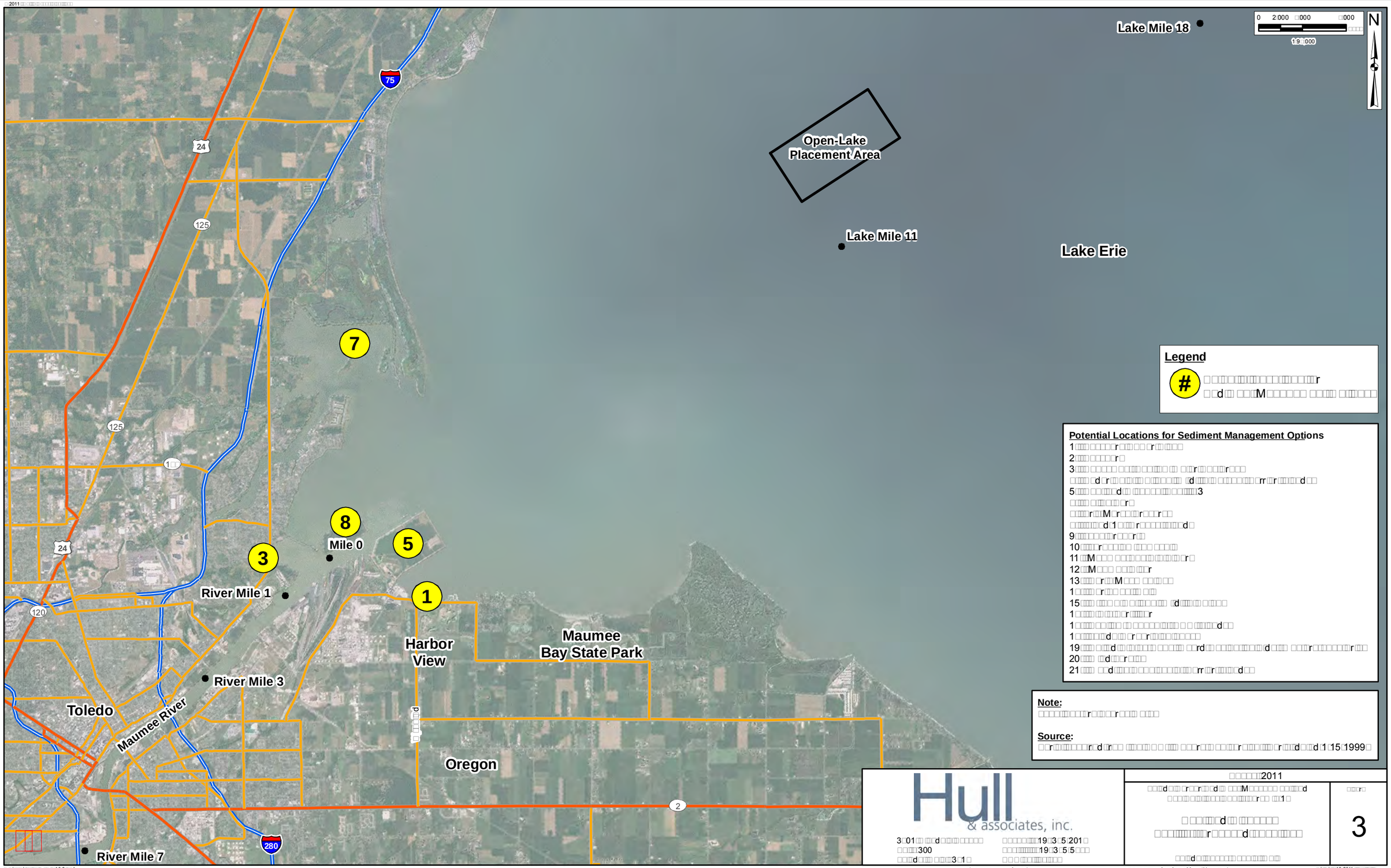
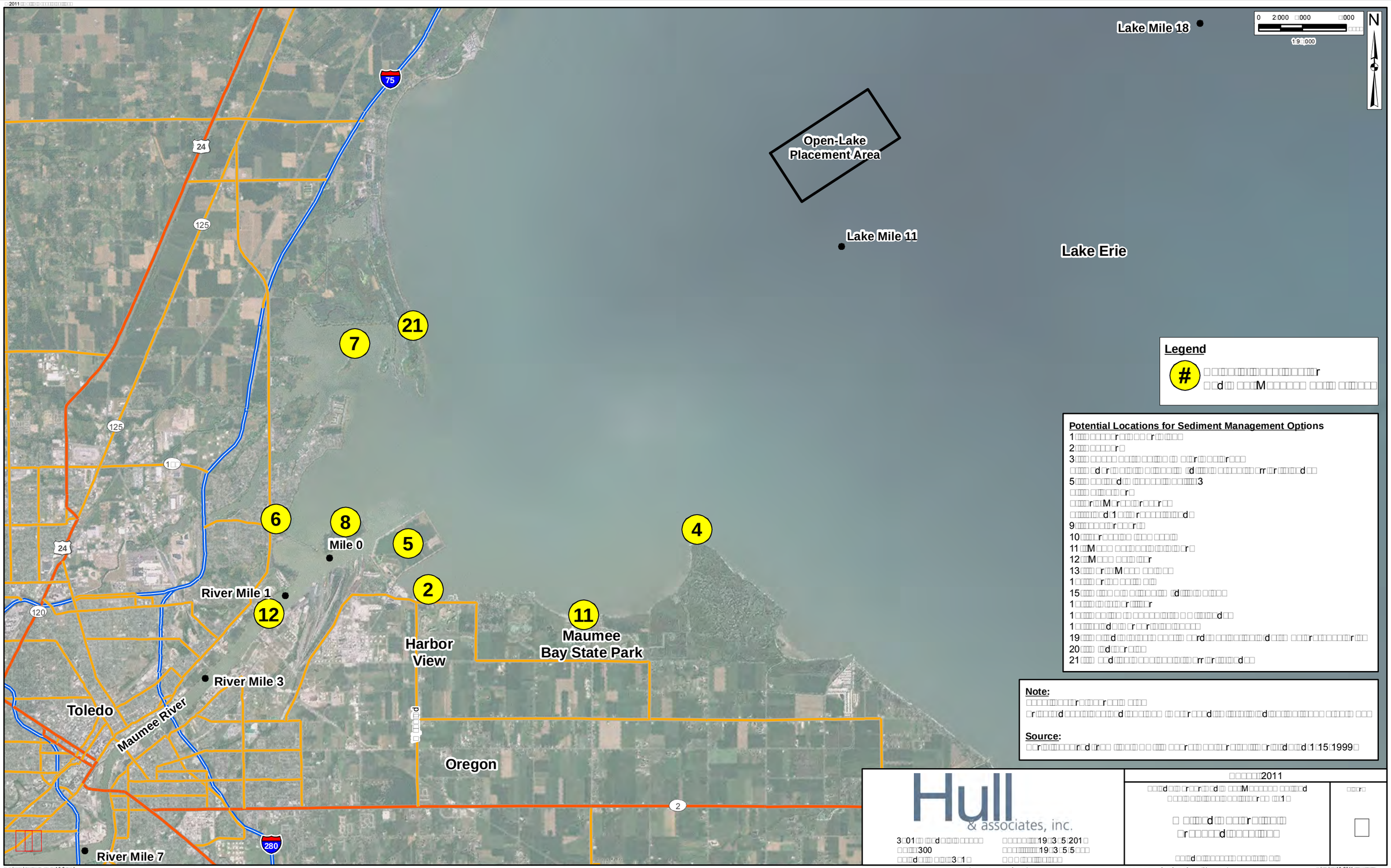
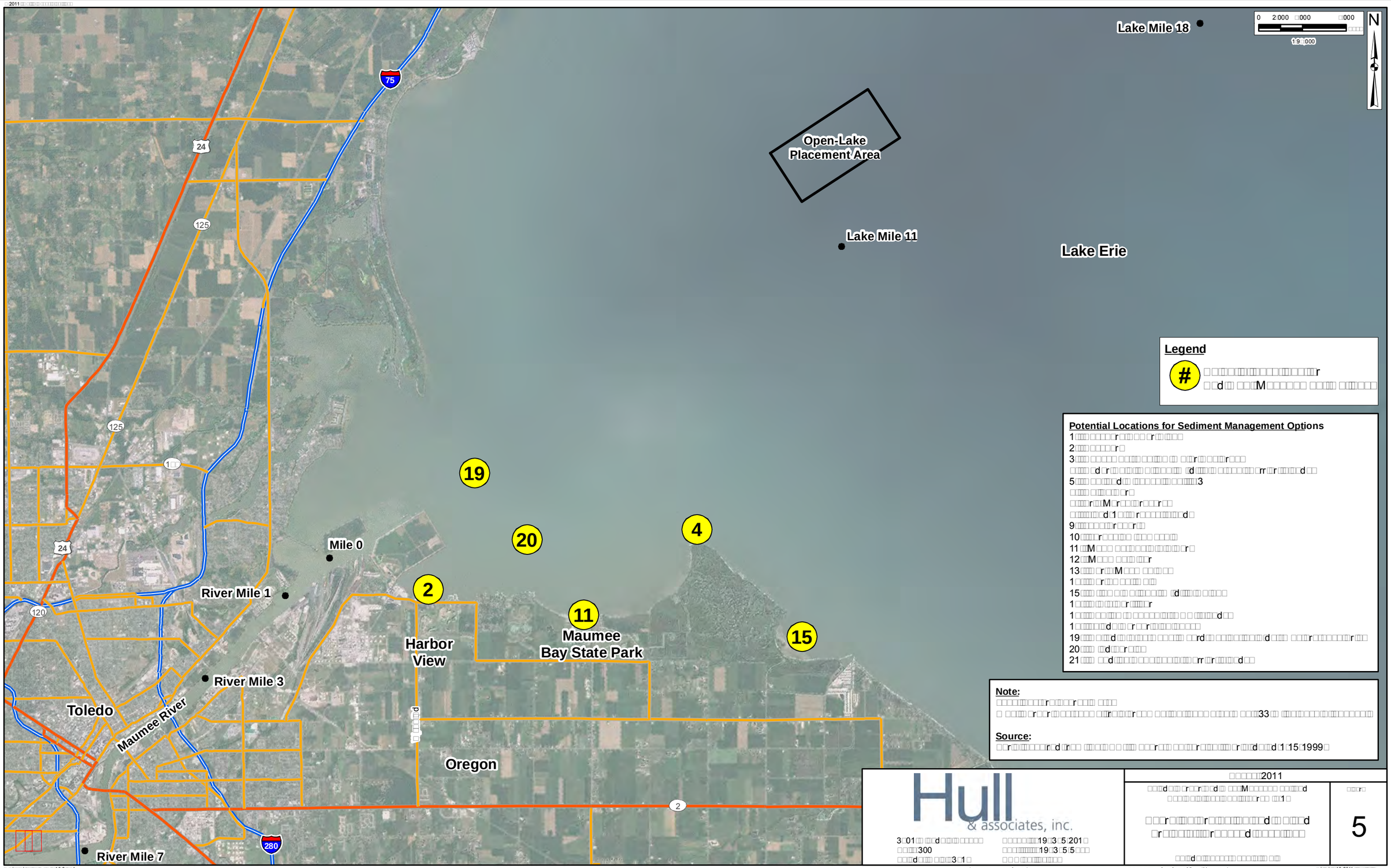

Lake Mile 18
Open-Lake
Placement Area
Lake Mile 11
Lake Erie
Mile 0
River Mile 1
River Mile 3
River Mile 7
Harbor
View
Maumee
Bay State Park
Toledo
Maumee River
Oregon
Legend
Potential Locations for Sediment Management Options
Note:
Source:
Hull
& associates, inc.
2011
1

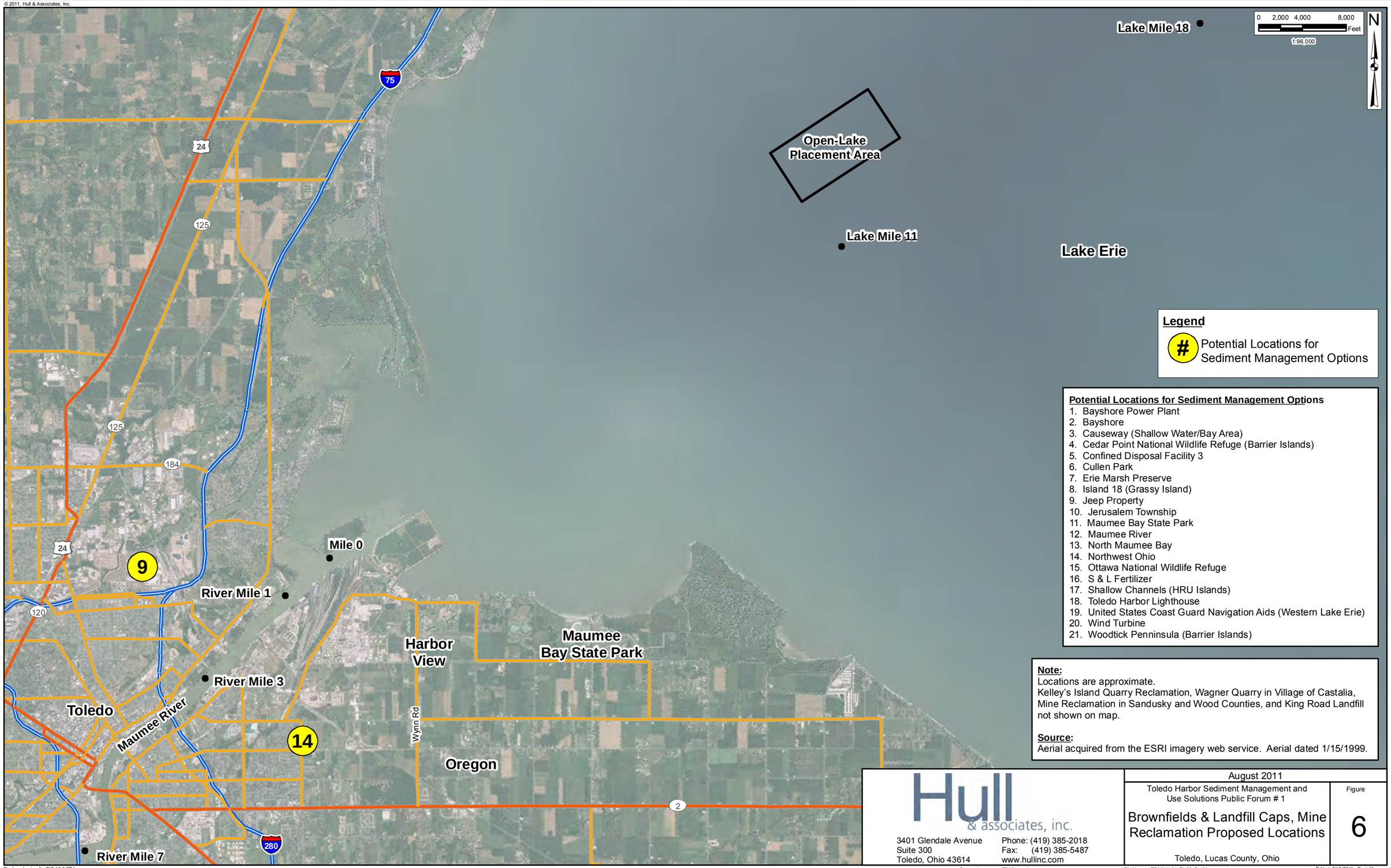

Lake Mile 18
0 2,000 4,000 8,000
19,000
N
Open-Lake
Placement Area
Lake Mile 11
Lake Erie
18
8
17
Mile 0
River Mile 1
River Mile 3
Toledo
Maumee River
Harbor
View
Maumee
Bay State Park
Oregon
River Mile 7
75
24
125
120
280
2
Legend
#
Potential Locations for Sediment Management Options
Note:
Source:
Hull
& associates, inc.
2011
2

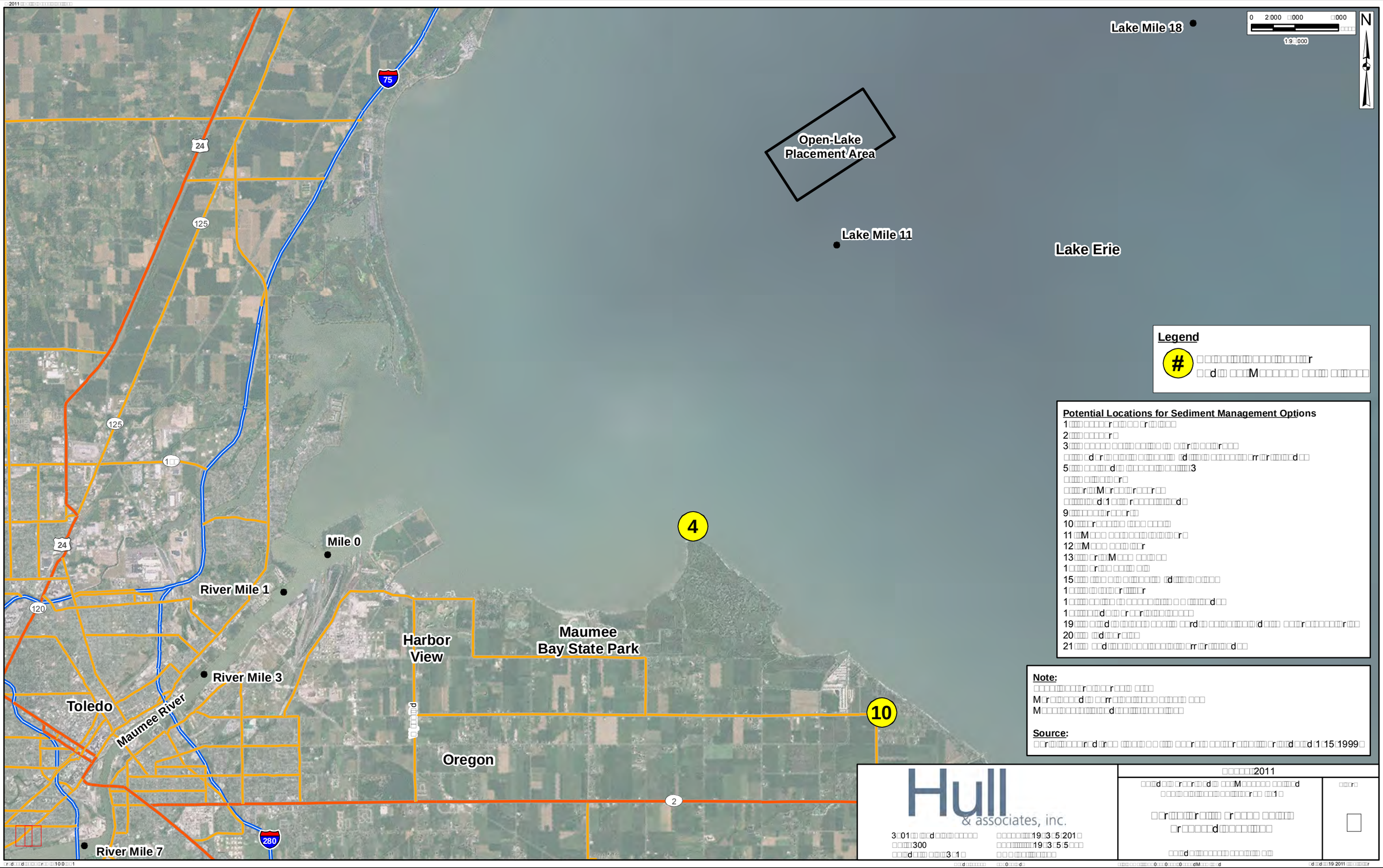

Lake Mile 18
Open-Lake Placement Area
Lake Mile 11
Lake Erie
7
8
Mile 0
5
3
River Mile 1
1
Harbor View
Maumee Bay State Park
River Mile 3
Toledo
Maumee River
Oregon
River Mile 7
75
24
125
120
280
2
N
Legend
#
Potential Locations for Sediment Management Options
Note:
Source:
Hull & associates, inc.
2011
3

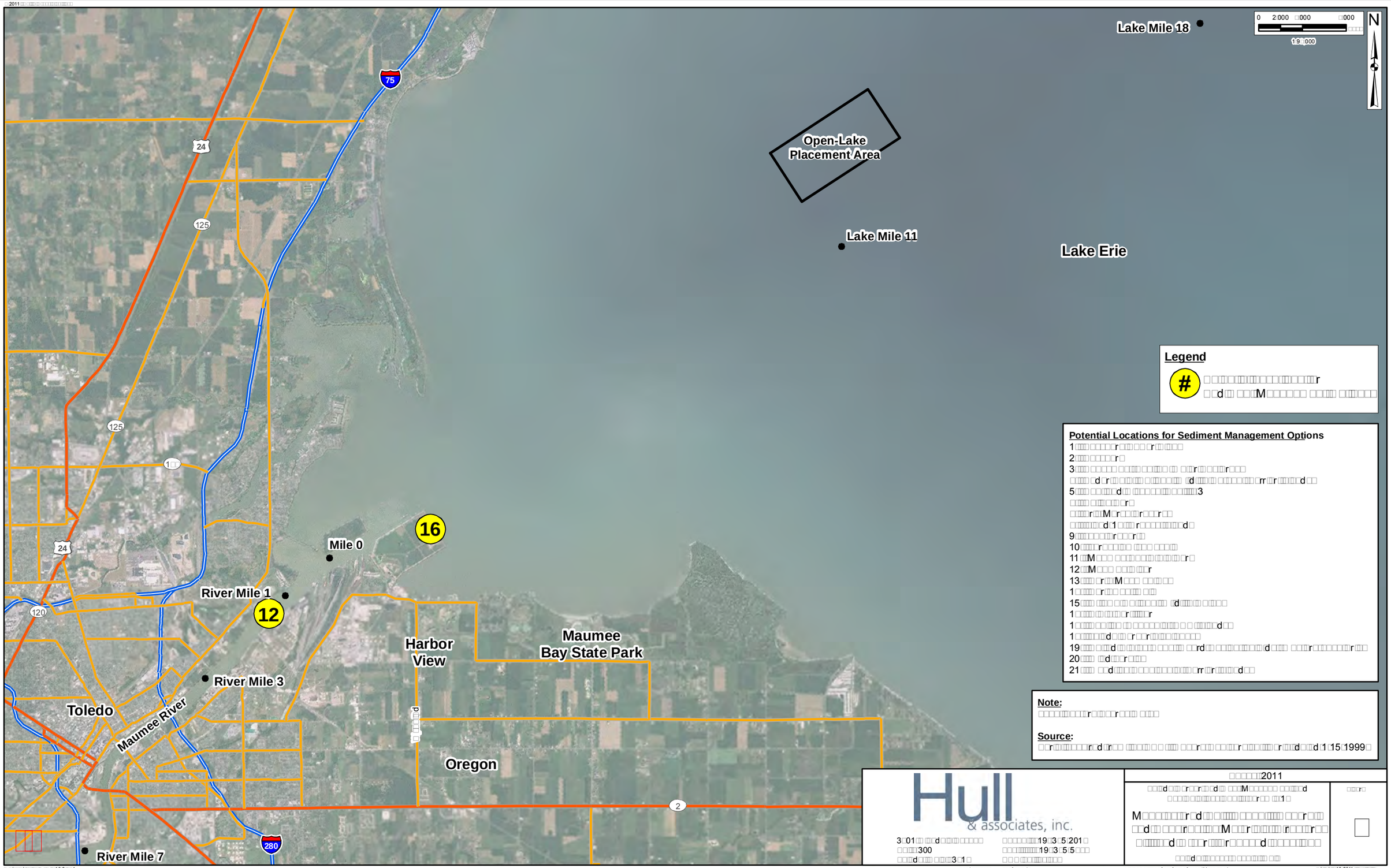

Lake Mile 18
Open-Lake Placement Area
Lake Mile 11
Lake Erie
N
75
24
125
120
280
2
21
7
6
8
Mile 0
5
4
2
12
11
River Mile 1
Harbor View
Maumee Bay State Park
River Mile 3
Toledo
Maumee River
Oregon
River Mile 7
Legend
#
Potential Locations for Sediment Management Options
Note:
Source:
Hull & associates, inc.
2011


Lake Mile 18
Open-Lake Placement Area
Lake Mile 11
Lake Erie
Mile 0
River Mile 1
River Mile 3
River Mile 7
Toledo
Maumee River
Harbor View
Maumee Bay State Park
Oregon
19
20
4
2
11
15
75
24
125
120
280
N
Legend
Potential Locations for Sediment Management Options
Note:
Source:
Hull & associates, inc.
2011
5

© 2011, Hull & Associates, Inc.




Lake Mile 18
N
Open-Lake
Placement Area
Lake Mile 11
Lake Erie
Legend
#
Mile 0
River Mile 1
Harbor
View
Maumee
Bay State Park
River Mile 3
Toledo
Maumee River
Oregon
River Mile 7
4
10
75
24
125
120
280
2
Potential Locations for Sediment Management Options
Note:
Source:
Hull
& associates, inc.
2011


Lake Mile 18
Open-Lake
Placement Area
Lake Mile 11
Lake Erie
Mile 0
16
River Mile 1
12
Harbor
View
Maumee
Bay State Park
River Mile 3
Toledo
Maumee River
Oregon
River Mile 7
75
24
125
120
280
2
N
Legend
Potential Locations for Sediment Management Options
Note:
Source:
Hull
& associates, inc.
2011

# ATTACHMENT A

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**Toledo Harbor Sediment Management and Use Solutions:**
***Technology Development, Project Identification, Prioritization & Implementation***
**Public Forum #1**

Thursday, June 16, 2011
1:00 p.m. - 5:00 p.m.
Toledo Maritime Center, 1701 Front Street, Toledo, Ohio 43605

Introduction

Please join us in a public forum to discuss sediment management and use solutions for the Toledo Harbor. The Great Lakes Commission, Ohio Lake Erie Commission, Toledo-Lucas County Port Authority, and other members of the Toledo Harbor Long-Term Dredge Management Task Force are identifying and evaluating sustainable practices to manage dredged material from the Toledo Harbor in an economically sound and environmentally acceptable manner. This forum will bring together a diverse set of stakeholders to identify potential sediment management and use solutions that are essential to the short and long-term viability of the Toledo Harbor. At this forum and future events planned this year, we want to hear your ideas, issues, and concerns, and solicit your help in determining priorities for evaluation of technical alternatives to create a comprehensive sediment management and use strategy for the Toledo Harbor dredge material program.

Background

Finding solutions for sediment management in the Toledo Harbor is imperative. The Port of Toledo is the most heavily dredged port in the Great Lakes with the annual removal of approximately one million cubic yards of sediment from the federal and non-federal channels located in the lower seven miles of the Maumee River and the approach channel that extends 19 miles in Maumee Bay. The Port of Toledo is critical to the economic viability of Northwest Ohio, providing commerce to the entire Great Lakes region and facilitating international commerce and commodity transportation through the St. Lawrence Seaway by annually handling approximately 11 million tons of cargo.

Purpose

Sediment dredged from the Toledo Harbor is currently managed by a combination of open lake disposal and placement into confined disposal facilities - with a minor portion of dredged material being beneficially used. Due to environmental impacts resulting from the significant re-suspension of sediment in the shallow western basin of Lake Erie, Ohio EPA has limited future open lake disposal of dredged sediments. While reductions in erosion and sediment loads in the watershed are recognized components of a good long-term management strategy, at this forum, we will focus on approaches to manage dredged material, including:

- exploring sediment use for product manufacturing
- nearshore improvements
- upland/farmland placement
- strip mine reclamation
- in-water habitat restoration units
- others

We hope you can join us!
There is no charge for this event, but an RSVP is required.
Please complete the attached RSVP form and email the form to lakeeriecommission@ameritech.net.

Visit www.toledoseaport.org for more information and the forum agenda.

Forum presented by:

Great Lakes Commission des Grands Lacs

Ohio | Lake Erie Commission

TOLEDO | LUCAS COUNTY PORT AUTHORITY

*This effort is funded in part through a*
*Great Lakes Restoration Initiative Grant through U.S. EPA.*

**RSVP**

**Toledo Harbor Sediment Management and Use Solutions:**

***Technology Development, Project Identification, Prioritization & Implementation***

**Public Forum #1**

Thursday, June 16, 2011
1:00 p.m. - 5:00 p.m.
Toledo Maritime Center, 1701 Front Street, Toledo, Ohio

**R.S.V.P.** ____ I will attend. ____ I cannot attend, but please keep me informed of future activities.

Name:_____ Organization: _____

Address: _____ E-mail:_____

_____ Phone number: _____

1. Would you like to share your ideas or specific concepts for dredge material management that could include product manufacturing, nearshore improvements, upland/farmland placement, strip mine reclamation, and in-water habitat restoration unit applications? Please briefly describe your idea(s) or concepts and attach any detailed information that you may have to allow us to thoroughly develop your ideas for later assessment. Please do so even if you cannot attend the forum.

2. Have you been involved with any sediment management and use planning efforts for the Toledo Harbor? If so, briefly describe.

3. Which of the following are you most concerned about regarding dredge material management? (Select one)

Environmental Aspects _____ Economic Aspects _____ Both Equally _____

Please email this RSVP form by June 9th to lakeeriecommission@ameritech.net or mail it to:

Ohio Lake Erie Commission
One Maritime Plaza, 4th Floor
Toledo, OH 43604

Visit www.toledoseaport.org for more information and the forum agenda.

Forum presented by:

Great Lakes Commission des Grands Lacs

Ohio | Lake Erie Commission

TOLEDO | LUCAS COUNTY PORT AUTHORITY

*This effort is funded in part through a*
*Great Lakes Restoration Initiative Grant through U.S. EPA.*

# ATTACHMENT B

[illegible]d [illegible]d [illegible]r [illegible] [illegible]r [illegible]

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toledoBlade.com

# Use for river, bay dredgings to be forum topic

BLADE STAFF

The public is invited to a free, four-hour session Thursday about potential markets for millions of pounds of muck the U.S. Army Corps of Engineers digs up each year so that large cargo ships can continue to ply through Toledo-area water.

For years, the corps has spent roughly $20 million a year to dredge 4 million cubic yards of sediment from Great Lakes harbors and channels, the equivalent of 400,000 truckloads of soil.

Nearly a quarter of that comes from the Toledo shipping channel in the Maumee River and western Lake Erie's Maumee Bay, the shallowest and most heavily dredged part of the Great Lakes.

From 1 to 5 p.m., officials will seek ideas from the public on how best to keep the shipping channel from filling in so quickly with more sediment runoff. Most of it comes from northwest Ohio and northeastern Indiana farms.

Officials also are looking for markets for the dirt, such as product manufacturing, fishing reefs, or strip-mine reclamation. The majority of it gets dumped into Lake Erie's North Maumee Bay, one of the region's most productive fish nurseries. Biologists claim the turbidity it creates hurts the region's $7 billion fishery.

The session will be at the Toledo Maritime Center, 1701 Front St. in Toledo's Marina District. It is being presented by the Great Lakes Commission, the Ohio Lake Erie Commission, and the Toledo-Lucas County Port Authority, with funding from the U.S. Environmental Protection Agency. For more information, contact the Ohio Lake Erie Commission at 419-245-2514.

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To contact a specific department or an individual person, click here.
The Toledo Times ®

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# ATTACHMENT C

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## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS INITIAL PUBLIC FORUM

### ATTACHMENT C

### LIST OF PARTICIPANTS

| | FIRST NAME | LAST NAME | ORGANIZATION |
|---|---|---|---|
| 1 | [illegible] | [illegible] | [illegible] |
| 2 | [illegible] | [illegible] | [illegible] |
| 3 | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| 5 | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| 9 | [illegible] | [illegible] | [illegible] |
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| [illegible] | [illegible] | [illegible] | [illegible] |
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| [illegible] | [illegible] | [illegible] | [illegible] |
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| 21 | [illegible] | [illegible] | [illegible] |
| 22 | [illegible] | [illegible] | [illegible] |
| 23 | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| 25 | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| 29 | [illegible] | [illegible] | [illegible] |
| 30 | [illegible] | [illegible] | [illegible] |
| 31 | [illegible] | [illegible] | [illegible] |
| 32 | [illegible] | [illegible] | [illegible] |
| 33 | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| 35 | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| 39 | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
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# ATTACHMENT D

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**Toledo Harbor Sediment Management and Use Solutions**

**Stakeholder Forum #1**

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1 00 [illegible] r [illegible]
*Dave Knight, Special Projects Manager, Great Lakes Commission*

1 10 [illegible] d [illegible] r [illegible]
*John Hull, P.E., Principal, Hull & Associates, Inc.*

1 20 [illegible] r [illegible] d [illegible] r [illegible] r [illegible] r [illegible] r [illegible]
*Ed Hammett, Executive Director, Ohio Lake Erie Commission*

1 30 [illegible] r [illegible] d [illegible] r [illegible] r [illegible] r [illegible]
*Joseph Cappel, Director of Cargo Development, Toledo-Lucas County Port Authority*

1 0 [illegible] r d [illegible] d [illegible] M [illegible] d [illegible] r [illegible] r [illegible] r [illegible] r d [illegible]
*John Hull*

2 00 [illegible] r [illegible] r [illegible] d [illegible]
*John Hull*

2 20 [illegible] r [illegible]

2 35 [illegible] r [illegible]

3 0 [illegible] r [illegible] r [illegible]

30 [illegible] r [illegible] r [illegible] d [illegible]
*Ed Hammett*
*John Hull*

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# ATTACHMENT E

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# Toledo Harbor Sediment Management and Use Solutions

Thursday, June 16, 2011
Toledo Maritime Center

## Forum Organizations and Funders

Ohio Lake Erie Commission

TOLEDO | LUCAS COUNTY PORT AUTHORITY

Great Lakes Commission des Grands Lacs

Great Lakes RESTORATION

Great Lakes Commission
des Grands Lacs

Great Lakes RESTORATION

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r r M 10 91
3 9 1 9135
d r

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- [illegible] 2011 [illegible] 350 [illegible]
- [illegible] 2010 [illegible] 300 [illegible]

## Five focus areas

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Hull & associates, inc.

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[illegible] [illegible]r [illegible]

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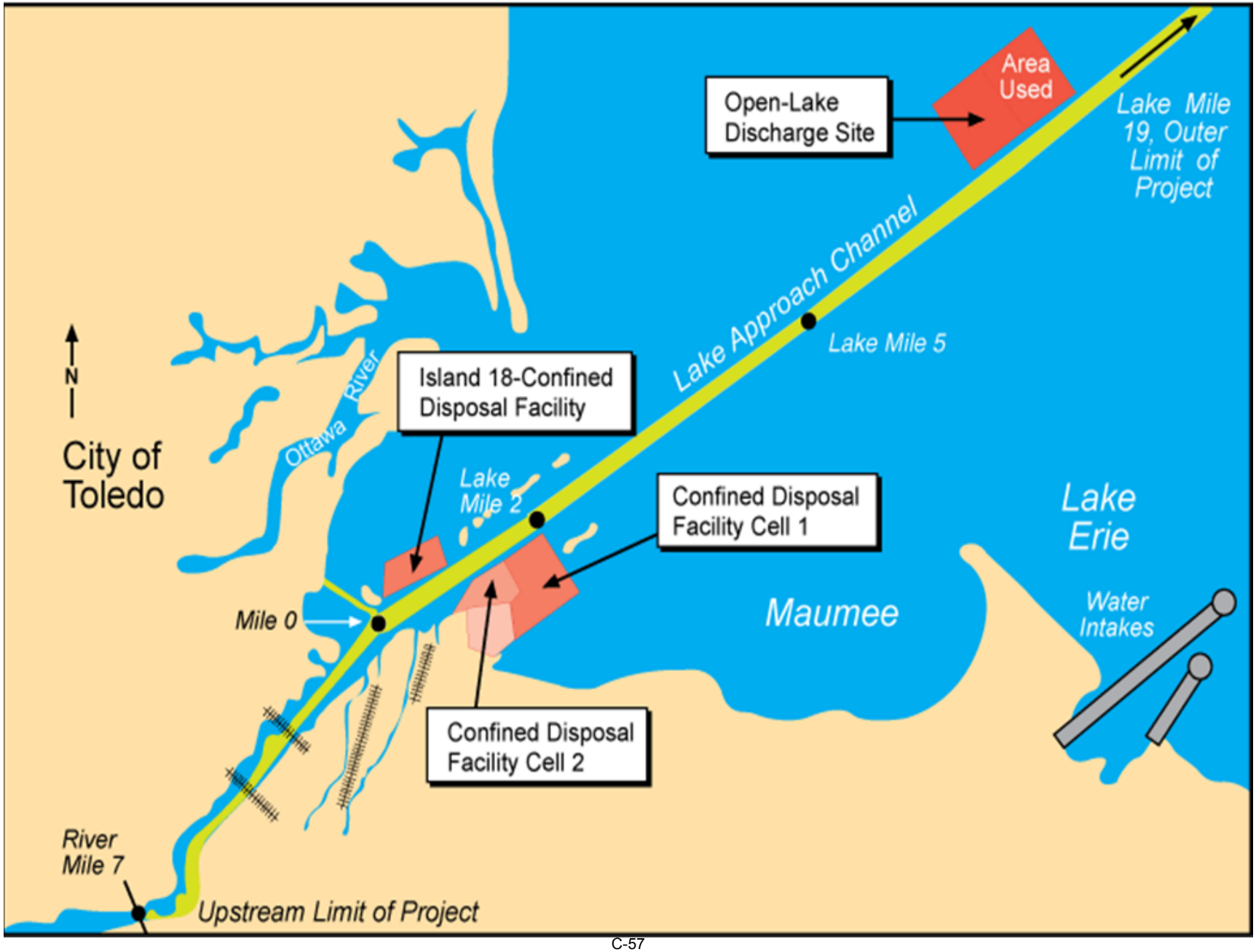
Open-Lake Discharge Site
Area Used
Lake Mile 19, Outer Limit of Project
Lake Approach Channel
Lake Mile 5
N
City of Toledo
Ottawa River
Island 18-Confined Disposal Facility
Lake Mile 2
Confined Disposal Facility Cell 1
Lake Erie
Mile 0
Maumee
Water Intakes
Confined Disposal Facility Cell 2
River Mile 7
Upstream Limit of Project

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  - [illegible]
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    - [illegible] 30 [illegible]
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  - [illegible]

# [illegible]

[illegible]

[illegible]

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[illegible]

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  - [illegible] 2011

Ohio Lake Erie Commission

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19 2 5 251
d r

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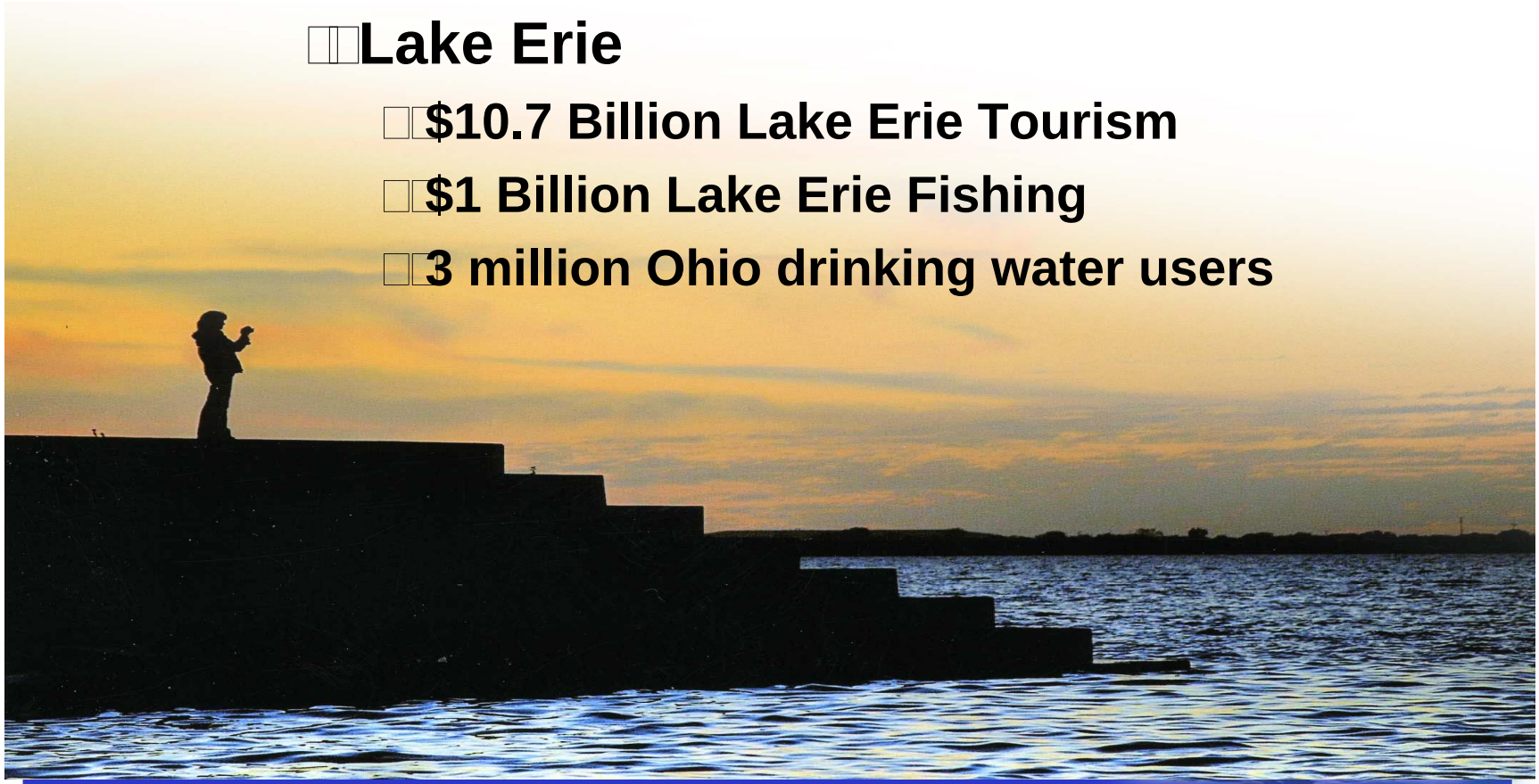
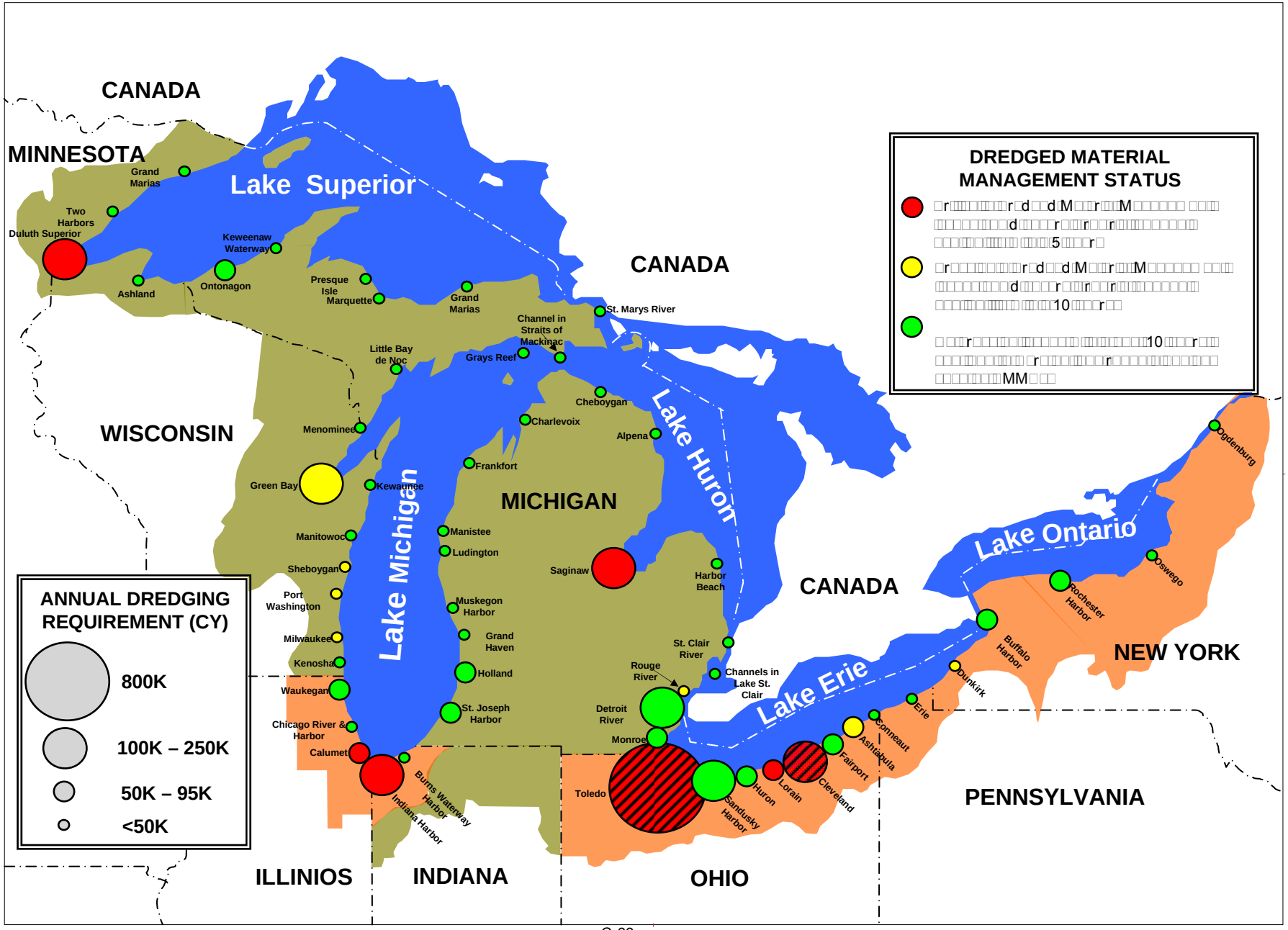
- □□Lake Erie
  - □□$10.7 Billion Lake Erie Tourism
  - □□$1 Billion Lake Erie Fishing
  - □□3 million Ohio drinking water users




CANADA
MINNESOTA
Lake Superior
Grand Marias
Two Harbors
Duluth Superior
Keweenaw Waterway
Ontonagon
Ashland
Presque Isle
Marquette
Grand Marias
CANADA
St. Marys River
Channel in Straits of Mackinac
Grays Reef
Little Bay de Noc
Cheboygan
Charlevoix
Alpena
Lake Huron
WISCONSIN
Menominee
Frankfort
Green Bay
Kewaunee
MICHIGAN
Lake Michigan
Manitowoc
Manistee
Ludington
Sheboygan
Saginaw
Harbor Beach
Port Washington
Muskegon Harbor
Milwaukee
Grand Haven
St. Clair River
Kenosha
Holland
Rouge River
Channels in Lake St. Clair
Waukegan
St. Joseph Harbor
Detroit River
Chicago River & Harbor
Monroe
Calumet
Burns Waterway Harbor
Indiana Harbor
Toledo
Sandusky Harbor
Huron
Lorain
Cleveland
Fairport
Ashtabula
Conneaut
Erie
Dunkirk
Buffalo Harbor
Rochester Harbor
Oswego
Ogdenburg
Lake Ontario
Lake Erie
CANADA
NEW YORK
PENNSYLVANIA
ILLINIOS
INDIANA
OHIO
DREDGED MATERIAL MANAGEMENT STATUS
ANNUAL DREDGING REQUIREMENT (CY)
800K
100K – 250K
50K – 95K
<50K

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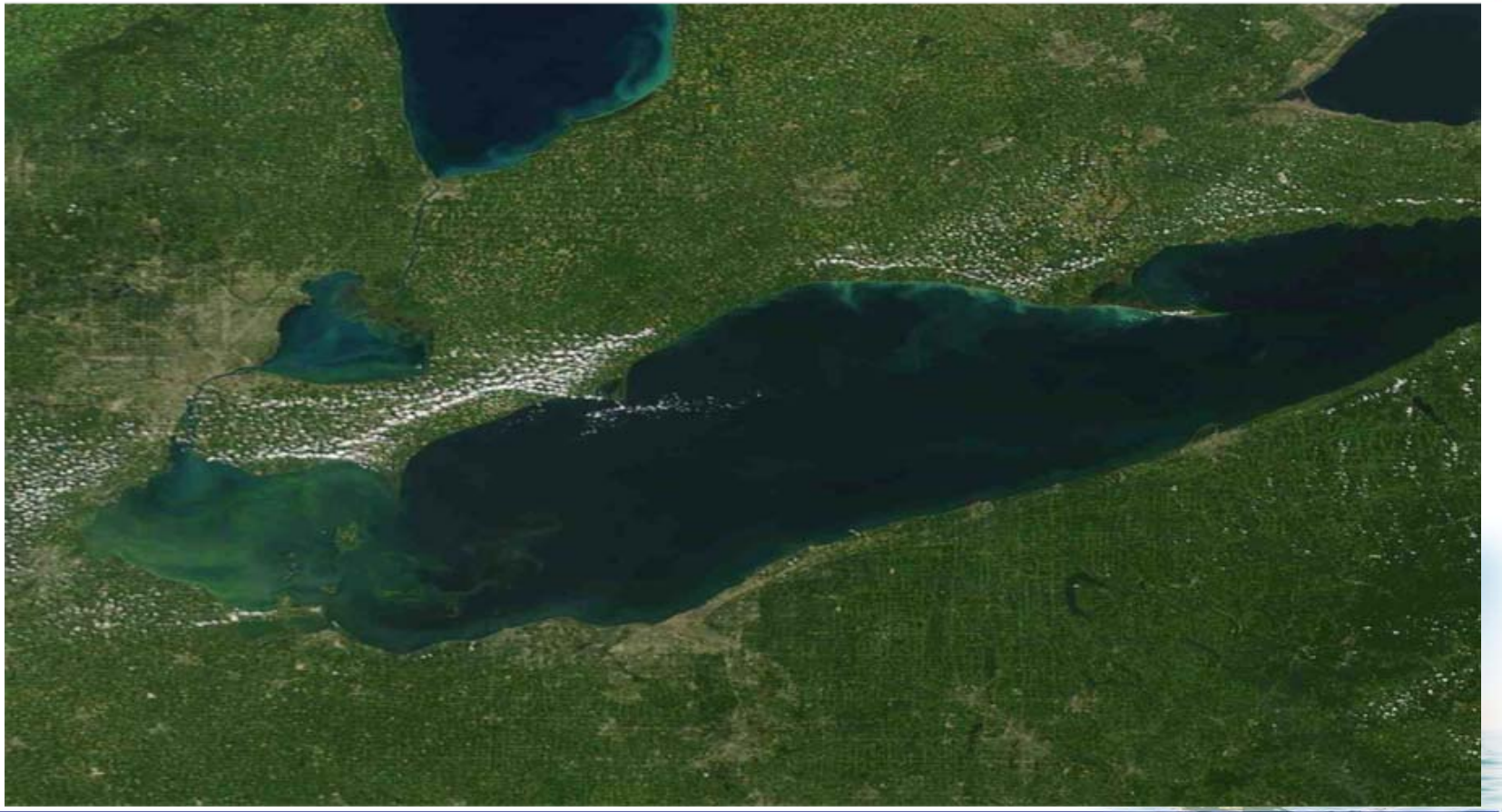

# [illegible]

## Current : 850,000 yd³

[illegible] 850,000 yd³

[illegible] 22 [illegible]

[illegible]

## Proposed : 1,250,000 yd3

[illegible] 1,250,000 yd³

[illegible] 33 [illegible]

[illegible]

[illegible]

# WWTP Effluent vs. Dredged Sediment

| Parameter | Toledo Bay View WWTP Effluent (based on 2008 data) | Toledo Harbor Dredged Sediment (based on 2004 data & 1.25 million cu. Yds) |
|---|---|---|
| [illegible] | [illegible] | 2[illegible]50[illegible] |
| [illegible] | [illegible] | [illegible]03[illegible] |
| M[illegible] | 2[illegible]1[illegible] | [illegible]20[illegible] |
| [illegible] | [illegible] | 0[illegible]1[illegible] |
| [illegible] | 5[illegible]1[illegible] | 250[illegible] |
| [illegible] | [illegible]9[illegible] | 120[illegible]2[illegible] |
| [illegible] | 9[illegible]3[illegible] | 2[illegible]0[illegible]2[illegible]500[illegible] |
| [illegible] | [illegible] | 1[illegible]25[illegible] |
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| [illegible] | [illegible]1[illegible]200[illegible] | [illegible]10[illegible]5[illegible] |

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[illegible] r [illegible] r [illegible] r d [illegible] d [illegible]

[illegible] d [illegible] r [illegible] r d [illegible]

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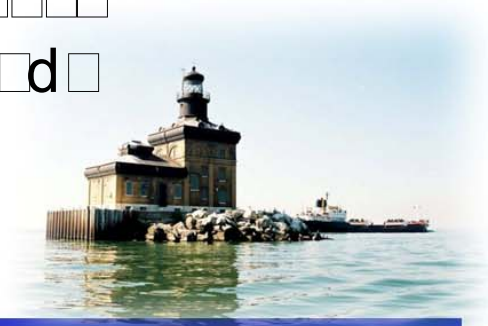

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TOLEDO | LUCAS COUNTY
PORT AUTHORITY

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[illegible]

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[illegible]3000[illegible]

[illegible]90[illegible]0[illegible]

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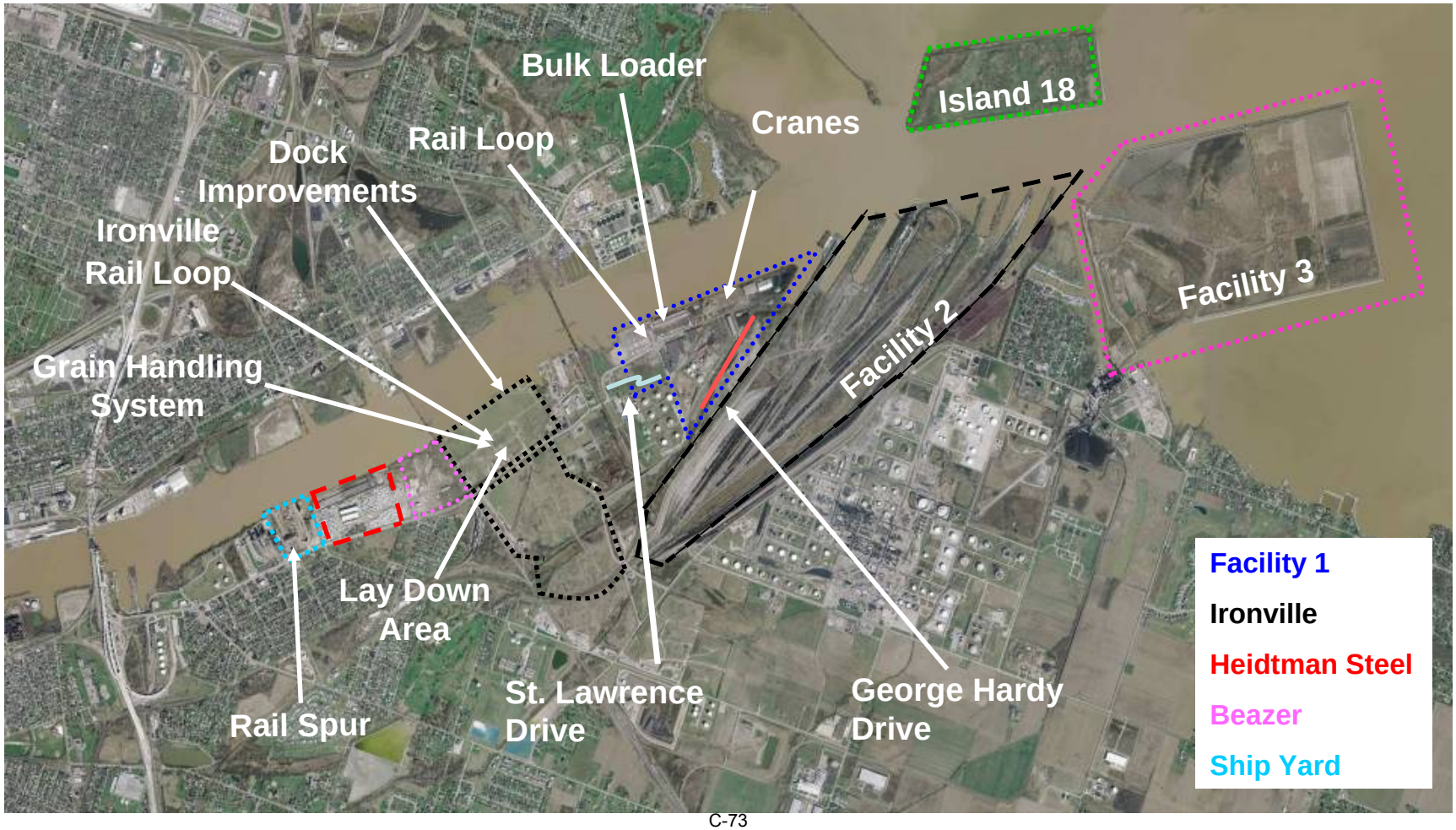
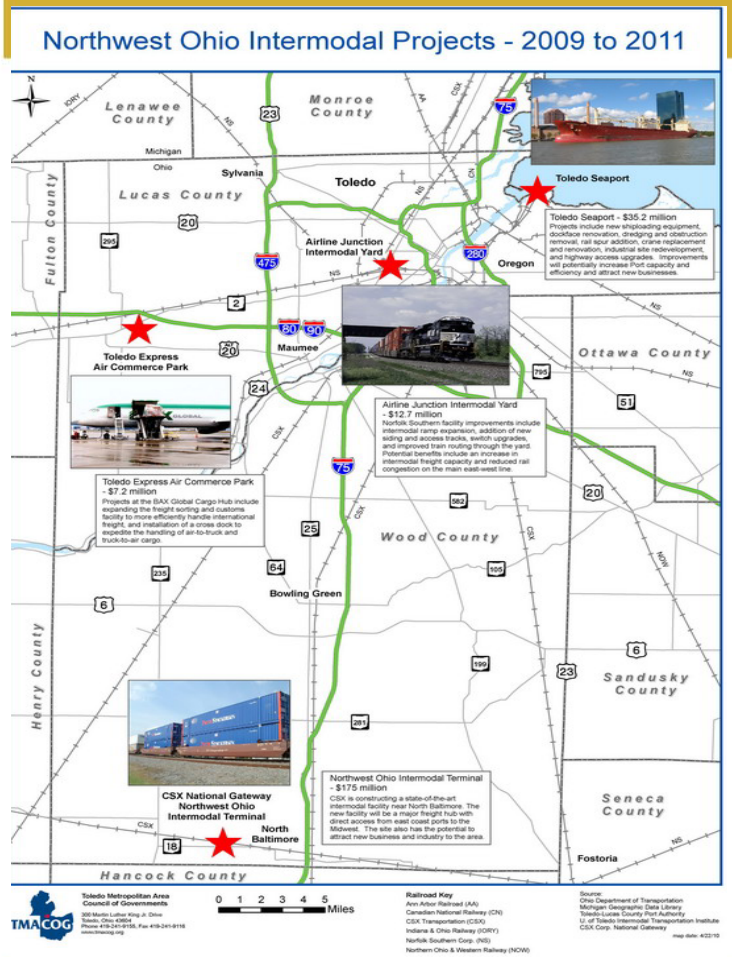

Bulk Loader
Island 18
Cranes
Rail Loop
Dock Improvements
Ironville Rail Loop
Facility 3
Facility 2
Grain Handling System
Lay Down Area
Rail Spur
St. Lawrence Drive
George Hardy Drive
Facility 1
Ironville
Heidtman Steel
Beazer
Ship Yard

# □□ □□ □□□□□□□□r□ □d□□□r□□□□□□□
# 2009□2011




- □□ **Port Authority $35.2 M**
  - □□**Ship/Rail/Truck**
- □□ **Airline Yard $12.8 M**
  - □□**Rail/Truck**
- □□ **Toledo Express $7.2 M**
  - □□**Air/Truck**
- □□ **CSX Gateway <u>$175 M</u>**
  - □□**Rail/Truck**

**Total Intermodal Construction : $230.2 M**

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- [illegible]
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& associates, inc.

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- □□ **Dredged Material Management**

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Grassy Island
(Island 18)
Cell 2
Facility 3
Cell 1
Facility 3
Maumee River

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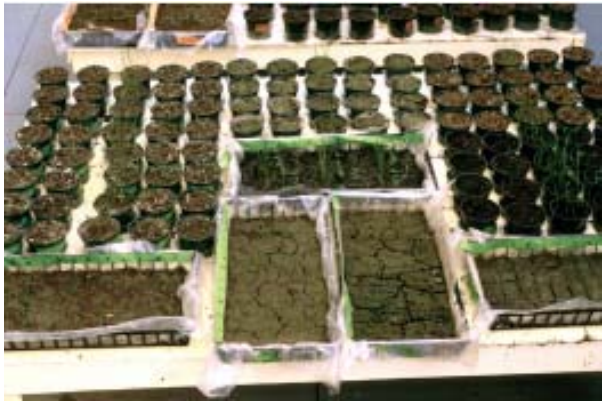

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□□d□□□□
□□r□□□

Define problem

Generate project concepts

Identify criteria to compare project concepts

Gather value judgments on relative importance of criteria

Screen/eliminate locally impractical project concepts

Determine performance of project concepts for criteria

Rank/select final project concepts/combinations

Stakeholder Final Review

Draft Plan Presented May 2012

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[illegible]

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## [illegible]

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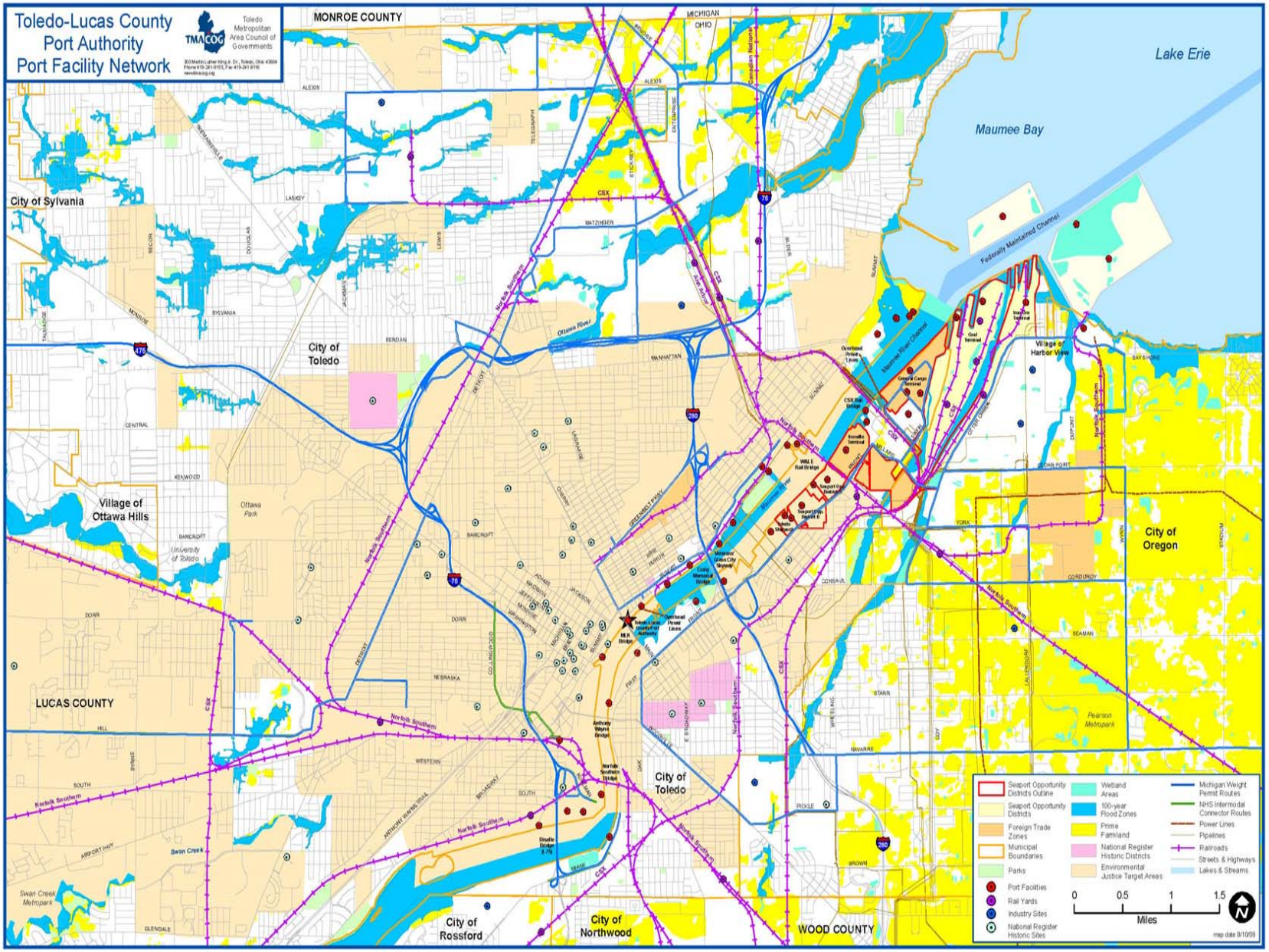
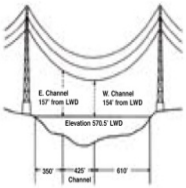

Toledo-Lucas County
Port Authority
Port Facility Network
Toledo Metropolitan Area Council of Governments
MONROE COUNTY
MICHIGAN
OHIO
Lake Erie
Maumee Bay
Federally Maintained Channel
City of Sylvania
City of Toledo
Village of Ottawa Hills
Village of Harbor View
City of Oregon
LUCAS COUNTY
City of Rossford
City of Northwood
WOOD COUNTY
Ottawa Park
University of Toledo
Pearson Metropark
Swan Creek Metropark
Seaport Opportunity Districts Outline
Seaport Opportunity Districts
Foreign Trade Zones
Municipal Boundaries
Parks
Port Facilities
Rail Yards
Industry Sites
National Register Historic Sites
Wetland Areas
100-year Flood Zones
Prime Farmland
National Register Historic Districts
Environmental Justice Target Areas
Michigan Weight Permit Routes
NHS Intermodal Connector Routes
Power Lines
Pipelines
Railroads
Streets & Highways
Lakes & Streams
0
0.5
1
1.5
Miles
map date 8/1/09

# Toledo Harbor Map / Maumee River / Lake Erie

Overhead Wire Crossing Map Key 1

(View Looking Upriver)

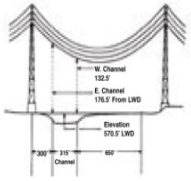



Maintain 15 feet Minimum For Electrical Clearance

(River and channel measurements are approximate)

Overhead Wire Crossing Map Key 2

(View Looking Upriver)

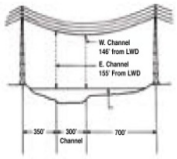



Maintain 10 feet Minimum For Electrical Clearance

(River and channel measurements are approximate)

Overhead Wire Crossing Map Key 3

(View Looking Upriver)




Maintain 10 feet Minimum For Electrical Clearance

(River and channel measurements are approximate)

**Structures across Maumee River at Toledo**

*Miles above the mouth of the river

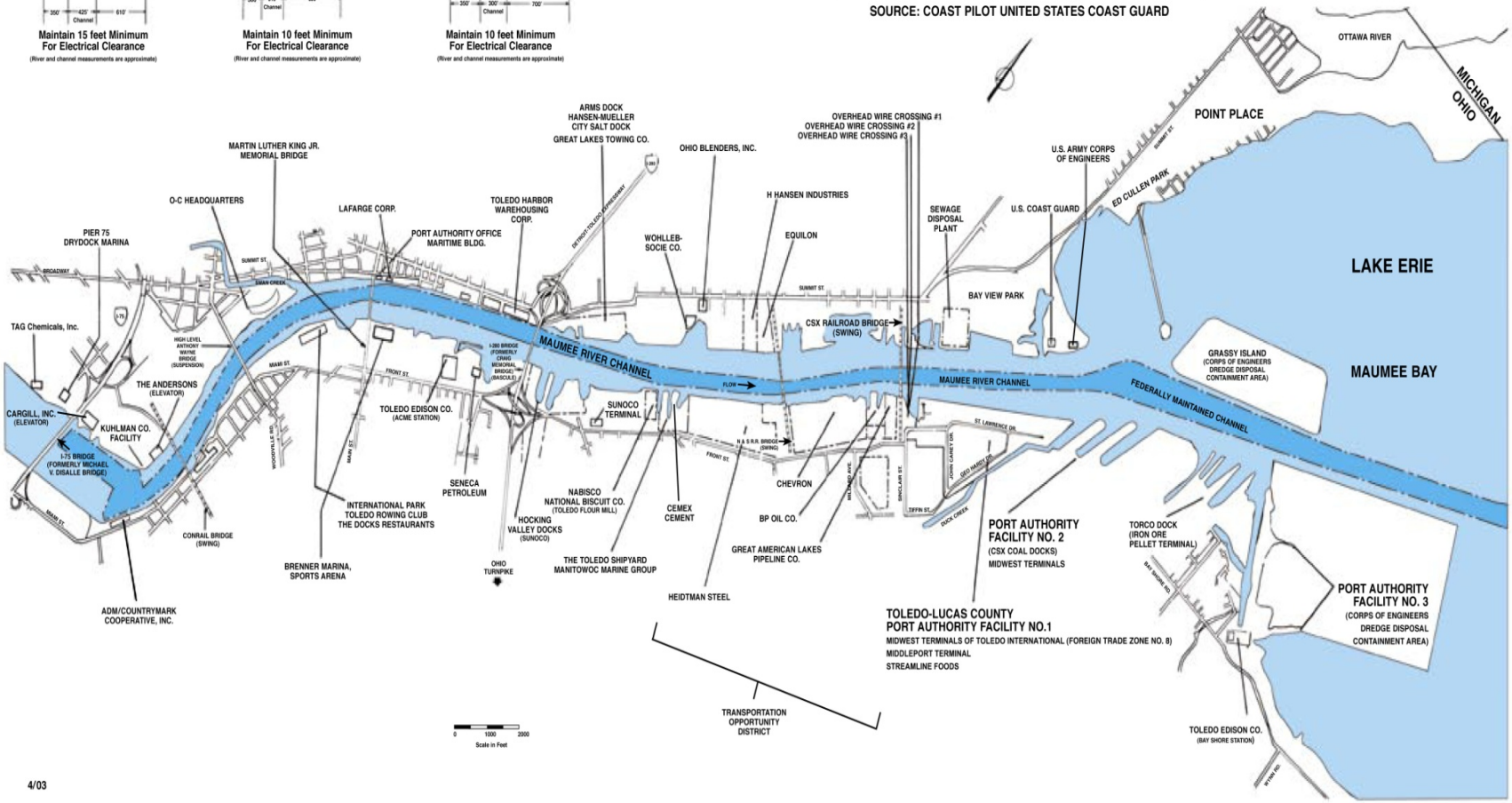
** Clear width in feet proceeding upstream

| No. | Location and Name | Kind | Miles* | Clear width in feet of draw or span openings** | | | Clear height in feet above Low Water Datum | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Right | Left | Center | | |
| 1 | Overhead Cable | Power | 0.92 | | | | 154 | |
| 2 | Overhead Cable | Power | 1.03 | | | | 129 | 132 feet over channel |
| 3 | Overhead Cable | Power | 1.06 | | | | 146 | |
| 4 | Toledo Terminal RR Bridge | Railroad | 1.07 | 143 | 145 | | 22 | Swing |
| 5 | Norfolk & Western Ry. | Railroad | 1.80 | 145 | 136 | | 20 | Swing |
| 6 | Craig Memorial Bridge | Highway | 3.30 | | | 200 | 38 | Bascule. 44 feet at center |
| 7 | Overhead cable | Power | 4.06 | | | | 140 | |
| 8 | Martin Luther King Memorial Bridge | Highway | 4.30 | | | 200 | 21 | Bascule. 31 feet at center |
| 9 | Anthony Wayne Bridge | Highway | 5.16 | | | 747 | 104 | Fixed. Note 1. |
| 10 | ConRail Bridge | Railroad | 5.76 | 115 | 115 | | 17 | Swing |
| 11 | Overhead cable | Power | 5.76 | | | | 105 | |
| 12 | Michael DiSalle Bridge | Highway | 6.73 | 110 | 110 | | 45 | Fixed |

SOURCE: COAST PILOT UNITED STATES COAST GUARD

TOLEDO | LUCAS COUNTY PORT AUTHORITY


TOLEDO-LUCAS COUNTY PORT AUTHORITY
ONE MARITIME PLAZA
TOLEDO, OHIO 43604-1866
(419) 243-8251
FAX (419) 243-1835
www.toledoportauthority.org


4/03

## Submerged Aquatic Habitat Restoration Unit (HRU)

| Idea | Location |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |

# [illegible]

| Criteria | |
|---|---|
| Human Benefits | [illegible] |
| | [illegible] |
| | [illegible] |
| | [illegible] |
| | [illegible] |
| Ecological Benefits | [illegible] |
| | [illegible] |
| | [illegible] |
| Economic Benefits | [illegible] |
| | [illegible] |
| | [illegible] |

| | |
|---|---|
| Feasibility | [illegible] |
| | [illegible] |
| | [illegible] |
| | [illegible] |
| Implementation Costs | [illegible] |
| | [illegible] |
| | [illegible] |
| | [illegible] |
| Environmental Impacts | [illegible] |
| | [illegible] |
| | [illegible] |

# Criteria Ranking

| Criteria | Rank Criteria in Order of Highest Priority (1 is highest priority and 6 is lowest priority) |
|---|---|
| Human Benefits | |
| Ecological Benefits | |
| Economic Benefits | |
| Feasibility | |
| Implementation Costs | |
| Environmental Impacts | |

# [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

# [illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible] 2011

Ohio | Lake Erie Commission

Great Lakes Commission des Grands Lacs

TOLEDO | LUCAS COUNTY PORT AUTHORITY

Great Lakes RESTORATION

# APPENDIX D

Weighting Factor Memorandum

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Hull & associates, inc.

[illegible]

# Memorandum

[illegible]

[illegible]

[illegible] 2011

[illegible]

[illegible]

## SCORING OF TECHNICAL CRITERIA FOR TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE OPTIONS EVALUATION

### TABLE 1

### LIST OF SEDIMENT MANAGEMENT AND USE OPTIONS

| Option/Alternative Category | Option/Alternative |
|---|---|
| [illegible] | [illegible] |
| | [illegible] |
| | [illegible] |
| [illegible] | [illegible] |
| | [illegible] |
| [illegible] | [illegible] |
| | [illegible] |
| | [illegible] |
| [illegible] | [illegible] |

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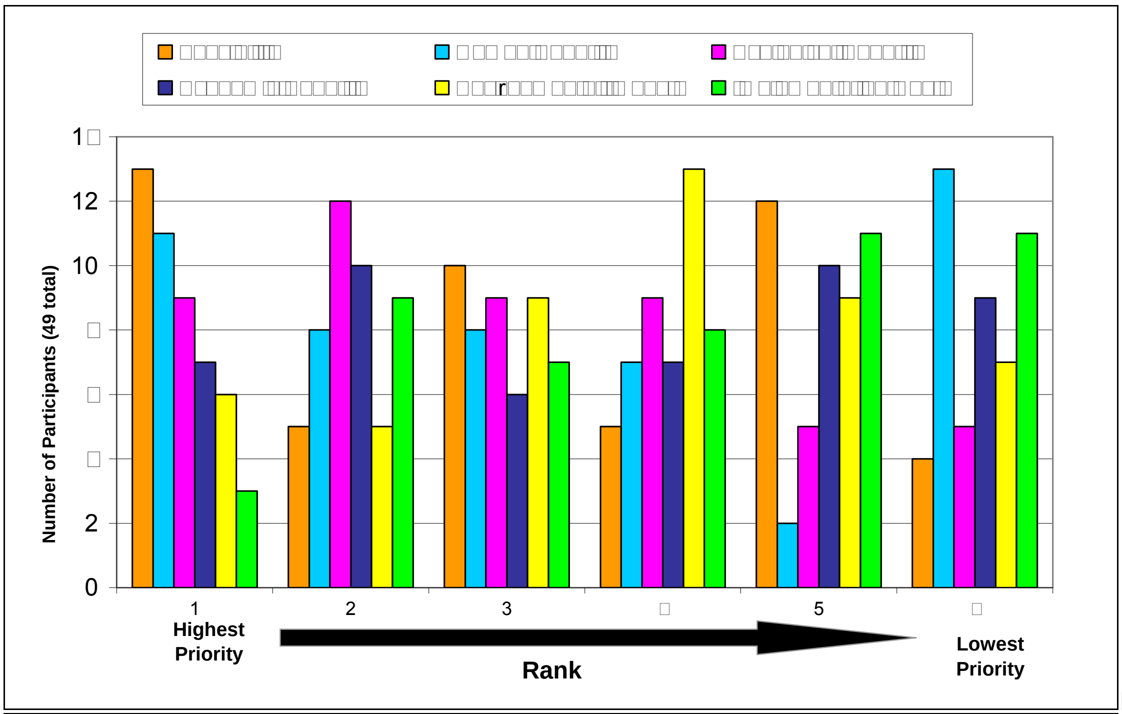
## SCORING OF TECHNICAL CRITERIA FOR TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE OPTIONS EVALUATION

### FIGURE 1

### INITIAL PUBLIC FORUM PRIORITIZATION OF TECHNICAL CRITERIA




[illegible]

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□□□0□□□100□0011□

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**SCORING OF TECHNICAL CRITERIA FOR**
**SEDIMENT MANAGEMENT STRATEGY AND USE EVALUATION**

**ATTACHMENT A**

**TASK FORCE MEMBER WORKSHEET**

**Name:** Pat Smith **Organization:** XYZ

**Address:** 123 Main St., Toledo, Ohio 43604

**Phone:** 419-555-1111 **E-mail:** psmith@xyz.com

| Category of Technical Criteria | Examples of Technical Criteria | Assigned Weighting Factor (assign value between zero and 100) (Cumulative = 100% for the category, not individual examples) |
|---|---|---|
| **Feasibility** | [illegible] | 2 |
| **Ecological Benefits** | [illegible] | 47 |
| **Environmental Impacts** | [illegible] | 10 |
| **Human Benefits** | [illegible] | 5 |
| **Economic Benefits** | [illegible] | 22 |
| **Implementation Costs** | [illegible] | 14 |
| | ***TOTAL:*** | ***100*** |

[illegible] 100

Example

**SCORING OF TECHNICAL CRITERIA FOR**
**SEDIMENT MANAGEMENT STRATEGY AND USE EVALUATION**

**ATTACHMENT A**

**TASK FORCE MEMBER WORKSHEET**

**Name:** **Organization:**

**Address:**

**Phone:** **E-mail:**

| Category of Technical Criteria | Examples of Technical Criteria | Assigned Weighting Factor (assign value between zero and 100) (Cumulative = 100% for the category, not individual examples) |
|---|---|---|
| **Feasibility** | | |
| **Ecological Benefits** | | |
| **Environmental Impacts** | | |
| **Human Benefits** | | |
| **Economic Benefits** | | |
| **Implementation Costs** | | |
| | ***TOTAL:*** | ***100*** |

100

# APPENDIX E

Agricultural Property Review

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SCALE IN MILES

0 1/2 1 2

Potential Sediment Placement Alternatives

T.L.C.P.A.

1/1

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| PARCEL # | TILLABLE ACRES | OWENERS NAME |
|---|---|---|
| OWNERS WITHIN 2 MILE RADIUS OF INTERSECTION OF BAY SHORE & STADIUM | | |
| 4435768 | 14 | JEANN KURP-BRUGGMANN |
| 4435769 | 35 | JEANN KURP-BRUGGMANN-ETAL |
| 4435047 | 45 | WTOL LLC |
| 4436097 | 38 | IVAN C. SR. & MARGIE C. MYERS |
| 4436217 | 9 | WILLIAM J. MYERS, ETAL |
| 4435947 | 10 | WILLIAM J. MYERS |
| 4435917 | 9 | JAMES D. HAUTER, ETAL |
| 4436007 | 9 | JANICE SWOPE |
| 4436037 | 9 | DEBORAH LOFQUIST |
| 4436067 | 8 | DEBORAH LOFQUIST |
| 4441071 | 18 | DEBORAH LOFQUIST |
| 4436871 | 2 | OREGON CITY SCHOOL |
| 4436804 | 20 | OREGON CITY SCHOOL |
| 4436887 | 12 | OREGON CITY SCHOOL |
| 4436881 | 2 | OREGON CITY SCHOOL |
| 4436927 | 6 | DEBORAH LOFQUIST |
| 4436951 | 6 | JANICE SWOPE |
| 4436757 | 15 | IC SR. & MC MYERS |
| 4437024 | 57 | IVAN C. MYERS JR., ETAL |
| 4436674 | 2 | SHARON L. LANZ |
| 4436691 | 2 | SHARON L. LANZ |
| 4436641 | 2 | THOMAS L. STEIGER |
| 4436657 | 2 | WILLIAM A. BRICE, ETAL |
| 4437264 | 28 | DONALD L. & VIRGINIA MEYERS |
| 4437354 | 25 | MILDRED G. HANCOCK |
| 4437401 | 24 | DONALD L. & VIRGINIA MEYERS |
| 4437508 | 77 | TOLEDO ALFALFA MILLS INC. |
| 4437827 | 5 | MILDRED G. HANCOCK |
| 4437917 | 23 | WILLIAM J. MYERS, ETAL |
| 4438007 | 20 | WILLIAM J. MYERS, ETAL |
| 4438106 | 27 | BARBARA S. SCHNEIDER |
| 4438191 | 5 | CLOYD R. & DEBORAH EASTON |
| 4438224 | 5 | ROBERT J. MYERS |
| 4438067 | 12 | WILLIAM J. MYERS, ETAL |
| 4438241 | 5 | ROBERT J. MYERS |
| 4437824 | 2 | DL & VL MEYER |
| 4437884 | 2 | CLEO HILL |
| 4439357 | 28 | GARY L. & LINDA S. ZUNK |
| 4439267 | 28 | IVAN C. JR. & AMIE SUE MYERS |
| 4439465 | 15 | CARL WILLIAM & LI LORENZEN |
| 4439511 | 13 | CARL WILLIAM & LI LORENZEN |
| 4439555 | 13 | PATRICIA LEE |
| 4439614 | 22 | FIFTH THIRD BANK |
| 4438617 | 9 | JAMES E. & JENNY A. KING |
| 4438636 | 20 | DEBORAH A. LOFQUIST |
| 4438497 | 37 | DENNIS M. & GAY A. BARKER |
| 4438377 | 38 | JOSEPHINE SCHUMAKER |
| 4438257 | 36 | GLEN E. ACKERMAN |
| 4401739 | 5 | DAVID W. & LORE V. WARNKE |
| 4402224 | 5 | DALE VELLIQUETTE |
| 4402214 | 5 | NOAH E. BROADWAY JR. |
| 4402264 | 27 | KEVIN M. & KATHY S.E. FOX |
| 4402424 | 15 | WILIAM J. & SALETTA MYERS |
| 4402427 | 15 | WILLIAM J. & ROBERT MYERS |

| | | |
|---|---|---|
| 4402514 | 15 | WILLIAM J. MYERS, ETAL |
| 4402574 | 14 | WILLIAM J. MYERS, ETAL |
| 4403291 | 6 | NATHAN A. BRINKMAN |
| 4403331 | 20 | KEVIN M. & KATHY S. FOX |
| 4403204 | 20 | CLARA LEE HARRELL, TRUSTEE |
| 4403391 | 18 | CLARA LEE HARRELL, TRUSTEE |
| 4403514 | 19 | KEVIN M. & KATHY S. FOX |
| 4403574 | 19 | CITY OF OREGON |
| 4404514 | 19 | CITY OF OREGON |
| 4405017 | 25 | BP-HUSKY REFINING LLC |
| 4404224 | 8 | BP-HUSKY REFINING LLC |
| 4404934 | 23 | BP-HUSKY REFINING LLC |
| 4499061 | 5 | NORFOLK SOUTHERN R.R. |
| 4449292 | 12 | FIRST ENERGY GENERATION CORP. |
| 4403791 | 9 | ROBERT C. MCDONALD |
| 4403784 | 11 | GRADEL REALTY CO. |
| 4409984 | 39 | MARG STEELE |
| 4413419 | 5 | BONNIE LOU LEICHTY, ETAL |
| 4413237 | 58 | KEVIN M. & KATHY S. FOX |
| 4413177 | 69 | FRANK T. POKORNIC, SUCCESSOR |
| 4412377 | 31 | ROBERT J. MYERS |
| 4412251 | 36 | FRANK T. POKORNIC, SUCCESSOR |
| 4412197 | 13 | SALLIE J. CULVER, TRUSTEE |
| 4412167 | 10 | WILLIAM J. MYERS |
| 4412151 | 5 | SALLIE J. CULVER, TRUSTEE |
| 4412134 | 5 | SALLIE J. CULVER, TRUSTEE |
| 4411987 | 8 | IVAN C. & MARGIE C. MYERS, TRUSTEE |
| 4411984 | 3 | IVAN C. & MARGIE C. MYERS, TRUSTEE |
| 4411955 | 4 | IVAN C. & MARGIE C. MYERS, TRUSTEE |
| 4412021 | 9 | IVAN C. & MARGIE C. MYERS, TRUSTEE |
| 4412060 | 20 | BARBARA J. TISCHINAE, TRUSTEE |
| 4403907 | 11 | JACOR BROADCASTING CORP. |
| 4404004 | 8 | WILLIAM E. NELSON |
| 4403694 | 25 | WILLIAM E. NELSON |
| 4403634 | 18 | WILLIAM J. MYERS, ETAL |
| 4403637 | 18 | ROBERT J. MYERS |
| 4403021 | 14 | GREATER METROPOLITIAN TITLE |
| 4403082 | 15 | MICHAEL C. GRUSS, TRUSTEE |
| 4402901 | 38 | DEBORAH A. LOFQUIST |
| 4402664 | 8 | JAMES W. & PAMELA S. MARTIN |
| 4402665 | 5 | JAMES W. & PAMELA S. MARTIN |
| 4402636 | 3 | WALTER M. & NICOLE GEBICKI |
| 4402695 | 2 | HAROLD R. & SHARON MARKLEY |
| 4402696 | 3 | TINA WALSH |
| 4402691 | 3 | TIMOTHY B. & MELINDA ELLIOTT |
| TOTAL IN 2 MILE RADIUS= | 1,652 | |

| PARCEL # | TILLABLE ACRES | OWENERS NAME |
|---|---|---|
| OWNERS S.E. OF 2 MILE RADIUS AND WITHIN 5 MILE RADIUS OF INTERSECTION OF BAYSHORE & STADIUM | | |
| 3307944 | 158 | JOHN GRADEL & SONS FARMS |
| 3308424 | 134 | JOHN GRADEL & SONS FARMS |
| 3310767 | 9 | PAUL A. & PATRICIA A. ZEILER |
| 3310831 | 12 | FRANCES K. MEAGHER |
| 3311524 | 6 | ERNEST H. & CAROL HUMBERGER |
| 3311582 | 14 | KEITH A. & ROSE SCHWIERKING |
| 3311704 | 14 | MAYNARD W. & MARGARET KNITZ |
| 3312793 | 4 | LARRY J.& TRACY H. BOLANDER |
| 3312794 | 4 | LARRY J. II & TRACY BOLANDER |
| 3312795 | 4 | LARRY J. II & TRACY BOLANDER |
| 3312796 | 4 | LARRY J. II & TRACY BOLANDER |
| 3312584 | 26 | DEBORAH A. LOFQUIST |
| 3312644 | 28 | WILLIAM J. MYERS |
| 3312375 | 28 | PAUL & ROSEMARY FREDERICKSEN |
| 3312376 | 9 | PAUL R. SR. & R. FREDERICKSEN |
| 3313354 | 38 | DIANE R. SCHMIDT, ETAL |
| 3313657 | 34 | PAUL & ROSEMARY FREDERICKSEN |
| 3313507 | 41 | GRACE A. DEITEMYER, ETAL |
| 4435234 | 10 | CITY OF OREGON |
| 4435231 | 10 | CITY OF OREGON |
| 4435227 | 19 | CITY OF OREGON |
| 4440914 | 47 | GLEN E. ACKERMAN |
| 4440180 | 34 | LORRAINE CRAPSEY, ETAL |
| 4440184 | 35 | CITY OF OREGON |
| 3315984 | 38 | DANIEL L. & MARSHA M. WOLF |
| 3315804 | 52 | JANICE AKA JANIS WOLF |
| 3316227 | 19 | CLIFFORD C. & MADONNA BURY |
| 3315234 | 18 | CLIFFORD C. & MADONNA BURY |
| 3315174 | 19 | CLIFFORD C. & MADONNA BURY |
| 3315294 | 10 | CLIFFORD C. & MADONNA BURY |
| 3314911 | 22 | CATHY S. BERGER |
| 3314834 | 24 | WALTER E. BERGER JR., TRUSTEE |
| 3317807 | 129 | PAMELA WOLF, SUCCESSOR TRUSTEE |
| 3317002 | 40 | JOHN D. CHMIELEWSKI |
| 3319198 | 23 | DARRELL D. WITTY |
| 3319577 | 39 | DARRELL D. WITTY |
| 3319451 | 18 | DARRELL D. WITTY |
| 3316406 | 115 | ROBERT F. WOLF, TRUSTEE |
| 3315684 | 38 | KENNETH WOLF, TRUSTEE |
| 3315384 | 20 | KENNETH C. & BARBARA WOLF |
| 3315324 | 20 | KENNETH C. WOLF, TRUSTEE |
| 3315564 | 36 | NED W. WRIGHT, SUCESSOR |
| 3318234 | 150 | WHITNEY HOLDINGS INC. |
| 4444421 | 18 | MICHAEL A. & ELSIE DIPPMAN |
| 4444451 | 19 | MICHAEL A. & ELSIE DIPPMAN |
| 4444461 | 44 | LUANN ELIZABETH SPOERL, TRUSTEE |
| 4443317 | 34 | DOLORES F. RABLE |
| 4442337 | 28 | JEFFREY J. NAVARRE |
| 4442521 | 19 | JEFFREY J. NAVARRE |

| | | |
|---|---|---|
| 4441724 | 38 | DOUGLAS M. NELSON, ETAL |
| 3330471 | 41 | TOLEDO ALFALFA MILLS INC. |
| 3329411 | 73 | DONNA S. NELSON |
| 3328691 | 79 | LAJT I FARMS INC. |
| 3327492 | 38 | JENNIFER K. SCHNEIDER |
| 3327491 | 38 | CHRISTINE SCHUMAKER |
| 3327731 | 74 | MARIE A . RAKOLTA, TRUSTEE |
| 3326644 | 38 | ZACHEL |
| 3326524 | 38 | DARRELL D. WITTY |
| 3325556 | 73 | HELEN O. TURNOW, TRUSTEE |
| 3325804 | 79 | PAMELA WOLF, SUCCESSOR TRUSTEE |
| | | |
| 4444781 | 38 | JANE E. NEAL, ETAL |
| 4444542 | 95 | GERALD A. PEACH |
| 4443804 | 37 | KURT H. ACKERMAN |
| 4442577 | 55 | PERRY BUCHANAN III, ETAL |
| 4442757 | 95 | RICHARD L. & ALI STROSHINE |
| 4441841 | 37 | WILLIAM E. NELSON |
| 4441844 | 37 | MARK D. HECKLINGER, ETAL |
| 3330617 | 37 | MARK D. HECKLINGER, ETAL |
| 3330737 | 36 | DWIGHT J. WITTY, TRUSTEE |
| 3330014 | 35 | RICHARD D. NISSEN |
| 3329894 | 37 | JUDITH L. & HOWARD WAGONER |
| 3329171 | 40 | WILLIAM D. & CAROLY BARTLEY |
| 3329291 | 37 | EUNICE G. NISSEN |
| 3328931 | 75 | LAJTI FARMS INC. |
| 3327971 | 32 | CHRISTINE SCHUMAKER |
| 3328331 | 39 | CHRISTINE SCHUMAKER |
| 3328091 | 78 | FJL FARMS INC. |
| 3327247 | 15 | JEANETTE A. CEDOZ, SUCCESSOR TRUSTEE |
| 3327367 | 20 | JEANETTE A. CEDOZ, SUCCESSOR TRUSTEE |
| 3327307 | 20 | JEANETTE A. CEDOZ, SUCCESSOR TRUSTEE |
| | | |
| 4446457 | 37 | RAMOND E. KOWALKA, ETAL |
| 4445054 | 21 | KURT H. ACKERMAN |
| 4445137 | 16 | KURT H. ACKERMAN |
| 4447787 | 39 | KEVIN RUEDY |
| 4447727 | 18 | BYRON GARY & LINDA KUSIAN |
| 4447547 | 31 | B.G. & L.K. KUSIAN |
| 4447907 | 39 | MARIAN M. JOEHLIN, TRUSTEE |
| 4447187 | 38 | PERRY BUCHANAN III, ETAL |
| 4447067 | 28 | PERRY BUCHANAN III, ETAL |
| 3331697 | 38 | CHARLES C. GREIM, ETAL |
| 3331577 | 39 | CHARLES C. GREIM, SUCCESSOR, ETAL |
| 3331424 | 36 | STANLEY G. BURY |
| 3331337 | 27 | STANLEY G. BURY |
| 3334237 | 38 | DWIGHT J. WITTY, TRUSTEE |
| 3334477 | 38 | JEANNETTE A. DEDOZ, TRUSTEE |
| | | |
| 4446587 | 64 | CLIFFORD C. BURY, TRUSTEE |
| 4446947 | 10 | GEORGE F. & ELAINE ACKERMAN |
| 4447007 | 19 | G.F. & E.L. ACKERMAN |
| 4446827 | 12 | G.F. & E.L. ACKERMAN |
| 4446887 | 9 | G.F. & E.L. ACKERMAN |
| 4445567 | 31 | JAMES S. & JANICE R. SHEAHAN |
| 4448027 | 147 | JAMES S. & JANICE R. SHEAHAN |
| 4447307 | 20 | BONNIE JEAN VARGA, TRUSTEE |

| | | |
|---|---|---|
| 3331097 | 17 | BONNIE JEAN VARGA, TRUSTEE |
| 4447367 | 30 | MICHAEL KEGERIZE |
| 3331157 | 25 | MICHAEL KEGERIZE |
| 4447457 | 29 | EDWARD D. JR. KLAWITTER |
| 3331248 | 22 | JAMES A. & PENNY KLAWITTER |
| 3331249 | 5 | JAMES A. & PENNY KLAWITTER |
| 3332967 | 86 | BONNIE JEAN VARGA, SUCCESSOR |
| 3332177 | 39 | WILLIAM C. KOWALKA |
| 3332014 | 12 | STANLEY G. BURY |
| 3331877 | 41 | MADONNA A. BURY, TRUSTEE |
| 4449281 | 43 | ROBERT J. JOEHLIN JR., TRUSTEE |
| 4448990 | 39 | THOMAS A. & JOAN C. TRUMAN |
| S S.W. OF 2 MILE RADIUS AND WITHIN 5 MILE RADIUS OF INTERSECTION OF BAYSHORE & S | | |
| 4405101 | 45 | BP-HUSKY REFINING LLC |
| 4405459 | 25 | TOLEDO EDISON COMPANY |
| 4405467 | 10 | TOLEDO EDISON COMPANY |
| 4405221 | 18 | TOLEDO EDISON COMPANY |
| 4411051 | 36 | GARY A. JOHLIN, ETAL |
| 4410281 | 36 | GARY A. JOHLIN, ETAL |
| 4409694 | 3 | G.A.F. SOCIETY, AN OHIO COMPANY |
| 4409605 | 10 | G.A.F. SOCIETY |
| 4409634 | 10 | G.A.F. SOCIETY, AN OHIO COMPANY |
| 4409574 | 15 | G.A.F. SOCIETY, AN OHIO COMPANY |
| 4413601 | 52 | OREGON HOMES LLC |
| 4412781 | 38 | FRANK T. POKORNIK, SUCCESSOR |
| 4418121 | 28 | VERLENE A. SCHWEIZER, SUCCESSOR |
| 4417941 | 27 | VERLENE A. SCHWEIZER, SUCCESSOR |
| 4418151 | 28 | VERLENE A. SCHWEIZER, ETAL |
| 4415274 | 50 | LOUISVILLE TITLE AGENCY |
| 4415276 | 20 | CITY OF OREGON |
| 4414174 | 55 | CITY OF OREGON |
| 4428971 | 10 | JOHN M. NISSEN, ETAL |
| 4428831 | 31 | JOHN M. & JONI E. NISSEN |
| 4431294 | 52 | TOTH FARMS II, LLC, AN OHIO COMPANY |
| 4431001 | 50 | KEVIN RUEDY, ETAL |

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# APPENDIX F

Upland Placement of Dredged Material at East Harbor State Park Memorandum

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Hull & associates, inc.

3401 Glendale Avenue, Suite 300 ◆ Toledo, Ohio 43614 ◆ (419) 385-2018 ◆ (419) 385-5487 fax

# Memorandum

TO: John Hull, P.E. and Kelly Bensman

FROM: Philip A. Hicks

DATE: June 6, 2012

RE: Summary of East Harbor – Upland Placement of Dredged Material; TPA044.100.0023

---

This memorandum has been prepared to provide a summary of the current upland placement of dredged material from the East Harbor State Park. The ODNR Division of Parks and Recreation is funding the dredging of the East Harbor and the placement of dredged materials to the upland Wadsworth property. The Wadsworth property is a Fruit Farm owned by Joyce and Donald Wadsworth and is approximately 30 acres of flat agricultural land. William (Bill) E. Bopp of the ODNR has designed and implemented the current process and is the person in charge of coordinating all permits and communication with the USACE. During a phone conversation, Bill discussed the following key points of the process:

- Method of Dredging – A small hydraulic dredge pumps the material to a booster pump which then transports the material to the placement site.

- Relocation Area – The area was designed for 4 separate cells. Each cell is contained by dikes approximately 9.5' in height. The intent is to fill cell 1 first and then construct the remaining cells sequentially. It is expected that material in cell 1 will consolidate while other material is placed into cell 2, potentially allowing additional material placement into cell 1.

- Dikes – The dikes are designed with the intentions to stay below the definition of a dam. A dam is defined by a certain height, width, and/or storage capacity behind the embankment. If a design meets the dam definition, the regulations and permit requirements may increase due to potential of flooding, loss of life, etc. Dike/dam heights are measured from the exterior grade elevation. A "bowl" was excavated to hold more dredge material and the material dredged from the "bowl" was used to build the dikes.

- Outlet / Discharge – A box weir was used to control the discharge of water runoff. Water runoff was discharged to an open ditch with installed check/filter dams that eventually discharged back into the lake.

- Sediment Testing – Sediment at the placement location as well as the lake sediment was analyzed prior to implementation to ensure the material was appropriate for the end-use.

- Easements – Right of entry was required in three places. Two places were leased and one place was free passage. Boring under Route 163 was necessary in order to reach the dredged material placement area.

- Final / Closure – An agreement to return the land to the owner with a new specific elevation is in place. In other words, re-grading of the site after final placement to achieve the specified elevations might be required. The end use of the property is unknown, but could include agricultural use or subdivision development.

- Funding – The project was funded by the Waterway Safety Fund, which includes monies from state motor vehicle gas tax, boating registration and titling fees, federal grants, and fines.

Based on the project outcomes, coordinators recommended that the public be kept informed and remain hands on. For this project, the public was invited out to watch the dredging and allowed to board the dredging vessel.

Since the process involved placement upland (less environmental impact), a waiver was applied for to allow dredging during the environmental window to reduce costs and compress the schedule duration.

ODNR intends to complete dredging in West Harbor next year, which was previously completed by the USACE and recently discontinued due to budget cuts.

ODNR is currently dredging and placing material in cell 1 as well as constructing cell 2. Approximately 60,000 cubic yards has been dredged, with plans to dredge around 250,000 cubic yards in the next 4 years.

# APPENDIX G

## Drawings and Details for Sediment Management and Use Options

*Note: Appendix G provides drawings and details for sediment management and use options evaluated in the Toledo Harbor Sediment Management and Use Plan. The conceptual drawings and details of conceptual containment structures developed for the wetland restoration/shoreline protection option, deep water and shallow water submerged HRU options, deep water and shallow water emergent HRU options, and the new CDF option, developed by Moffatt & Nichol, are provided in Appendix G-3 through Appendix G-6. The conceptual containment structures are oriented to minimize the amount of slope protection needed to accommodate typical water levels, local storm surges, and a preliminary wind-wave hindcast.*

*During the course of the project, it was apparent that the USACE was in progress of completing, or had completed, similar structure designs such as an HRU near the Toledo Harbor Lighthouse location. Although public presentations and conceptual designs for preliminary cost estimates were completed, the USACE elected not to share calculations and data as requested by some Task Force representatives. USACE responded that even though the level of work was sufficient to develop costs and to solicit public comment, the supporting documentation could not be released based on USACE internal guidelines and that the requested information and data would not be released until senior peer review was completed. In December 2012, USACE informed the Task Force that the project would not continue due to the lack of a non-federal sponsor. Not having the benefit to use existing USACE data and information, the Hull Team used methods, procedures, and guidelines (e.g. Costal Engineering Manual, USACE Manuals) similar to those used by USACE to develop an appropriate level of design. Wind data was obtained from the Toledo Express Airport. Fetch distances and average water depths were obtained from National Oceanic and Atmospheric Administration Charts 14830, 14846, and 14847. The Hull Team's preliminary wind-wave hindcast was used to establish preliminary dike heights used in the conceptual designs. The results of preliminary wind-wave hindcast were similar to those reported in the portions of USACE-managed "Toledo Harbor Habitat Restoration Unit Conceptual Design Report" (URS/Baird, 2011) that were released to the Task Force.*

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# APPENDIX G-1

Beneficial Use

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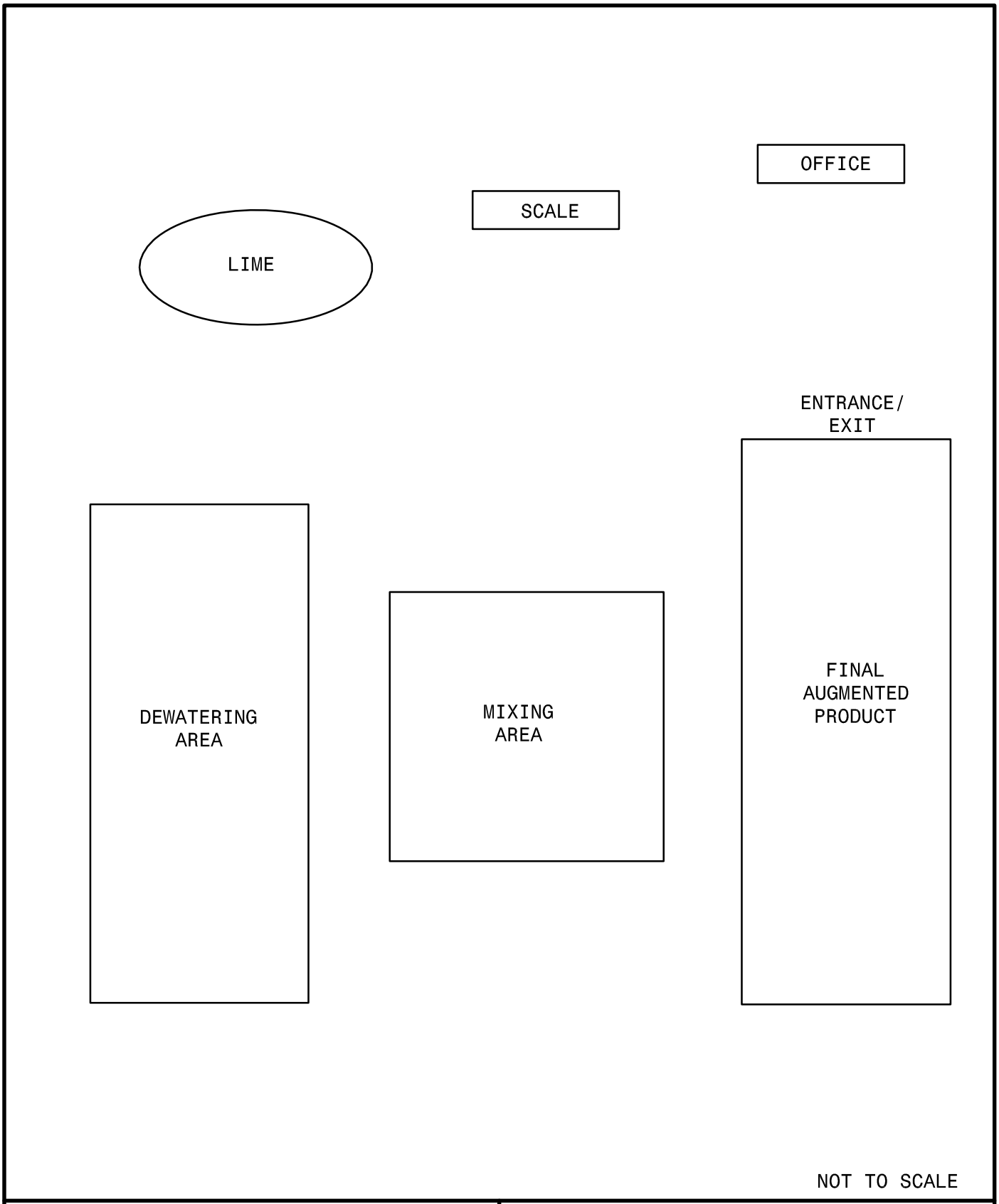


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TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FIGURE 1
APPENDIX G-1
PROCESS/DEWATERING SITE CONCEPTUAL LAYOUT

MAUMEE RIVER/LAKE ERIE, OHIO

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| PROJECT NO.: TPA044 | SUBMITTAL DATE: SEPTEMBER 2012 |
| CAD DWG FILE: TPA044.100.0010 | PLOT DATE: 9/13/12 |

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# APPENDIX G-2

Agricultural Field Improvements

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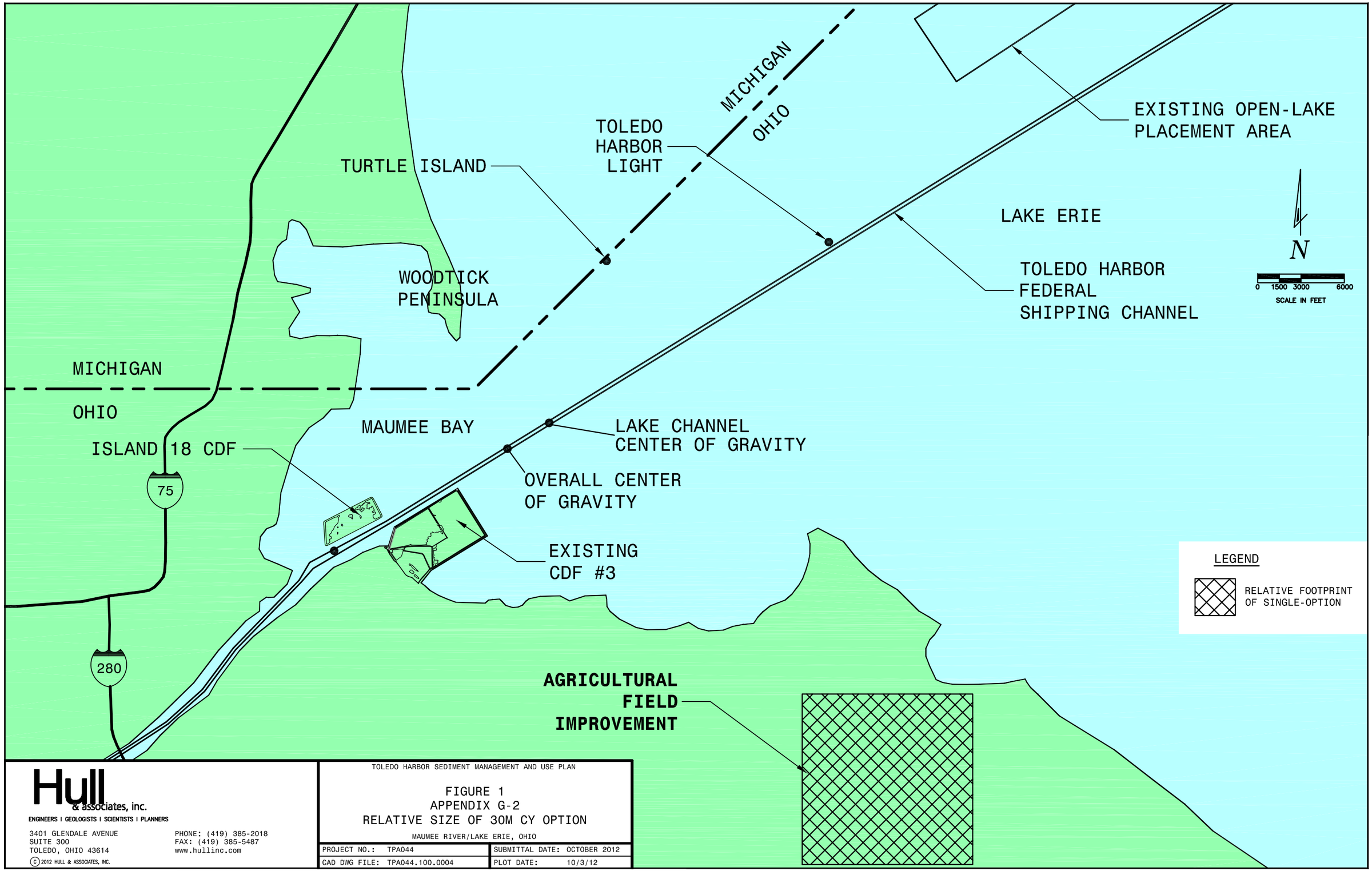


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TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FIGURE 1
APPENDIX G-2
RELATIVE SIZE OF 30M CY OPTION

MAUMEE RIVER/LAKE ERIE, OHIO

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| PROJECT NO.: TPA044 | SUBMITTAL DATE: OCTOBER 2012 |
| CAD DWG FILE: TPA044.100.0004 | PLOT DATE: 10/3/12 |

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# APPENDIX G-3

Wetland Restoration and Shoreline Protection

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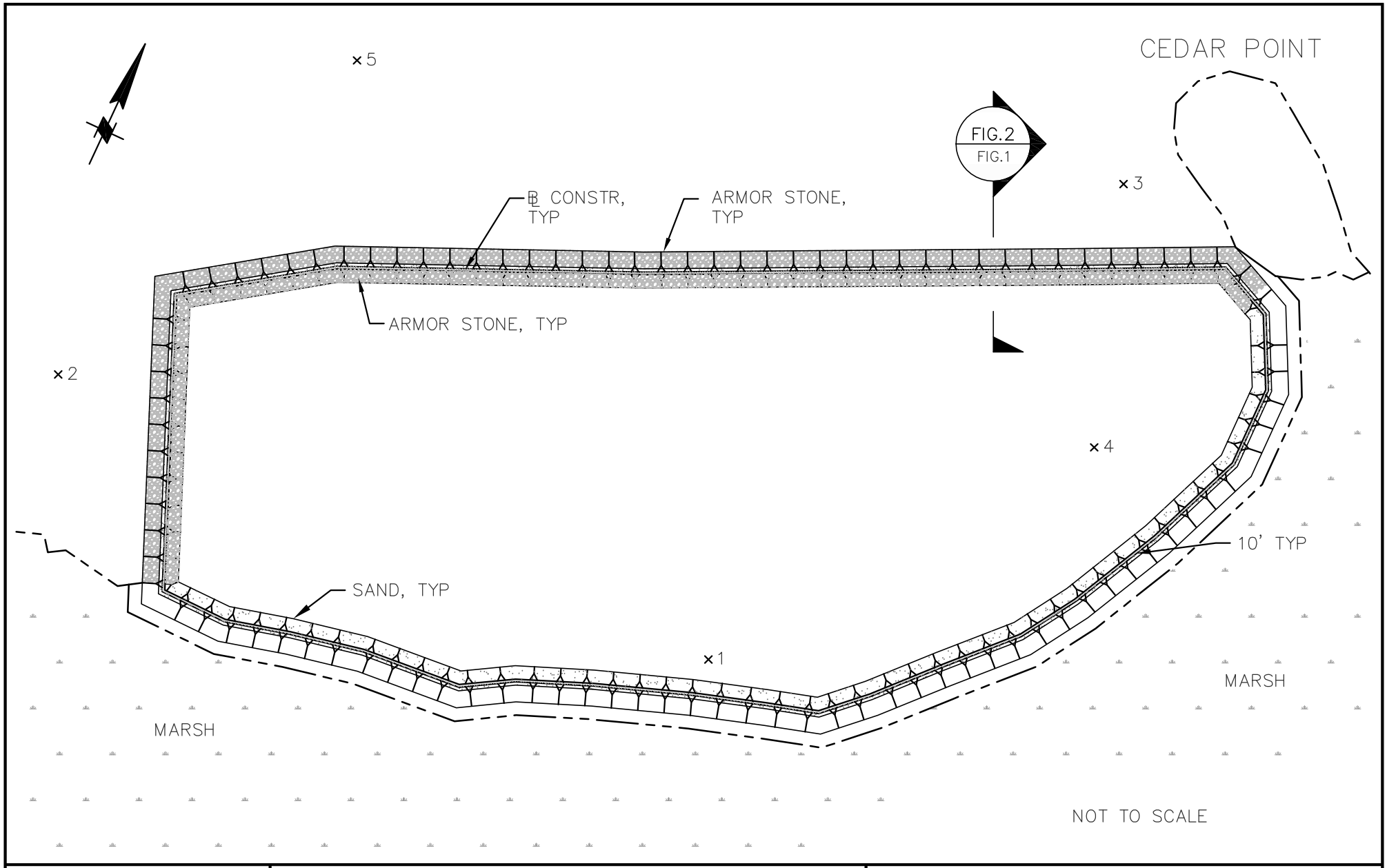
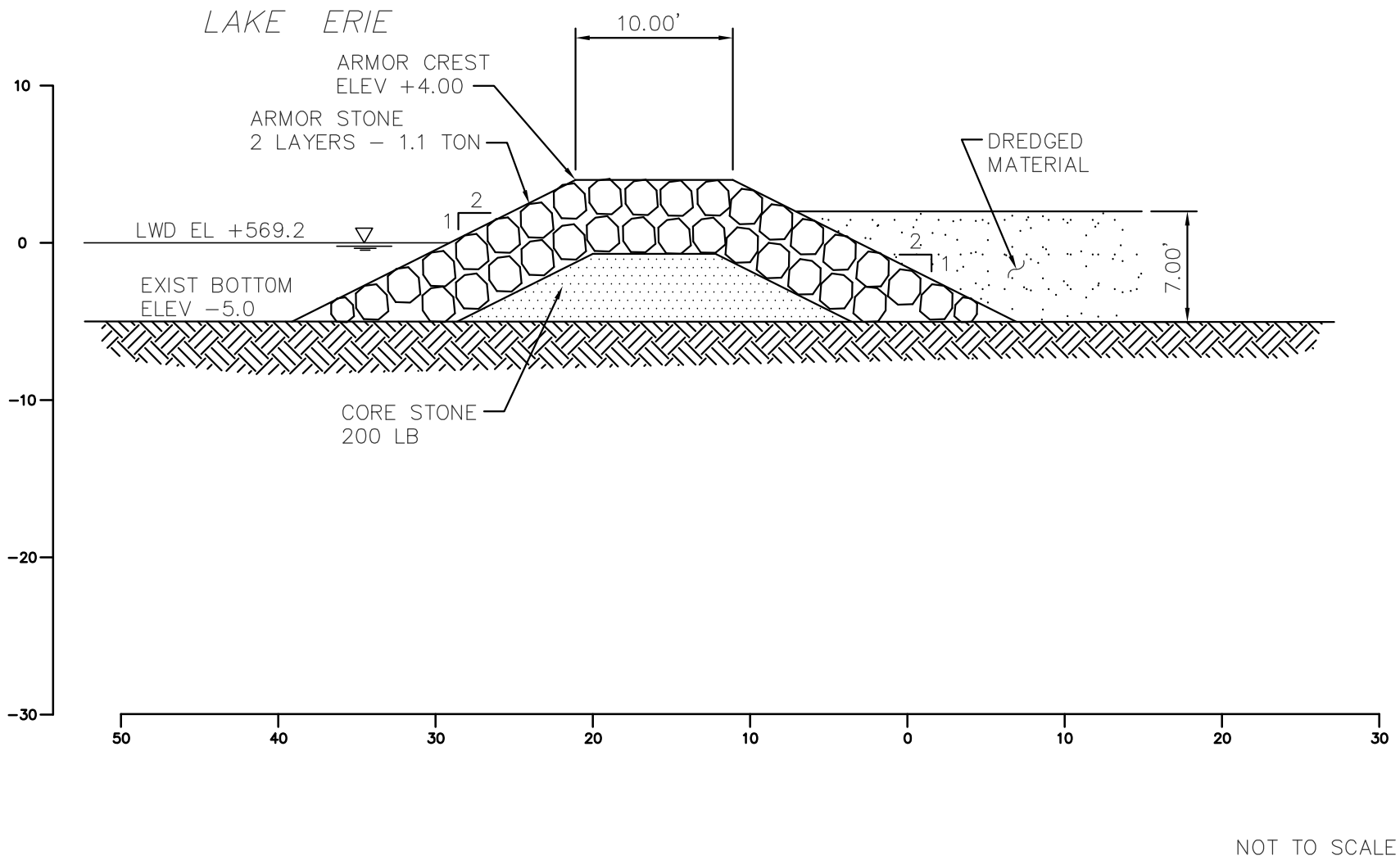



moffatt & nichol

TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-3

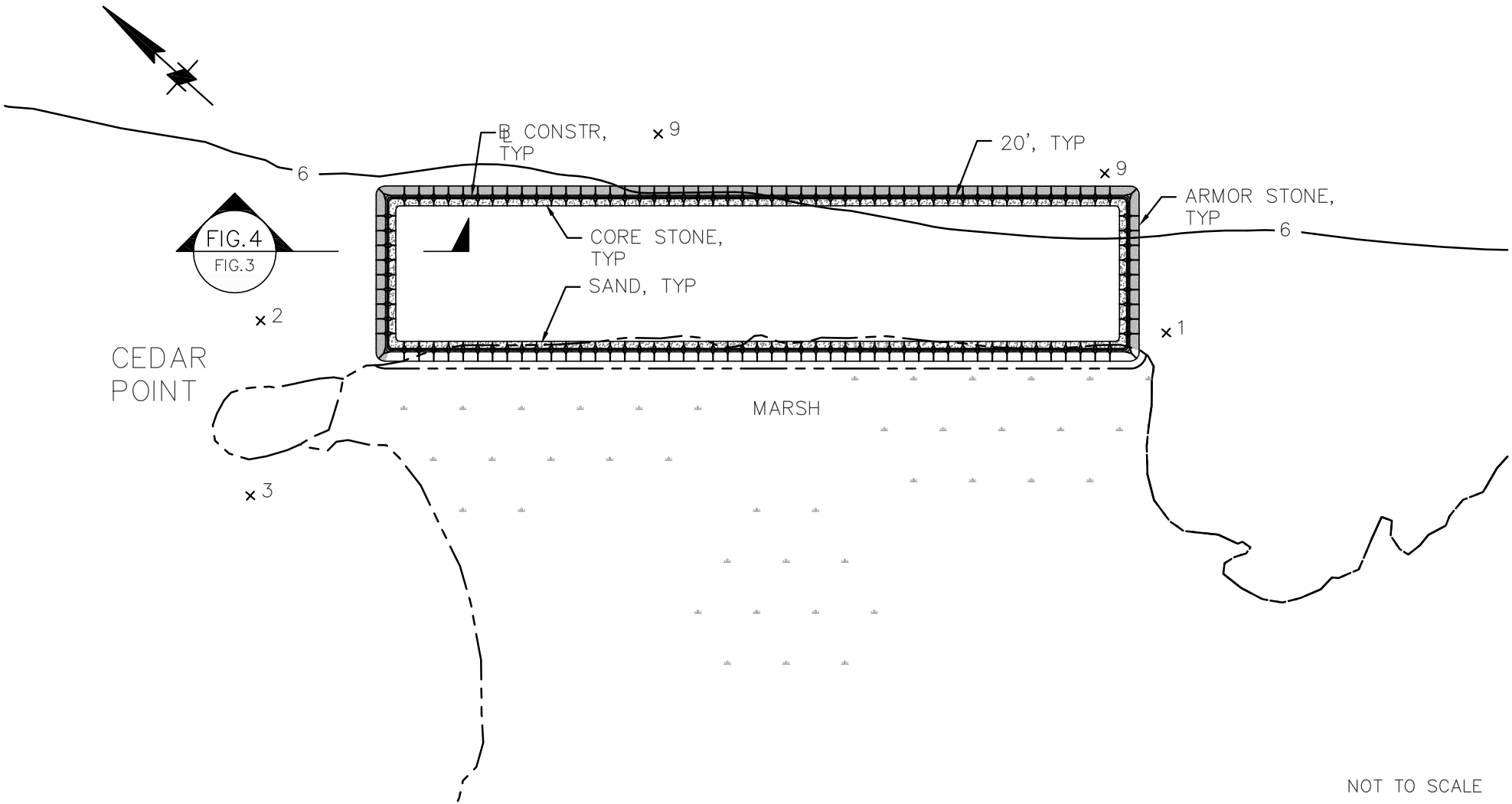
FIGURE 1
WETLAND RESTORATION AND SHORELINE PROTECTION
WEST SIDE OF CEDAR POINT




moffatt & nichol

TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-3

FIGURE 2
WETLAND RESTORATION AND SHORELINE PROTECTION
NORTH DIKE FOR WEST OF CEDAR POINT

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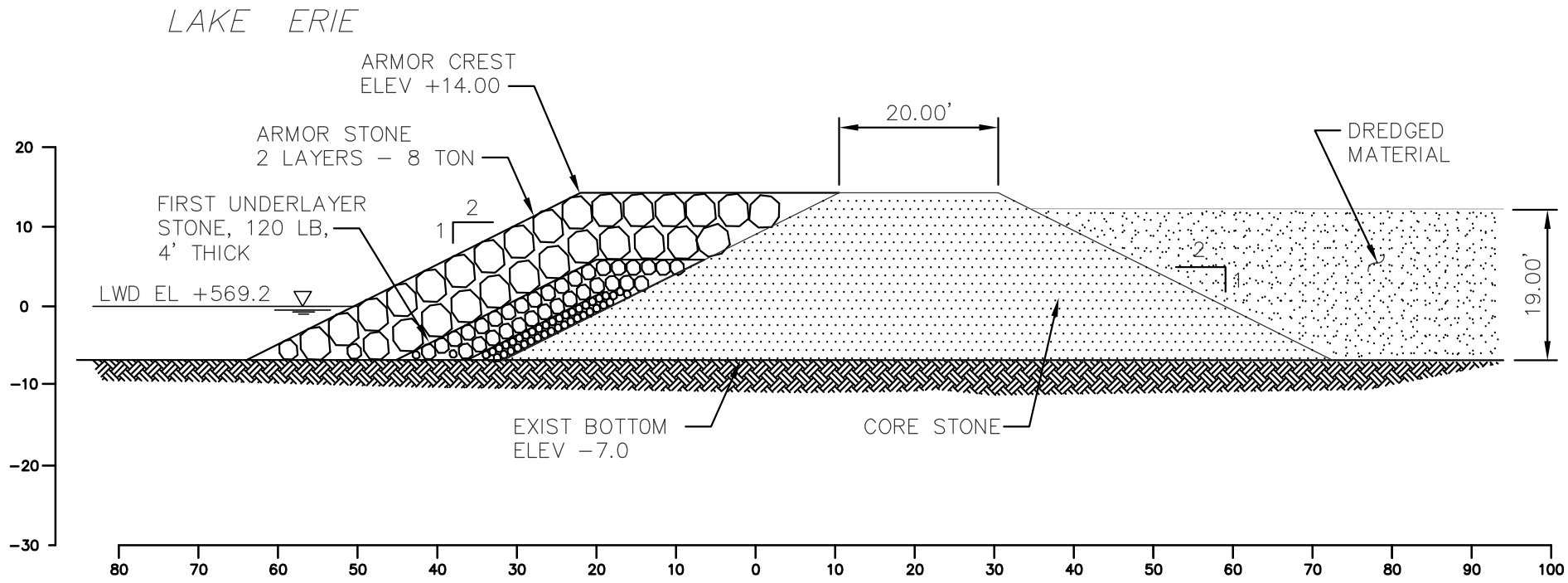
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-3

FIGURE 3
WETLAND RESTORATION AND SHORELINE PROTECTION
EAST SIDE OF CEDAR POINT

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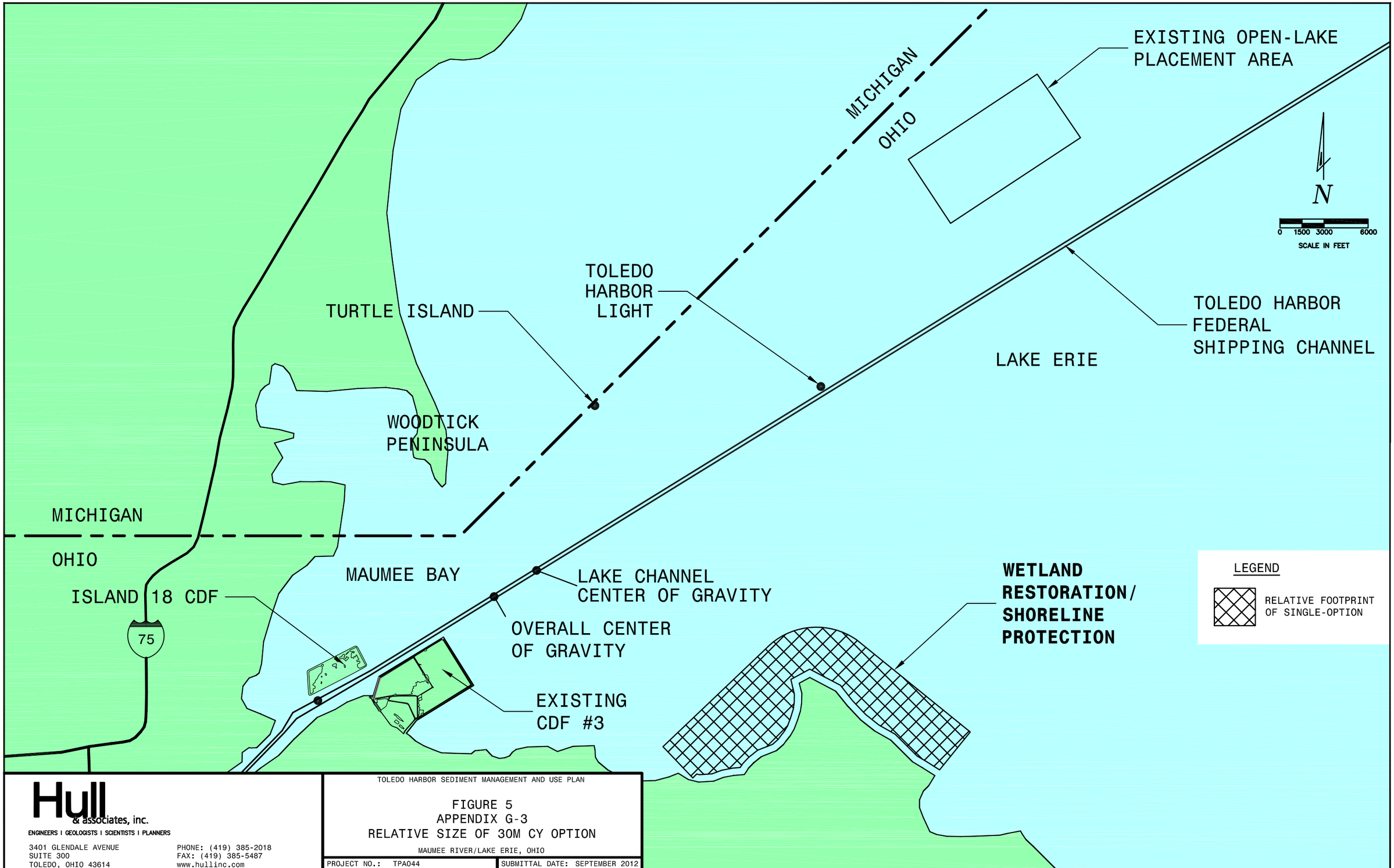
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-3 | FIGURE 4<br>WETLAND RESTORATION AND SHORELINE PROTECTION<br>NORTH CONTAINMENT DIKE<br>EAST OF CEDAR POINT |

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TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FIGURE 5
APPENDIX G-3
RELATIVE SIZE OF 30M CY OPTION

MAUMEE RIVER/LAKE ERIE, OHIO

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| PROJECT NO.: TPA044 | SUBMITTAL DATE: SEPTEMBER 2012 |
| CAD DWG FILE: TPA044.100.0004 | PLOT DATE: 9/13/12 |

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# APPENDIX G-4

Submerged Habitat Restoration Unit

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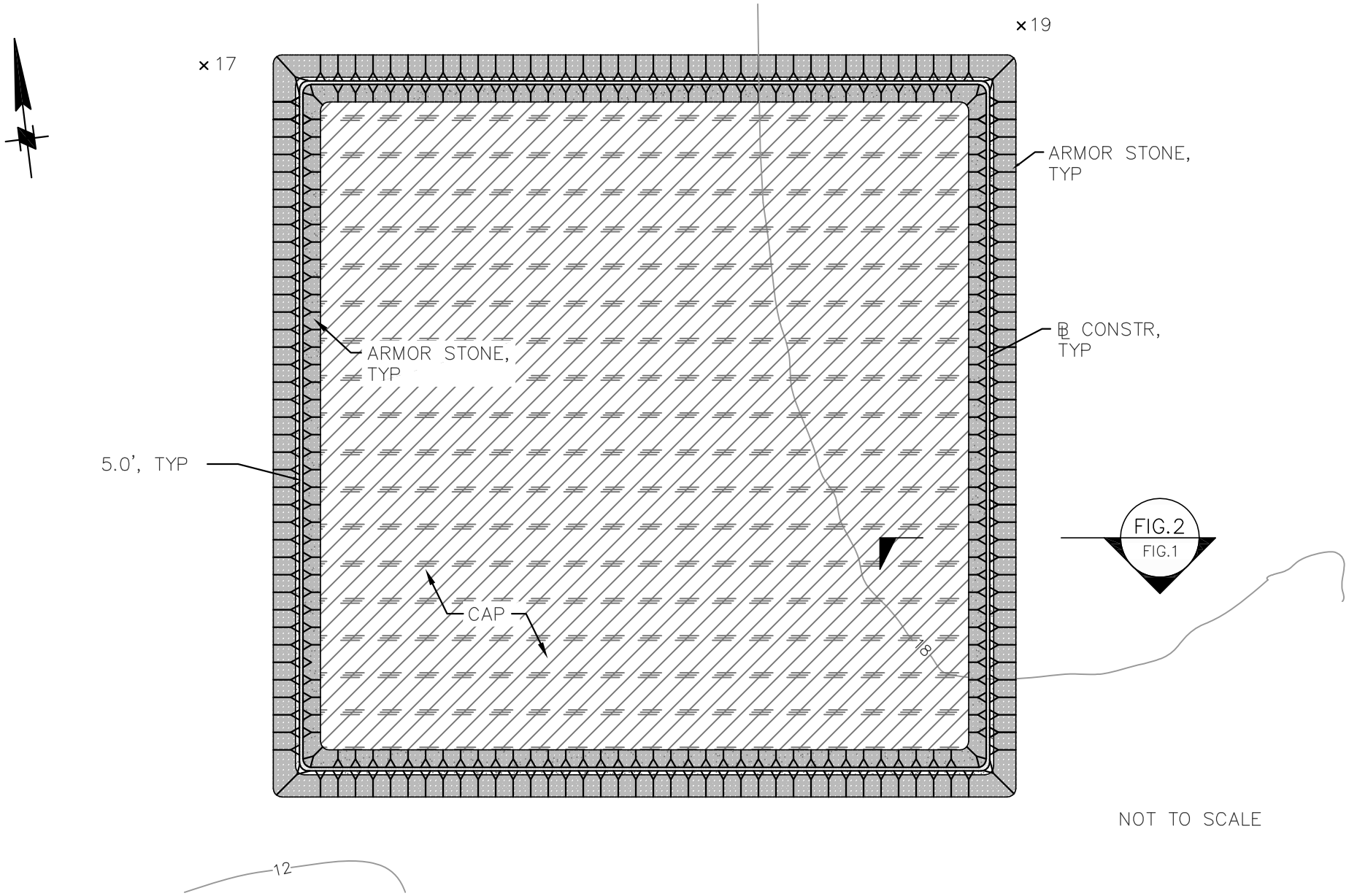


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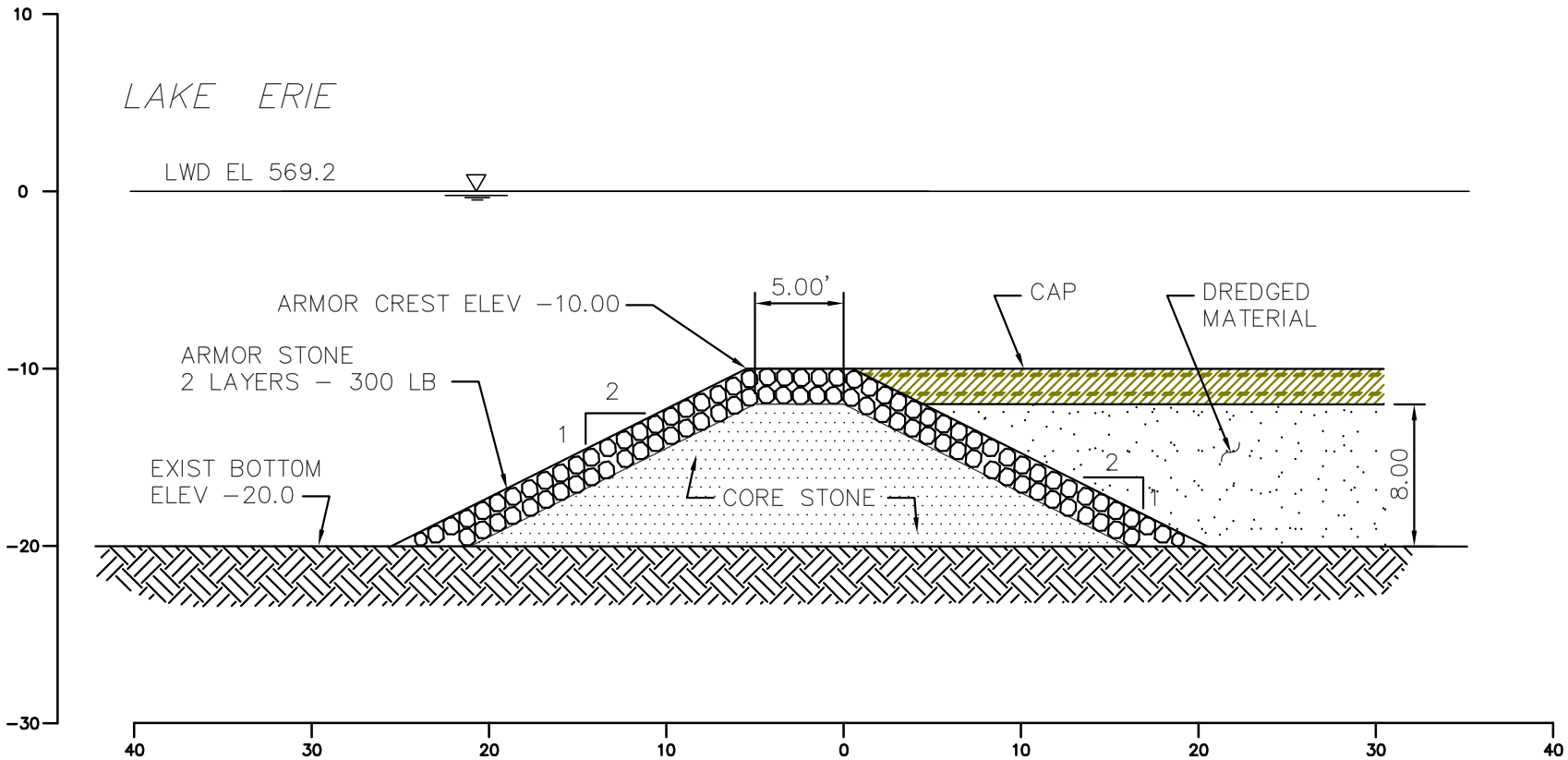
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-4

FIGURE 1
SUBMERGED HABITAT RESTORATION UNIT (SHRU)
DEEP WATER

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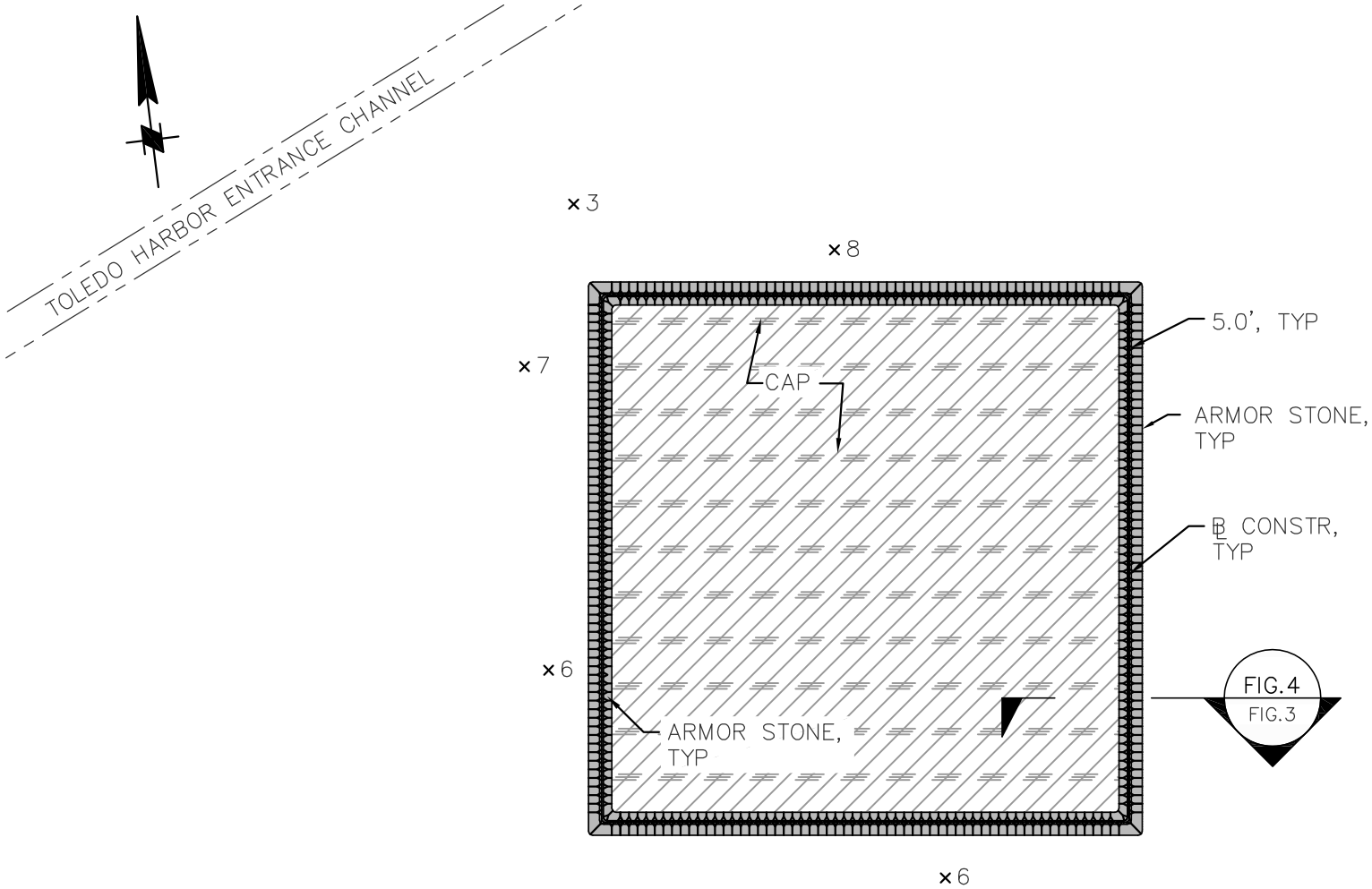
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-4

FIGURE 2
SUBMERGED HABITAT RESTORATION UNIT (SHRU)
DEEP WATER

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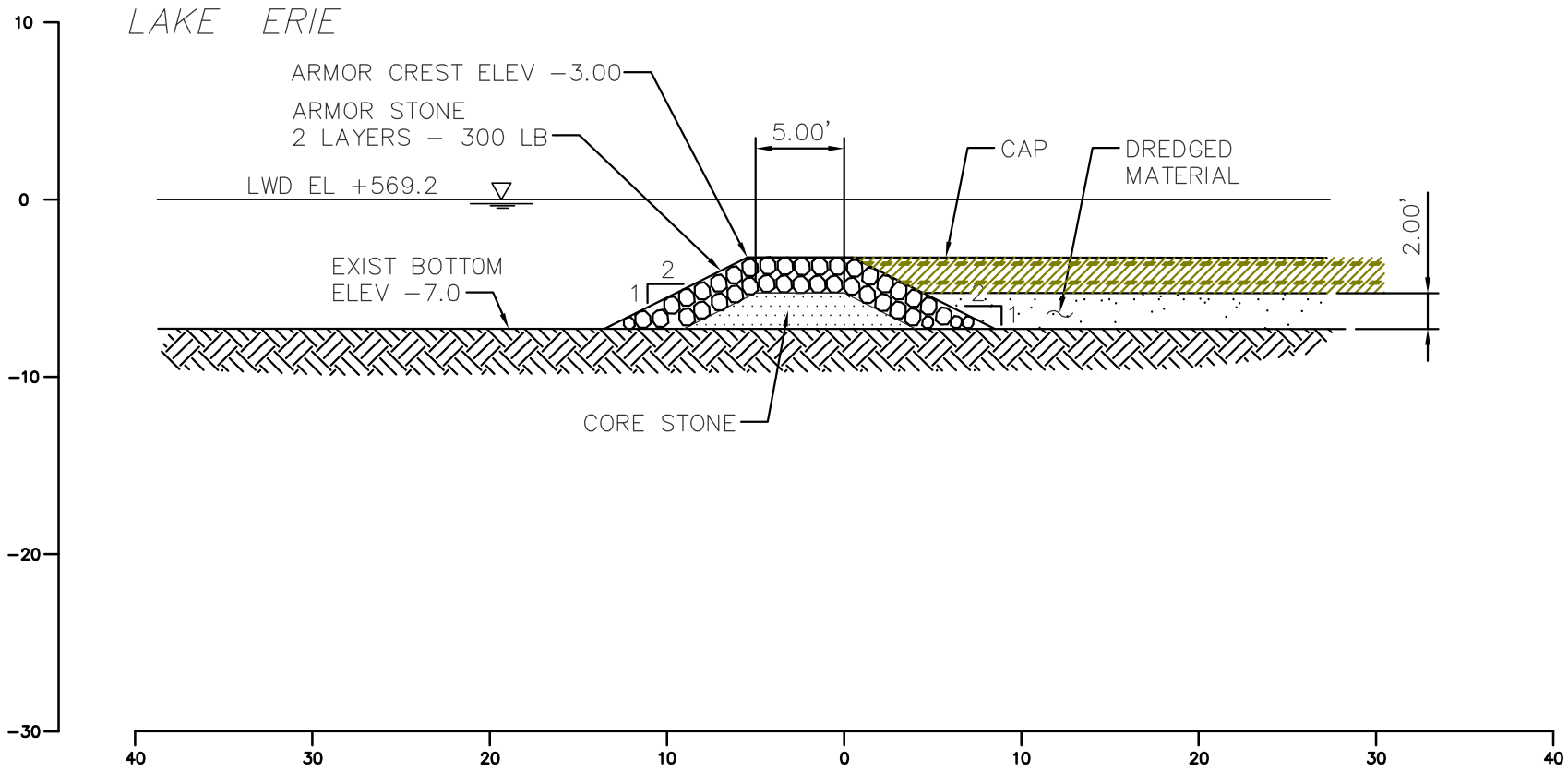
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-4 | FIGURE 3<br>SUBMERGED HABITAT RESTORATION UNIT (SHRU)<br>SHALLOW WATER |

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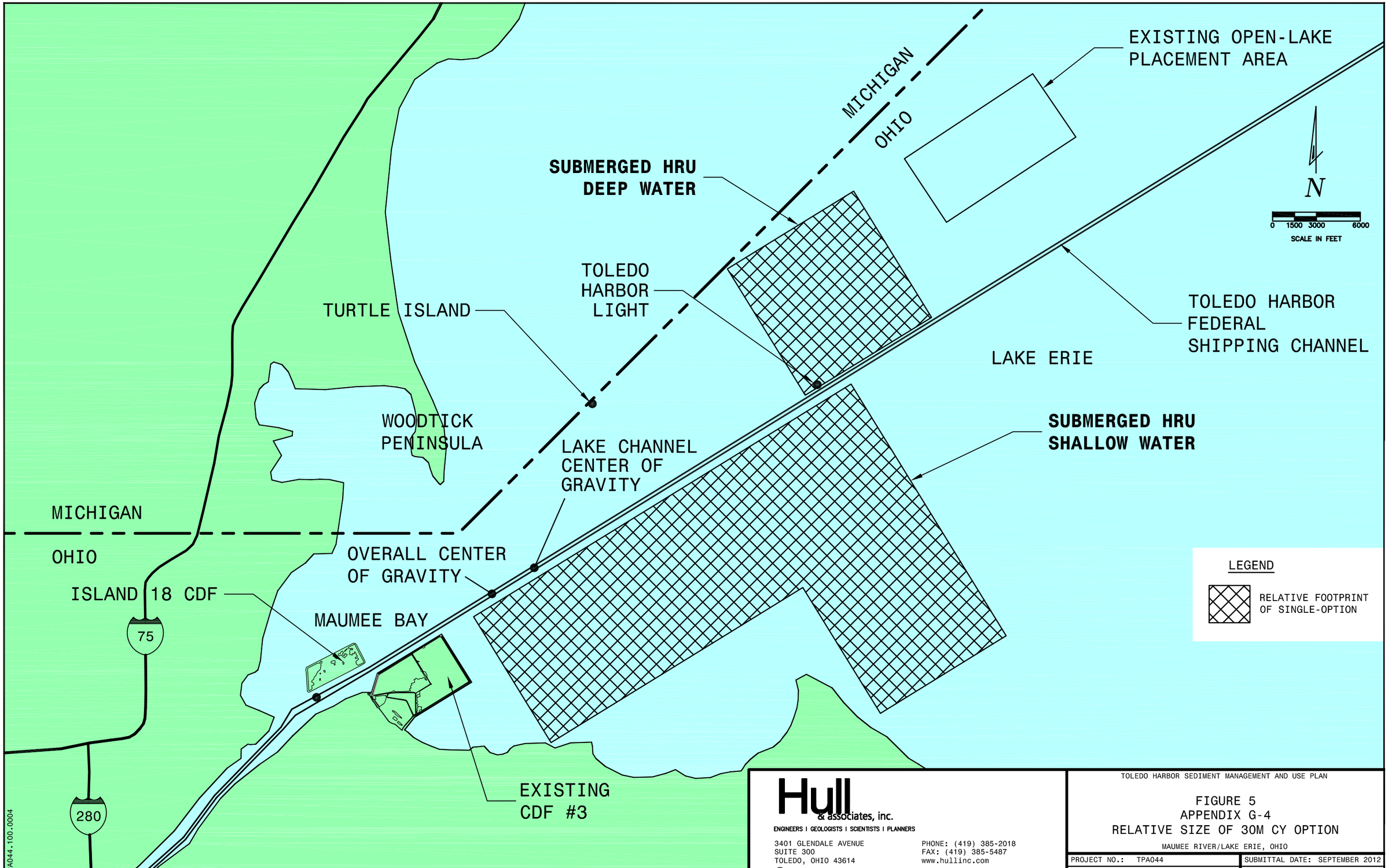
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-4 | FIGURE 4<br>SUBMERGED HABITAT RESTORATION UNIT (SHRU)<br>SHALLOW WATER |

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TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FIGURE 5
APPENDIX G-4
RELATIVE SIZE OF 30M CY OPTION

MAUMEE RIVER/LAKE ERIE, OHIO

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| PROJECT NO.: TPA044 | SUBMITTAL DATE: SEPTEMBER 2012 |
| CAD DWG FILE: TPA044.100.0004 | PLOT DATE: 9/13/12 |

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# APPENDIX G-5

Emergent Habitat Restoration Unit

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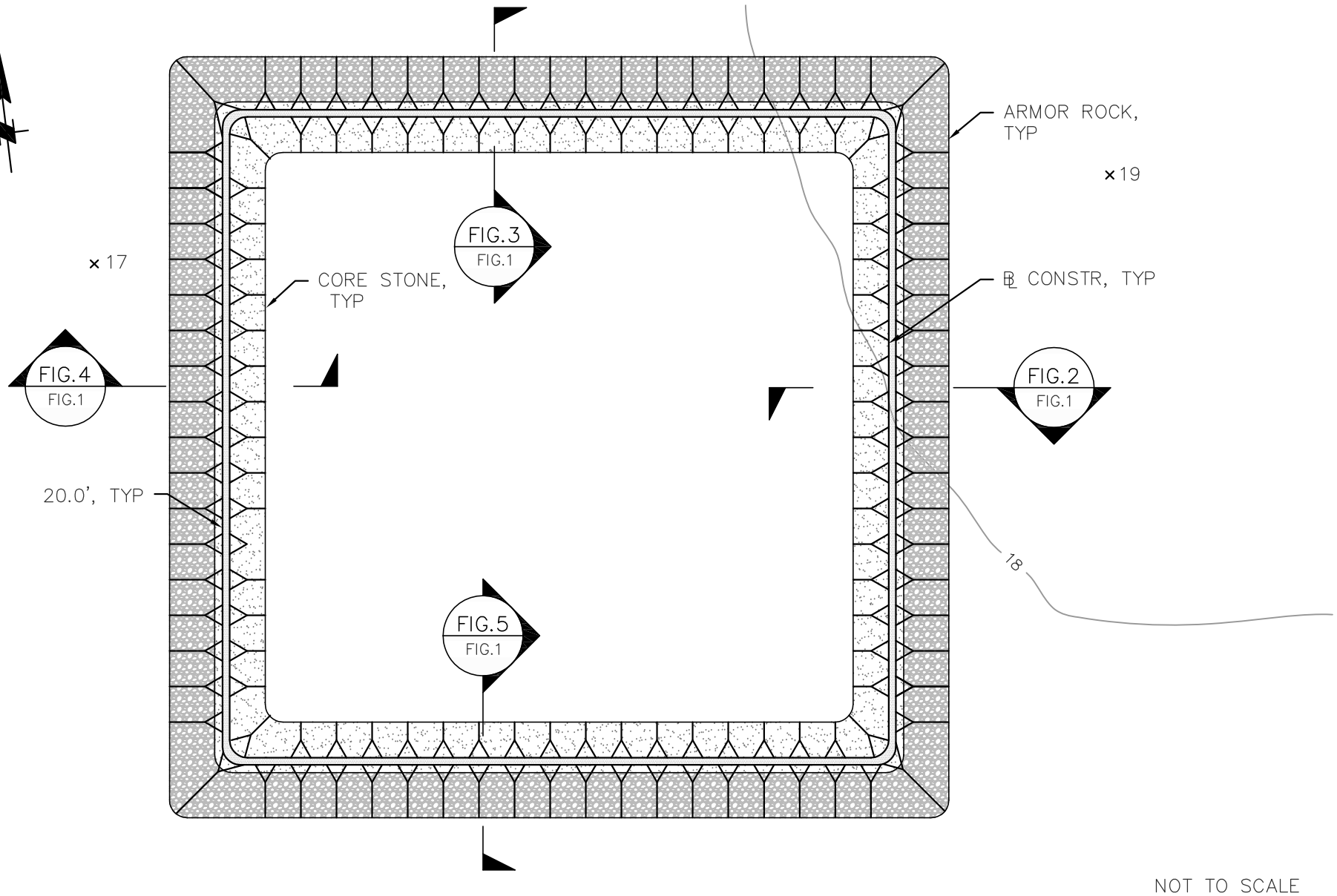


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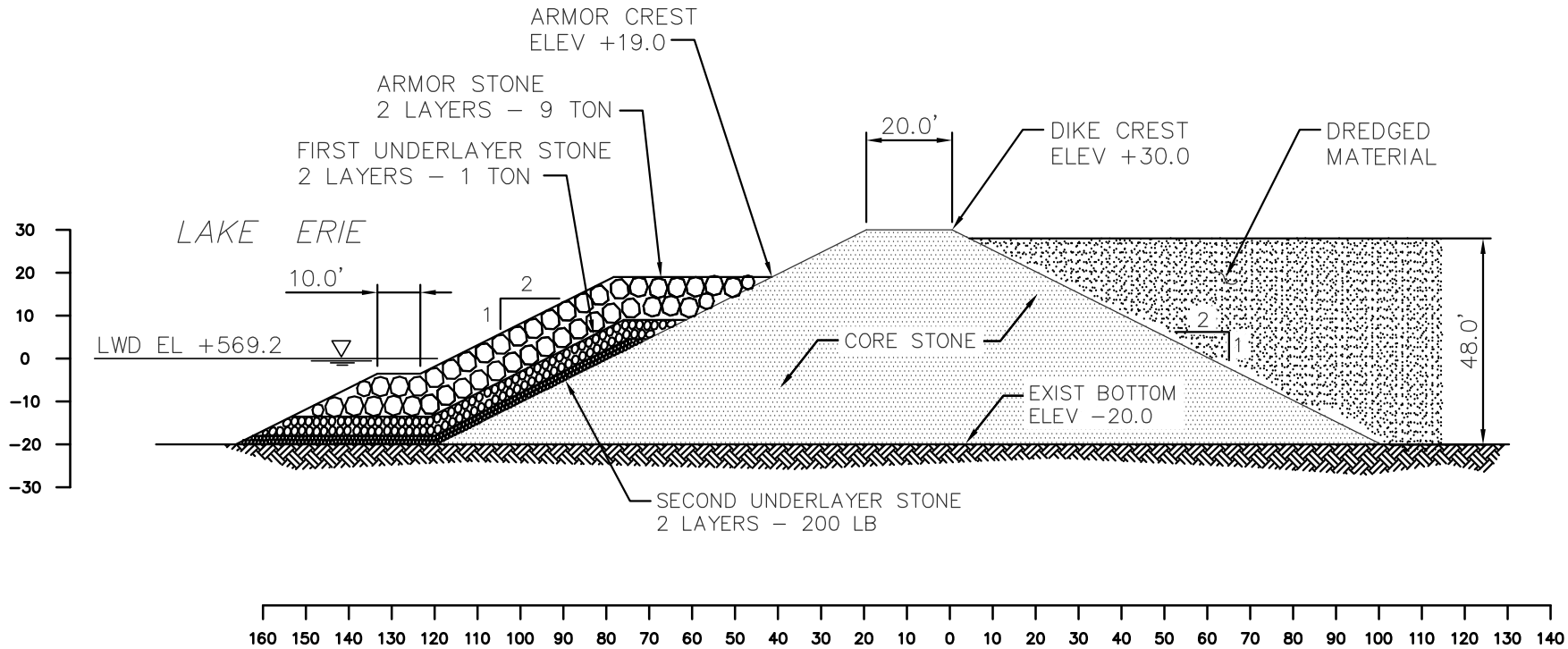
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-5

FIGURE 1
EMERGENT HABITAT RESTORATION UNIT
DEEP WATER

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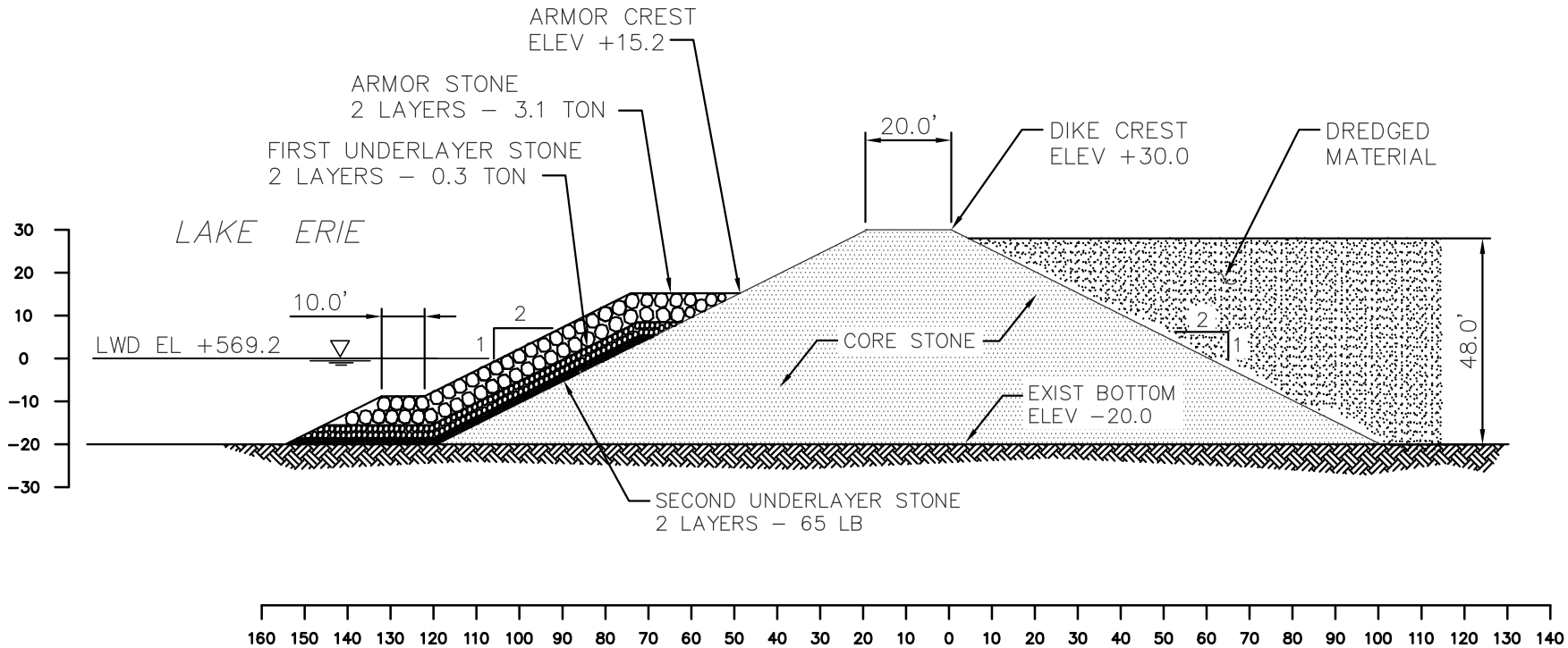
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-5 | FIGURE 2<br>EMERGENT HABITAT RESTORATION UNIT<br>DEEP WATER |

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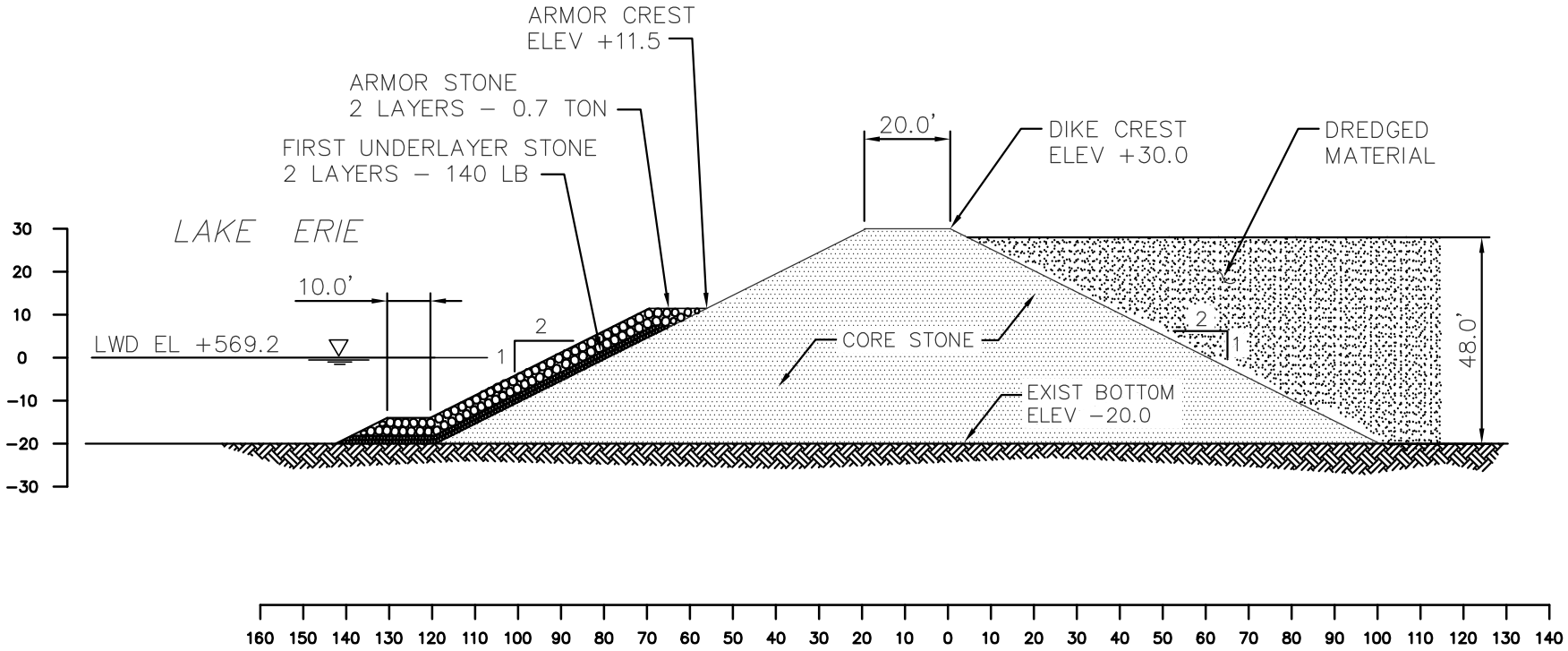
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-5 | FIGURE 3<br>EMERGENT HABITAT RESTORATION UNIT<br>DEEP WATER |

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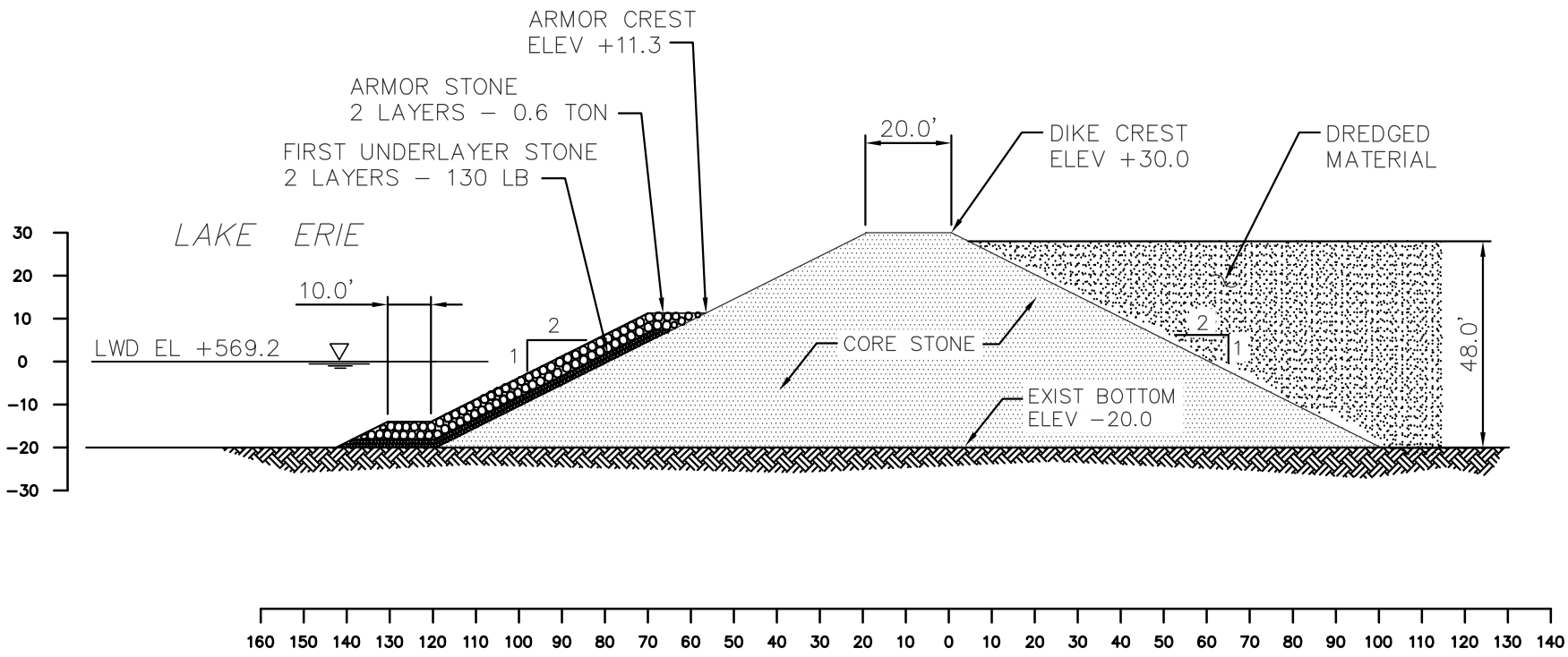
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-5

FIGURE 4
EMERGENT HABITAT RESTORATION UNIT
DEEP WATER

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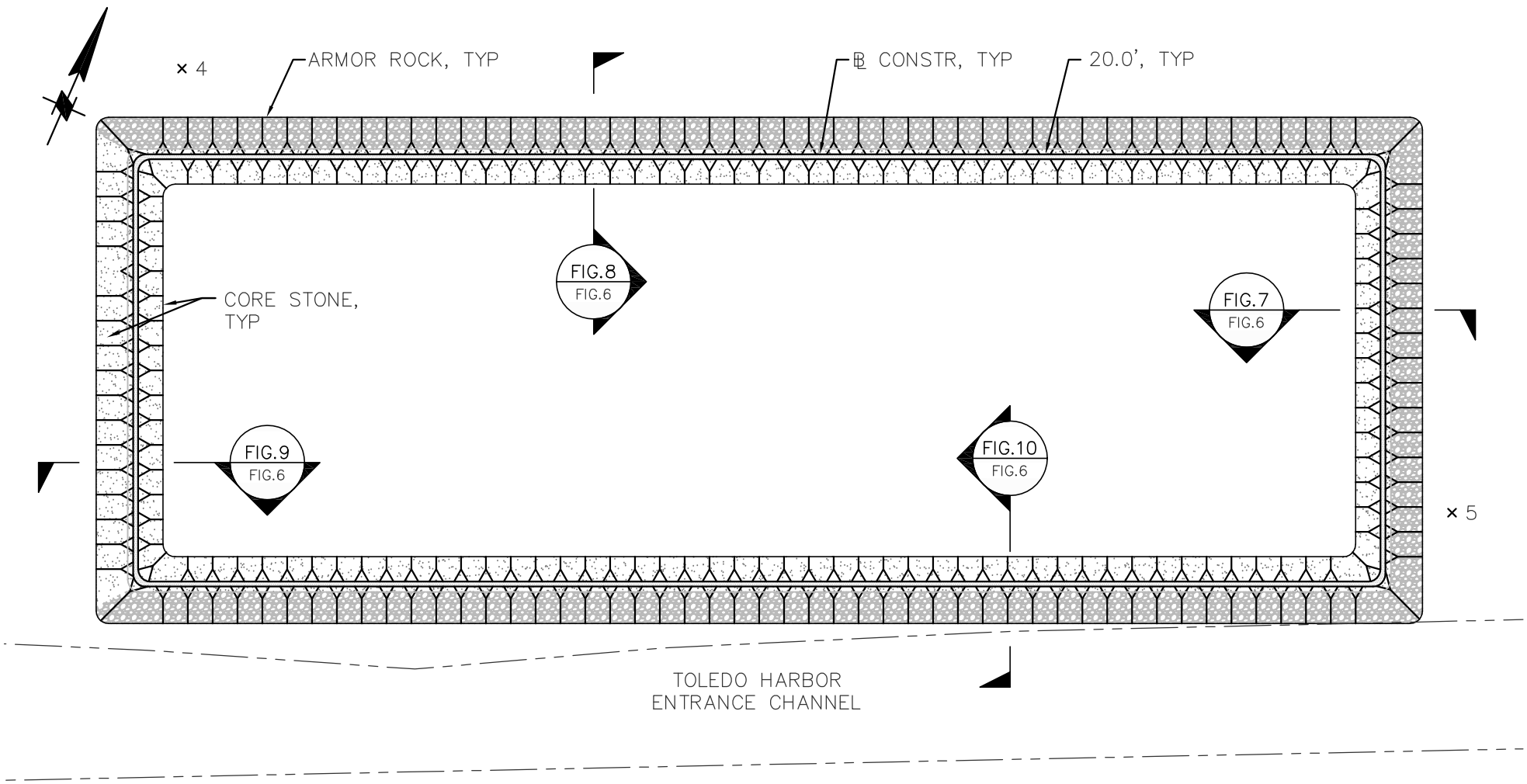
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-5 | FIGURE 5<br>EMERGENT HABITAT RESTORATION UNIT<br>DEEP WATER |

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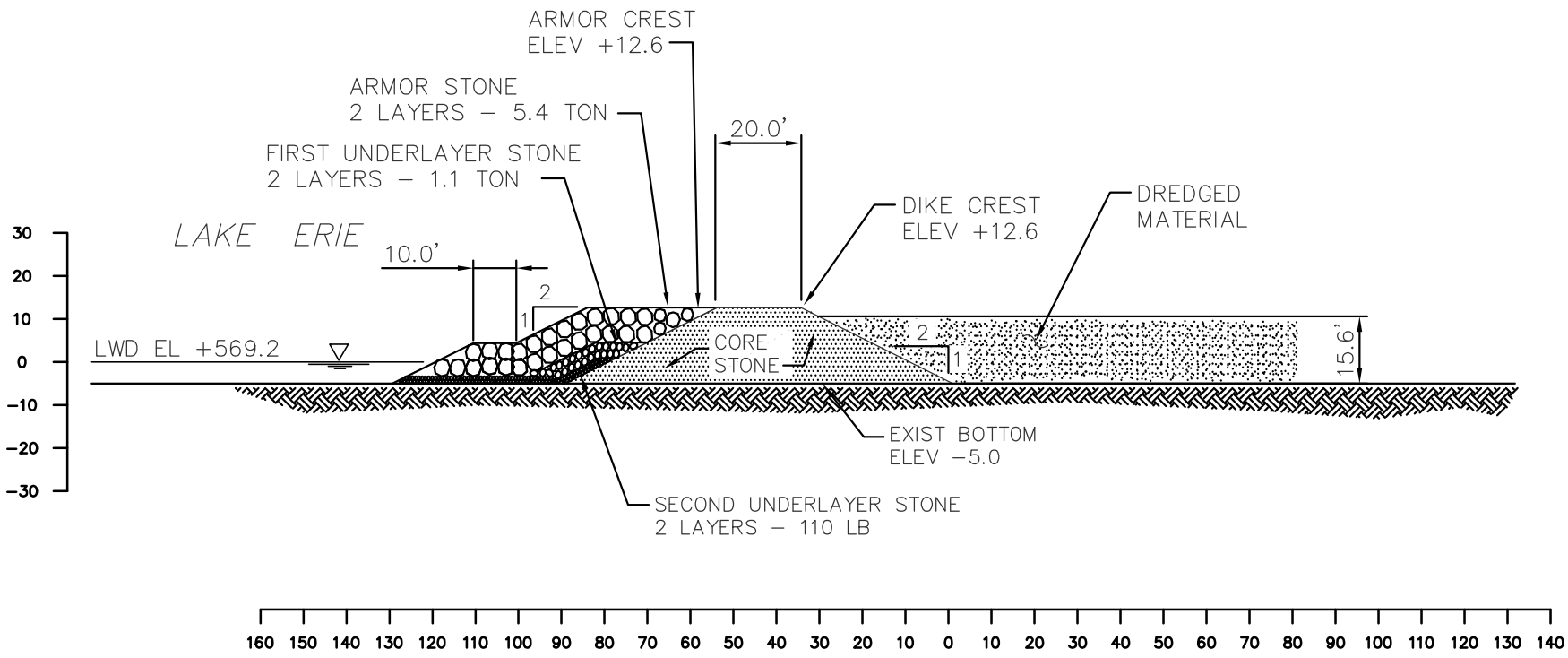
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-5

FIGURE 6
EMERGENT HABITAT RESTORATION UNIT
SHALLOW WATER

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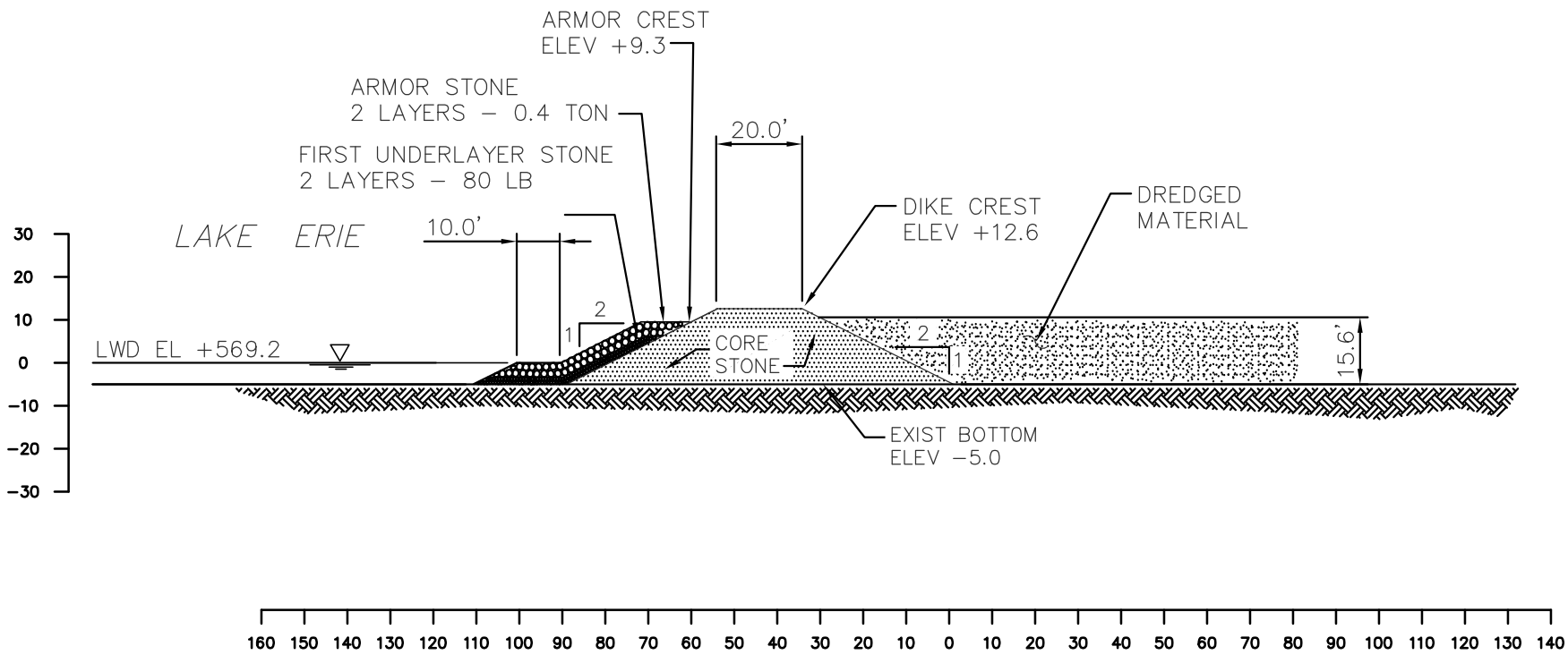
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-5 | FIGURE 7<br>EMERGENT HABITAT RESTORATION UNIT<br>SHALLOW WATER |

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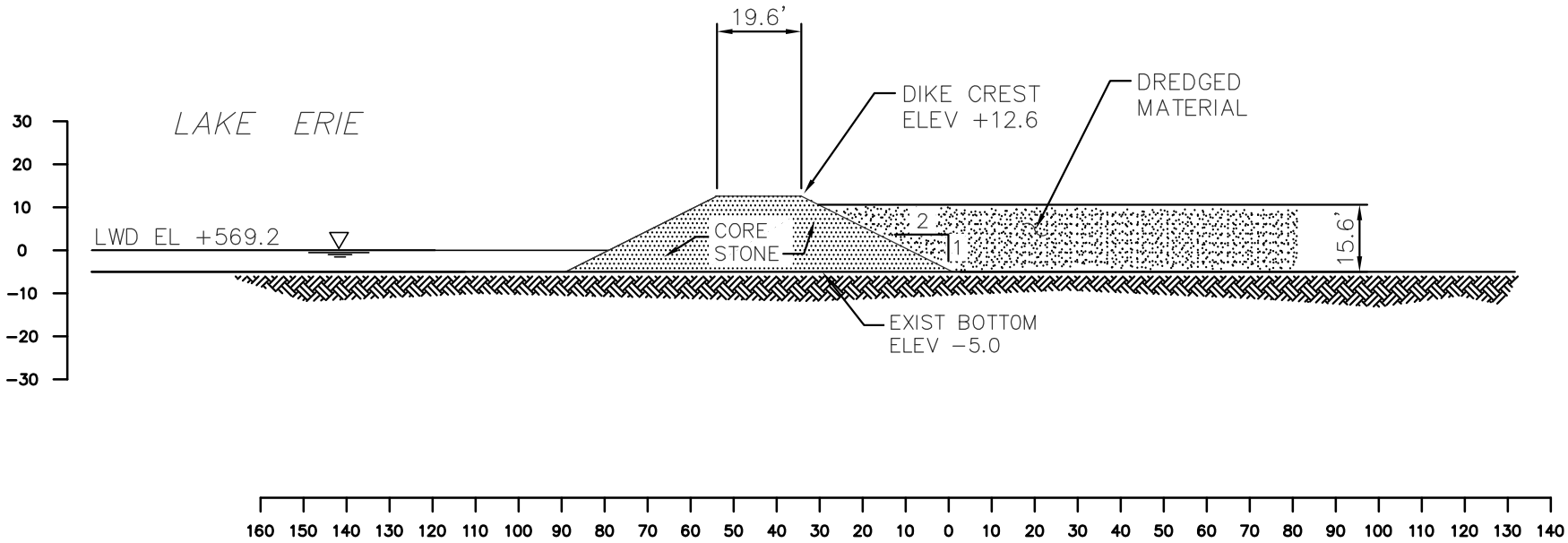
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-5

FIGURE 8
EMERGENT HABITAT RESTORATION UNIT
SHALLOW WATER

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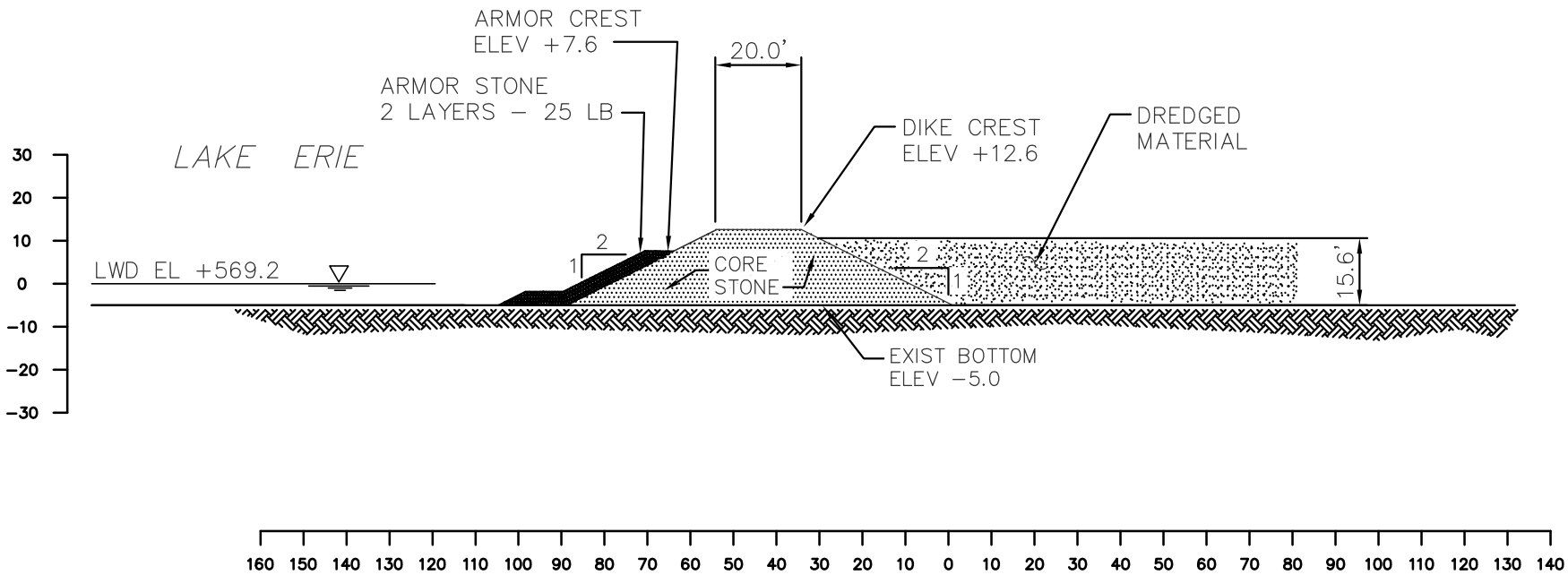
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-5

FIGURE 9
EMERGENT HABITAT RESTORATION UNIT
SHALLOW WATER

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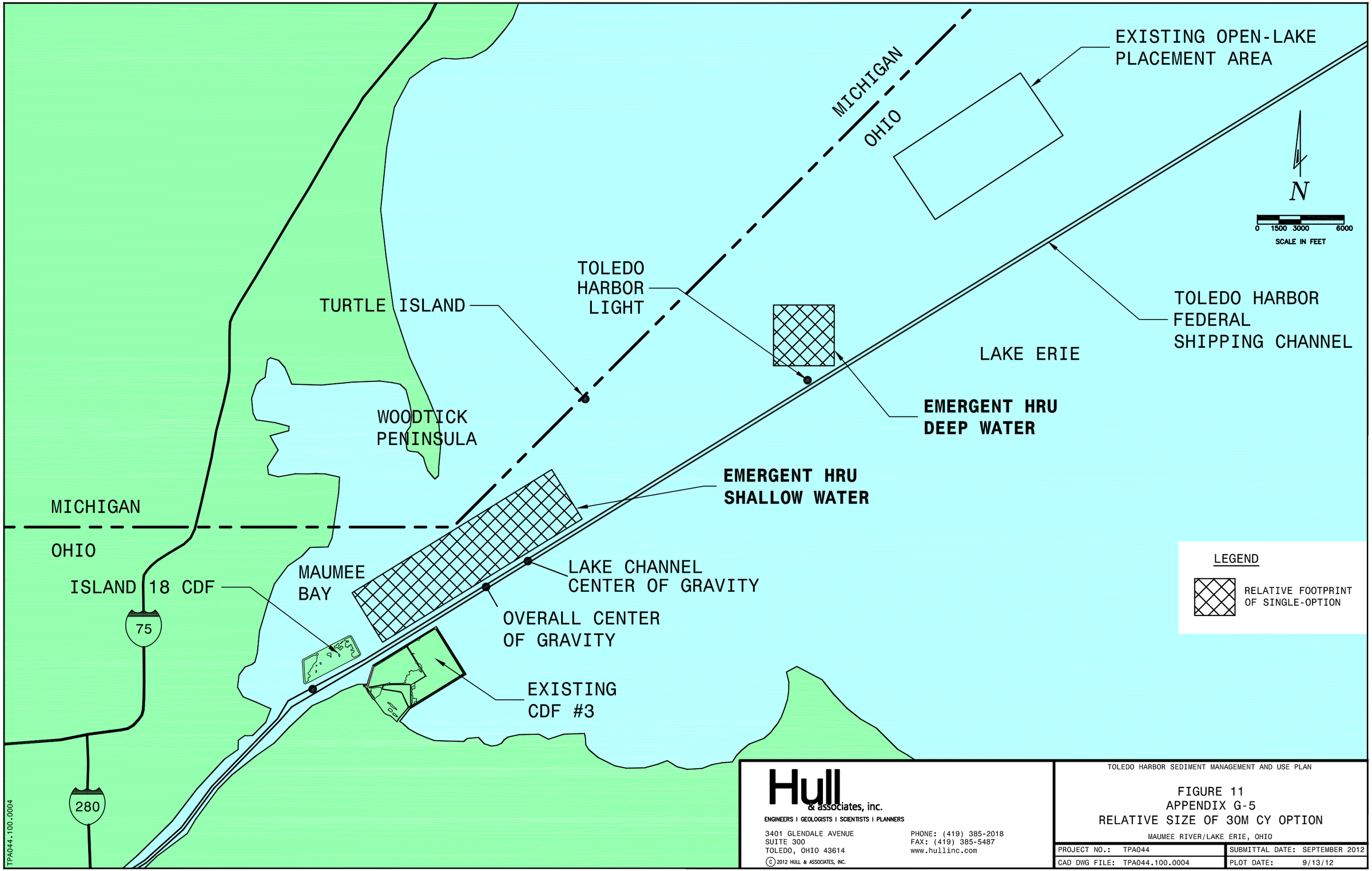
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-5

FIGURE 10
EMERGENT HABITAT RESTORATION UNIT
SHALLOW WATER

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TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FIGURE 11
APPENDIX G-5
RELATIVE SIZE OF 30M CY OPTION

MAUMEE RIVER/LAKE ERIE, OHIO

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| CAD DWG FILE: TPA044.100.0004 | PLOT DATE: 9/13/12 |

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# APPENDIX G-6

New Confined Disposal Facility

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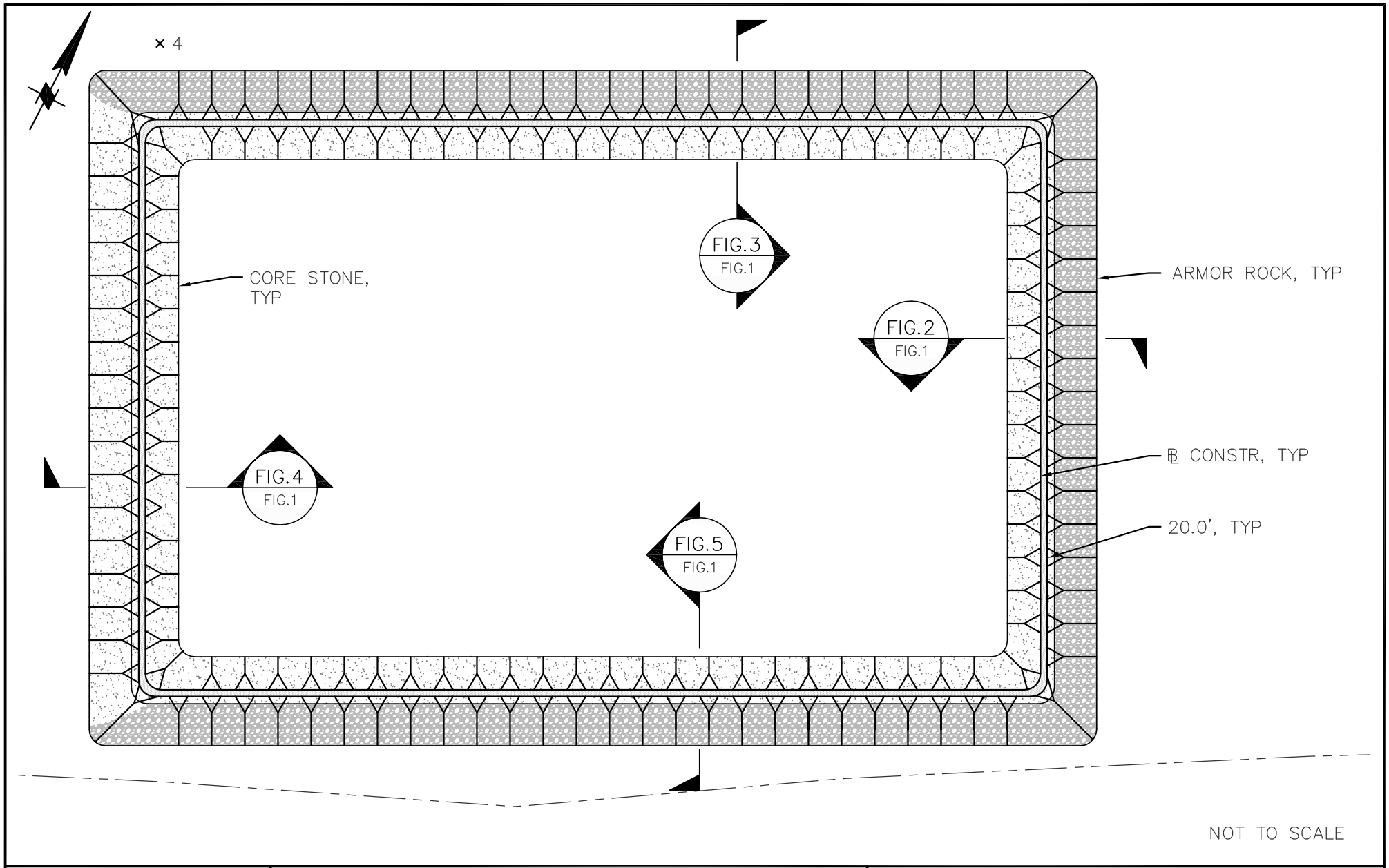


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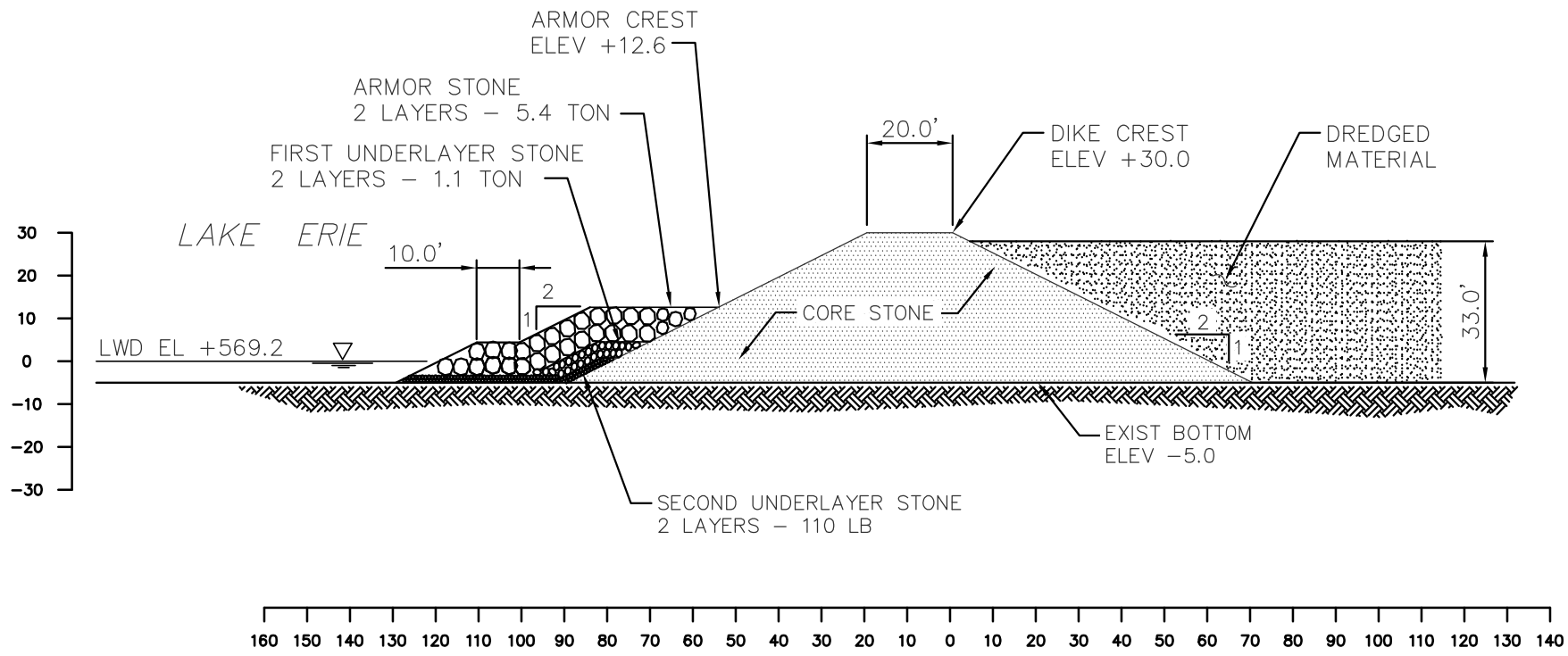
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-6

FIGURE 1
NEW CONFINED DISPOSAL FACILITY (CDF)

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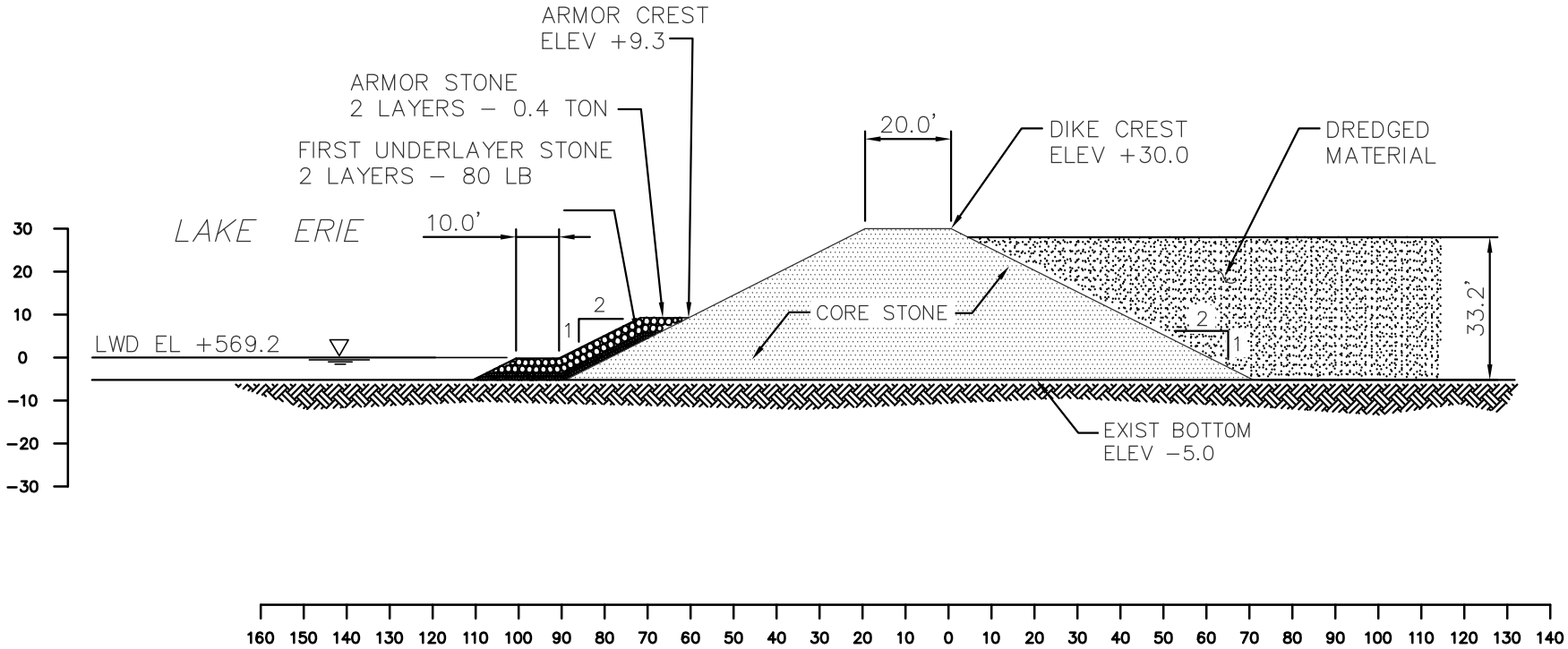
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-6 | FIGURE 2<br>NEW CONFINED DISPOSAL FACILITY (CDF) |

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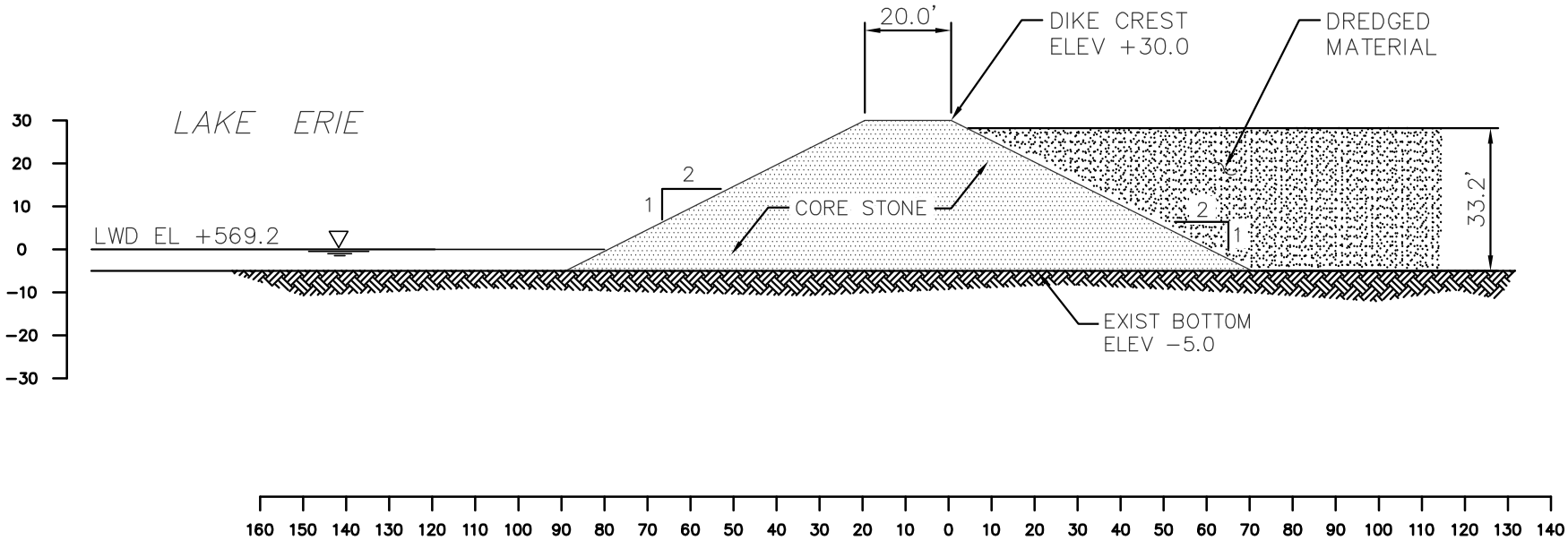
| moffatt & nichol | TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN<br>APPENDIX G-6 | FIGURE 3<br>NEW CONFINED DISPOSAL FACILITY (CDF) |

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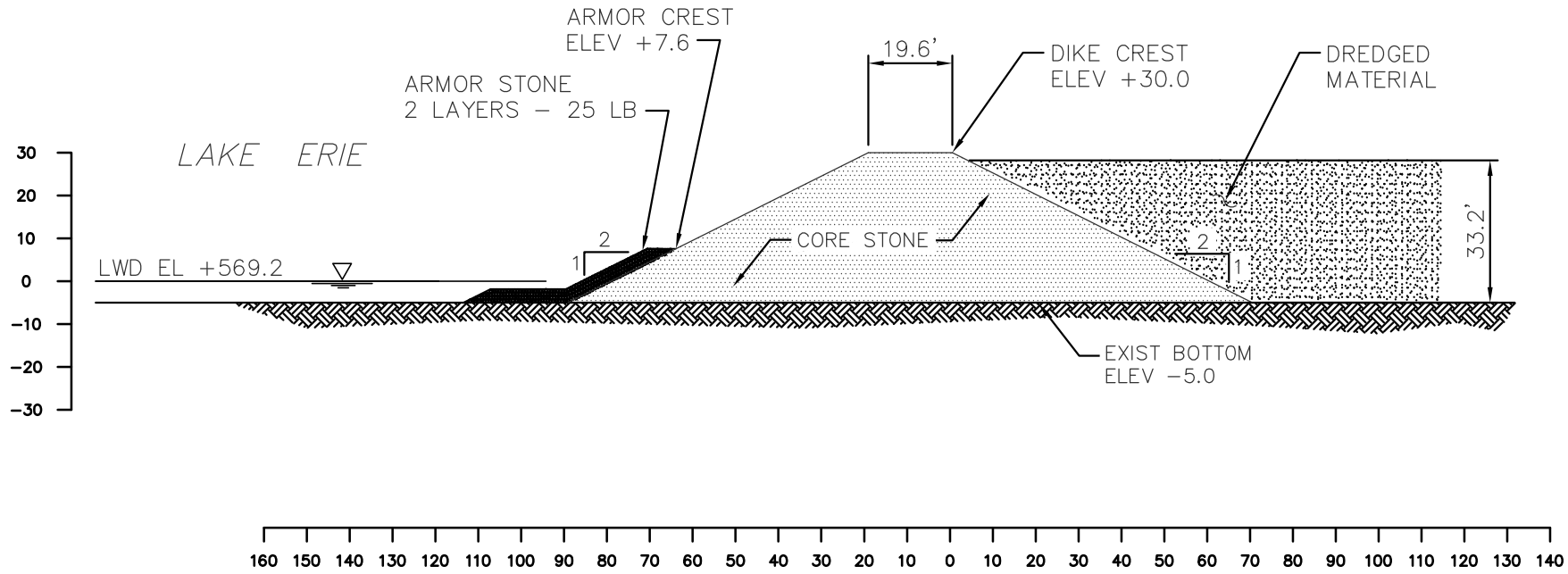
moffatt & nichol

TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-4

FIGURE 4
NEW CONFINED DISPOSAL FACILITY (CDF)

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moffatt & nichol

TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
APPENDIX G-6

FIGURE 5
NEW CONFINED DISPOSAL FACILITY (CDF)

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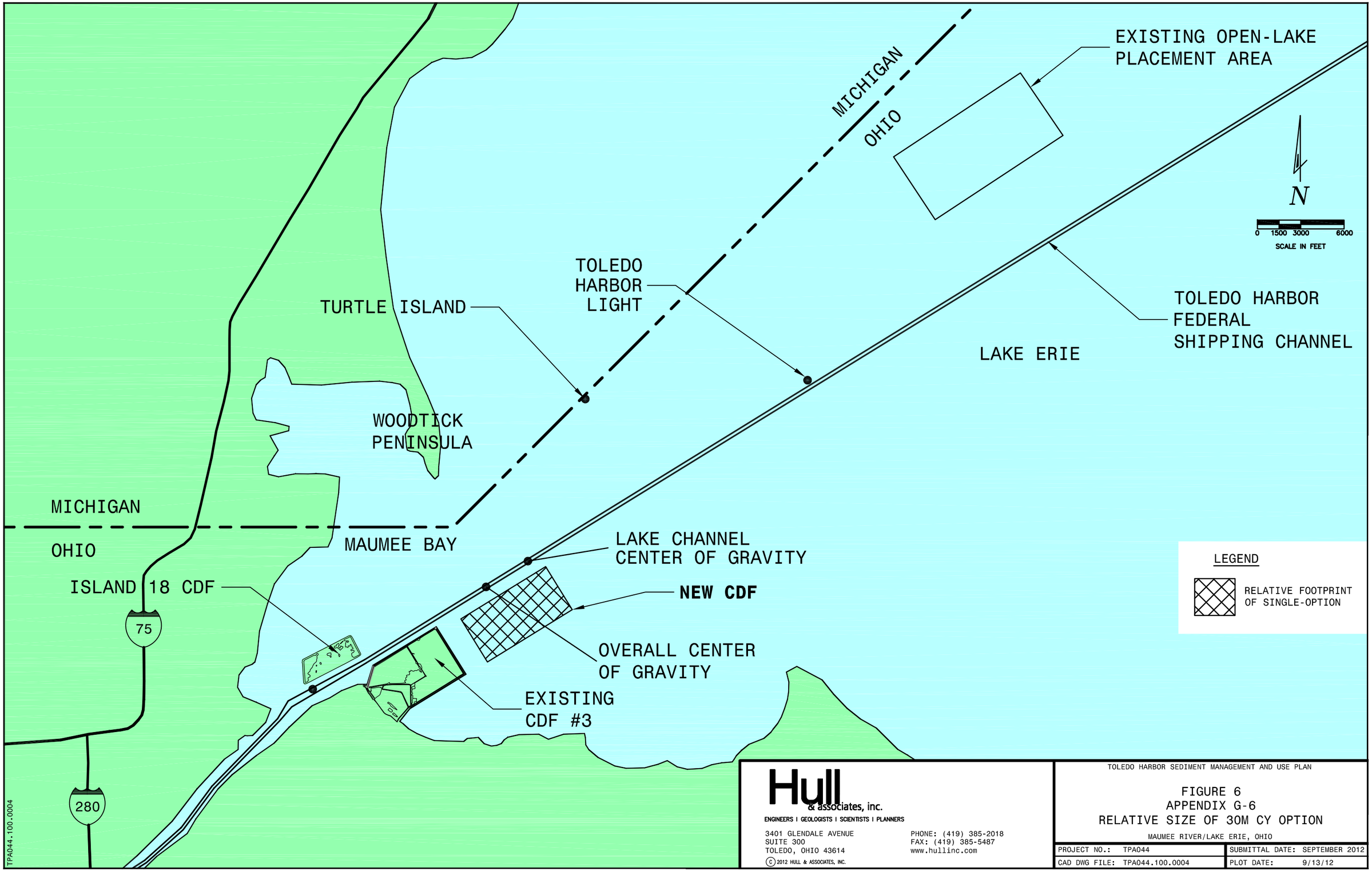


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TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FIGURE 6
APPENDIX G-6
RELATIVE SIZE OF 30M CY OPTION

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# APPENDIX G-7

Open-Lake Placement

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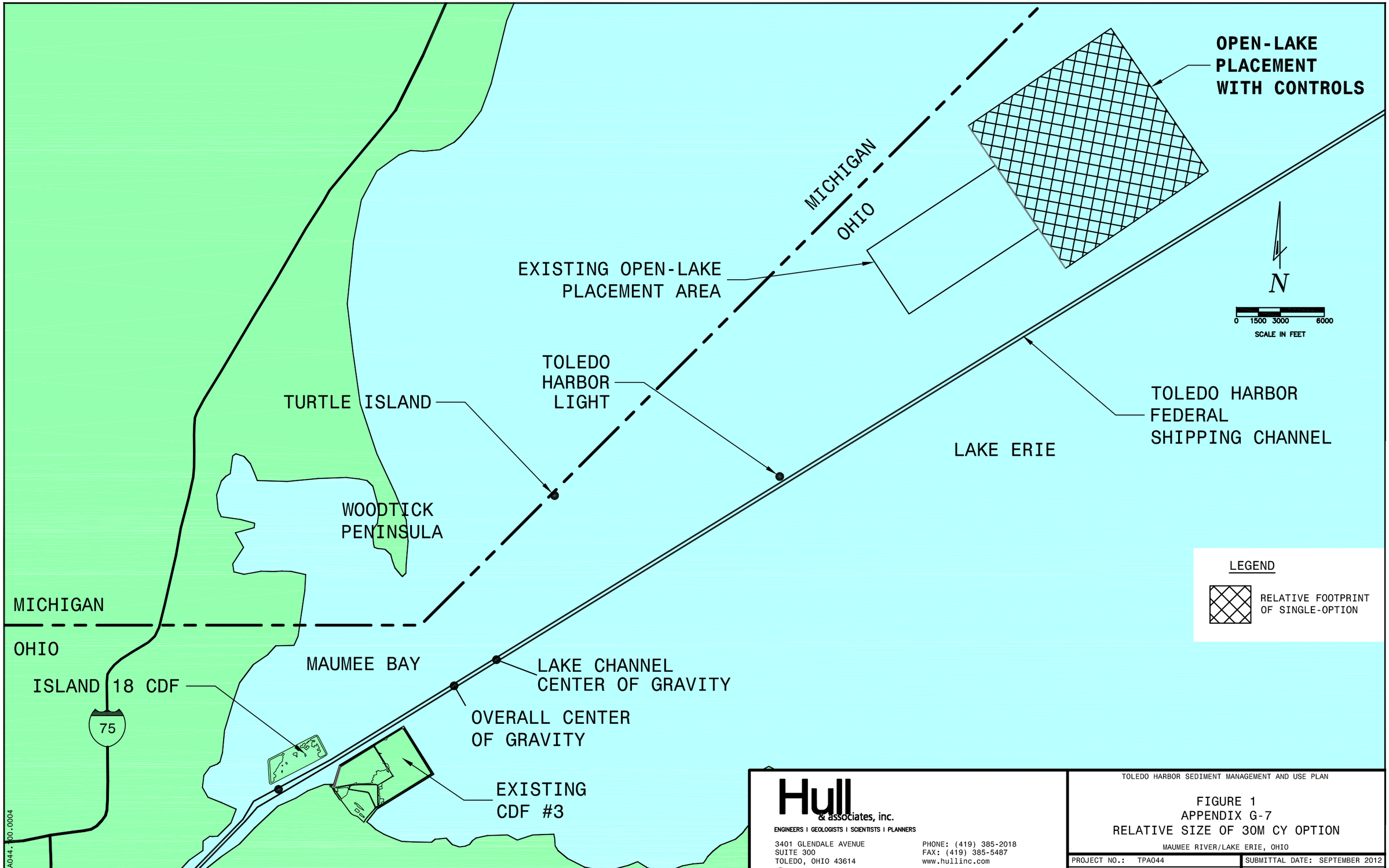


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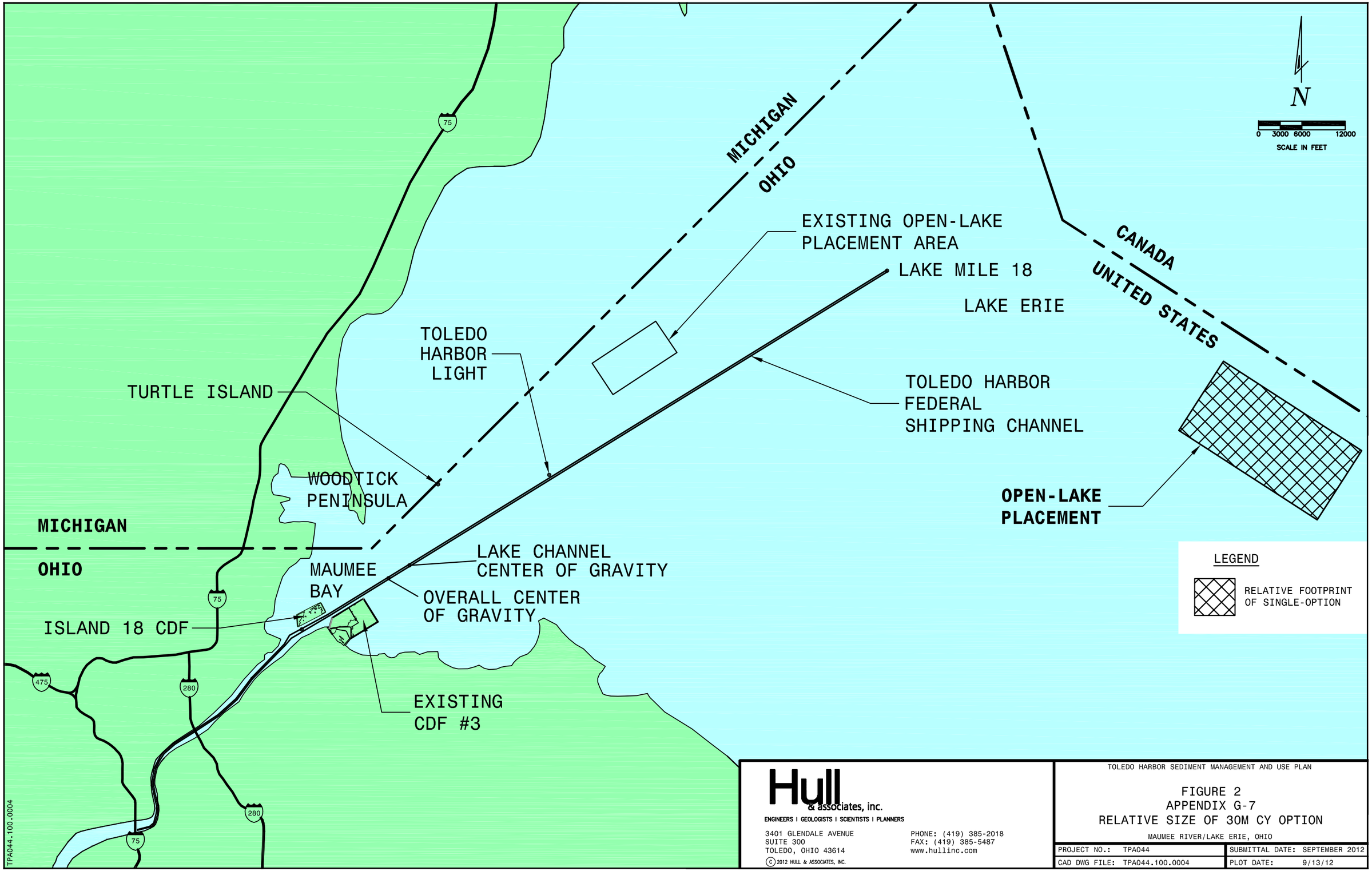
TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FIGURE 1
APPENDIX G-7
RELATIVE SIZE OF 30M CY OPTION

MAUMEE RIVER/LAKE ERIE, OHIO

| | |
|---|---|
| PROJECT NO.: TPA044 | SUBMITTAL DATE: SEPTEMBER 2012 |
| CAD DWG FILE: TPA044.100.0004 | PLOT DATE: 9/13/12 |

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TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FIGURE 2
APPENDIX G-7
RELATIVE SIZE OF 30M CY OPTION

MAUMEE RIVER/LAKE ERIE, OHIO

| | |
|---|---|
| PROJECT NO.: TPA044 | SUBMITTAL DATE: SEPTEMBER 2012 |
| CAD DWG FILE: TPA044.100.0004 | PLOT DATE: 9/13/12 |

# APPENDIX G-8

Combination Approach

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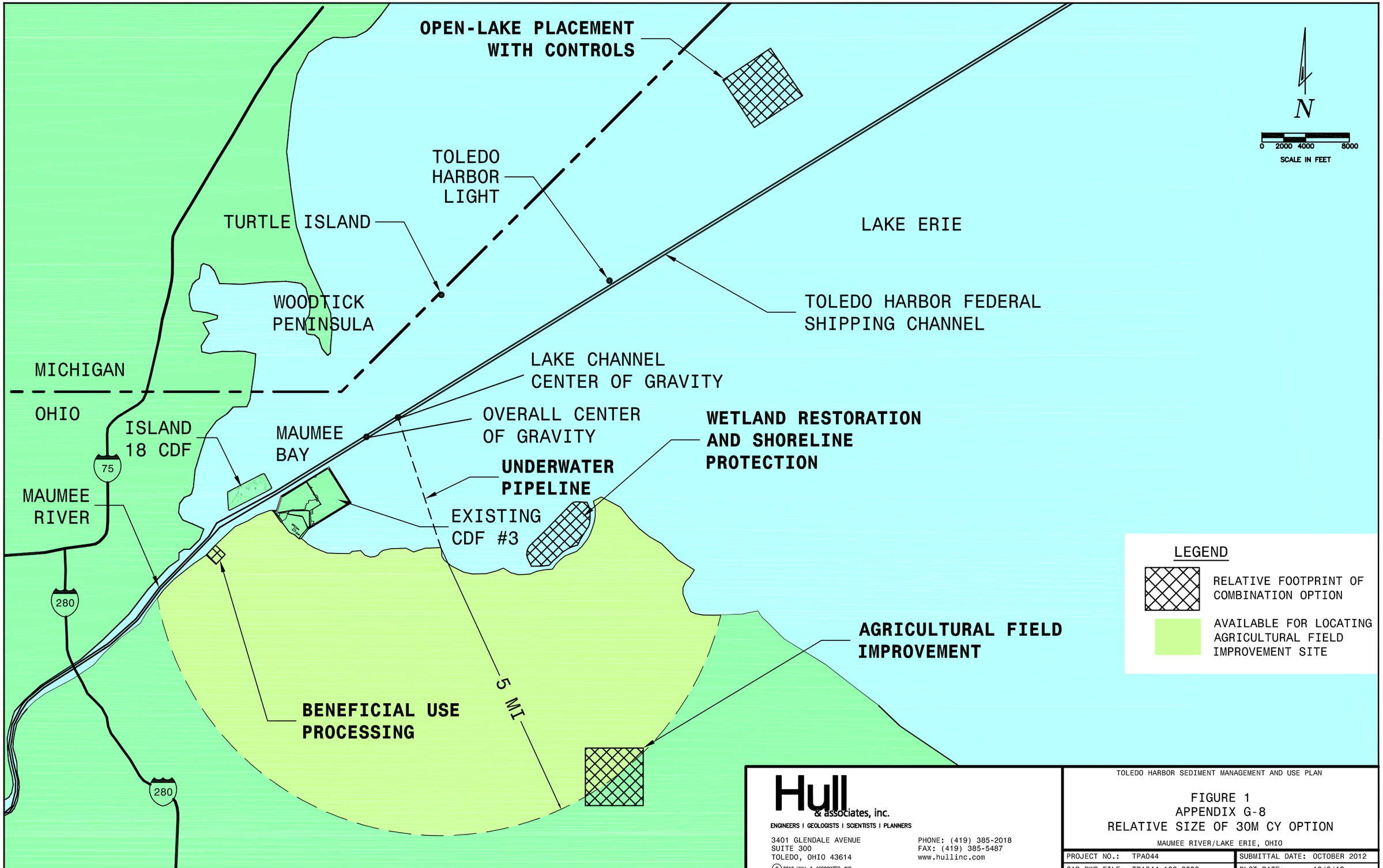
OPEN-LAKE PLACEMENT WITH CONTROLS
N
0 2000 4000 8000
SCALE IN FEET
TOLEDO HARBOR LIGHT
TURTLE ISLAND
LAKE ERIE
WOODTICK PENINSULA
TOLEDO HARBOR FEDERAL SHIPPING CHANNEL
MICHIGAN
LAKE CHANNEL CENTER OF GRAVITY
OHIO
OVERALL CENTER OF GRAVITY
ISLAND 18 CDF
MAUMEE BAY
WETLAND RESTORATION AND SHORELINE PROTECTION
75
UNDERWATER PIPELINE
MAUMEE RIVER
EXISTING CDF #3
LEGEND
RELATIVE FOOTPRINT OF COMBINATION OPTION
AVAILABLE FOR LOCATING AGRICULTURAL FIELD IMPROVEMENT SITE
280
AGRICULTURAL FIELD IMPROVEMENT
5 MI
BENEFICIAL USE PROCESSING
280
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TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN
FIGURE 1
APPENDIX G-8
RELATIVE SIZE OF 30M CY OPTION
MAUMEE RIVER/LAKE ERIE, OHIO
PROJECT NO.: TPA044
SUBMITTAL DATE: OCTOBER 2012
CAD DWG FILE: TPA044.100.0006
PLOT DATE: 10/3/12

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# APPENDIX H

Detailed Cost Estimates for Sediment Management and Use Options

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**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-1**

**RELATIVE UNIT COST AND TOTAL COST OF THE SINGLE-OPTIONS[1,2,3]**

| | | Sediment Management and Use Option | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upland | | | Nearshore | In-Water | | | | | | |
| Item # | Description | Beneficial Use | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Wetland Restoration and Shoreline Protection | Submerged Habitat Restoration Unit (Deep Water) | Submerged Habitat Restoration Unit (Shallow Water) | Emergent Habitat Restoration Unit (Deep Water) | Emergent Habitat Restoration Unit (Shallow Water) | New CDF | Open-Lake Placement with Controls | New Open-Lake Placement Area without Controls |
| 1.0 | Processing, hauling, handling | $7.70 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 2.0 | Containment structure (dike) | N/A | $0.10 | $0.10 | $0.60 | $1.00 | $0.40 | $6.30 | $3.10 | $5.20 | N/A | N/A |
| 3.0 | Containment structure (cap) | N/A | N/A | N/A | N/A | $13.50 | $27.00 | N/A | N/A | N/A | N/A | N/A |
| 4.0 | Containment structure - (slope protection) | N/A | N/A | N/A | $0.80 | $0.70 | $0.50 | $2.30 | $0.90 | $0.60 | N/A | N/A |
| 5.0 | Habitat/site development | $0.10 | $1.30 | $1.90 | $0.40 | N/A | N/A | $0.10 | $0.10 | N/A | $<0.10 | N/A |
| 6.0 | Nutrient loading controls | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | $1.50 | N/A |
| 7.0 | Pump-out area development | N/A | $0.70 | $0.70 | $0.70 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 8.0 | Capping | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | $0.50 | N/A |
| | **Subtotal 1** | **$7.80** | **$2.10** | **$2.70** | **$2.50** | **$15.20** | **$27.90** | **$8.70** | **$4.10** | **$5.80** | **$2.00** | **$0.00** |
| 9.0 | Mobilization and Demobilization (8% of subtotal 1)[5] | $0.60 | $0.20 | $0.20 | $0.20 | $1.20 | $2.20 | $0.70 | $0.40 | $0.50 | N/A | N/A |
| | **Subtotal 2** | **$8.40** | **$2.30** | **$2.90** | **$2.70** | **$16.40** | **$30.10** | **$9.40** | **$4.50** | **$6.30** | **$2.00** | **$0.00** |
| 10.0 | Dredged material placement | $7.50 | N/A | N/A | N/A | $7.50 | $7.50 | $7.50 | $7.50 | $7.50 | N/A | N/A |
| 11.0 | Site proximity to center of gravity[4] | ($0.20) | ($0.30) | ($0.30) | ($0.30) | $0.50 | $<0.10 | $0.50 | $<0.10 | $<0.10 | $0.50 | $2.10 |
| | **Subtotal 3** | **$15.70** | **$2.00** | **$2.60** | **$2.40** | **$24.40** | **$37.60** | **$17.40** | **$12.00** | **$13.80** | **$2.50** | **$2.10** |
| 12.0 | Planning, engineering, and design (10% of subtotal 3)[6] | $1.60 | $0.20 | $0.30 | $0.20 | $2.40 | $3.80 | $1.70 | $1.20 | $1.40 | $0.30 | $0.20 |
| 13.0 | Operation and maintenance (5% of subtotal 3)[7] | $0.80 | $0.10 | $0.10 | $0.10 | $1.20 | $1.90 | $0.90 | $0.60 | $0.70 | $0.10 | $0.10 |
| | **Subtotal 4** | **$18.10** | **$2.30** | **$3.00** | **$2.70** | **$28.00** | **$43.30** | **$20.00** | **$13.80** | **$15.90** | **$2.90** | **$2.40** |
| 14.0 | Dredging (clamshell) | $6.00 | $6.00 | $6.00 | $6.00 | $6.00 | $6.00 | $6.00 | $6.00 | $6.00 | $6.00 | $6.00 |
| | **Subtotal 5** | **$24.10** | **$8.30** | **$9.00** | **$8.70** | **$34.00** | **$49.30** | **$26.00** | **$19.80** | **$21.90** | **$8.90** | **$8.40** |
| 15.0 | Contingency (25% of subtotal 5)[8] | $6.00 | $2.00 | $2.20 | $2.20 | $8.60 | $12.40 | $6.40 | $4.90 | $5.40 | $2.20 | $2.10 |
| | **Relative unit costs ($/CY)** | **$30.10** | **$10.30** | **$11.20** | **$10.90** | **$42.60** | **$61.70** | **$32.40** | **$24.70** | **$27.30** | **$11.10** | **$10.50** |
| | **Total relative costs[9]** | **$903,000,000** | **$309,000,000** | **$336,000,000** | **$327,000,000** | **$1,278,000,000** | **$1,851,000,000** | **$972,000,000** | **$741,000,000** | **$819,000,000** | **$333,000,000** | **$315,000,000** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

$<0.10 – Cost was estimated to be less than $0.10 and is not included in the relative cost CY – Cubic yard N/A – Not applicable

1. Detailed assumptions for each option and major cost elements are presented in Section 6.0 of the Toledo Harbor Sediment Management and Use Plan.
2. Cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assumed each single-option would accommodate 30 million CY.
3. Unit cost calculations are included in subsequent Tables H-3 through H-12.
4. Since the initial dredging cost included a one-way haul of 2 miles, an increase or decrease was given to sites that were farther away or closer than the 2-mile range, respectively. The cost of $0.16/CY of material per mile to haul the material was determined by the average size of the current scows used and the travel time of these scows. Values listed in parenthesis indicate a cost credit based on the option being closer than the 2-mile range.
5. Cost for mobilization and demobilization was assumed to be 8% of all construction costs, not including the baseline dredging cost.
6. Planning, engineering, and design (PED) was assumed to be 10% of all additional costs implemented to the baseline dredge cost, including the mobilization and demobilization.
7. Operation and maintenance (O&M) was assumed to be 5 percent of all additional costs implemented to the baseline dredge cost, including the mobilization and demobilization.
8. A contingency was assumed to be 25% of all costs, including the baseline dredge cost. The contingency is to account for additional project requirements and associated costs that were not determined during this preliminary evaluation. These requirements and associated costs will be included in a detailed design.
9. Total relative costs do not include adjustments for inflation and are based on 2012 dollars.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by, and reviewed under the supervision of, professionals who are competent in construction cost estimating, possess a working knowledge of construction, and capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values, but they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-2**

**RELATIVE UNIT COST AND TOTAL COST OF COMBINATION OPTION [1,2,3]**

| | | Potential Sediment Management and Use Option | | | | |
|---|---|---|---|---|---|---|
| | | Single-Option Components Comprising the Combination Option | | | | |
| Item # | Description | Beneficial Use[10] | Wetland Restoration and Shoreline Protection[11] | Agricultural Field Improvements[12] | Open-Lake Placement with Controls[13] | Combination Option[14] |
| 1.0 | Processing, hauling, handling | $5.70 | N/A | N/A | N/A | $0.60 |
| 2.0 | Containment structure (dike) | N/A | $1.40 | $0.10 | N/A | $0.40 |
| 3.0 | Containment structure (cap) | N/A | N/A | N/A | N/A | N/A |
| 4.0 | Containment structure - (slope protection) | N/A | $1.70 | N/A | N/A | $0.40 |
| 5.0 | Habitat/site development | $0.10 | $0.50 | $2.20 | $<0.10 | $0.60 |
| 6.0 | Nutrient loading controls | N/A | N/A | N/A | $1.50 | $0.70 |
| 7.0 | Pump-out area development | N/A | $0.70 | $0.70 | N/A | $0.30 |
| 8.0 | Capping | N/A | N/A | N/A | $0.50 | $0.20 |
| | **Subtotal 1** | **$5.80** | **$4.30** | **$3.00** | **$2.00** | **$3.20** |
| 9.0 | Mobilization and Demobilization (8% of subtotal 1)[5] | $0.50 | $0.40 | $0.30 | N/A | $0.20 |
| | **Subtotal 2** | **$6.30** | **$4.70** | **$3.30** | **$2.00** | **$3.40** |
| 10.0 | Dredged material placement | $7.50 | N/A | N/A | N/A | $0.70 |
| 11.0 | Site proximity to center of gravity[4] | ($0.20) | ($0.30) | ($0.30) | $0.50 | $0.10 |
| | **Subtotal 3** | **$13.60** | **$4.40** | **$3.00** | **$2.50** | **$4.20** |
| 12.0 | Planning, engineering, and design (10% of subtotal 3)[6] | $1.40 | $0.40 | $0.30 | $0.30 | $0.40 |
| 13.0 | Operation and maintenance (5% of subtotal 3)[7] | $0.70 | $0.20 | $0.20 | $0.10 | $0.20 |
| | **Subtotal 4** | **$15.70** | **$5.00** | **$3.50** | **$2.90** | **$4.80** |
| 14.0 | Dredging (clamshell) | $6.00 | $6.00 | $6.00 | $6.00 | $6.00 |
| | **Subtotal 5** | **$21.70** | **$11.00** | **$9.50** | **$8.90** | **$10.80** |
| 15.0 | Contingency (25% of subtotal 5)[8] | $5.40 | $2.80 | $2.40 | $2.20 | $2.70 |
| | **Relative unit costs ($/CY)** | **$27.10** | **$13.80** | **$11.90** | **$11.10** | **$13.50** |
| | **Total relative costs[9]** | **$81,311,000** | **$96,271,000** | **$83,306,000** | **$144,901,000** | **$405,789,000** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

$<0.10 – Cost was estimated to be less than $0.10 and is not included in the relative cost CY – Cubic yard N/A – Not applicable

1. Detailed assumptions for each option and major cost elements are presented in Section 6.0 of the Toledo Harbor Sediment Management and Use Plan.
2. Cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assumed the combination option would accommodate 30 million CY.
3. Unit cost calculations are included in subsequent Tables H-13 through H-16.
4. Since the initial dredging cost included a one-way haul of 2 miles, an increase or decrease was given to sites that were farther away or closer than the 2-mile range, respectively. The cost of $0.16/CY of material per mile to haul the material was determined by the average size of the current scows used and the travel time of these scows. Values listed in parenthesis indicate a cost credit based on the option being closer than the 2-mile range.
5. Cost for mobilization and demobilization was assumed to be 8% of all construction costs, not including the baseline dredging cost.
6. Planning, engineering, and design (PED) was assumed to be 10% of all additional costs implemented to the baseline dredge cost, including the mobilization and demobilization.
7. Operation and maintenance (O&M) was assumed to be 5 percent of all additional costs implemented to the baseline dredge cost, including the mobilization and demobilization.
8. A contingency was assumed to be 25% of all costs, including the baseline dredge cost. The contingency accounts for additional project requirements and associated costs that were not identified during this preliminary evaluation. These requirements and associated costs will be included in a detailed design.
9. Total relative costs do not include adjustments for inflation and are based on 2012 dollars.
10. These relative unit costs assume the option would accommodate 3 million CY.
11. These relative unit costs assume the option would accommodate 7 million CY.
12. These relative unit costs assume the option would accommodate 7 million CY.
13. These relative unit costs assume the option would accommodate 13 million CY.
14. These relative unit costs are an overall average of the combined options determined by the adding the total cost of all four options and dividing it by the total dredged material quantity of 30M CY.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by, and reviewed under the supervision of, professionals who are competent in construction cost estimating, possess a working knowledge of construction, and capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potent funding values, but they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-3**

**RELATIVE UNIT COST CALCULATIONS FOR THE BENEFICIAL USE SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **1.0** | **Processing, hauling, handling** | | | | | | | | | |
| 1.1 | Haul to Process Site[b] | 1 | CY | 30,000,000 | CY | 30,000,000 | CY | $5.50 | $165,000,000 | $5.50 |
| 1.2 | Dewatering Cost[c] | 0.02 | LF/SF | 21,780,000 | SF | 435,600 | LF | $2.00 | $871,200 | $0.03 |
| 1.3 | Additives (Lime)[d] | 0.004 | TON/CY | 18,000,000 | CY | 77,005 | TON | $150 | $11,550,750 | $0.39 |
| 1.4 | Blending / Mixing[e] | 1 | CY | 18,000,000 | CY | 18,000,000 | CY | $1.50 | $27,000,000 | $0.90 |
| 1.5 | Loading[f] | 1 | CY | 18,077,005 | CY | 18,077,005 | CY | $1.50 | $27,115,508 | $0.90 |
| 1.6 | Material management plan[g] | 1 | EA | 1 | EA | 1 | EA | $50,000 | $50,000 | $<0.01 |
| | | | | | | | | **Subtotal - 1.0 Processing, hauling, handling** | $231,587,458 | $7.70 |
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Property / Land - Processing[h] | 1 | AC | 500 | AC | 500 | AC | $6,000 | $3,000,000 | $0.10 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $3,000,000 | $0.10 |
| | | | | | | | | **Total** | **$234,587,458** | **$7.80** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume each single-option would accommodate 30 million CY.
b. This item is based on a local round trip transportation price provided by local broker for a distance within 3 miles.
c. This item includes the cost to purchase and install a 4"-6" perforated drain tile every 50 feet on center on top of the existing surface of the process site to collect water during the dewatering process.
d. This item includes the cost to add lime as an additive to the dredge material at a rate of 4 tons of lime per 935 CY of dredged material.
e. This item includes the cost of an operator and a piece of equipment (dozer) to mix the additive and sediment at the process site.
f. This item includes the cost of an operator and a piece of equipment (loader) to load the augmented material onto the recipient's truck.
g. This item includes the cost to prepare a material management plan.
h. This item includes the cost to purchase property at a local land value of $6,000 per acre to develop a process site.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-4**

**RELATIVE UNIT COST CALCULATIONS FOR THE AGRICULTURAL FIELD IMPROVEMENTS (5-MILE) SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)** | | | | | | | | | |
| 2.1 | Berms / Containment Structures[b] | 60,000 | CY/EA | 5 | EA | 300,000 | CY | $10 | $3,000,000 | $0.10 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $3,000,000 | $0.10 |
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Drain Tiles[c] | 0.02 | LF/SF | 127,575,000 | SF | 2,551,500 | LF | $3.00 | $7,654,500 | $0.26 |
| 5.2 | Misc. Improvements / Access[d] | 1 | EA/YR | 30 | YR | 30 | EA | $6,500 | $195,000 | $0.01 |
| 5.3 | Booster Pump Facility[e] | 1 | EA | 8 | EA | 8 | EA | $50,000 | $400,000 | $0.01 |
| 5.4 | Pump Cost[f] | 1 | EA | 8 | EA | 8 | EA | $100,000 | $800,000 | $0.03 |
| 5.5 | Pump Operations (electric)[g] | 680 | KW/HR | 33,333 | HR | 22,666,440 | KWH | $0.15 | $3,399,966 | $0.11 |
| 5.6 | Upland HDPE Pipe[h] | 5,280 | FT/MI | 15 | MI | 79,200 | FT | $200 | $15,840,000 | $0.53 |
| 5.7 | Easement Cost[i] | 15 | MI | 2,376,000 | SF | 55 | AC | $6,000 | $330,000 | $0.01 |
| 5.8 | On Site piping[j] | 3000 | AC | 4.69 | SM | 24,763 | FT | $100 | $2,476,320 | $0.08 |
| 5.9 | Management/placement/pumping[k] | 3 | EA | 33,333 | HR | 100,000 | HR | $50 | $5,000,000 | $0.17 |
| 5.10 | Land Rental[l] | 3000 | AC | 3 | YR | 9,000 | AC-YR | $200 | $1,800,000 | $0.06 |
| 5.11 | Land Cover (alfalfa)[m] | 1 | EA | 3,000 | AC | 3,000 | AC | $100 | $300,000 | $0.01 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $38,195,786 | $1.30 |
| **7.0** | **Pump-out area development** | | | | | | | | | |
| 7.1 | Dredging for Rehandling Basin[n] | 6,000 | CY/VF | 20 | VF | 120,000 | CY | $20 | $2,400,000 | $0.08 |
| 7.2 | Dredging for Pipeline[o] | 1 | CY/LF | 12,000 | LF | 12,000 | CY | $20 | $240,000 | $0.01 |
| 7.3 | HDPE Pipe[p] | 1 | LF | 12,000 | LF | 12,000 | LF | $500 | $6,000,000 | $0.20 |
| 7.4 | Concrete Ballast Weights[q] | 0.02 | TON/LF | 12,000 | LF | 240 | TON | $600 | $144,000 | <$0.01 |
| 7.5 | Docking Structure (mounting pump)[r] | 1 | EA/PUMP | 3 | PUMP | 3 | EA | $1,000,000 | $3,000,000 | $0.10 |
| 7.6 | Pump Cost[s] | 30,000,000 | CY | 240,000 | CY/MO | 125 | MO | $12,000 | $1,500,000 | $0.05 |
| 7.7 | Pump Operations (labor)[t] | 1 | MH | 45,000 | HR | 45,000 | HR | $50 | $2,250,000 | $0.08 |
| 7.8 | Pump Operations (diesel)[u] | 23.4 | GPH | 45000 | HR | 1,053,000 | GAL | $4 | $4,212,000 | $0.14 |
| | | | | | | | | **Subtotal - 7.0 Pump-out area development** | $19,746,000 | $0.70 |
| | | | | | | | | **Total** | **$60,941,786** | **$2.10** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assumed each single-option would accommodate 30 million CY.
b. The item is based one square mile sites consisting of a perimeter containment berm with a volume determined by the perimeter length and a height of five feet max.
c. This item includes a 4"-6" drain tile installed approximately 12" deep with a collection header discharging to an existing drainage ditch.
d. This item includes the cost to develop an access point to the placement area each year for labor and maintenance crews, which consists of a 15' x 100' aggregate based access road, culvert and security gate.
e. This item includes the cost to install a booster pump facility for every two miles of discharge line from the pump-out discharge point on land to the placement area.
f. This item includes the cost to purchase and maintain a pump at every booster pump facility within the discharge line from the pump-out discharge point on land to the placement area.
g. This item is based on typical local electrical rates to operate half of the booster pumps with minimal labor effort at a rate of 170 KW/HR (each) at an approximate dredging rate of 900 CY per hour.
h. This item includes the 18" HDPE pipe required to transfer material from the pump-out discharge point on land to the placement area, which assumes 15 miles of pipe and three or more potential sites to accommodate the overall area required.
i. This item includes the cost to purchase easement property 30 feet wide by the length of the upland transportation pipe (15 miles) at a local land value of $6,000 per acre.
j. This item includes the additional length of one mile of 18" HDPE pipe for every square mile of placement area to transport the material throughout the site.
k. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 900 CY per hour.
l. This item includes the cost to rent the land at a local agricultural land value of $200 per acre per year during, an improvement period of three years.
m. This item includes the cost to plant a cover crop one time to establish vegetation and introduce organics into the new soil.
n. This item includes the cost to dredge an area of 1,600 square feet to allow scows to maneuver in and out of the pump-out area at an average rate of $20/CY to dredge and place the material.
o. This item includes the cost to dredge an area below the lake bottom to install the discharge pipe from the pump-out area to the discharge point on land at an average rate of $20 per CY to dredge and place the material.
p. This item includes the installation of an 18" HDPE pipe, at an increased cost due to working in and/or below water, from the pump-out area to the discharge point on land.
q. This item includes the cost of installing a 40 pound concrete weight every lineal foot to prevent the pipe from floating or moving.
r. This item includes the installation of a permanent structure to accommodate the pumps, tie off barges and/or provide lighting, etc.
s. This item is based on a pump rental cost for each of the three pumps, but could be purchased overtime and would include costs associated with maintenance, repairs and/or replacements.
t. This item includes a 1-man crew, at a rate of $50 per hour, to operate the pumps 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.
u. This item is based on typical local fuel rates to operate the 18" diesel pumps at a rate of 23.4 gallons per hour 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-5**

**RELATIVE UNIT COST CALCULATIONS FOR THE AGRICULTURAL FIELD IMPROVEMENTS (10-MILE) SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)** | | | | | | | | | |
| 2.1 | Berms / Containment Structures[b] | 60,000 | CY/EA | 5 | EA | 300,000 | CY | $10 | $3,000,000 | $0.10 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $3,000,000 | $0.10 |
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Drain Tiles[c] | 0.02 | LF/SF | 127,575,000 | SF | 2,551,500 | LF | $3 | $7,654,500 | $0.26 |
| 5.2 | Misc. Improvements / Access[d] | 1 | EA/YR | 30 | YR | 30 | EA | $6,500 | $195,000 | $0.01 |
| 5.3 | Booster Pump Facility[e] | 1 | EA | 15 | EA | 15 | EA | $50,000 | $750,000 | $0.03 |
| 5.4 | Pump Cost[f] | 1 | EA | 15 | EA | 15 | EA | $100,000 | $1,500,000 | $0.05 |
| 5.5 | Pump Operations (electric)[g] | 1,275 | KW/HR | 33,333 | HR | 42,499,575 | KWH | $0.15 | $6,375,000 | $0.21 |
| 5.6 | Upland HDPE Pipe[h] | 5,280 | FT/MI | 30 | MI | 158,400 | FT | $200 | $31,680,000 | $1.06 |
| 5.7 | Easement Cost[i] | 30 | MI | 4,752,000 | SF | 109 | AC | $6,000 | $654,000 | $0.02 |
| 5.8 | On Site piping[j] | 3000 | AC | 4.69 | SM | 24,763 | FT | $100 | $2,476,320 | $0.08 |
| 5.9 | Management/placement/pumping[k] | 3 | EA | 33,333 | HR | 100,000 | HR | $50 | $5,000,000 | $0.17 |
| 5.10 | Land Rental[l] | 3000 | AC | 3 | YR | 9,000 | AC-YR | $200 | $1,800,000 | $0.06 |
| 5.11 | Land Cover (alfalfa)[m] | 1 | EA | 3,000 | AC | 3,000 | AC | $100 | $300,000 | $0.01 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $58,384,820 | $1.90 |
| **7.0** | **Pump-out area development** | | | | | | | | | |
| 7.1 | Dredging for Rehandling Basin[n] | 6,000 | CY/VF | 20 | VF | 120,000 | CY | $20 | $2,400,000 | $0.08 |
| 7.2 | Dredging for Pipeline[o] | 1 | CY/LF | 12,000 | LF | 12,000 | CY | $20 | $240,000 | $0.01 |
| 7.3 | HDPE Pipe[p] | 1 | LF | 12,000 | LF | 12,000 | LF | $500 | $6,000,000 | $0.20 |
| 7.4 | Concrete Ballast Weights[q] | 0.02 | TON/LF | 12,000 | LF | 240 | TON | $600 | $144,000 | <$0.01 |
| 7.5 | Docking Structure (mounting pump)[r] | 1 | EA/PUMP | 3 | PUMP | 3 | EA | $1,000,000 | $3,000,000 | $0.10 |
| 7.6 | Pump Cost[s] | 30,000,000 | CY | 240,000 | CY/MO | 125 | MO | $12,000 | $1,500,000 | $0.05 |
| 7.7 | Pump Operations (labor)[t] | 1 | MH | 45,000 | HR | 45,000 | HR | $50 | $2,250,000 | $0.08 |
| 7.8 | Pump Operations (diesel)[u] | 23.4 | GPH | 45,000 | HR | 1,053,000 | GAL | $4 | $4,212,000 | $0.14 |
| | | | | | | | | **Subtotal - 7.0 Pump-out area development** | $19,746,000 | $0.70 |
| | | | | | | | | **Total** | **$81,130,820** | **$2.70** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assumed each single-option would accommodate 30 million CY.
b. The item is based one square mile sites consisting of a perimeter containment berm with a volume determined by the perimeter length and a height of five feet max.
c. This item includes a 4"-6" drain tile installed approximately 12" deep with a collection header discharging to an existing drainage ditch.
d. This item includes the cost to develop an access point to the placement area each year for labor and maintenance crews, which consists of a 15' x 100' aggregate based access road, culvert and security gate.
e. This item includes the cost to install a booster pump facility for every two miles of discharge line from the pump-out discharge point on land to the placement area.
f. This item includes the cost to purchase and maintain a pump at every booster pump facility within the discharge line from the pump-out discharge point on land to the placement area.
g. This item is based on typical local electrical rates to operate half of the booster pumps with minimal labor effort at a rate of 170 KW/HR (each) at an approximate dredging rate of 900 CY per hour.
h. This item includes the 18" HDPE pipe required to transfer material from the pump-out discharge point on land to the placement area, which assumes 15 miles of pipe and three or more potential sites to accommodate the overall area required.
i. This item includes the cost to purchase easement property 30 feet wide by the length of the upland transportation pipe (30 miles) at a local land value of $6,000 per acre.
j. This item includes the additional length of one mile of 18" HDPE pipe for every square mile of placement area to transport the material throughout the site.
k. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 900 CY per hour.
l. This item includes the cost to rent the land at a local agricultural land value of $200 per acre per year during, an improvement period of three years.
m. This item includes the cost to plant a cover crop one time to establish vegetation and introduce organics into the new soil.
n. This item includes the cost to dredge an area of 1,600 square feet to allow scows to maneuver in and out of the pump-out area at an average rate of $20 per CY to dredge and place the material.
o. This item includes the cost to dredge an area below the lake bottom to install the discharge pipe from the pump-out area to the discharge point on land at an average rate of $20 per CY to dredge and place the material.
p. This item includes the installation of an 18" HDPE pipe, at an increased cost due to working in and/or below water, from the pump-out area to the discharge point on land.
q. This item includes the cost of installing a 40 pound concrete weight every lineal foot to prevent the pipe from floating or moving.
r. This item includes the installation of a permanent structure to accommodate the pumps, tie off barges and/or provide lighting, etc.
s. This item is based on a pump rental cost for each of the three pumps, but could be purchased overtime and would include costs associated with maintenance, repairs and/or replacements.
t. This item includes a 1-man crew, at a rate of $50 per hour, to operate the pumps 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.
u. This item is based on typical local fuel rates to operate the 18" diesel pumps at a rate of 23.4 gallons per hour 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-6**

**RELATIVE UNIT COST CALCULATIONS FOR THE WETLAND RESTORATION/SHORELINE PROTECTION SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)[b]** | | | | | | | | | |
| 2.1 | Core Stone | 7.5 | TON/LF | 51,000 | LF | 382,500 | TON | $50 | $19,125,000 | $0.64 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $19,125,000 | $0.60 |
| **4.0** | **Containment structure (slope protection)[b]** | | | | | | | | | |
| 4.1 | 1 ton Armor Stone - North Dike | 8 | TON/LF | 19,400 | LF | 155,200 | TON | $100 | $15,520,000 | $0.52 |
| 4.2 | 200 lb. Underlayer Stone -North Dike | 4 | TON/LF | 19,400 | LF | 77,600 | TON | $90 | $6,984,000 | $0.23 |
| | | | | | | | | **Subtotal - 4.0 Containment structure (slope protection)** | $22,504,000 | $0.80 |
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Land / Habitat Improvements[c] | 1 | AC/SM | 2,650 | AC | 2,650 | AC | $1,000 | $2,650,000 | $0.09 |
| 5.2 | Pump Cost[d] | 30,000,000 | CY | 240,000 | CY/MO | 125 | MO | $4,000 | $500,000 | $0.02 |
| 5.3 | Pump Operations (electric)[e] | 230 | KW/HR | 45,000 | HR | 10,350,000 | KWH | $0.15 | $1,552,500 | $0.05 |
| 5.4 | On Site piping[f] | 2650 | AC | 4.14 | SM | 30,859 | LF | $100 | $3,085,920 | $0.10 |
| 5.5 | Management/placement/pumping[g] | 3 | EA | 33,333 | HR | 99,999 | HR | $50 | $4,999,950 | $0.17 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $12,788,370 | $0.40 |
| **7.0** | **Pump-out area development** | | | | | | | | | |
| 7.1 | Dredging for Rehandling Basin[h] | 6,000 | CY/VF | 20 | VF | 120,000 | CY | $20 | $2,400,000 | $0.08 |
| 7.2 | Dredging for Pipeline[i] | 1 | CY/LF | 12,000 | LF | 12,000 | CY | $20 | $240,000 | $0.01 |
| 7.3 | HDPE Pipe[j] | 1 | LF | 12,000 | LF | 12,000 | LF | $500 | $6,000,000 | $0.20 |
| 7.4 | Concrete Ballast Weights[k] | 0.02 | TON/LF | 12,000 | LF | 240 | TON | $600 | $144,000 | <$0.01 |
| 7.5 | Docking Structure (mounting pump)[l] | 1 | EA/PUMP | 3 | PUMP | 3 | EA | $1,000,000 | $3,000,000 | $0.10 |
| 7.6 | Pump Cost[m] | 30,000,000 | CY | 240,000 | CY/MO | 125 | MO | $12,000 | $1,500,000 | $0.05 |
| 7.7 | Pump Operations (labor)[n] | 1 | MH | 45,000 | HR | 45,000 | HR | $50 | $2,250,000 | $0.08 |
| 7.8 | Pump Operations (diesel)[o] | 23.4 | GPH | 45,000 | HR | 1,053,000 | GAL | $4 | $4,212,000 | $0.14 |
| | | | | | | | | **Subtotal - 7.0 Pump-out area development** | $19,746,000 | $0.70 |
| | | | | | | | | **Total** | **$74,163,370** | **$2.50** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assumed each single-option would accommodate 30 million CY. Costs per CY assumed each single-option would accommodate 30 million CY.
b. This item is based on a material and installation price provided by a local marine contractor familiar with the construction requirements.
c. This item includes an initial cost to develop an emergent habitat that will be self-sufficient. The unit cost of $2,000 was suggested by a professional wetland scientist familiar with the implementing similar habitats.
d. This item is based on a pump rental cost, but could be purchased overtime and would include costs associated with maintenance, repairs and/or replacements.
e. This item is based on typical local electrical rates to operate the pump with minimal labor effort.
f. This item includes the length of 18" HDPE pipe (9,000 feet) required to transfer material from the pump-out discharge point on land to the placement area. This item also includes an additional length of one mile of pipe for every square mile of placement area to transport the material throughout the site.
g. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 900 CY per hour.
h. This item includes the cost to dredge an area of 1,600 square feet to allow scows to maneuver in and out of the pump-out area at an average rate of $20 per CY to dredge and place the material.
i. This item includes the cost to dredge an area below the lake bottom to install the discharge pipe from the pump-out area to the discharge point on land at an average dredge and placement rate of $20 per CY.
j. This item includes the installation of an 18" HDPE pipe, at an increased cost due to working in and/or below water, from the pump-out area to the discharge point on land.
k. This item includes the cost of installing a 40 pound concrete weight every lineal foot to prevent the pipe from floating or moving.
l. This item includes the installation of a permanent structure to accommodate the pumps, tie off barges and/or provide lighting, etc.
m. This item is based on a pump rental cost for each of the three pumps, but could be purchased overtime and would include costs associated with maintenance, repairs and/or replacements.
n. This item includes a 1-man crew, at a rate of $50 per hour, to operate the pumps 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.
o. This item is based on typical local fuel rates to operate the 18" diesel pumps at a rate of 23.4 gallons per hour 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 C per month.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-7**

**RELATIVE UNIT COST CALCULATIONS FOR THE SUBMERGED HRU (DEEP WATER) SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)[b]** | | | | | | | | | |
| 2.1 | Core Stone | 15 | TON/LF | 40,600 | LF | 609,000 | TON | $50 | $30,450,000 | $1.02 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $30,450,000 | $1.00 |
| **3.0** | **Containment structure (cap)** | | | | | | | | | |
| 3.1 | Composite Cap[c] | 2,325 | AC | 100% | AC/AC | 2,325 | AC | $174,240 | $405,108,000 | $13.50 |
| | | | | | | | | **Subtotal - 3.0 Containment structure (cap)** | $405,108,000 | $13.50 |
| **4.0** | **Containment structure (slope protection)[b]** | | | | | | | | | |
| 4.1 | 300 pound Armor Stone - All Dikes | 5 | TON/LF | 40,600 | LF | 203,000 | TON | $100 | $20,300,000 | $0.68 |
| | | | | | | | | **Subtotal - 4.0 Containment structure (slope protection)** | $20,300,000 | $0.70 |
| | | | | | | | | **Total** | **$455,858,000** | **$15.20** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume each single-option would accommodate 30 million CY.
b. This item is based on a material and installation price provided by a local marine contractor familiar with the construction requirements.
c. This item includes the use of a composite material to cap the entire (100%) placement area. The unit cost of $4 per square foot ($174,240 per acre) was suggested by the manufacturer familiar with the installation of such material.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-8**

**RELATIVE UNIT COST CALCULATIONS FOR THE SUBMERED HRU (SHALLOW WATER) SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)[b]** | | | | | | | | | |
| 2.1 | Core Stone | 3.5 | TON/LF | 80,900 | LF | 242,700 | TON | $50 | $12,135,000 | $0.40 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $12,135,000 | $0.40 |
| **3.0** | **Containment structure (cap)** | | | | | | | | | |
| 3.1 | Composite Cap[c] | 9,300 | AC | 50% | AC/AC | 4,650 | AC | $174,240 | $810,216,000 | $27.01 |
| | | | | | | | | **Subtotal - 3.0 Containment structure (cap)** | $810,216,000 | $27.00 |
| **4.0** | **Containment structure (slope protection)[b]** | | | | | | | | | |
| 4.1 | 300 pound Armor Stone - All Dikes | 2 | TON/LF | 80,900 | LF | 161,800 | TON | $100 | $16,180,000 | $0.54 |
| | | | | | | | | **Subtotal - 4.0 Containment structure (slope protection)** | $16,180,000 | $0.50 |
| | | | | | | | | **Total** | **$838,531,000** | **$27.90** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume each single-option would accommodate 30 million CY.
b. This item is based on a material and installation price provided by a local marine contractor familiar with the construction requirements.
c. This item includes the use of a composite material to cap the entire (100%) placement area. The unit cost of $4 per square foot ($174,240 per acre) was suggested by the manufacturer familiar with the installation of such material.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-9**

**RELATIVE UNIT COST CALCULATIONS FOR THE EMERGENT HRU (DEEP WATER) SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 | **Containment structure (dike)[b]** | | | | | | | | | |
| 2.1 | Core Stone | 225 | TON/LF | 16,800 | LF | 3,780,000 | TON | $50 | $189,000,000 | $6.30 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $189,000,000 | $6.30 |
| 4.0 | **Containment structure (slope protection)[b]** | | | | | | | | | |
| 4.1 | 9 ton Armor Stone - East Dike | 45 | TON/LF | 4,200 | LF | 189,000 | TON | $100 | $18,900,000 | $0.63 |
| 4.2 | 3 ton Armor Stone - North Dike | 29 | TON/LF | 4,200 | LF | 121,800 | TON | $100 | $12,180,000 | $0.41 |
| 4.3 | 1 ton Armor Stone - West Dike | 18 | TON/LF | 4,200 | LF | 75,600 | TON | $100 | $7,560,000 | $0.25 |
| 4.4 | 1 ton Armor Stone - South Dike | 18 | TON/LF | 4,200 | LF | 75,600 | TON | $100 | $7,560,000 | $0.25 |
| 4.5 | First Underlayer Stone - East Dike | 21 | TON/LF | 4,200 | LF | 88,200 | TON | $90 | $7,938,000 | $0.26 |
| 4.6 | First Underlayer Stone -North Dike | 13 | TON/LF | 4,200 | LF | 54,600 | TON | $90 | $4,914,000 | $0.16 |
| 4.7 | Second Underlayer Stone - East Dike | 10 | TON/LF | 4,200 | LF | 42,000 | TON | $80 | $3,360,000 | $0.11 |
| 4.8 | Second Underlayer Stone -North Dike | 6 | TON/LF | 4,200 | LF | 25,200 | TON | $80 | $2,016,000 | $0.07 |
| 4.9 | Underlayer Stone - West Dike | 7 | TON/LF | 4,200 | LF | 29,400 | TON | $90 | $2,646,000 | $0.09 |
| 4.10 | Underlayer Stone - South Dike | 7 | TON/LF | 4,200 | LF | 29,400 | TON | $90 | $2,646,000 | $0.09 |
| | | | | | | | | **Subtotal - 4.0 Containment structure (slope protection)** | $69,720,000 | $2.30 |
| 5.0 | **Habitat/site development** | | | | | | | | | |
| 5.1 | Land / Habitat Improvements[c] | 1 | EA | 405 | AC | 405 | AC | $2,000 | $810,000 | $0.03 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $810,000 | $0.10 |
| | | | | | | | | **Total** | **$259,530,000** | **$8.70** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume each single-option would accommodate 30 million CY.
b. This item is based on a material and installation price provided by a local marine contractor familiar with the construction requirements.
c. This item includes an initial cost to develop an emergent habitat that will be self-sufficient. The unit cost of $2,000 was suggested by a professional wetland scientist familiar with implementing similar habitats.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-10**

**RELATIVE UNIT COST CALCULATIONS FOR THE EMERGENT HRU (SHALLOW WATER) SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)[b]** | | | | | | | | | |
| 2.1 | Core Stone | 60 | TON/LF | 31,300 | LF | 1,878,000 | TON | $50 | $93,900,000 | $3.13 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $93,900,000 | $3.10 |
| **4.0** | **Containment structure (slope protection)[b]** | | | | | | | | | |
| 4.1 | 5.5 ton Armor Stone - East Dike | 17 | TON/LF | 5,100 | LF | 86,700 | TON | $100 | $8,670,000 | $0.29 |
| 4.2 | 1.7 ton Armor Stone - North Dike | 6 | TON/LF | 10,550 | LF | 63,300 | TON | $100 | $6,330,000 | $0.21 |
| 4.3 | 50 lb. Armor Stone - South Dike | 5 | TON/LF | 10,550 | LF | 52,750 | TON | $100 | $5,275,000 | $0.18 |
| 4.4 | First Underlayer Stone - East Dike | 8 | TON/LF | 5,100 | LF | 40,800 | TON | $90 | $3,672,000 | $0.12 |
| 4.5 | First Underlayer Stone -North Dike | 3 | TON/LF | 10,550 | LF | 31,650 | TON | $90 | $2,848,500 | $0.09 |
| 4.6 | Second Underlayer Stone - East Dike | 3 | TON/LF | 5,100 | LF | 15,300 | TON | $80 | $1,224,000 | $0.04 |
| | | | | | | | | **Subtotal - 4.0 Containment structure (slope protection)** | $28,019,500 | $0.90 |
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Land / Habitat Improvements[c] | 1 | EA | 1,200 | AC | 1,200 | AC | $2,000 | $2,400,000 | $0.08 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $2,400,000 | $0.10 |
| | | | | | | | | **Total** | **$124,319,500** | **$4.10** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume each single-option would accommodate 30 million CY.
b. This item is based on a material and installation price provided by a local marine contractor familiar with the construction requirements.
c. This item includes an initial cost to develop an emergent habitat that will be self-sufficient. The unit cost of $2,000 was suggested by a professional wetland scientist familiar with implementing similar habitats.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-11**

**RELATIVE UNIT COST CALCULATIONS FOR THE NEW CDF SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)[b]** | | | | | | | | | |
| 2.1 | Core Stone | 150 | TON/LF | 20,800 | LF | 3,120,000 | TON | $50 | $156,000,000 | $5.20 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $156,000,000 | $5.20 |
| **4.0** | **Containment structure (slope protection)[b]** | | | | | | | | | |
| 4.1 | 5.5 ton Armor Stone - East Dike | 17 | TON/LF | 3,500 | LF | 59,500 | TON | $100 | $5,950,000 | $0.20 |
| 4.2 | 1.7 ton Armor Stone - North Dike | 6 | TON/LF | 6,900 | LF | 41,400 | TON | $100 | $4,140,000 | $0.14 |
| 4.3 | 50 lb. Armor Stone - South Dike | 5 | TON/LF | 6,900 | LF | 34,500 | TON | $100 | $3,450,000 | $0.12 |
| 4.4 | First Underlayer Stone - East Dike | 8 | TON/LF | 3,500 | LF | 28,000 | TON | $90 | $2,520,000 | $0.08 |
| 4.5 | First Underlayer Stone -North Dike | 3 | TON/LF | 6,900 | LF | 20,700 | TON | $90 | $1,863,000 | $0.06 |
| 4.6 | Second Underlayer Stone - East Dike | 3 | TON/LF | 3,500 | LF | 10,500 | TON | $80 | $840,000 | $0.03 |
| | | | | | | | | **Subtotal - 4.0 Containment structure (slope protection)** | $18,763,000 | $0.60 |
| | | | | | | | | **Total** | **$174,763,000** | **$5.80** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume each single-option would accommodate 30 million CY.
b. This item is based on a material and installation price provided by a local marine contractor familiar with the construction requirements.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-12**

**RELATIVE UNIT COST CALCULATIONS FOR THE OPEN-LAKE PLACEMENT WITH CONTROLS SINGLE OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Site Preparation[b] | 1 | EA | 1 | EA | 1 | EA | $5,000 | $5,000 | $<0.01 |
| 5.2 | Storage Facility[b] | 1 | EA | 1 | EA | 1 | EA | $60,000 | $60,000 | $<0.01 |
| 5.3 | Testing Dosage[b] | 1 | EA | 1 | EA | 1 | EA | $7,000 | $7,000 | $<0.01 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $72,000 | $<0.10 |
| **6.0** | **Nutrient loading controls** | | | | | | | | | |
| 6.1 | Alum Tank[c] | 1 | EA | 1 | EA | 1 | EA | $27,000 | $27,000 | $<0.10 |
| 6.2 | 2" Pump - Alum Solution[c] | 1 | EA | 1 | EA | 1 | EA | $2,000 | $2,000 | $<0.10 |
| 6.3 | Alum Cost - Material[c] | 0.006 | TON/TON | 15,750,000 | TON | 94,500 | TON | $325 | $30,712,500 | $1.02 |
| 6.4 | Alum Cost - Shipping[c,d] | 30,000,000 | CY | 8,000 | CY/DAY | 3,750 | DAY | $1,000 | $3,750,000 | $0.13 |
| 6.5 | Applying Alum[d,e] | 30,000,000 | CY | 8,000 | CY/DAY | 3,750 | DAY | $900 | $3,375,000 | $0.11 |
| 6.6 | Mixing / Loading Alum[f] | 30,000,000 | CY | 8,000 | CY/DAY | 3,750 | DAY | $1,950 | $7,312,500 | $0.24 |
| | | | | | | | | **Subtotal - 6.0 Nutrient loading controls** | $45,179,000 | $1.50 |
| **8.0** | **Capping** | | | | | | | | | |
| 8.1 | Bentonite Cost - Material[c] | 0.0005 | TON/TON | 15,750,000 | TON | 7,875 | TON | $225 | $1,771,875 | $0.06 |
| 8.2 | Bentonite Cost - Shipping[c] | 30,000,000 | CY | 8,000 | CY/DAY | 3,750 | DAY | $1,000 | $3,750,000 | $0.13 |
| 8.3 | Applying Bentonite[d,e] | 30,000,000 | CY | 8,000 | CY/DAY | 3,750 | DAY | $900 | $3,375,000 | $0.11 |
| 8.4 | Mixing / loading Bentonite[f] | 30,000,000 | CY | 8,000 | CY/DAY | 3,750 | DAY | $1,950 | $7,312,500 | $0.24 |
| | | | | | | | | **Subtotal - 8.0 Capping** | $16,209,375 | $0.50 |
| | | | | | | | | **Total** | **$61,460,375** | **$2.00** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume each single-option would accommodate 30 million CY.
b. This item was based on information acquired from historical records and/or professional judgment.
c. This item was based on information acquired from a local supplier.
d. This item is based on a dredging rate of 8,000 CY per day.
e. This item includes a 3-man crew, at a rate of $50 per hour per man, to apply the solution or material for 6 hours during a typical dredging day.
f. This item includes a 2-man crew and a piece of equipment (backhoe), at a rate of $195 per hour, to mix and load the solution or material for 10 hours during a typical dredging day.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE H-13

## RELATIVE UNIT COST CALCULATIONS FOR THE BENEFICIAL USE COMBINATION OPTION

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **1.0** | **Processing, hauling, handling** | | | | | | | | | |
| 1.1 | Haul to Process Site[b] | 1 | CY | 3,000,000 | CY | 3,000,000 | CY | $3.50 | $10,500,000 | $3.50 |
| 1.2 | Dewatering Cost[c] | 0.02 | LF/SF | 2,178,000 | SF | 43,560 | LF | $2.00 | $87,120 | $0.03 |
| 1.3 | Additives (Lime)[d] | 0.004 | TON/CY | 1,800,000 | CY | 7,701 | TON | $150 | $1,155,080 | $0.39 |
| 1.4 | Blending / Mixing[e] | 1 | CY | 1,800,000 | CY | 1,800,000 | CY | $1.50 | $2,700,000 | $0.90 |
| 1.5 | Loading[f] | 1 | CY | 1,807,700 | CY | 1,807,700 | CY | $1.50 | $2,711,550 | $0.90 |
| 1.6 | Material management plan[g] | 1 | EA | 1 | EA | 1 | EA | $50,000 | $50,000 | $0.02 |
| | | | | | | | | **Subtotal - 1.0 Processing, hauling, handling** | $17,203,750 | $5.70 |
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Property / Land - Processing[h] | 1 | AC | 50 | AC | 50 | AC | $6,000 | $300,000 | $0.10 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $300,000 | $0.10 |
| | | | | | | | | **Total** | **$17,503,750** | **$5.80** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume this option would accommodate 3 million CY.
b. This item is based on a local round trip transportation price provided by local broker for a distance within 2 miles.
c. This item includes the cost to purchase and install a 4"-6" perforated drain tile every 50 feet on center on top of the existing surface of the process site to collect water during the dewatering process.
d. This item includes the cost to add lime as an additive to the dredge material at a rate of 4 tons of lime per 935 CY of dredged material.
e. This item includes the cost of an operator and a piece of equipment (dozer) to mix the additive and sediment at the process site.
f. This item includes the cost of an operator and a piece of equipment (loader) to load the augmented material onto the recipients truck.
g. This item includes the cost to prepare a material management plan.
h. This item includes the cost to purchase property at a local land value of $6,000 per acre to develop a process site

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by, and reviewed under the supervision of, professionals who are competent in construction cost estimating, possess a working knowledge of construction, and capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values, but they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-14**

**RELATIVE UNIT COST CALCULATIONS FOR THE WETLAND RESTORATION/SHORELINE PROTECTION COMBINATION OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)[b]** | | | | | | | | | |
| 2.1 | Core Stone | 5 | CY/LF | 25,400 | LF | 190,500 | TON | $50 | $9,525,000 | $1.36 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $9,525,000 | $1.40 |
| **4.0** | **Containment structure (slope protection)[b]** | | | | | | | | | |
| 4.1 | 1 ton Armor Stone - North Dike | 8 | TON/LF | 10,000 | LF | 80,000 | TON | $100 | $8,000,000 | $1.14 |
| 4.2 | 200 lb. Underlayer Stone -North Dike | 4 | TON/LF | 10,000 | LF | 40,000 | TON | $90 | $3,600,000 | $0.51 |
| | | | | | | | | **Subtotal - 4.0 Containment structure (slope protection)** | $11,600,000 | $1.70 |
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Land / Habitat Improvements[c] | 1 | AC/SM | 620 | AC | 620 | AC | $1,000 | $620,000 | $0.09 |
| 5.2 | Pump Cost[d] | 7,000,000 | CY | 240,000 | CY/MO | 29 | MO | $4,000 | $116,667 | $0.02 |
| 5.3 | Pump Operations (electric)[e] | 115 | KW/HR | 13,622 | HR | 1,566,486 | KWH | $0.15 | $234,973 | $0.03 |
| 5.4 | On Site piping[f] | 640 | AC/SM | 0.97 | MI | 14,115 | LF | $100 | $1,411,500 | $0.20 |
| 5.5 | Management/placement/pumping[g] | 3 | EA | 7,778 | HR | 23,333 | HR | $50 | $1,166,667 | $0.17 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $3,549,807 | $0.50 |
| **7.0** | **Pump-out area development[p]** | | | | | | | | | |
| 7.1 | Dredging for Rehandling Basin[h] | 4,000 | CY/VF | 20 | VF | 120,000 | CY | $10 | $800,000 | $0.06 |
| 7.2 | Dredging for Pipeline[i] | 1 | CY/LF | 12,000 | LF | 12,000 | CY | $10 | $120,000 | $0.01 |
| 7.3 | HDPE Pipe[j] | 1 | LF | 12,000 | LF | 12,000 | LF | $500 | $6,000,000 | $0.43 |
| 7.4 | Concrete Ballast Weights[k] | 0.02 | TON/LF | 12,000 | LF | 240 | TON | $600 | $144,000 | $0.01 |
| 7.5 | Docking Structure (mounting pump)[l] | 1 | EA/PUMP | 2 | PUMP/YR | 30 | YR | $30,000 | $900,000 | $0.06 |
| 7.6 | Pump Cost[m] | 7,000,000 | CY | 240,000 | CY/MO | 29 | MO | $8,000 | $232,000 | $0.03 |
| 7.7 | Pump Operations (labor)[n] | 1 | MH | 8,700 | HR | 8,700 | HR | $50 | $435,000 | $0.06 |
| 7.8 | Pump Operations (diesel)[o] | 15.6 | GPH | 8,700 | HR | 135,720 | GAL | $4 | $542,880 | $0.08 |
| | | | | | | | | **Subtotal - 7.0 Pump-out area development** | $9,173,880 | $0.70 |
| | | | | | | | | **Total** | **$33,848,687** | **$4.30** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assumed this option would accommodate 7 million CY.
b. This item is based on a material and installation price provided by a local marine contractor familiar with the construction requirements.
c. This item includes an initial cost to develop an emergent habitat that will be self-sufficient. The unit cost of $2,000 was suggested by a professional wetland scientist familiar with the implementing similar habitats.
d. This item is based on a pump rental cost, but could be purchased overtime and would include costs associated with maintenance, repairs and/or replacements.
e. This item is based on typical local electrical rates to operate the pump with minimal labor effort.
f. This item includes the 18" HDPE pipe required to transfer material from the pump-out discharge point on land to the placement area. This item also includes an additional length of one mile of pipe for every square mile of placement area to transport the material throughout the site.
g. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 900 CY per hour.
h. This item includes the cost to dredge an area of 1,600 square feet to allow scows to maneuver in and out of the pump-out area at an average rate of $20 per CY to dredge and place the material.
i. This item includes the cost to dredge an area below the lake bottom to install the discharge pipe from the pump-out area to the discharge point on land at an average rate of $20 per CY to dredge and place the material.
j. This item includes the installation of an 18" HDPE pipe, at an increased cost due to working in and/or below water, from the pump-out area to the discharge point on land.
k. This item includes the cost of installing a 40 pound concrete weight every lineal foot to prevent the pipe from floating or moving.
l. This item includes the installation of a permanent structure to accommodate the pumps, tie off barges and/or provide lighting, etc.
m. This item is based on a pump rental cost for each of the three pumps, but could be purchased overtime and would include costs associated with maintenance, repairs and/or replacements.
n. This item includes a 1-man crew, at a rate of $50 per hour, to operate the pumps 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.
o. This item is based on typical local fuel rates to operate the 18" diesel pumps at a rate of 23.4 gallons per hour 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.
p. The infrastructure cost is split between all options (agricultural field improvements and wetland restoration/shoreline protection) that will use the pipeline.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by, and reviewed under the supervision of, professionals who are competent in construction cost estimating, possess a working knowledge of construction, and capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values, but they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE H-15**

**RELATIVE UNIT COST CALCULATIONS FOR THE AGRICULTURAL FIELD IMPROVEMENTS (10-MILE) COMBINATION OPTION**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)** | | | | | | | | | |
| 2.1 | Berms / Containment Structures[b] | 60,000 | CY/EA | 1 | EA | 64,066 | CY | $10 | $640,657 | $0.09 |
| | | | | | | | | **Subtotal - 2.0 Containment structure (dike)** | $640,657 | $0.10 |
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Drain Tiles[c] | 0.02 | LF/SF | 29,767,500 | SF | 595,350 | LF | $3 | $1,786,050 | $0.26 |
| 5.2 | Misc. Improvements / Access[d] | 1 | EA/YR | 30 | YR | 30 | EA | $4,000 | $120,000 | $0.02 |
| 5.3 | Booster Pump Facility[e] | 1 | EA | 3 | EA | 3 | EA | $50,000 | $150,000 | $0.02 |
| 5.4 | Pump Cost[f] | 1 | EA | 3 | EA | 3 | EA | $100,000 | $300,000 | $0.04 |
| 5.5 | Pump Operations (electric)[g] | 255 | KW/HR | 7,778 | HR | 1,983,333 | KWH | $0.15 | $297,500 | $0.04 |
| 5.6 | Upland HDPE Pipe[h] | 5,280 | FT/MI | 10 | MI | 52,800 | FT | $200 | $10,560,000 | $1.51 |
| 5.7 | Easement Cost[i] | 10 | MI | 1,584,000 | SF | 36 | AC | $6,000 | $218,182 | $0.03 |
| 5.8 | On Site piping[j] | 685 | AC | 1.07 | SM | 5,650 | FT | $100 | $564,960 | $0.08 |
| 5.9 | Management/placement/pumping[k] | 3 | EA | 7,778 | HR | 23,333 | HR | $50 | $1,166,667 | $0.17 |
| 5.10 | Land Rental[l] | 685 | AC | 3 | YR | 2,055 | AC-YR | $200 | $411,000 | $0.06 |
| 5.10 | Land Cover (alfalfa)[m] | 1 | EA | 685 | AC | 685 | AC | $100 | $68,500 | $0.01 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $15,642,859 | $2.20 |
| **7.0** | **Pump-out area development[v]** | | | | | | | | | |
| 7.1 | Dredging for Rehandling Basin[n] | 4,000 | CY/VF | 20 | VF | 120,000 | CY | $10 | $800,000 | $0.06 |
| 7.2 | Dredging for Pipeline[o] | 1 | CY/LF | 12,000 | LF | 12,000 | CY | $10 | $120,000 | $0.01 |
| 7.3 | HDPE Pipe[p] | 1 | LF | 12,000 | LF | 12,000 | LF | $500 | $6,000,000 | $0.43 |
| 7.4 | Concrete Ballast Weights[q] | 0.02 | TON/LF | 12,000 | LF | 240 | TON | $600 | $144,000 | $0.01 |
| 7.5 | Docking Structure (mounting pump)[r] | 1 | EA/PUMP | 2 | PUMP/YR | 30 | YR | $30,000 | $900,000 | $0.06 |
| 7.6 | Pump Cost[s] | 7,000,000 | CY | 240,000 | CY/MO | 29 | MO | $8,000 | $232,000 | $0.03 |
| 7.7 | Pump Operations (labor)[t] | 1 | MH | 8,700 | HR | 8,700 | HR | $50 | $435,000 | $0.06 |
| 7.8 | Pump Operations (diesel)[u] | 15.6 | GPH | 8,700 | HR | 135,720 | GAL | $4 | $542,880 | $0.08 |
| | | | | | | | | **Subtotal - 7.0 Pump-out area development** | $9,173,880 | $0.70 |
| | | | | | | | | **Total** | **$25,457,396** | **$3.00** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assumed this option would accommodate 7 million CY.
b. The item is based one square mile sites consisting of a perimeter containment berm with a volume determined by the perimeter length and a height of five feet max.
c. This item includes a 4"-6" drain tile installed approximately 12" deep with a collection header discharging to an existing drainage ditch.
d. This item includes the cost to develop an access point to the placement area each year for labor and maintenance crews, which consists of a 15' x 100' aggregate based access road, culvert and security gate.
e. This item includes the cost to install a booster pump facility for every two miles of discharge line from the pump-out discharge point on land to the placement area.
f. This item includes the cost to purchase and maintain a pump at every booster pump facility within the discharge line from the pump-out discharge point on land to the placement area.
g. This item is based on typical local electrical rates to operate half of the booster pumps with minimal labor effort at a rate of 170 KW/HR (each) at an approximate dredging rate of 900 CY per hour.
h. This item includes the 18" HDPE pipe required to transfer material from the pump-out discharge point on land to the placement area, which assumes 15 miles of pipe and three or more potential sites to accommodate the overall area required.
i. This item includes the cost to purchase easement property 30 feet wide by the length of the discharge line (10 miles) at a local land value of $6,000 per acre.
j. This item includes the additional length of one mile of 18" HDPE pipe for every square mile of placement area to transport the material throughout the site.
k. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 900 CY per hour.
l. This item includes the cost to rent the land at a local agricultural land value of $200 per acre per year during, an improvement period of three years.
m. This item includes the cost to plant a cover crop one time to establish vegetation and introduce organics into the new soil.
n. This item includes the cost to dredge an area of 1,600 square feet to allow scows to maneuver in and out of the pump-out area at an average rate of $20 per CY to dredge and place the material.
o. This item includes the cost to dredge an area below the lake bottom to install the discharge pipe from the pump-out area to the discharge point on land at an average rate of $20 per CY to dredge and place the material.
p. This item includes the installation of an 18" HDPE pipe, at an increased cost due to working in and/or below water, from the pump-out area to the discharge point on land.
q. This item includes the cost of installing a 40 pound concrete weight every lineal foot to prevent the pipe from floating or moving.
r. This item includes the installation of a permanent structure to accommodate the pumps, tie off barges and/or provide lighting, etc.
s. This item is based on a pump rental cost for each of the three pumps, but could be purchased overtime and would include costs associated with maintenance, repairs and/or replacements.
t. This item includes a 1-man crew, at a rate of $50 per hour, to operate the pumps 10 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.
u. This item is based on typical local fuel rates to operate the 18" diesel pumps at a rate of 15.6 gallons per hour 10 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 240,000 CY per month.
v. The infrastructure cost is split between all options (agricultural field improvements and wetland restoration/shoreline protection) that will use the pipeline.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by, and reviewed under the supervision of, professionals who are competent in construction cost estimating, possess a working knowledge of construction, and capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values, but they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

## TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE H-16

## RELATIVE UNIT COST CALCULATIONS FOR THE OPEN-LAKE PLACEMENT WITH CONTROLS COMBINATION OPTION

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| **5.0** | **Habitat/site development** | | | | | | | | | |
| 5.1 | Site Preparationb | 1 | EA | 1 | EA | 1 | EA | $5,000 | $5,000 | $<0.01 |
| 5.2 | Storage Facilityb | 1 | EA | 1 | EA | 1 | EA | $60,000 | $60,000 | $<0.01 |
| 5.3 | Testing Dosage[b] | 1 | EA | 1 | EA | 1 | EA | $7,000 | $7,000 | $<0.01 |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | $72,000 | $<0.10 |
| **6.0** | **Nutrient loading controls** | | | | | | | | | |
| 6.1 | Alum Tank[c] | 1 | EA | 1 | EA | 1 | EA | $27,000 | $27,000 | $<0.01 |
| 6.2 | 2" Pump - Alum Solution[d] | 1 | EA | 1 | EA | 1 | EA | $2,000 | $2,000 | $<0.01 |
| 6.3 | Alum Cost - Material[e] | 0.006 | TON/TON | 6,825,000 | TON | 40,245 | TON | $325 | $13,079,544 | $1.01 |
| 6.4 | Alum Cost - Shipping[c,d] | 13,000,000 | CY | 8,000 | CY/DAY | 1,625 | DAY | $1,000 | $1,625,000 | $0.13 |
| 6.5 | Applying Alum[d,e] | 13,000,000 | CY | 8,000 | CY/DAY | 1,625 | DAY | $900 | $1,462,500 | $0.11 |
| 6.6 | Mixing / Loading Alum[f] | 13,000,000 | CY | 8,000 | CY/DAY | 1,625 | DAY | $1,950 | $3,168,750 | $0.24 |
| | | | | | | | | **Subtotal - 6.0 Nutrient loading controls** | $19,364,794 | $1.50 |
| **8.0** | **Capping** | | | | | | | | | |
| 8.1 | Bentonite Cost - Material[c] | 0.0005 | TON/TON | 6,825,000 | TON | 3,413 | TON | $225 | $767,813 | $0.06 |
| 8.2 | Bentonite Cost - Shipping[c] | 13,000,000 | CY | 8,000 | CY/DAY | 1,625 | DAY | $1,000 | $1,625,000 | $0.13 |
| 8.3 | Applying Bentonite[d,e] | 13,000,000 | CY | 8,000 | CY/DAY | 1,625 | DAY | $900 | $1,462,500 | $0.11 |
| 8.4 | Mixing / loading Bentonite[f] | 13,000,000 | CY | 8,000 | CY/DAY | 1,625 | DAY | $1,950 | $3,168,750 | $0.24 |
| | | | | | | | | **Subtotal - 8.0 Capping** | $7,024,063 | $0.50 |
| | | | | | | | | **Total** | **$26,460,857** | **$2.00** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

a. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10. Costs per CY assume this option would accommodate 13 million CY.
b. This item was based on information acquired from historical records and/or professional judgment.
c. This item was based on information acquired from a local supplier.
d. This item is based on a dredging rate of 8,000 CY per day.
e. This item includes a 3-man crew, at a rate of $50 per hour per man, to apply the solution or material for 6 hours during a typical dredging day.
f. This item includes a 2-man crew and a piece of equipment (backhoe), at a rate of $195 per hour, to mix and load the solution or material for 10 hours during a typical dredging day.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by, and reviewed under the supervision of, professionals who are competent in construction cost estimating, possess a working knowledge of construction, and capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values, but they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

# APPENDIX I

Open-Lake Placement of Dredged Material with Controls:
A Method to Reduce Phosphorus and Turbidity

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# Open-Lake Placement of Dredged Material with Controls: A Method to Reduce Phosphorus and Turbidity

## 1.0 INTRODUCTION

While the U.S. Army Corps of Engineers (USACE) maintains that open lake placement is the most economically feasible sediment management alternative that meets to federal guidelines, the State of Ohio and other stakeholders have concerns about potential environmental impacts attributed to current open-lake placement practices. Specifically, increased turbidity and the re-suspension of nutrient-laden sediment during open-lake placement increase the relative bioavailability of phosphorus, which can promote the development of harmful algal blooms.

Harmful algal blooms, which include the toxic and non-toxic forms of *Microcystis aerunginosa,* a blue-green algae, have been increasing during the summer in Lake Erie since the mid-1990s (Conroy et al., 2005). Additionally, increasing phosphorus concentrations promote the growth of the toxic strain of *Microcystis* (Davis et al., 2009).

The deteriorating lake condition is having a significant impact on Lake Erie's environment and economy. During the summer of 2009, the City of Toledo spent an additional $3,000 to $5,000 per day for 90 days to treat the lake water entering the City's drinking water intake (Toledo Blade, 2011). Additionally, Lake Erie charter boat captains have reported a significant decrease in fishing reservations.

Excluding inputs from the Upper Great Lakes and Michigan via the Detroit River, the Maumee River is the greatest external source of phosphorus to the western basin (Bridgeman et al., 2010). While the majority of phosphorus loading to Lake Erie occurs via the tributaries, the State of Ohio has taken steps to limit open-lake placement of dredged material to minimize phosphorus loadings that occur with this practice. In 2010, the Ohio Environmental Protection Agency (Ohio EPA) and Ohio Department of Natural Resources (Ohio DNR) requested that the USACE take interim steps to lessen the environmental impact while long-term solutions are investigated.

## 2.0 PROJECT CONCEPT, APPLICATION METHODS, AND MONITORING PROGRAM

The large-scale pilot phosphorus reduction project being considered would include amending material dredged from the Toledo Harbor Federal navigation channel (Federal channel) with aluminum sulfate (alum) and bentonite clay and/or other polymers prior to or during placement in the open-lake disposal area. Depending on project funding, a portion of the material dredged from the Federal channel would be amended with alum and bentonite and/or other polymers. There are a variety of potential dosing methods (i.e. incorporation into the dredged material or broadcasting into the water). The purpose of the alum is to reduce available phosphorus while bentonite has been demonstrated to be an effective flocculant to reduce turbidity during and following placement.

Alum treatment using water treatment-grade aluminum sulfate ($Al_2(SO_4)_3 \cdot (14H_2O)$) is a proven lake restoration practice for addressing internal phosphorus loading. Aluminum ions ($Al^{3+}$) chemically react with phosphate ($PO_4^{3-}$) to create insoluble aluminum phosphate ($AlPO_4$):

$$Al^{3+} + PO_4^{3-} \rightarrow AlPO_4$$

The above formula suggests that the molar ratio of aluminum (Al) to phosphorus (P) is 1:1. The weight of Al required to precipitate a given weight of P is based on the 1:1 molar ratio and the molecular weights (grams/mole) of the two substances, 26.98/30.97 = 0.87 pounds (lbs.) Al/lb. P. Several factors such as pH, alkalinity, and competition for binding sites affect the actual ratio of Al:P, often resulting in ratios higher than the theoretical 1:1. Binding ratios of aluminum added: aluminum-bound phosphorus formed ranged from 5:1 to 11:1 in Wisconsin and Washington lake sediments (Rydin and Welsh, 1999; Rydin et al., 2000). Wastewater treatment plants have reported using a 2.2:1 molar ratio in plants targeting a 1 milligrams per liter (mg/L) effluent total phosphorus (TP) limit (CDM, 2001).

Alum treatment results in the settling and removal of insoluble aluminum phosphate, which reduces water column TP and chlorophyll *a* concentrations (Welsh and Cooke, 2009). The reduced phosphorus concentration limits the food source for blue-green algae, potentially reducing the generation of harmful algal blooms.

Bentonite and/or other polymers could act as a flocculant during placement to reduce turbidity and increase the shear strength of the placed sediment while also helping to neutralize the alum dosed dredged material. Bentonite, a member of the smectite family of clays, is primarily composed of montmorillonite and is one of the most cohesive common clays. It is used in a variety of areas, including construction, cat litter, food additives, foundry, and paper making. Jiang and Kim (2008) found that bentonite was highly effective as a coagulant at removing chlorophyll *a* and reducing turbidity from water dosed with *Microcystis.* In addition, bentonite has been shown to increase the shear stress of sediments, reducing erosion rates and enhancing the stability of the sediments when incorporated with capping materials. The addition of even 0.5% bentonite mixture was shown to increase shear strength and a 2% bentonite mixture increased the shear strength by up to two orders of magnitude (USACE, 2001).

Acknowledging the logistical challenges of the USACE dredging process, a contract to dose the dredged material could likely be added onto the existing federal contract or as a separate contract once the dredging contractor is selected. Both options would require coordination with the USACE, in addition to appropriate approvals.

There are several potential methods for dosing dredged material with alum and bentonite and/or other polymers:

1. Dose the open lake placement area following placement of dredged material.

    a. Inject/broadcast water column with a liquid slurry of alum and bentonite/polymers.

    b. Inject/broadcast water column with liquid alum solution; apply granular or powdered bentonite/polymers over the open lake placement area at some frequency.

One method is to dose the open lake placement area with alum and bentonite and/or polymers in a broadcast/injection manner following the release of materials into the open lake placement area. A flash mixer or similar equipment could be used to mix the bentonite/polymers with an alum solution to form a slurry. This slurry could be injected or broadcast into the water column in a similar manner as traditional lake treatment. Another option would be to inject or broadcast an alum solution (liquid alum or dry alum mixed with lake water) into the water column as

described above and then followed with a granular and/or powdered bentonite and/or other polymer application.

2. Dose dredged material as it is placed into scows during dredging operations.

    a. Pump/spray with a liquid slurry of alum and bentonite/polymers.

    b. Pump/spray with liquid alum solution as the scow is loaded to gain some distribution of the alum through the load; apply granular or powdered bentonite on top of material in the scow prior to open-lake placement.

The slurry could be applied using a mobile spray unit on the contractors' dredging unit/scow or by pumping the slurry from a separate barge holding the slurry into the dredging scow. Dredged sediments would be dosed with a diluted blend of treatment amendments as the dredgings are placed into scows for transport to the open lake placement area. Additionally, bentonite could be applied independently of the alum solution by spreading granular or powdered bentonite on the top of the scow carrying the dredged material once it is full.

Due to the increased contact time with the sediments, dosing the dredged material with alum in the scow prior to placement is expected to yield better results compared to injection into the water column following open-lake placement.

Gaining cooperation from the USACE to treat the dredged material prior to placement in the open lake placement area must be a first order of priority if a project partner opts to pursue this option. Another application method would be to treat the open lake placement area in the broadcast/injection manner described above concurrent with USACE program activities. While direct treatment is expected to be more cost-effective and yield greater phosphorus and turbidity reduction, broadcast treatment would still be beneficial and could potentially promote this method as a practical best management practice (BMP) of placement of fine grained P-containing sediments. Additionally, should the USACE not allow the placement of treated dredged material in the open lake placement area, a new test plot area could be established. However, National Environmental Policy Act regulations, environmental considerations, and other regulatory permitting/approval processes could preclude a new open lake disposal site in conjunction with treatment from being a feasible short-term option.

Prior to implementation a monitoring program would need to be developed to optimize the dosing rate of alum and bentonite as well as to monitor project performance. The monitoring program would consist of the following:

- pre-treatment testing to determine the optimal method of dosing and appropriate dosing rate;
- application monitoring and testing to ensure conformance with project specifications; and
- pre- and post-project testing to evaluate degree of phosphorus and turbidity reduction and to allow for adaptive management of dosing rate.

Pre-treatment testing will be completed to identify the final amount of alum and bentonite that should be added to dredged material as part of the final project design. The pre-treatment monitoring program would include several water and sediment quality evaluations. Alkalinity, pH, and dissolved aluminum would be measured to ensure protection of aquatic species from aluminum toxicity. Total phosphorus and soluble reactive phosphorus (SRP) would be measured to evaluate phosphorus removal. This test would maximize phosphorus inactivation while ensuring that the pH level remains within an allowable pH range, 6.0 to 8.5 standard units (S.U.), to protect aquatic biota.

Application monitoring would be conducted during the project to ensure project conditions are acceptable. At a minimum, pH would be continuously monitored as alum is applied to the dredged material, as well during the placement of the dosed material in the open lake placement area.

Pre- and post-project monitoring would be necessary to quantify the reduction of phosphorus in the dredged sediment and water column within the open lake disposal area. Pre- and post-monitoring measurements would include parameters such as dissolved Al, nitrate, SRP, TP, chlorophyll *a*, Secchi depth, temperature, dissolved oxygen, and conductivity. A final pre- and post-project monitoring work plan should be developed prior to implementation.

## 3.0 PROJECT ASSUMPTIONS AND COST ESTIMATE

A preliminary cost estimate was developed for this option. This cost estimate was based on several assumptions including the amount of phosphorus in the dredged material, alum effectiveness, and sediment characteristics. Costs are based on 2012 dollars and did not

include inflation of current market costs. The proposed approach and cost estimate presented should not be considered as a final project design and cost, but is provided as a guide to project partners in planning next steps and to secure potential implementation funding.

The cost estimate assumed that 800,000 CY would be removed from the Federal channel, and that the dredging scow capacity is 1,800 CY with two to three scows used to complete four to five scow loads per day. Dredging was assumed to occur over 20 weeks with an approximate average of 40,000 CY of material dredged each week. A moisture content of 145% and a dry sediment unit weight of 39 lbs. per cubic foot (cf), or 1.44 lbs. per cubic yards (CY), were used to estimate the amount of dry sediment in dredged material. The average phosphorus concentration from 2004 and 2006 sediment testing results (USACE, 2009), or 616.2 milligrams per kilogram (mg/kg), was used to estimate the amount of total phosphorus in dredged sediment. Using these assumptions, there are approximately 4,200 tons of dry sediment and two tons of TP in the average daily amount of dredged material (Table 1).

**TABLE 1**

**ESTIMATED AMOUNT OF DRY SEDIMENT AND TOTAL PHOSPHORUS IN ANNUAL AND DAILY DREDGED MATERIAL FROM TOLEDO HARBOR**

| | Per cubic yard Dredged Material (CY) | One Scow Load Dredged Material (1,500 CY-2,250 CY) | Daily Scow Load Dredged Material (8,000 CY) | Annual Permitted Open-Lake Placement Amount (800,000 CY) |
|---|---|---|---|---|
| Dry Sediment | 0.53 tons | 800-1,200 tons | 4,200 tons | 420,000 tons |
| Total Phosphorus | 0.65 lbs. | 980-1,500 lbs. | 2.6 tons | 260 tons |

The ratio of 0.87 lbs. Al to 1 lb. P was applied for estimating the amount of alum needed to treat dredged material. Using the amount of TP in dredged sediment, all of which was assumed is bioavailable, the amount of aluminum needed to dose the dredged sediment is 0.57 lb. Al/CY.

While it is possible to make a solution using dry alum and lake water, the solution would have to be made in relatively low concentration batches. In addition, the dry alum can expose workers to the hazards of alum dust. As a result, most wastewater treatment facilities and lake managers prefer to use alum already prepared in solution. Additionally, General Chemical has a liquid alum plant in Toledo, Ohio. Based on General Chemical's product specifications, liquid

alum is 48% dry alum and has a density of 11.1 lbs./gallon alum solution. Using the amount of Al required per CY and the product specs, the amount of alum required is 1.2 gallons of alum solution/CY (6.4 lbs. dry alum/CY).

Using the liquid alum cost of $325/dry ton, or $0.16/lb., and the amount of dry alum/CY, it is estimated to cost $1.02/CY to treat dredged material with alum solution, or approximately $1.50/ lb. TP (material cost only). For the purposes of this estimate, it was assumed there is little competition for binding sites as it was also assumed earlier that all of the TP was readily bioavailable (a potentially very conservative assumption). Given these assumptions, a Al:P ratio of 0.87:1 was used.

As reported in Table 2, it would cost approximately $1/CY for alum materials in order to dose dredged sediment with a liquid alum solution. Extrapolated to the average daily and annual dredging amount, the estimated cost is $8,160 and $816,000, respectively.

It is important to note that this estimate assumed that all of the phosphorus would bind with the alum, when in reality only a portion of the total phosphorus would be available to react with the alum. Pre-treatment testing would estimate the phosphorus removal rate. The amount of dredged sediment treated would depend on the amount of funding available and the results of pre-treatment testing.

**TABLE 2**

**ESTIMATED ALUM COST TO BIND TP IN VARYING VOLUMES OF DREDGED MATERIAL, ASSUMING AN AL:P BINDING RATIO OF 0.87:1**

| | Aluminum Needed (lbs.) | Dry Alum Needed (lbs.) | Liquid Alum Needed (gallons) | Alum Cost |
|---|---|---|---|---|
| Per cubic yard (CY) | 0.57 | 6.4 | 1.2 | $1.02 |
| One Scow Load Amount (1,500-2,250 CY) | 860-1,300 | 9,600-14,000 | 1,800-2,700 | $1,530-$2,295 |
| Daily Scow Load Amount (8,000 CY) | 4,600 | 51,000 | 9,600 | $8,160 |
| Annual Permitted Open-Lake Placement Amount (800,000 CY) | 460,000 | 5,100,000 | 960,000 | $816,000 |

Bulk bentonite is estimated to cost $225/ton, or $0.11/lb., which includes transport of the material via rail from the source to a shoreline offload site in Toledo, Ohio. Bentonite dosing could occur at the end of the dredging week, when weather conditions are appropriate, with the granular and/or powered bentonite being placed on top of a full scow load. For the purposes of this cost estimate, it was assumed that 1% of the full scow would be topped with powdered and/or granular bentonite (approximately 8-12 tons of bentonite). The cost per scow load is estimated to be $1,800-$2,700. For the entire dredging season, it is estimated that approximately 20 scow loads would receive a bentonite treatment at a cost of $36,000-$54,000 for material, or approximately $0.05-$0.07/CY.

The above cost estimates are for alum and bentonite material costs only and do not include mobilization/demobilization, permitting costs, monitoring costs, or labor. Application costs for alum and bentonite are expected to cost approximately $1/CY.

## 4.0 SUMMARY

Alum dosing would decrease the availability of phosphorus in the dredged material as well as the water column. In addition, bentonite could also act as a flocculant potentially reducing phosphorus even further. Bentonite would also serve to increase the shear strength of the material, reducing the probability of sediment re-suspension along the lakebed of the placement area. These benefits would in turn lead to less re-suspension of phosphorus within dredged material, reducing the availability for algae.

The use of dosed dredged material could also benefit future habitat restoration unit (HRU) projects and the implementation of other sediment management and use options (i.e. wetland restoration and shoreline protection). The treated material would have increased shear strength, reducing the potential for loss of material within the HRU. This project would also help quantify the increase in shear strength through the addition of bentonite.

Should this method of reducing phosphorus and turbidity prove successful, dosing dredged material with alum and bentonite/polymers could become a BMP as part of a Section 401 water quality certification. The results of this project would also assist the USACE Environmental Research and Development Center, which has been charged by the USEPA to develop ways to

improve sediment caps in evaluating the use of flocculants like bentonite to increase sediment strength. Results from this project could have significant implications and replication opportunities for the management and beneficial use of dredged material throughout the Great Lakes.

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# APPENDIX J

Second Public Forum Report

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# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS
# SECOND PUBLIC FORUM

## Introduction

[illegible]

## Purpose

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]

## Notification

[illegible]

## Participation

## Forum Agenda and Presentation

## Results of Participant Survey

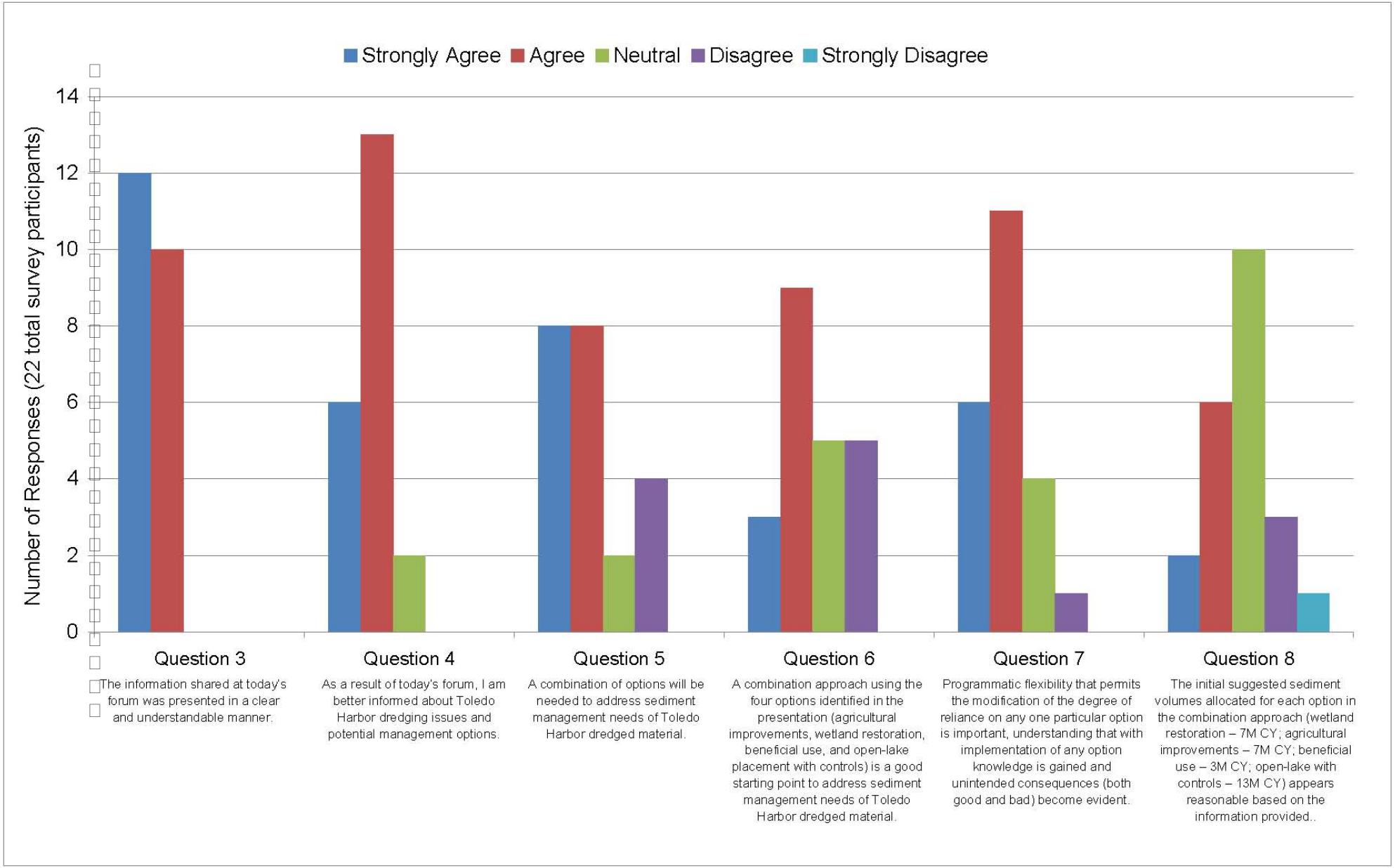
[illegible]

[illegible]

[illegible]

## Next Steps

[illegible]


Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
Number of Responses (22 total survey participants)
0
2
4
6
8
10
12
14
Question 3
The information shared at today's forum was presented in a clear and understandable manner.
Question 4
As a result of today's forum, I am better informed about Toledo Harbor dredging issues and potential management options.
Question 5
A combination of options will be needed to address sediment management needs of Toledo Harbor dredged material.
Question 6
A combination approach using the four options identified in the presentation (agricultural improvements, wetland restoration, beneficial use, and open-lake placement with controls) is a good starting point to address sediment management needs of Toledo Harbor dredged material.
Question 7
Programmatic flexibility that permits the modification of the degree of reliance on any one particular option is important, understanding that with implementation of any option knowledge is gained and unintended consequences (both good and bad) become evident.
Question 8
The initial suggested sediment volumes allocated for each option in the combination approach (wetland restoration – 7M CY; agricultural improvements – 7M CY; beneficial use – 3M CY; open-lake with controls – 13M CY) appears reasonable based on the information provided..

# APPENDIX A

d r

**Toledo Harbor Sediment Management and Use Solutions:**
***Evaluation of Sediment Management and Use Options for Toledo Harbor***
**Public Forum #2**

[illegible]

[illegible] 19, 2012

1:00 [illegible] 00 [illegible]

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300 [illegible] Martin [illegible]

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[illegible]

*Directions to the Dr. Martin Luther King, Jr. Plaza can be found on the next page.*

[illegible]

[illegible]

*This effort is funded in part through a*
*Great Lakes Restoration Initiative Grant through U.S. EPA.*

**Directions from ANTHONY WAYNE TRAIL/US-25:**

[illegible]

**Directions from WEST/I-475:**

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**Directions from NORTH/I-75:**

[illegible]

**Directions from the SOUTH:**

[illegible]

**Directions from EAST from Route 2:**

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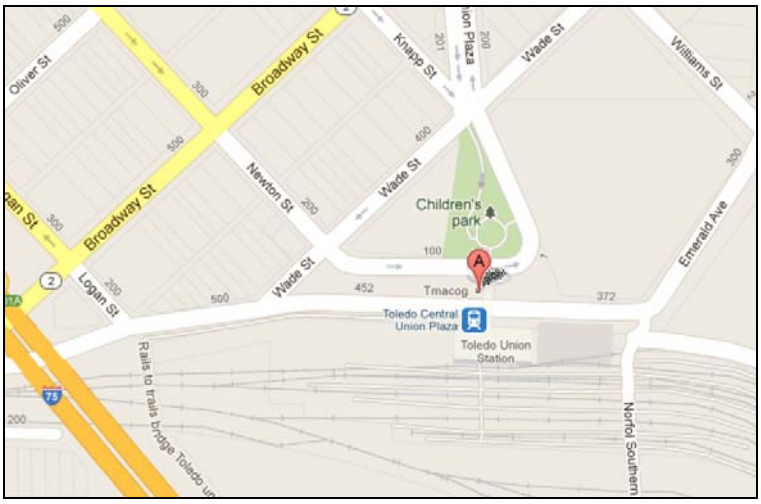


[illegible]

Great Lakes Commission des Grands Lacs

Ohio | Lake Erie Commission

TOLEDO | LUCAS COUNTY PORT AUTHORITY

*This effort is funded in part through a Great Lakes Restoration Initiative Grant through U.S. EPA.*

# APPENDIX B

d d r

toledoBlade.com

Printed Tuesday, June 26, 2012

# Public forum wants harbor dredging input

Alternatives for managing sediment and other material dredged from Toledo Harbor's channels will be the subject of a public forum next week at the Toledo Metropolitan Area Council of Governments.

Over the last year, members of a local task force and technical experts have studied options for dredging management "in a manner that balances economic and environmental aspects," according to a task-force statement.

During the forum, scheduled for June 19 from 1 to 4 p.m., project representatives are to explain the project's objectives and evaluation process and are to present the various options that have been identified.

The forum's purpose is to solicit feedback from various Toledo Harbor interests.

It is to conclude with a question-and-answer session.

Agencies involved include the Great Lakes Commission, Ohio Lake Erie Commission, and the Toledo-Lucas County Port Authority.

There is no charge to attend, but reservations are requested and may be made by calling 419-621-2040 or emailing **lakeeriecommission@lakeerie.ohio.gov**.

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To contact a specific department or an individual person, click here.
The Toledo Times ®

# APPENDIX C

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# USA: Public Forum over Toledo Harbor Dredging Set for June 19

Posted on Jun 11th, 2012 with tags 19, Americas, dredging, Forum, harbor, June, News, over, public, set, Toledo, USA.

**According to the Toledo Blade, alternatives for managing sediment and other material dredged from Toledo Harbor's channels will be the subject of a public forum next week at the Toledo Metropolitan Area Council of Governments.**

During the forum, scheduled for June 19, from 1 to 4 p.m., project representatives are to explain the project's objectives and evaluation process and are to present the various options that have been identified.

Agencies involved include the Great Lakes Commission, Ohio Lake Erie Commission, and the Toledo-Lucas County Port Authority.

# APPENDIX D

[illegible]d [illegible]r [illegible]r [illegible]

**TOLEDO HARBOR SECOND PUBLIC FORUM**

**ATTACHMENT D**

**LIST OF PARTICIPANTS**

| | FIRST NAME | LAST NAME | ORGANIZATION |
|---|---|---|---|
| 1 | Amy | Alduino | Ohio Department of Development |
| 2 | Kelly | Bensman* | Hull & Associates, Inc. |
| 3 | Sandy | Bihn | Western Lake Erie Waterkeepers, Inc. |
| 4 | Joseph | Cappel* | Toledo-Lucas County Port Authority |
| 5 | Fernando | Camargo* | Hull & Associates, Inc. |
| 6 | Tom | Chudde | TerraSea Environmental Solutions LLC |
| 7 | Libby | Dayton | Ohio State University |
| 8 | Janina | Douglas | Lake Erie Improvement Association |
| 9 | Kurt | Erichsen | Toledo Metropolitan Area Council of Governments |
| 10 | Kristin | Gardner* | Hull & Associates, Inc. |
| 11 | Sally | Gladwell | Mannik & Smith |
| 12 | Dan | Glomski | Ohio EPA |
| 13 | Sophie | Groach | Toledo Blade |
| 14 | Tom | Hays | Lucas County |
| 15 | Jeremy | Heyerly | URS |
| 16 | Gail | Hesse* | Ohio Lake Erie Commission |
| 17 | Phil | Hicks* | Hull & Associates, Inc. |
| 18 | Steven | Holland | Ohio Department of Natrual Resources -Office of Coastal Management |
| 19 | Alan | Horn | Ohio State University |
| 20 | Paul | Hotz | TTL |
| 21 | Jerry | King | NS Corp |
| 22 | David | Knight* | Great Lakes Commission |
| 23 | Roger | Knight | ODNR, Division of Wildlife |
| 24 | Mark | Loomis* | USEPA - Great Lakes National Program Office |
| 25 | Michael | Murray | National Wildlife Foundation |
| 26 | Arnold | Page | USACE |
| 27 | Terry | Perry | S&L Fertilizer |
| 28 | John | Recker | Ohio Deptartment of Transportation |
| 29 | Paul | Roman | City of Oregon |
| 30 | Rian | Sallee* | Ohio Lake Erie Commission |
| 31 | Terry | Shunkland | Partners for Clean Streams |
| 32 | Diane | Shunkland | Partners for Clean Streams |
| 33 | David | Spangler | Lake Erie Waterkeeper, Inc. |
| 34 | Roger | Streiffert | Toledo Metropolitan Area Council of Governments |
| 35 | Dan | Thomas | Resident |
| 36 | Pauline | Thorndike | USACE |
| 37 | Thea | Walsh | Ohio Department of Development |
| 38 | Lance | Wehrle | Cullen Park Org |
| 39 | John | Welch | West Sister Charter Boat |
| 40 | Scott | Woycik | LaFarge |

Notes:
(*) Forum Organizer

# APPENDIX E

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**Toledo Harbor Sediment Management and Use Solutions**

**Stakeholder Forum #2**
Tuesday, June 19, 2012
1:00 p.m. - 4:00 p.m.
Toledo Metropolitan Area Council of Governments Building
300 Dr. Martin Luther King Jr. Drive, Toledo, OH 43604

## AGENDA

| | |
|---|---|
| 1:00 p.m. | Welcome and Event Overview<br>*Dave Knight, Special Projects Manager, Great Lakes Commission* |
| 1:05 p.m. | Regional Perspective<br>*Dave Knight, Special Projects Manager, Great Lakes Commission* |
| 1:15 p.m. | State Perspective<br>*Gail Hesse, Executive Director, Ohio Lake Erie Commission* |
| 1:25 p.m. | Port Perspective<br>*Joseph Cappel, Director of Cargo Development, Toledo-Lucas County Port Authority* |
| 1:35 p.m. | Evaluation of Sediment Management and Use Options for the Toledo Harbor Sediment Management and Use Plan<br>*John Hull, P.E., Principal, Hull & Associates, Inc.* |
| 3:15 p.m. | Question and Answer Session<br>Moderator: *Dave Knight, Special Projects Manager, Great Lakes Commission* |
| 3:30 p.m. | Forum Wrap-Up, Next Steps, and Survey<br>*John Hull, P.E., Principal, Hull & Associates, Inc.*<br>*Dave Knight, Special Projects Manager, Great Lakes Commission*<br>*Gail Hesse, Executive Director, Ohio Lake Erie Commission*<br>*Joseph Cappel, Director of Cargo Development, Toledo-Lucas County Port Authority* |

**Toledo Harbor Sediment Management and Use Public Forum**

## PRESENTATION NOTES FORM

*Thank you for attending this forum. We created this notes form so you can jot down any ideas, questions, comments, etc. you might have during the presentation. The general headings correspond to the discussion topics for the presentation.*

**Regional, State, and Local Perspectives:**

_____

_____

_____

_____

**Toledo Harbor Sediment Management and Use Planning Introduction:**

_____

_____

_____

_____

**Potential Sediment Management and Use Options:**

_____

_____

_____

_____

**Ranking of Options:**

_____

_____

_____

_____

**Other Questions or Comments:**

_____

_____

_____

_____

_____

# APPENDIX F

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# Toledo Sediment Management and Use Solutions

## Evaluation of Sediment Management and Use Options for the Toledo Harbor Sediment Management and Use Plan

Public Forum #2
June 19, 2012
TMACOG Grand Lobby

Forum Organizers and Funders:

Ohio Lake Erie Commission

Toledo | Lucas County Port Authority

Great Lakes Commission des Grands Lacs

Great Lakes Restoration

*June 19, 2012*

# Great Lakes Commission

Dave Knight

Special Projects Manager

Great Lakes Commission

Great Lakes Commission des Grands Lacs

glc.org/dredging

Great Lakes RESTORATION

2805 S. Industrial Hwy, Suite 100
Ann Arbor, MI 48104-6791
734.971.9135
dknight@glc.org

# Logistics

- Restrooms
- Snacks/Beverages
- Health & Safety
- Agenda/Notes Page
- Survey

- Forum Rules
  - Please let the speaker know if something needs repeated
  - Please hold comments and questions pertaining to the content until the Q&A session
- Thank you for attending!

# Today's Schedule

- Introduction to the issues from a regional, state, and local perspective
  - Dave Knight, Great Lakes Commission
  - Gail Hesse, Ohio Lake Erie Commission
  - Joe Cappel, Toledo-Lucas County Port Authority
- Presentation of Toledo Harbor Sediment Management and Use Options
  - John Hull, Hull & Associates, Inc.
- Question and Answer Session

# Great Lakes Commission

- **The GLC interest historically**

GREAT LAKES DREDGING TEAM

The **Great Lakes Dredging Team** is a partnership of federal and state agencies created to assure that the dredging of U.S. harbors and channels throughout the Great Lakes, connecting channels and tributaries is conducted in a timely and cost effective manner while meeting environmental protection, restoration, and enhancement goals.

# Great Lakes Commission

Great Lakes Dredging Team - Windows Internet Explorer

Site created and maintained by the Great Lakes Commission | www.glc.org

GREAT LAKES DREDGING TEAM

MEETINGS GET INVOLVED PUBLICATIONS LINKS MEMBERSHIP ABOUT GLDT

Beneficial Use
Case Studies
Contaminated Sediment
Dredging Around the Great Lakes
Dredged Material Management
Navigation Depths & Lake Levels
Research & Development Technologies
Soil Erosion & Sedimentation
Contact GLDT

## WELCOME!

The **Great Lakes Dredging Team** is a partnership of federal and state agencies created to assure that the dredging of U.S. harbors and channels throughout the Great Lakes, connecting channels and tributaries is conducted in a timely and cost effective manner while meeting environmental protection, restoration, and enhancement goals.

## NEW & NOTABLE

- **NEW! Great Lakes Dredging Team Annual Meeting Materials**
  Maumee Bay, Ohio - May 17-18, 2012
- **Final Report - Beneficial Use of Dredged Material and Collaboration**
  - *Appendices B-F*
- **Great Lakes Dredging Team Annual Meeting Summary**
  Cleveland, Ohio 5.20.2010
  (PDF)
- **Great Lakes System Dredged Material Management Long Term Strategic Plan**
  (PDF 1M)
- **Great Lakes Dredging Team Proceedings: 7.14.2009**
  (PDF 0.5M)
- **U.S. Army Corps of Engineers Regional Sediment Management Spring Workshop**
  May 13-14, 2009
  Download Presentations
  (PDF 38M)

# Great Lakes Commission

- **Products:**
  - **"Testing and Evaluating Dredged Material for Upland Beneficial Uses: A Regional Framework"**
  - **"Open Water Disposal of Dredged Materials in the Great Lakes-St. Lawrence River Basin"**
  - **"Waste "Beneficially Using Dredged Materials to Resource: Beneficial Use of Great Lakes Dredged Material"**
  - **"Decision Making Process for Dredged Material Management"**
  - **"Regional Approach for Dredging Windows Determination"**
  - **"Create/Restore Habitat and Restore Brownfields"**

# Great Lakes Commission

- **The GLC interest going forward**
  - **Ongoing viability and growth for the Port of Toledo: Jobs**
  - **Environmental quality of the Lake Erie basin: Sustainability**
  - **Lessons for all Great Lakes navigation dredging projects: Technology transfer**
  - **Refinement of best management practices: Collaboration**

# State Perspective

Gail Hesse

Executive Director

Ohio Lake Erie Commission

Ohio | Lake Erie Commission

lakeerie.ohio.gov

111 Shoreline Drive
Sandusky, Ohio 44870
419-621-2040
gail.hesse@lakeerie.ohio.gov

# Lake Erie Economic Values

- **Lake Erie**
  - **$10.7 Billion Lake Erie Tourism**
  - **$1 Billion Lake Erie Fishing**
  - **3 million Ohio drinking water users**

# Sediment Entering Lake Erie – April 2008

# Algal Blooms in Lake Erie – August 2011

Photo: NOAA Satellite Image

# Ohio EPA Comparative Analysis

## WWTP Effluent vs. Dredged Sediment

For Quantity Perspective Only

| Parameter | Toledo Bay View WWTP Effluent (based on 2008 data) | Toledo Harbor Dredged Sediment (based on 2004 data & 1.25 million CY) |
|---|---|---|
| Cadmium | Samples below detection limit | 2.50 tons/yr |
| Lead | Samples below detection limit | 48.03 tons/yr |
| Mercury | 2.18 pounds/yr | 620 pounds/yr |
| Silver | Samples below detection limit | 0.61 tons/yr |
| Zinc | 5.1 tons/yr | 250.74 tons/yr |
| Total Phosphorus | 69.4 tons/yr | 1096 tons/yr (2010) |
| Total Suspended Solids | 983 tons/yr | 2,062,500 tons/yr (total solids) |
| Selenium | Samples below detection limit | 1.25 tons/yr |
| Ammonia | 20.4 tons/yr | 311.65 tons/yr |
| Operating Expenses | $41 million based on 2007 Annual Report | FY10 Budget - $5 million |

# Ohio's Regulatory Role

- Ohio EPA issues a Section 401 Water Quality Certification to the Corps of Engineers
  - Historically issued on a 5 year cycle
  - Recently issued annually

- Status of 2012 WQC
  - Will include sampling in the open-lake placement area

# Ohio's Position

- Toledo Harbor must be kept open
- Lake Erie must be restored
- Best approaches include beneficial use and source reduction
- Support cooperative partnerships
- Sustainable practices

# The Economic Impact of the Port of Toledo

Joseph Cappel

Director of Cargo Development

Toledo-Lucas County Port Authority

TOLEDO | LUCAS COUNTY PORT AUTHORITY

toledoportauthority.org
toledoseaport.org
tourtheport.com
toledoexpress.com

One Maritime Plaza, Suite 701
Toledo, Ohio 43604
419.243.8251
jcappel@toledoportauthority.org

# Great Lakes Shipping: Environmental Benefits

- Toledo's 15 Marine Terminals handle over 700 vessel calls and 12 million tons of cargo per year.

- Ships help preserve North American energy resources: Ships carry vast amounts of cargo long distances using significantly less fuel than trains and trucks. They are 4 times more efficient than trucks and 1.75 times more efficient than trains.

- Ships have the smallest carbon footprint: A Great Lakes freighter produces 70 percent less carbon dioxide per metric ton/kilometer compared to trucks.

- Ships remove congestion from roadways: The largest Great lakes vessel can carry 70,000 metric tons- the equivalent to 3000 truckloads or 700 rail cars.

# Great Lakes Shipping: Economic Benefits

- The shipping industry employs 227,000 people in the U.S. and Canada and produces business revenue of $33.5 billion.
- Shipping contributes $4.6 billion in federal, state and local taxes each year.
- Electrical utilities, steel mills, construction companies, mining companies, manufacturers and farmers all depend on the 164 million tons of cargo delivered by Great Lakes ships each year.
- Marine transportation on the System provides $3.6 billion in annual savings compared to the next best all land transportation alternative.

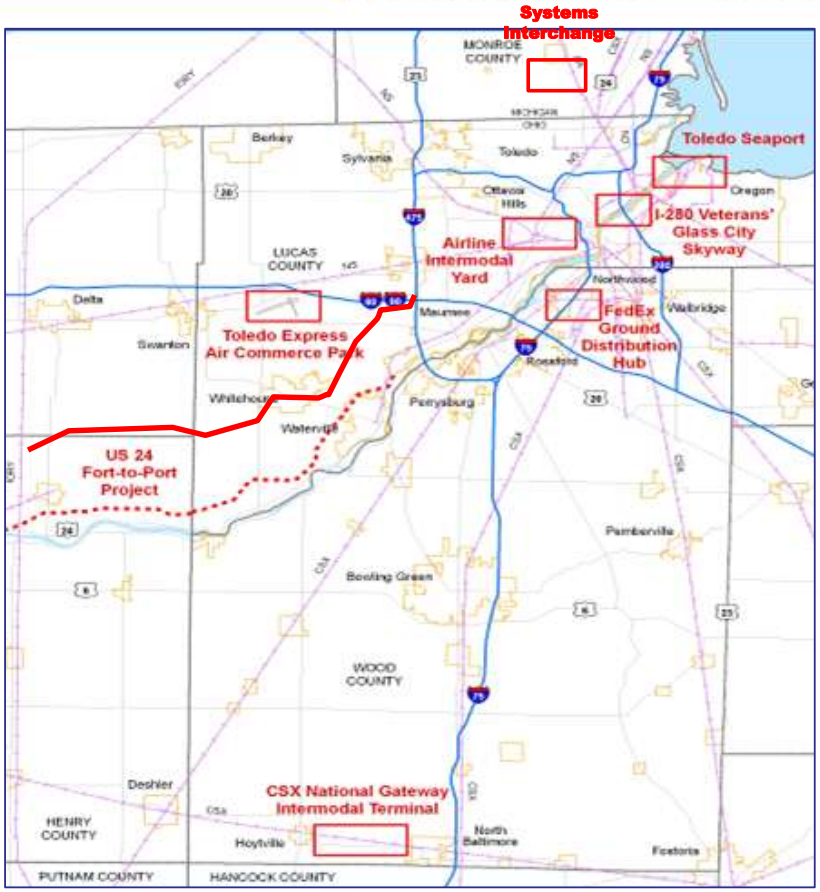
# The Port of Toledo's Economic Impact

- 6,971 jobs are supported by the cargo moving via Toledo's marine terminals. 2,521 jobs were directly generated by the maritime activity at the terminals with wages and salaries totaling over $109 million.
- Direct business revenue received by the firms dependent upon the cargo handled at the Port totaled $381.3 Million in 2010.
- A total of $154.7 million in state and federal taxes were generated by cargo and vessel activity in 2010.

# Regional Transportation Investment

- I-75/475 Systems Interchange Ph 1 $98 M
- Toledo Seaport Improvements $35 M
- I-280 Veterans Glass City Skyway Bridge & Roadway Proj. $300 M
- NS Airline Yard Intermodal $13 M
- **FedEx Ground Facility $87 M**
- Toledo Express Airport **$7 M**
- **US 24 Fort-to-Port Highway $490 M**
- **CSX Northwest OH Intermodal <u>$175 M</u>**

Regional Investment $1,205 M



# But…

- Investments in infrastructure & economic impact won't matter unless Toledo's dredging issues are addressed with sustainable solutions considering the needs of industry, community and environment.
- For every one inch of reduced draft, a lake trading vessel forfeits 50 to 270 tons of cargo from their payload. Ocean vessels lose 115 tons of cargo for each inch of lost draft.
- The International Reputation of the Port of Toledo is on the Line! One bad experience can cause a vessel never to return.
- This is a complex issue and there is no silver bullet solution. We need the best and brightest to collaborate - this plan is a result of the efforts of many stakeholders.
- If we can continue to work together to address the needs of commerce and the environment we will achieve great things!

# Toledo Harbor Dredging Task Force

- Membership
  - Toledo-Lucas County Port Authority
  - State agencies
  - Federal agencies
  - Local officials
  - Non-governmental organizations (environmental, commercial, and recreational)

# Overview of Options

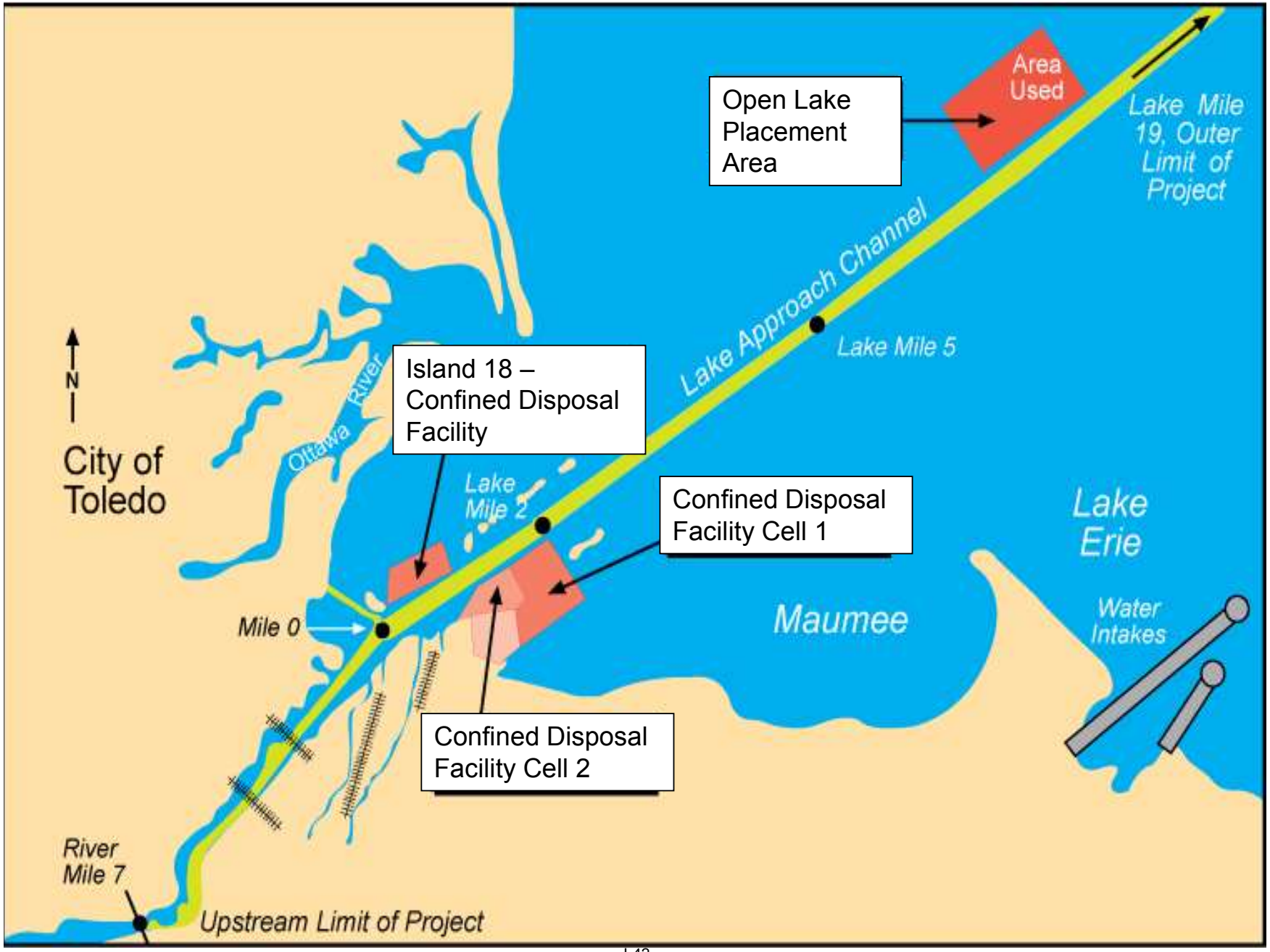
John H. Hull, P.E.
Principal
Hull & Associates, Inc.

Hull & associates, inc.
hullinc.com

3401 Glendale Ave
Toledo, Ohio 43614
419.385.2018
jhull@hullinc.com

# Toledo Harbor Sediment Management and Use

- Issues and Opportunities
- Technical Approaches
- Project Identification
- Prioritization for Implementation


Open Lake Placement Area
Area Used
Lake Mile 19, Outer Limit of Project
Lake Approach Channel
Lake Mile 5
N
City of Toledo
Ottawa River
Island 18 – Confined Disposal Facility
Lake Mile 2
Confined Disposal Facility Cell 1
Lake Erie
Mile 0
Maumee
Water Intakes
Confined Disposal Facility Cell 2
River Mile 7
Upstream Limit of Project

# Toledo Harbor Sediment Management and Use Planning

- Introduction to the Project
  - The Ohio Lake Erie Commission was awarded a GLRI grant to create a sediment management strategy/plan for the Toledo Harbor that identifies and addresses:
    - recommended short-term (1-5 years) options
    - recommended long-term (30 year) options
    - funding needs/sources/mechanisms
    - timelines for implementation of recommended approaches

# Toledo Harbor Sediment Management and Use Planning

- Sediment management and use plan status:
  - Solicited input on potential options and gathered value judgments from stakeholders on the importance of relative criteria to evaluate options (weighting factors)
    - Completion of June 2011 public forum
    - Completion of December 2011 Task Force consensus
  - Evaluation of short term (1-5 years) and long term (5-30 years) options
    - Compiled relevant data and information
    - Estimated dredge capacity needs
    - Completed preliminary screening of potential options identified internally and by stakeholders

# Today's Objectives

- Review potential sediment use options
- Present Technical Team's evaluation process and results
- Present prioritized approaches for sediment management options
- Solicit input from stakeholders

# Potential Sediment Use Options

- Solicited input on potential options from stakeholders at June 2011 Public Forum
  - Create Wetlands
  - Create Islands
  - New Metropark
  - Use of Geotubes
  - Erosion Control
  - Beneficial Use
  - Floodplain Berms

# Identification of Options

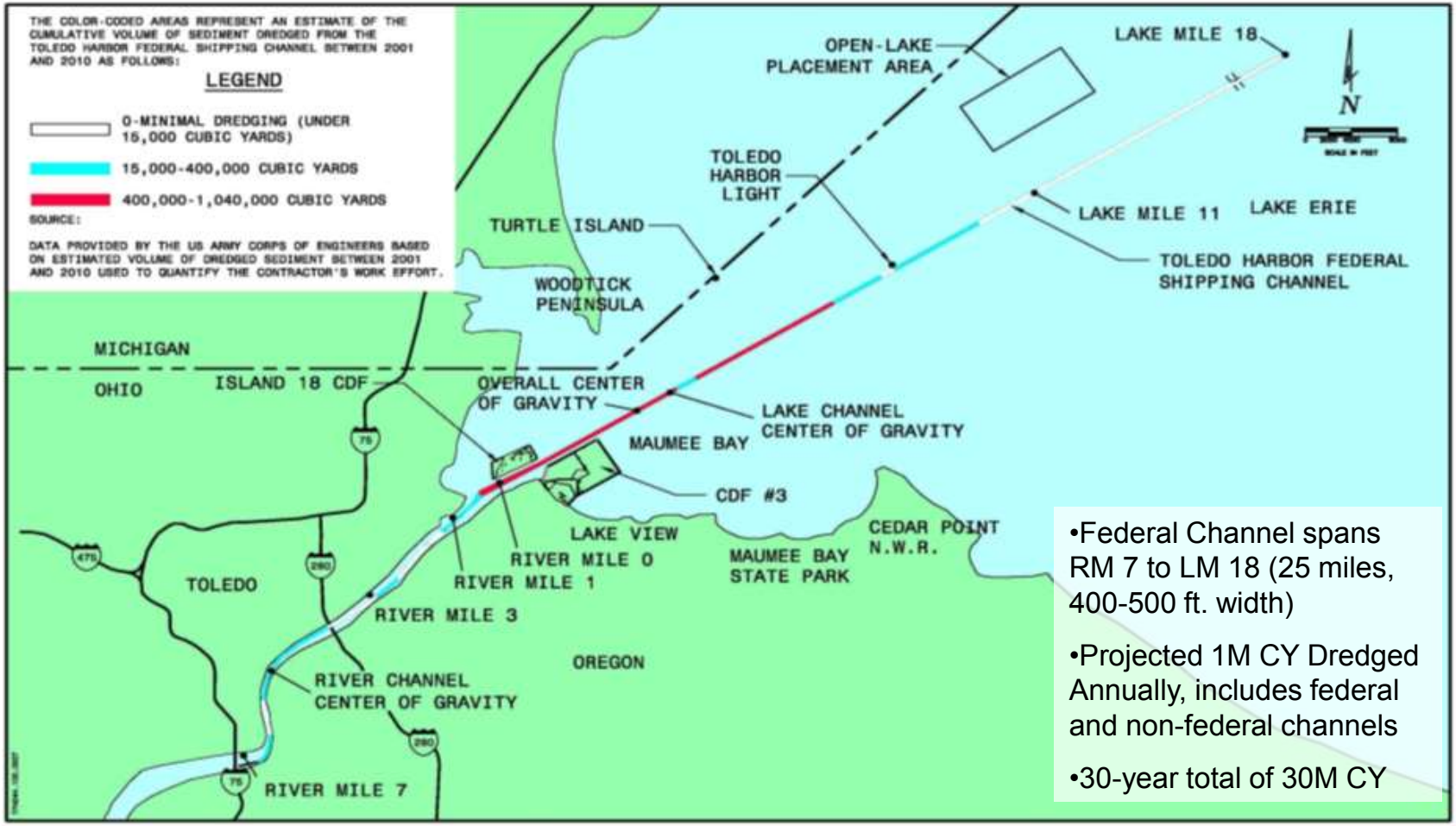
- Ideas from the 1st Public Forum were evaluated by the Technical Team

- Technical Team identified options/conceptual approaches to carry forward in the detailed evaluation using best professional judgment with respect to the conditions of Toledo Harbor and surrounding areas

# Major Assumptions

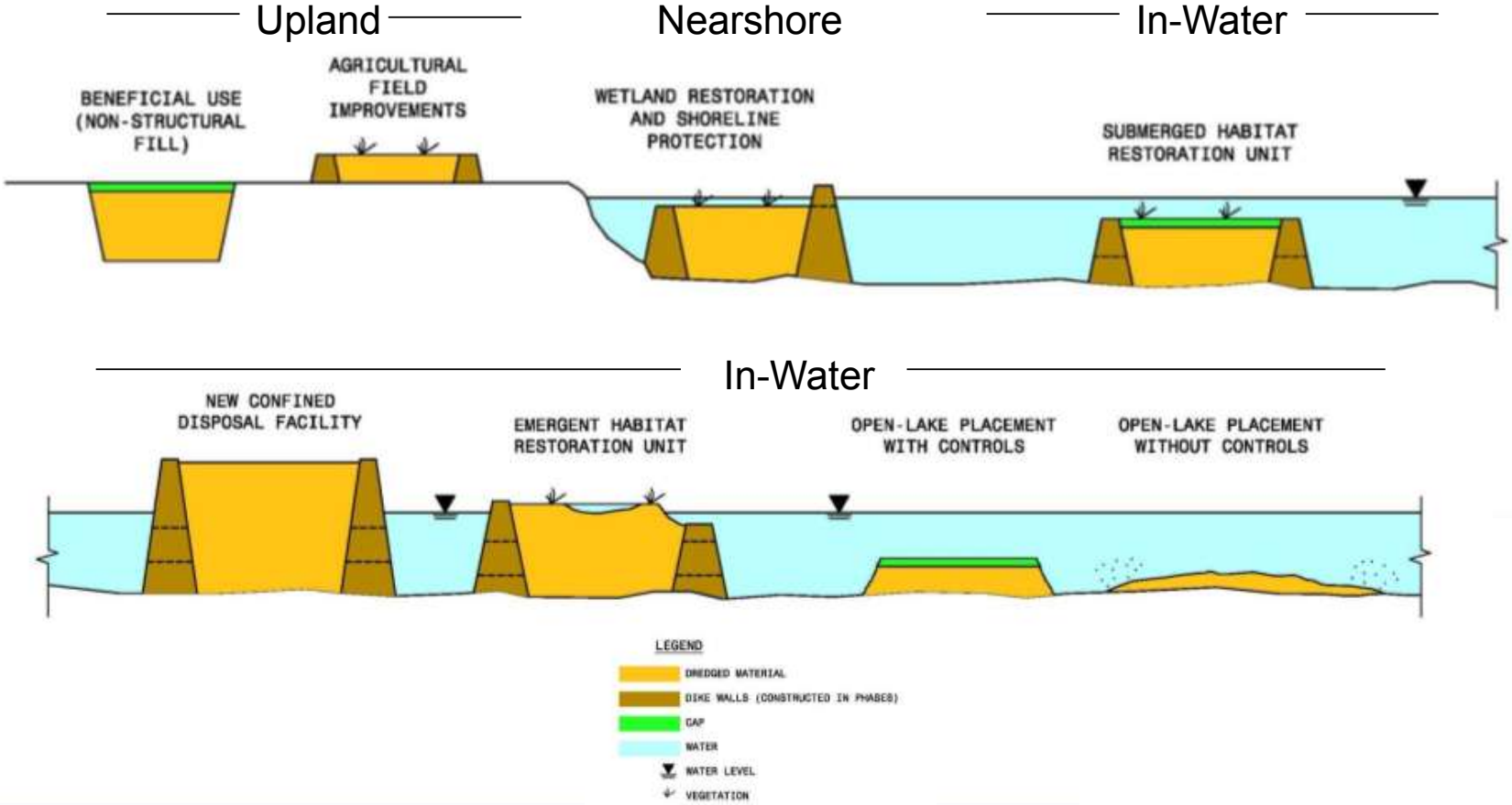
- No programmatic constraints
- A combination option is likely a better solution
- Option Costs
  - Basic recognition of major capital improvement and O&M costs
  - Used to serve as a relative comparison between options - not to be used as comprehensive cost estimate for each alternative
  - Approximate location of option used for estimating purposes

# Toledo Harbor Dredging

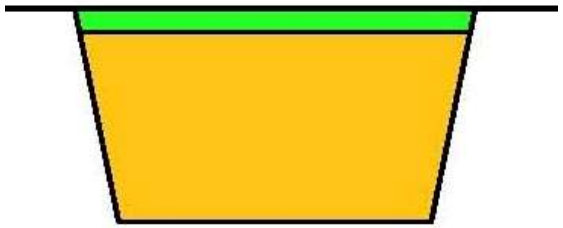



- Federal Channel spans RM 7 to LM 18 (25 miles, 400-500 ft. width)
- Projected 1M CY Dredged Annually, includes federal and non-federal channels
- 30-year total of 30M CY

# Potential Sediment Management and Use Options



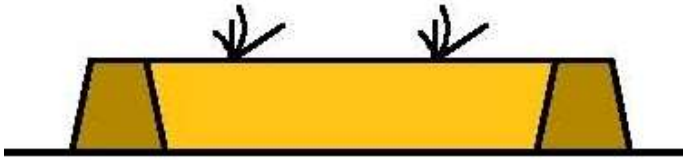
# Beneficial Use of Dredged Material as Non-Structural Fill



*Sediment off-loaded from barge/scow near the shore*

- Use dredged materials in productive ways as a resource that results in environmental, economic, or social benefits.
- Examples:
  - Brownfield revitalization
  - Strip mine reclamation & solid waste management
  - Construction and industrial use (port development, airports, urban, residential)
  - Material transfer (fill, dikes, levees, parking lots, roads)

# Agricultural Field Improvements

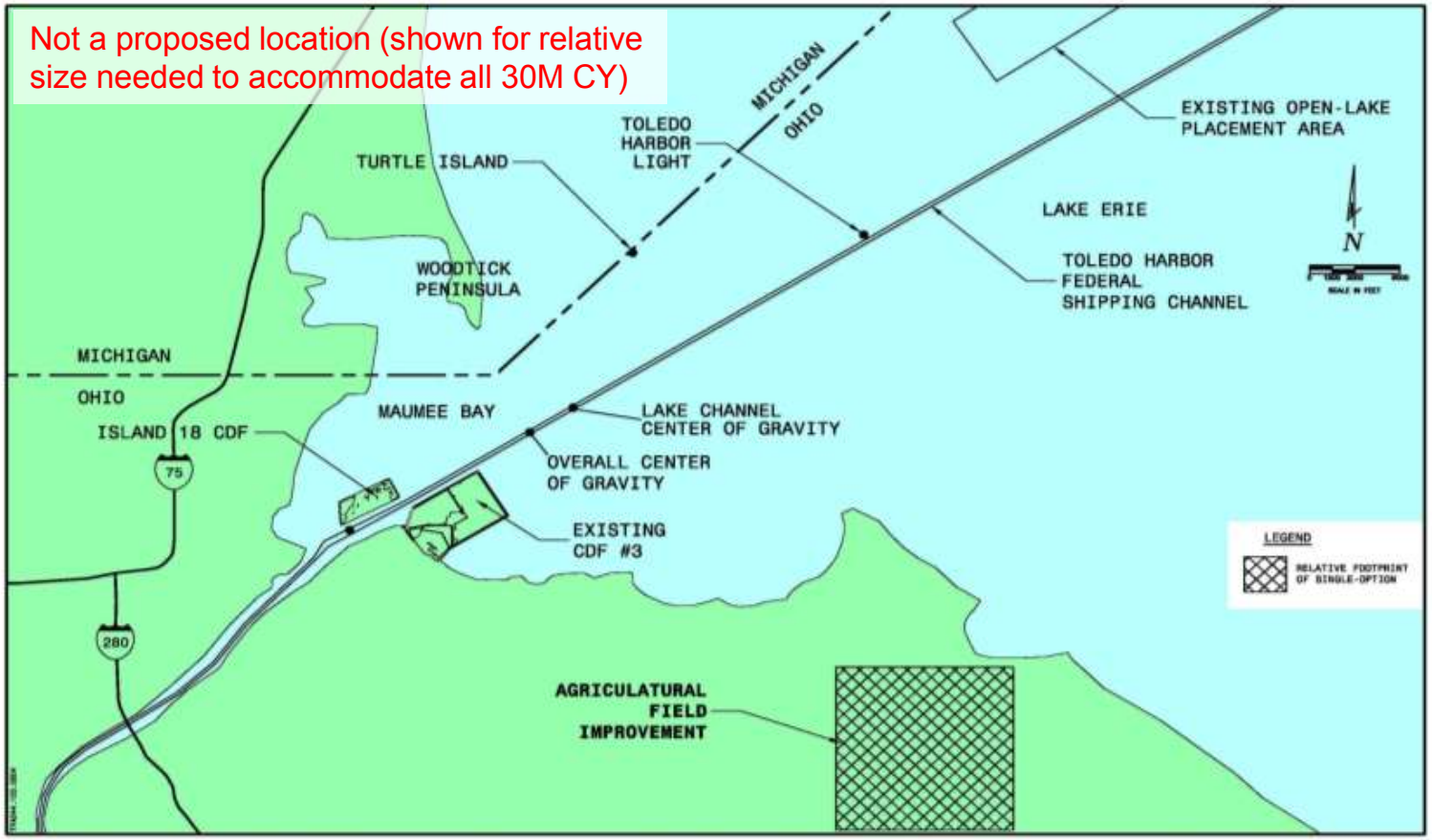


*Sediment pumped onto shore from dredging operations center of gravity and subsequently pumped to final site via booster pump structure(s)*

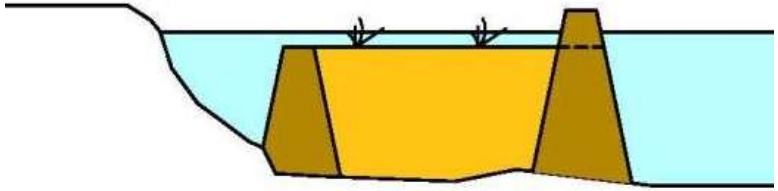
- Use dredged material to raise the elevation of agricultural fields, thus, improving drainage and future productivity
  - 5-mile radius
  - 10-mile radius
    - 4 ft. improvement height

# Agricultural Field Improvements

*Relative Footprint of 30M CY for Single-Option*



# Wetland Restoration and Shoreline Protection

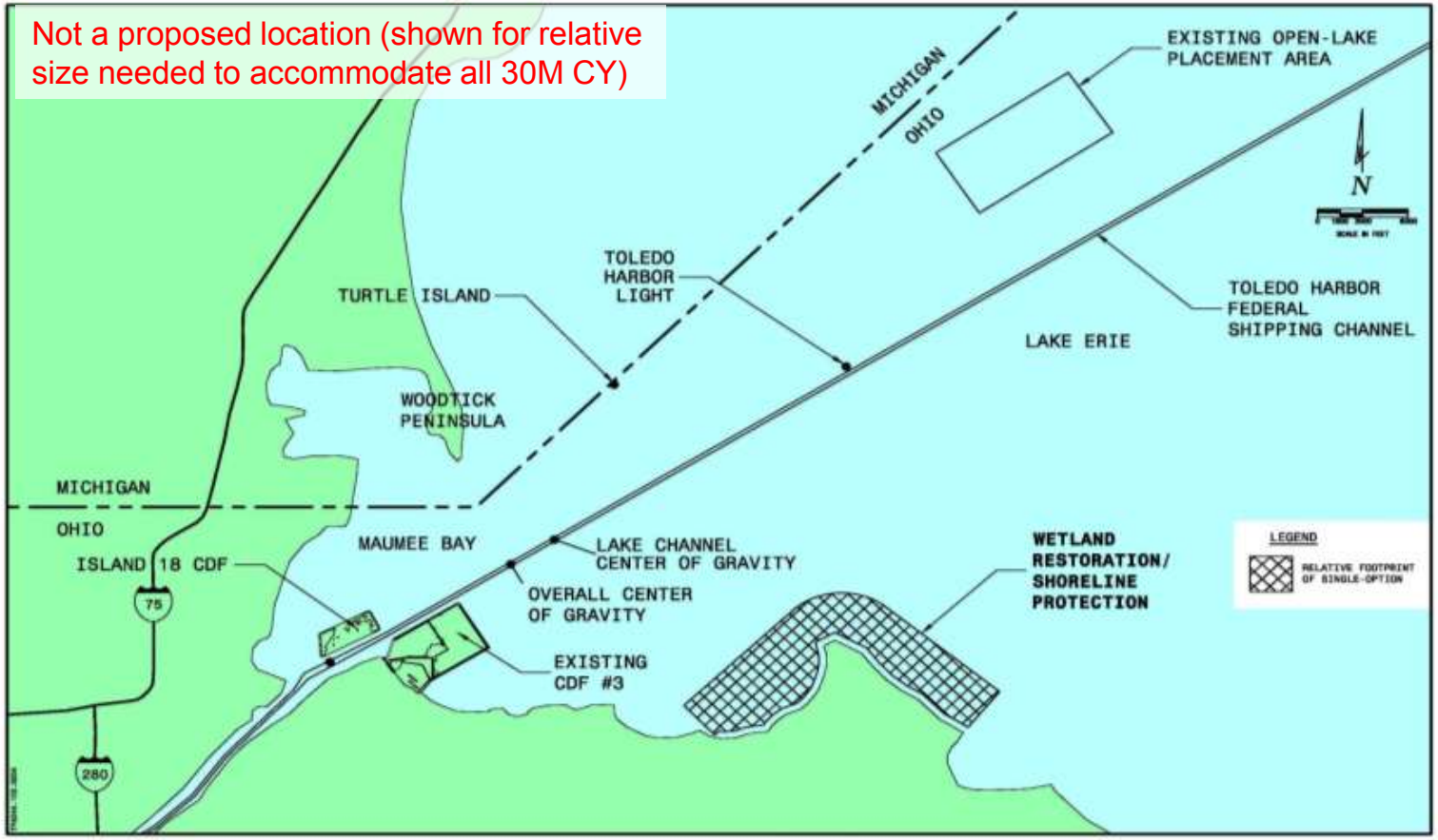


*Sediment pumped from dredging operations center of gravity to final location*

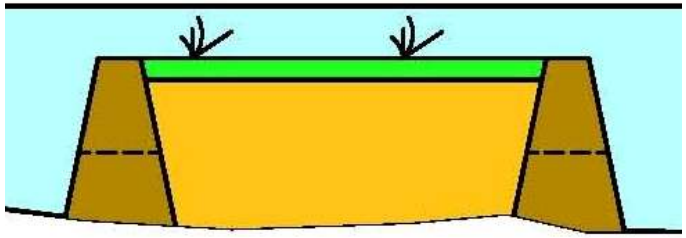
- Use dredged material to create additional wetland areas and a protective barrier for the existing shoreline
  - Structure base 5-7 ft. below LWD
  - Final dike surface 4-12 ft. above LWD
  - Final wetland surface near LWD

# Wetland Restoration and Shoreline Protection

*Relative Footprint of 30M CY for Single-Option*



# Submerged Habitat Restoration Unit

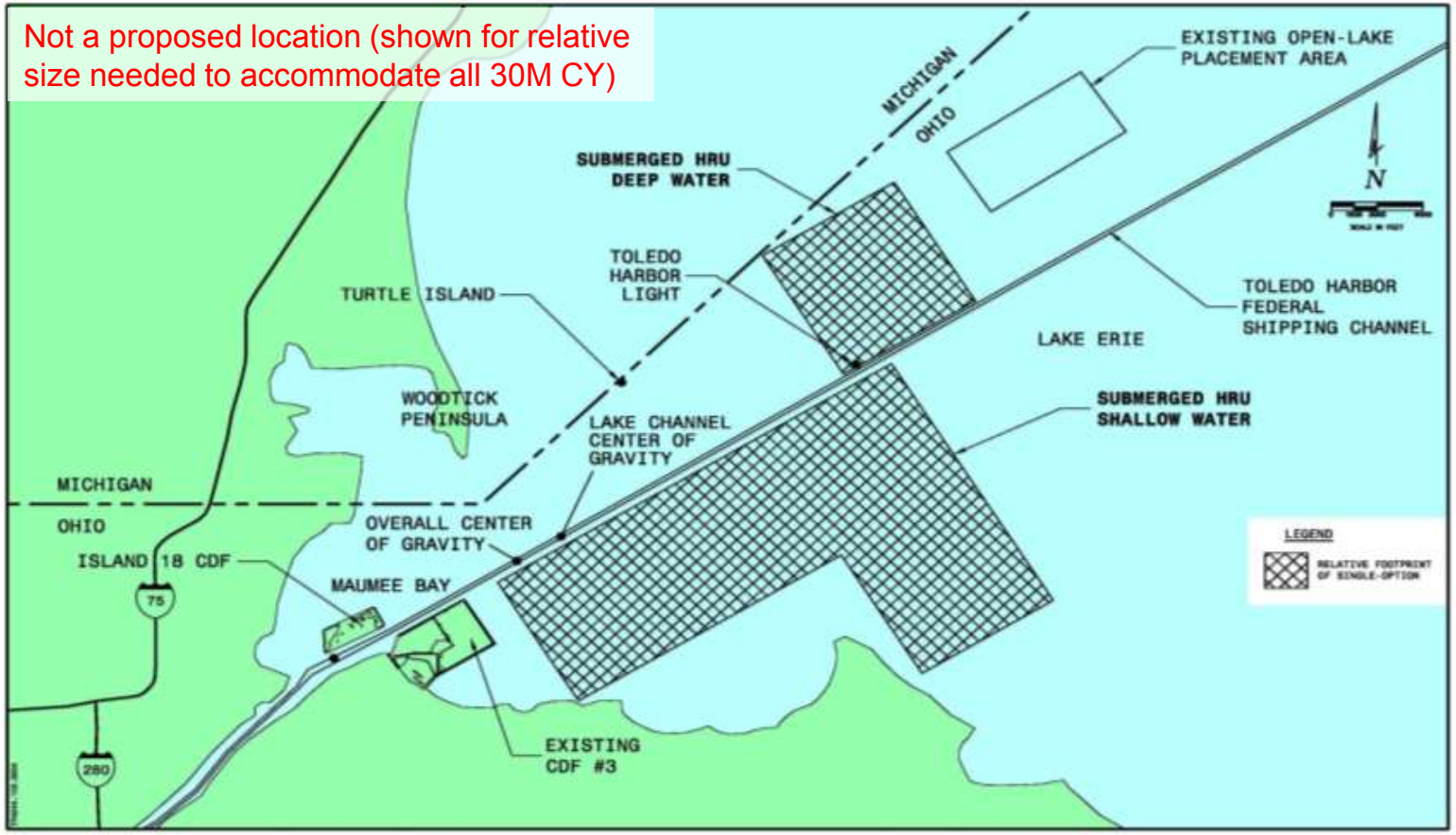


*Dredged material transported from channel to final location via scow/barge and pumped or released into HRU diked area*

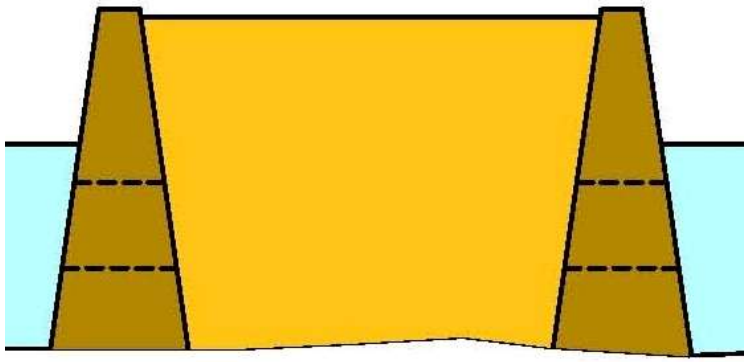
- Use of dredged material to assist in the development of a Habitat Restoration Unit (HRU) that will provide future submerged wildlife refuge/habitat
  - Deep water HRU
    - Structure base 20 ft. below LWD
    - Final structure surface 10 ft. below LWD
  - Shallow water HRU
    - Structure base 7 ft. below LWD,
    - Final structure surface 3 ft. below LWD

# Submerged Habitat Restoration Unit

*Relative Footprint of 30M CY for Shallow and Deep Single-Options*



# New Confined Disposal Facility

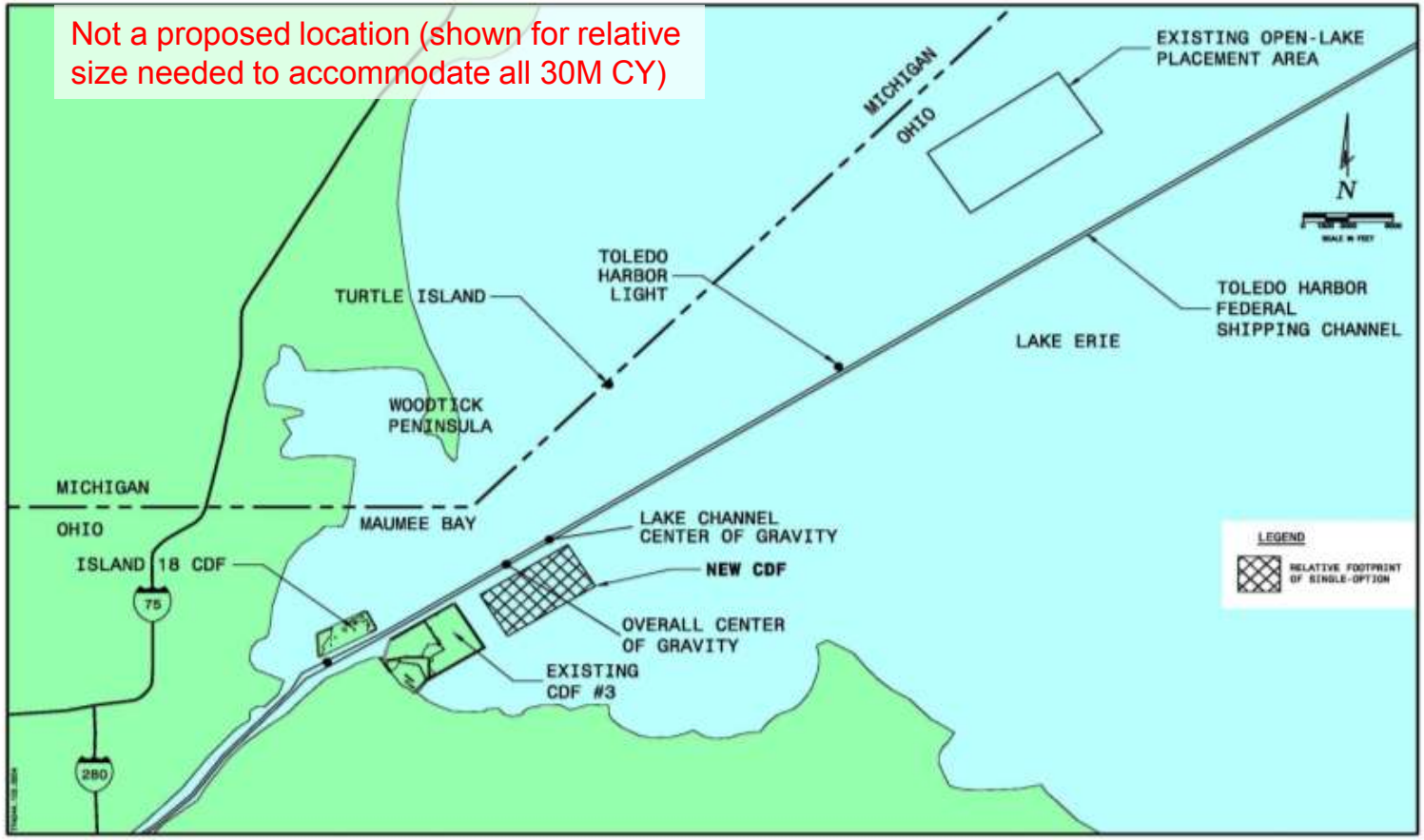


*Dredged material transported from channel to final location via scow/barge and pumped or released into contained area*

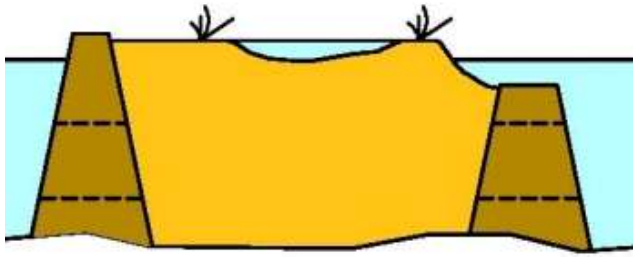
- Construct a new confined disposal facility (CDF) to contain the material
  - Not specifically designed for habitat enhancement
  - Structure base 5 ft. below LWD
  - Final structure surface 30 ft. above LWD

# New Confined Disposal Facility

*Relative Footprint of 30M CY for Single-Option*



# Emergent Habitat Restoration Unit

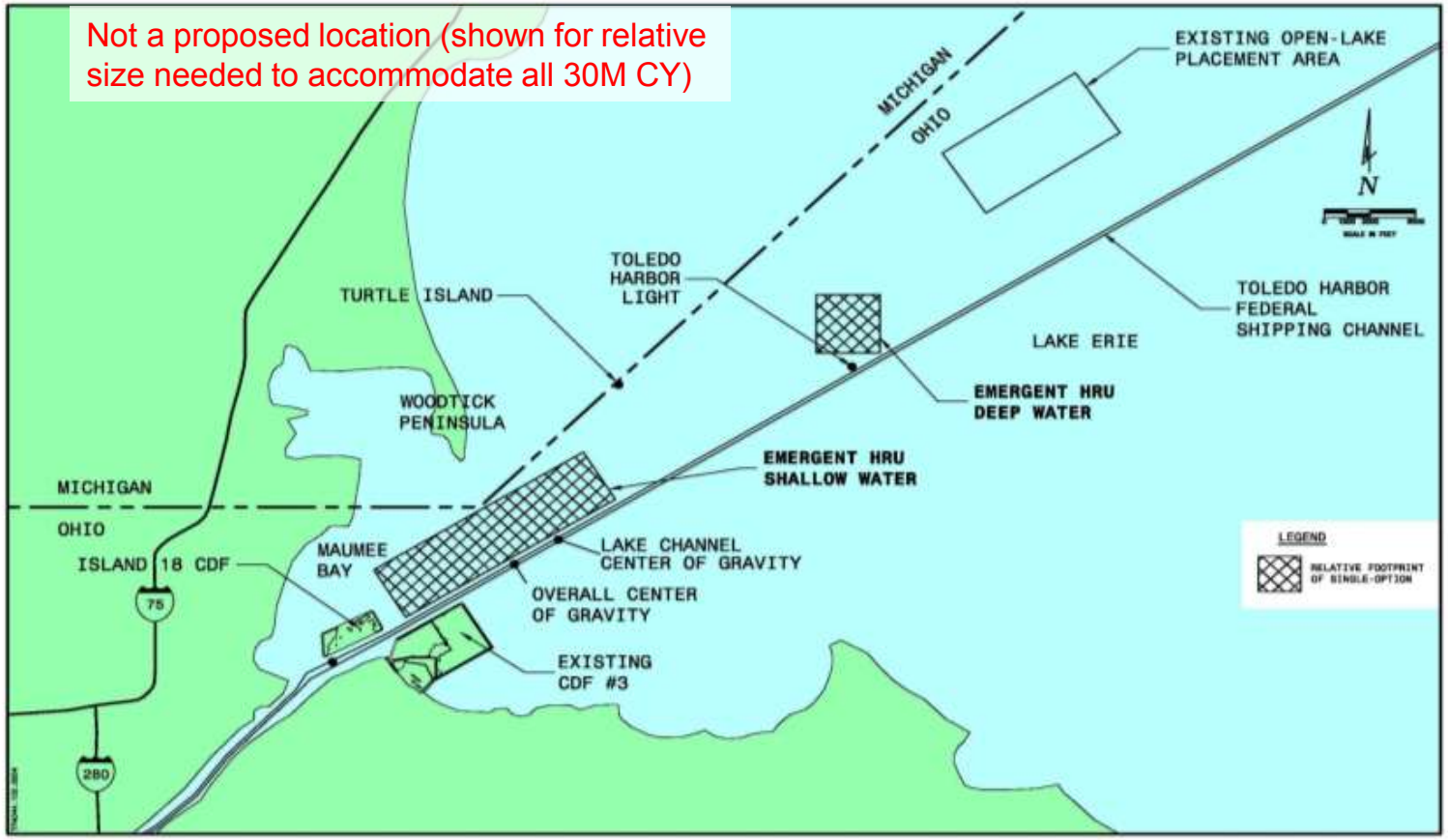


*Dredged material transported from channel to final location via scow/barge and pumped or released into HRU diked area*

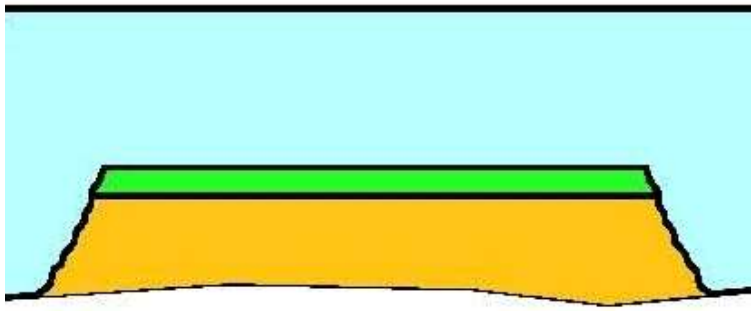
- Use of dredged material to assist in the development of a Habitat Restoration Unit (HRU) that will provide a future emergent wildlife refuge/habitat
- Deep water HRU
  - Structure base 20 ft. below LWD
  - Final structure surface 30 ft. above LWD
- Shallow water HRU
  - Structure base 5 ft. below LWD,
  - Final structure surface 12.5 ft. above LWD

# Emergent Habitat Restoration Unit

*Relative Footprint of 30M CY for Shallow and Deep Single-Options*



# Open-Lake Placement with Controls

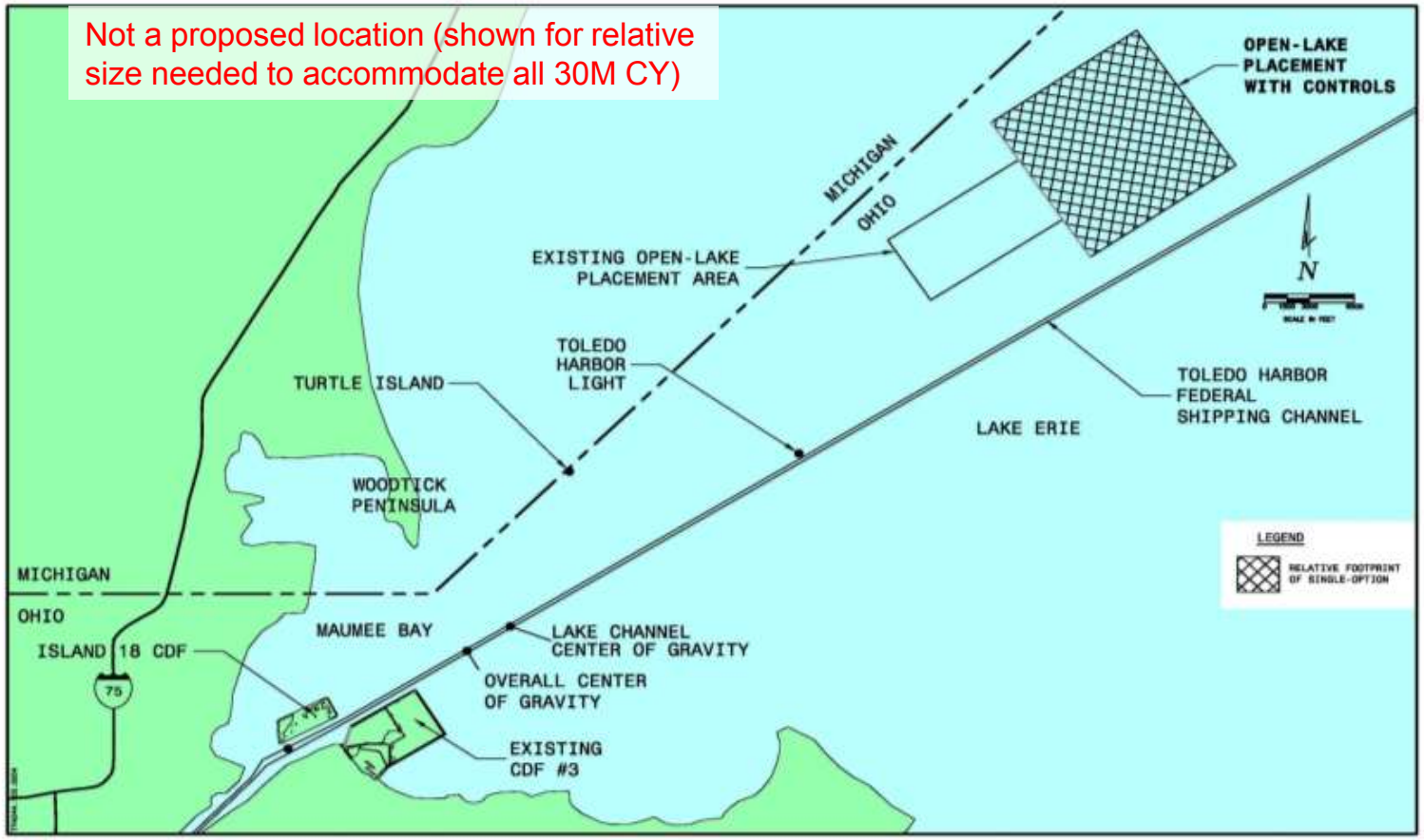


*Dredged material transported from channel to final location via scow/barge and released to placement area*

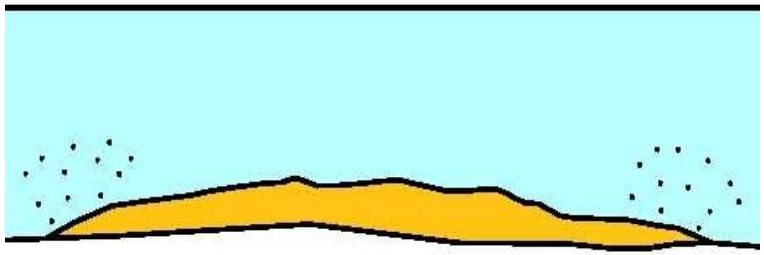
- Open-lake placement with controls to decrease nutrient availability and/or increase shear strength of material
  - Potential HRU aspect
  - Either at or near the current open lake placement area

# Open-Lake Placement with Controls

*Relative Footprint of 30M CY for Single-Option*



# Open-Lake Placement without Controls

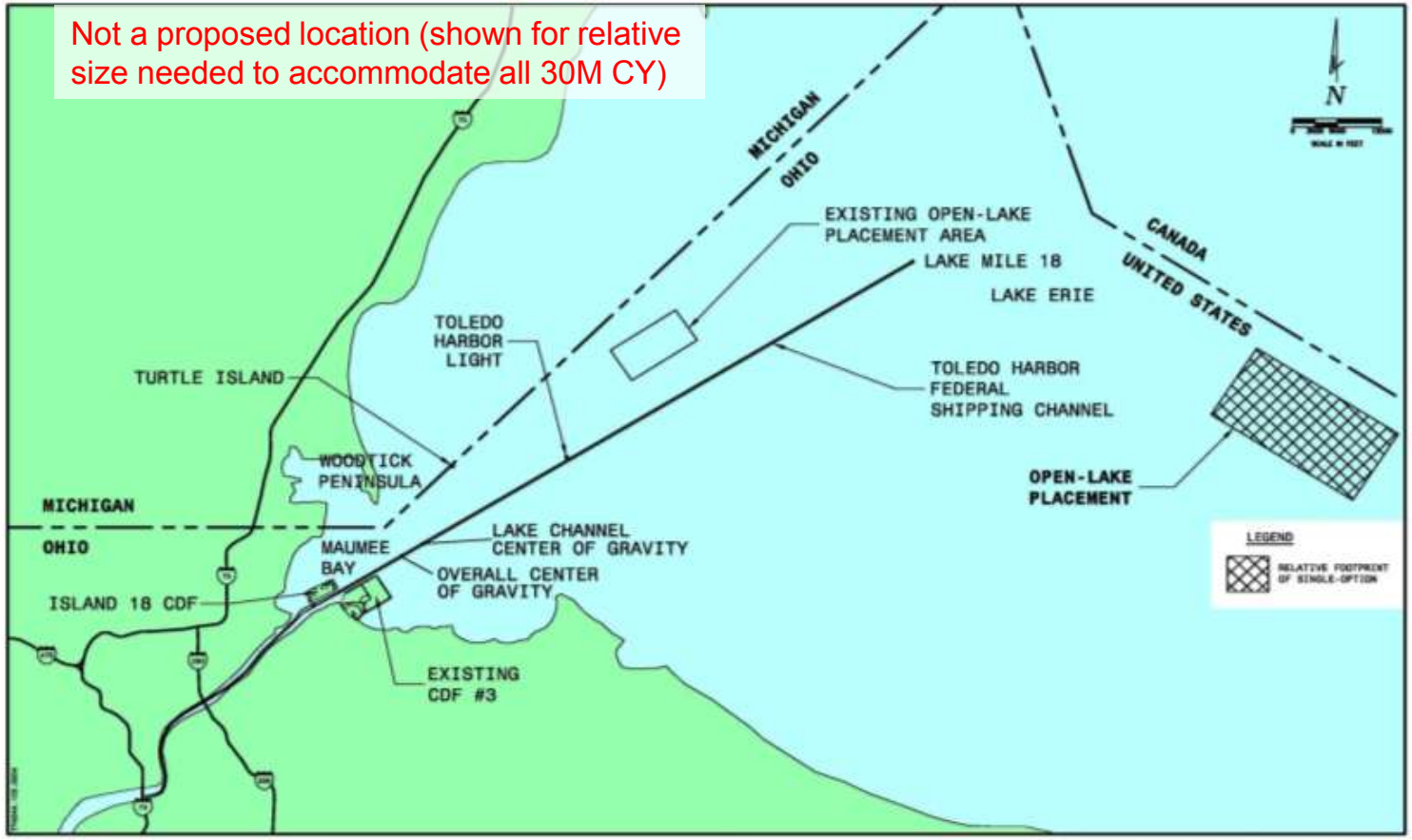


*Dredged material transported from channel to final location via scow/barge and released to placement area*

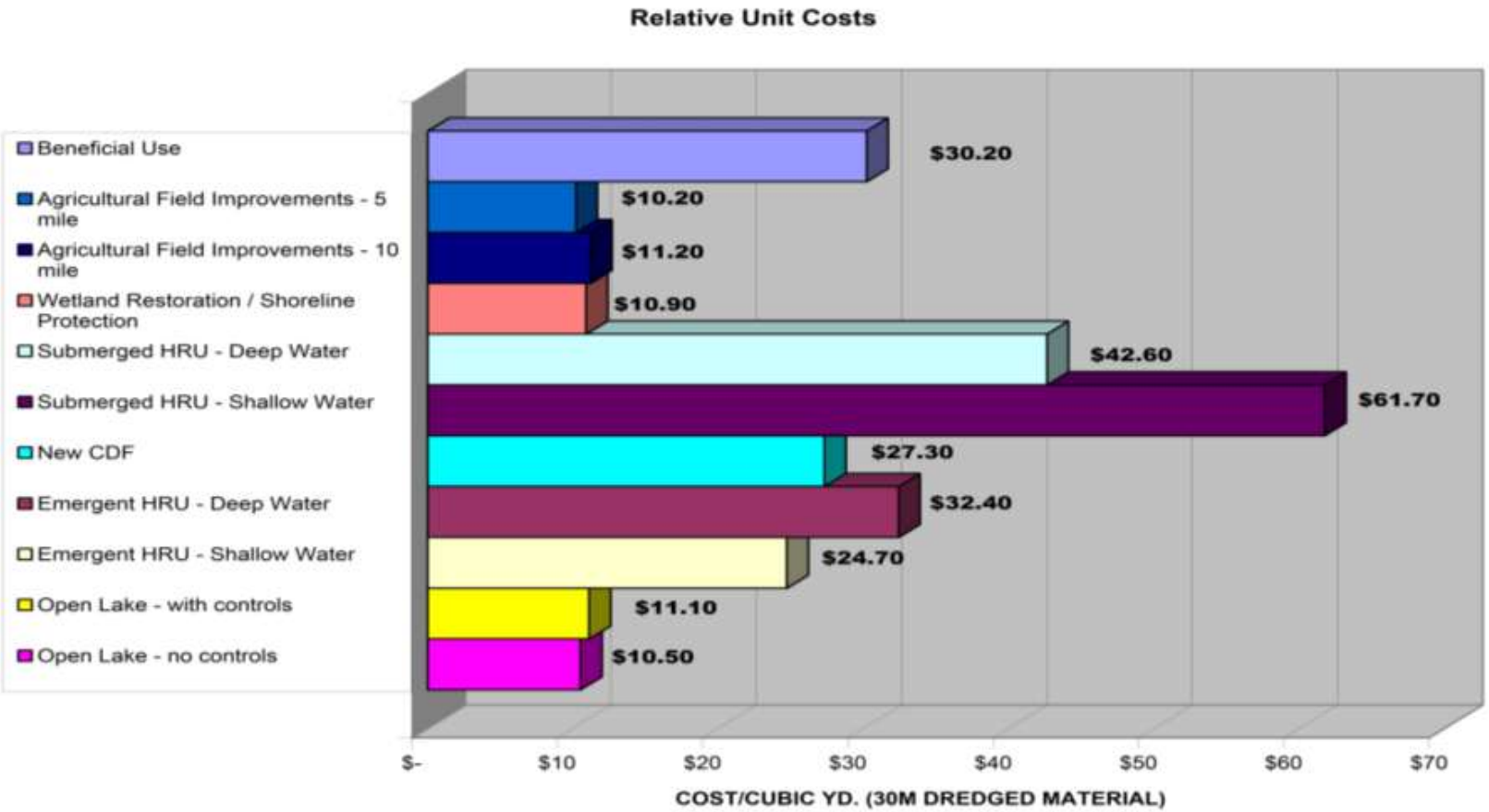
- Relocated/new open-lake placement from overall dredging operations center
  - No controls
  - Minimizes the potential for individual redistribution of sediment in the Western Lake Erie Basin
  - Possible reduction in influence of algae blooms

# Open-Lake Placement without Controls

*Relative Footprint of 30M CY for Single-Option*



# Single Option Relative Unit Costs



# Toledo Harbor Sediment Management and Use Options

- Is one option that can accommodate all 30 million CY feasible?
  - Complex logistics
  - Compounded eco-habitat uses/impacts
  - Unintended consequences
  - Programmatic constraints

# Evaluation Process

- Each option evaluated to receive all of the 30-year estimated dredged material volume (30M CY) – despite initial assumption that a Combination Option is likely a better solution
- Initial evaluation did not consider
  - All aspects of a specific location of option
  - Current programmatic/regulatory restrictions
  - Funding availability and sources
  - Limitations on currently accepted practices
  - Inflation of current market costs
- Initial evaluation did consider
  - Location relative to Center of Gravity of estimated volume of material dredged between 2001-2010
  - Current lake bathymetry
  - Current market costs

# Evaluation Process (Continued)

- Matrix to score the dredge material management and use options across six major categories of technical criteria and sub-categories identified and discussed at the June 2011 Public Forum:
  - Feasibility
  - Ecological Benefits
  - Environmental Impacts
  - Human Benefits
  - Economic Benefits
  - Implementation Cost

# Evaluation Process (Continued)

For each Technical Criteria category:

**Weighting Factors**

- Assigned by Task Force members
- 1-100, for each technical criteria category

**Technical Criteria**

- Assigned by Hull Technical Team
- 1-5, for multiple technical criteria for each option

Avg. Weighting Factor

x

Avg. Technical Criteria Score

=

Score for Each Option

# June 2011 Public Forum Input

- Summarized in public forum report and posted online and discussed at Task Force meeting
  - Input on ranking of major factors was considered by the Task Force in weighting factor determination
  - Input on sub-categories was considered by technical team in development of technical criteria scoring

# Feasibility

Scale:

1 - Highly complicated
2 - Moderately to highly complicated
3 - Moderately complicated
4 – Minimally to moderately complicated
5 - Minimally complicated

| Technical Criteria | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Placement Timing and Sequencing | 1 | 5 | 5 | 5 | 4 | 3 | 3 | 4 | 5 | 4 | 5 |
| Capacity Expansion Capability | 5 | 5 | 4 | 5 | 3 | 2 | 5 | 5 | 5 | 5 | 4 |
| Size of Overall Footprint | 2 | 4 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 3 |
| Implementation/Construction Complexity | 4 | 1 | 2 | 2 | 2 | 3 | 4 | 3 | 5 | 4 | 3 |
| Construction Duration | 5 | 1 | 2 | 2 | 2 | 3 | 4 | 4 | 5 | 5 | 2 |
| Site Accessibility | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 4 |
| **Average Score** | **3.5** | **3.3** | **3.2** | **3.3** | **2.7** | **2.8** | **3.7** | **3.5** | **4.2** | **4.2** | **3.5** |

# Ecological Benefits/Effects

Scale:

1- negative overall effect, high level of effort to overcome
2- negative effect, moderate level of effort to overcome
3 - minimal effect
4 - positive effect, moderate degree of benefit
5 - positive effect, high degree of benefit

| Technical Criteria | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Planktonic and Benthic Community/Habitat | 3 | 2 | 2 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 2 |
| Fish and Aquatic Inverterbrate species/habitat | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 2 |
| Wetlands (tidal, non-tidal) | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| Protected Species/Habitat | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| Pelagic Birds/Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 4 |
| Terrestrial Species/Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| Creation of Surface Water Features with Ecologically Beneficial Habitat | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 4 |
| **Average Score** | **3.0** | **3.6** | **3.7** | **3.3** | **3.3** | **4.0** | **3.0** | **3.0** | **2.7** | **2.7** | **3.0** |

# Environmental Impacts/Effects

Scale:

1- negative overall effect, high level of effort to overcome
2- negative effect, moderate level of effort to overcome
3 - minimal effect
4 - positive effect, moderate degree of benefit
5 - positive effect, high degree of benefit

| Technical Criteria | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydro-dynamic Effects | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 3 | 2 |
| Land Improvements | 5 | 4 | 4 | 3 | 3 | 4 | 5 | 5 | 3 | 3 | 4 |
| Surface Water Quality | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 1 | 4 | 2 |
| Groundwater Quality | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 3 |
| **Average Score** | **4** | **3.5** | **3.5** | **3.25** | **3.25** | **3.5** | **4.25** | **4.25** | **2** | **3.25** | **2.75** |

# Human Benefits/Effects

Scale:

1- negative overall effect, high level of effort to overcome
2- negative effect, moderate level of effort to overcome
3 - minimal effect
4 - positive effect, moderate degree of benefit
5 - positive effect, high degree of benefit

| Technical Criteria | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Recreation Opportunity | 3 | 4 | 5 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 |
| Flood Protection | 3 | 3 | 3 | 3 | 3 | 5 | 5 | 5 | 3 | 3 | 3 |
| Aesthetics | 3 | 4 | 5 | 3 | 3 | 4 | 2 | 2 | 3 | 2 | 2 |
| Human Health Risk | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 |
| Navigational Safety | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 |
| **Average Score** | **3** | **3.2** | **3.6** | **3** | **3** | **3.8** | **3.2** | **3.2** | **2.8** | **2.8** | **2.4** |

# Economic Benefits

Scale:

1- negative overall effect, high level of effort to overcome
2- negative effect, moderate level of effort to overcome
3 - minimal effect
4 - positive effect, moderate degree of benefit
5 - positive effect, high degree of benefit

| Technical Criteria | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue Generation - During Operation | 5 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 5 |
| Revenue Generation - Post-Operation | 4 | 4 | 4 | 3 | 3 | 3 | 5 | 5 | 3 | 3 | 4 |
| Public Need | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 |
| Job Creation | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 |
| Tourism | 3 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 |
| Local Commerce | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 3 | 3 | 3 |
| **Average Score** | **4.3** | **4.2** | **4.2** | **3.7** | **3.7** | **3.7** | **4.3** | **4.3** | **3.2** | **3.0** | **3.7** |

# Implementation Costs

Scale:

1 - Highest relative cost
5 – Lowest relative cost
Intermediate score values relatively based on range of costs per CY

| Technical Criteria | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Score (Based on Estimated Cost per CY) | 3.45 | 3.27 | 3.87 | 2.48 | 1.00 | 4.95 | 5.00 | 4.92 | 4.98 | 4.93 | 3.67 |

| Average Technical Criteria Scores | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feasibility Avg. Score | 3.5 | 3.3 | 3.2 | 3.3 | 2.7 | 2.8 | 3.7 | 3.5 | 4.2 | 4.2 | 3.5 |
| Ecological Benefits Avg. Score | 3.0 | 3.6 | 3.7 | 3.3 | 3.3 | 4.0 | 3.0 | 3.0 | 2.7 | 2.7 | 3.0 |
| Environmental Impacts Avg. Score | 4 | 3.5 | 3.5 | 3.25 | 3.25 | 3.5 | 4.25 | 4.25 | 2 | 3.25 | 2.75 |
| Human Benefits Avg. Score | 3 | 3.2 | 3.6 | 3 | 3 | 3.8 | 3.2 | 3.2 | 2.8 | 2.8 | 2.4 |
| Economic Benefits Avg. Score | 4.3 | 4.2 | 4.2 | 3.7 | 3.7 | 3.7 | 4.3 | 4.3 | 3.2 | 3.0 | 3.7 |
| Implementation Cost Score | 3.45 | 3.27 | 3.87 | 2.48 | 1.00 | 4.95 | 5.00 | 4.92 | 4.98 | 4.93 | 3.67 |
| **Total Score** | **21.3** | **21.0** | **22.0** | **19.0** | **16.9** | **22.8** | **23.5** | **23.2** | **19.8** | **20.9** | **19.0** |

# Ranking of Options Based on Average Technical Scores

| Rank | Option | Average Score |
|---|---|---|
| 1 | Agricultural Fields (5-mile Radius) | 23.5 |
| 2 | Agricultural Fields (10-mile Radius) | 23.2 |
| 3 | Wetland Restoration & Shoreline Protection | 22.8 |
| 4 | Emergent HRU - Shallow Water | 22.0 |
| 5 | Beneficial Use | 21.3 |
| 6 | Emergent HRU - Deep Water | 21.0 |
| 7 | Open-Lake - With Controls | 20.9 |
| 8 | Open-Lake - No Controls | 19.8 |
| 9 | Submerged HRU - Deep Water | 19.0 |
| 9 | New CDF | 19.0 |
| 11 | Submerged HRU - Shallow Water | 16.9 |

# Weighting Factors

| Category of Technical Criteria | Public Forum #1 Rank (n=100) | Task Force Rank (n=12) | Task Force Assigned Weighting Factors |
|---|---|---|---|
| Feasibility | 4 | 3 | 17 |
| Ecological Benefits | 2 | 1 | 22 |
| Environmental Impacts | 1 | 2 | 20 |
| Human Benefits | 6 | 6 | 10 |
| Economic Benefits | 5 | 5 | 14 |
| Implementation Costs | 3 | 3 | 17 |

| Weighted Technical Criteria Scores | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feasibility Weighted Score (17) | 59.5 | 56.7 | 53.8 | 56.7 | 45.3 | 48.2 | 62.3 | 59.5 | **70.8** | **70.8** | 59.5 |
| Ecological Benefits Weighted Score (22) | 66.0 | 78.6 | 81.7 | 72.3 | 72.3 | **88.0** | 66.0 | 66.0 | 59.7 | 59.7 | 66.0 |
| Environmental Impacts Weighted Score (20) | 80 | 70 | 70 | 65 | 65 | 70 | **85** | **85** | 40 | 65 | 55 |
| Human Benefits Weighted Score (10) | 30 | 32 | 36 | 30 | 30 | **38** | 32 | 32 | 28 | 28 | 24 |
| Economic Benefits Weighted Score (14) | **60.7** | 58.3 | 58.3 | 51.3 | 51.3 | 51.3 | **60.7** | **60.7** | 44.3 | 42.0 | 51.3 |
| Implementation Cost Weighted Score (17) | 58.7 | 55.6 | 65.8 | 42.2 | 17.0 | 84.2 | **85.0** | 83.6 | 84.7 | 83.8 | 62.4 |
| **Total Weighted Score** | **354.8** | **351.2** | **365.7** | **317.4** | **281.0** | **379.7** | **391.0** | **386.8** | **327.5** | **349.4** | **318.2** |

# Ranking of Options Based on Weighted Technical Score

| Rank | Option | Weighted Technical Score |
|---|---|---|
| 1 | Agricultural Fields (5-mile Radius) | 391.0 |
| 2 | Agricultural Fields (10-mile Radius) | 386.8 |
| 3 | Wetland Restoration & Shoreline Protection | 379.7 |
| 4 | Emergent HRU - Shallow Water | 365.7 |
| 5 | Beneficial Use | 354.8 |
| 6 | Emergent HRU - Deep Water | 351.2 |
| 7 | Open-Lake - With Controls | 349.4 |
| 8 | Open-Lake – No Controls | 327.5 |
| 9 | New CDF | 318.2 |
| 10 | Submerged HRU - Deep Water | 317.4 |
| 11 | Submerged HRU - Shallow Water | 281.0 |

# Single-Option Challenges

- Challenges of using only one alternative:
  - Practicality/Logistics (low flexibility, seasonal limitations)
  - Costs (high initial capital investment, balance between capital and O&M)
  - Location (large overall footprint)
  - Optimization of alternative (compromise/tradeoff between technical categories)
  - Size (large structural requirements/site-specific impacts)
- Both short-term and long-term plans will likely consist of a combination of approaches due to the challenges of single-option

# Combination Option

- Use a combination of options to minimize challenges
- Criteria for combination option:
  - Weighted scores
  - Estimated costs
  - Practicality/feasibility
  - Shorter implementation time
  - Improved short-term benefits

# Selection of Combination Option

| Rank | Single Option (30M CY) | Feasibility Weighted Score | Weighted Technical Score | Relative Total Cost |
|---|---|---|---|---|
| 1 | Agricultural Fields (5-mile Radius) | 62.3 | 391.0 | $305M |
| 2 | Agricultural Fields (10-mile Radius) | 59.5 | 386.8 | $336M |
| 3 | Wetland Restoration & Shoreline Protection | 48.2 | 379.7 | $326M |
| 4 | Emergent HRU - Shallow Water | 53.8 | 365.7 | $741M |
| 5 | Beneficial Use | 59.5 | 354.8 | $906M |
| 6 | Emergent HRU - Deep Water | 56.7 | 351.2 | $972M |
| 7 | Open-Lake - With Controls | 70.8 | 349.4 | $334M |
| 8 | Open-Lake – No Controls | 70.8 | 327.5 | $314M |
| 9 | New CDF | 59.5 | 318.2 | $820M |
| 10 | Submerged HRU - Deep Water | 56.7 | 317.4 | $1,280M |
| 11 | Submerged HRU - Shallow Water | 45.3 | 281.0 | $1,850M |

# Selection of Combination Option

- Options selected generally have a lower unit cost increase when a smaller footprint / feasible quantity was analyzed
- More feasible options
- Options selected ranked the highest in at least one technical category
- Arbitrary selection of volumes for purposes of discussion
- Will need a detailed design analysis completed

# Combination Option

- Wetland Restoration and Shoreline Protection (7M CY)
- Agricultural fields (7M CY)
- Beneficial Use (3M CY)
- Open-lake with controls (13M CY)

# Conceptual Locations of Combination Option

For illustrative purposes

OPEN-LAKE PLACEMENT WITH CONTROLS

TOLEDO HARBOR LIGHT

TURTLE ISLAND

WOODTICK PENINSULA

LAKE ERIE

TOLEDO HARBOR FEDERAL SHIPPING CHANNEL

MICHIGAN

OHIO

LAKE CHANNEL CENTER OF GRAVITY

OVERALL CENTER OF GRAVITY

WETLAND RESTORATION AND SHORELINE PROTECTION

ISLAND 18 CDF

MAUMEE BAY

UNDERWATER PIPELINE

EXISTING CDF #3

MAUMEE RIVER

BENEFICIAL USE PROCESSING

5 MI

AGRICULATURAL FIELD IMPROVEMENT

N

LEGEND

RELATIVE FOOTPRINT OF COMBINATION OPTION

AVAILABLE FOR LOCATING AGRICULTURAL FIELD IMPROVEMENT SITE

# Single and Combination Option Weighted Score Evaluation

| Technical Criteria | Beneficial Use | Emergent HRU - Deep Water | Emergent HRU - Shallow Water | Submerged HRU - Deep Water | Submerged HRU - Shallow Water | Wetland Restoration & Shoreline Protection | Agricultural Field Improvements (5-mile radius) | Agricultural Field Improvements (10-mile radius) | Open-Lake - No Controls | Open-Lake - With Controls | New CDF | Combination |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feasibility Weighted Score (17) | 59.5 | 56.7 | 53.8 | 56.7 | 45.3 | 48.2 | 62.3 | 59.5 | 70.8 | 70.8 | 59.5 | 79.3 |
| Ecological Benefits Weighted Score (22) | 66.0 | 78.6 | 81.7 | 72.3 | 72.3 | 88.0 | 66.0 | 66.0 | 59.7 | 59.7 | 66.0 | 75.4 |
| Environmental Impacts Weighted Score (20) | 80 | 70 | 70 | 65 | 65 | 70 | 85 | 85 | 40 | 65 | 55 | 75 |
| Human Benefits Weighted Score (10) | 30 | 32 | 36 | 30 | 30 | 38 | 32 | 32 | 28 | 28 | 24 | 32 |
| Economic Benefits Weighted Score (14) | 60.7 | 58.3 | 58.3 | 51.3 | 51.3 | 51.3 | 60.7 | 60.7 | 44.3 | 42.0 | 51.3 | 56 |
| Implementation Cost Weighted Score (17) | 58.7 | 55.6 | 65.8 | 42.2 | 17.0 | 84.2 | 85.0 | 83.6 | 84.7 | 83.8 | 62.4 | 79.9 |
| **Total Weighted Score** | **354.8** | **351.2** | **365.7** | **317.4** | **281.0** | **379.7** | **391.0** | **386.8** | **327.5** | **349.4** | **318.2** | **397.7** |

# Single and Combination Option Final Ranking and Relative Costs

| Rank | Option | Weighted Score | Relative Unit Costs ($/CY) |
|---|---|---|---|
| 1 | Combination | 397.7 | $13.50 |
| 2 | Agricultural Fields (5-mile Radius) | 391.0 | $10.20 |
| 3 | Agricultural Fields (10-mile Radius) | 386.8 | $11.20 |
| 4 | Wetland Restoration & Shoreline Protection | 379.7 | $10.90 |
| 5 | Emergent HRU - Shallow Water | 365.7 | $24.70 |
| 6 | Beneficial Use | 354.8 | $30.20 |
| 7 | Emergent HRU - Deep Water | 351.2 | $32.40 |
| 8 | Open-Lake - With Controls | 349.4 | $11.10 |
| 9 | Open-Lake – No Controls | 327.5 | $10.50 |
| 10 | New CDF | 318.2 | $27.30 |
| 11 | Submerged HRU - Deep Water | 317.4 | $42.60 |
| 12 | Submerged HRU - Shallow Water | 281.0 | $61.70 |

# Enhanced Environmental Dredging Techniques

- Hydraulic Dredging with permanent discharge lines
- Enhanced open-lake placement techniques

# Short-term vs. Long-term Options

- Short-term options have minimal delays resulting from permitting, design, etc.
  - Beneficial use of sediment from the river at upland locations
  - Enhanced open-lake placement
- Long-term options promote activities with lower habitat impacts and lower cost
  - Agricultural use
  - Nearshore options

# Acknowledgements

- Hull & Associates, Inc.
- Moffat & Nichol
- Proudfoot
- Great Lakes Marketing
- ARCADIS

# Toledo Harbor Sediment Management and Use Planning

## Questions and Answer Session

# Next Steps

- Survey – We would like your feedback!

- For additional information or to provide follow up input, please email lakeeriecommission@lakeerie.ohio.gov or call 419-621-2040.

# Next Steps

- Technical Team will:
  - Incorporate feedback from stakeholders and the Toledo Harbor Task Force
  - Complete Final Plan in Summer 2012

- Updates, forum results, and this presentation will soon be available at www.lakeerie.ohio.gov

# Thank You for Your Participation!

Ohio | Lake Erie Commission

lakeerie.ohio.gov

Great Lakes Commission des Grands Lacs

glc.org/dredging

Great Lakes RESTORATION

greatlakesrestoration.us

TOLEDO | LUCAS COUNTY PORT AUTHORITY

toledoportauthority.org
toledoseaport.org
toledoexpress.com

# APPENDIX G

[illegible]

[illegible]

[illegible]

**TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE SOLUTIONS**
**SECOND PUBLIC FORUM**

**APPENDIX G**

**QUESTION AND ANSWER SESSION MINUTES AND RESPONSES**

[illegible]

1. [illegible]

   [illegible]

   [illegible]

   [illegible]

   *[Project Team Response: Recent studies related to the use of dredged material for agricultural uses and more details of the Port Clinton-area project are included in the final Toledo Harbor Sediment Management and Use Plan.]*

[illegible]

2. [illegible]

   [illegible]

   [illegible]

*[Project Team Response: U.S. EPA and USACE are currently updating guidance related to evaluation of dredged sediment. The goal of this project is to create one guidance document for both inland and ocean testing that incorporates risk management concepts into engineering approaches for dredged material management. The completion date for this project is not known at this time. The status of this project and any revisions to the current federal dredged material evaluation methods will be included in the final Toledo Harbor Sediment Management and Use Plan.]*

3 [illegible]

[illegible]

[illegible]

1 M [illegible]

[illegible]

*[Project Team Response to Comments #3 & #4: The Task Force agreed to keep all placement options to be evaluated within the State of Ohio borders. Therefore, this project did not evaluate any options in Michigan or Canada. However, understanding that some stakeholders were interested in better understanding the viability of this option, the project team estimated that there is approximately 1.8M CY capacity at Woodtick Peninsula, or approximately two to three years capacity. While Woodtick Peninsula is not being proposed as an option as part of this project, it is a viable option should there be community support. For the purposes of this project, discussion on why this option was not considered, including some of the factors above will be included in the final Toledo Harbor Sediment Management and Use Plan.]*

5 [illegible]

[illegible]

*[Project Team Response to Comments #5 & #6: We understand there are concerns related to placing material in Maumee Bay. Should such options be carried forward, detailed engineering and analysis would be completed to ensure the design does not significantly negatively impact the hydrology and/or environment of the Bay. This option*

*is one of many being proposed. Ultimately, it is up to the Task Force and stakeholders to incorporate the recommendations from the final Toledo Harbor Sediment and Management Use Plan into an implementable strategy. Such a strategy would require following any appropriate protocols related to environmental reviews, permits, and other processes that consider engineering and science principles as well as community concerns and issues raised by stakeholders.*

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

*[Project Team Response: Proposed sediment management and use options focused on short and long-term options that could accept a significant amount of the 30-year dredging amount, or 30M CY. Due to the limited capacity at the existing CDF and Grassy Island, these options were not considered. While using the existing CDF or Grassy Island is not being proposed as an option, an explanation on why it was not considered, including some of the factors described above, is included in the final Toledo Harbor Sediment Management and Use Plan.]*

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

*[Project Team Response: The Task Force agreed to keep all placement options to be evaluated within the State of Ohio borders. Therefore, this study did not include the evaluation of options in Michigan or Canada. When the selected options are chosen, it may be of value to assess locations outside of Ohio if they are available. While Woodtick Peninsula is not being proposed as an option for this plan, an explanation on why it was not considered, including some of the factors above, will be included in the final Toledo Harbor Sediment Management and Use Plan.]*

9 [illegible]

[illegible]

[illegible]

*[Project Team Response: The concept of beneficial use is to use the dredged material for an upland use such as amended soil, brownfield revitalization, non-structural fill, agricultural field enhancer, etc. Selling of the dredged material as a beneficial use would require additional testing and a detailed evaluation of distribution methods that are dependent on the proposed use. The beneficial use option section in the final plan includes a discussion of market demand for material, as well as amendments that might be necessary to create marketable materials.]*

10 [illegible]

[illegible]

*[Project Team Response: The production of Nu-Soil at the CDF was not specifically evaluated under this project. The beneficial use option in the plan discusses many potential uses, including non-structural fill material. As a result, this comment will not be addressed in the final Toledo Harbor Sediment Management and Use Plan.]*

11 [illegible]

[illegible]

[illegible]

*[Project Team Response: Once the final location is selected, the land would be rented from the land owner(s) for the timeframe required to complete the improvements. In the Final Plan, the land rental cost at private farms was based on $200 per acre per year for three years (one year for placement, one year for consolidation and one year for land cover crop).]*

12. [illegible]

[illegible]

[illegible]

*[Project Team Response: An additional detailed study should be completed to determine potential locations for agricultural field improvements that would be the most beneficial and cost-efficient dependent on the projected dredging capacity. A containment structure would be designed and constructed to control and divert the dredged material and associated run-off water. Once the final location is selected, the land would be rented from the land owner(s) for the timeframe required to complete the improvements. The land rental cost at private farms was based on $200 per acre per year for 3 years (one year for placement, one year for consolidation and one year for land cover crop).]*

13. [illegible]

[illegible]

[illegible]

*[Project Team Response: The ODNR Division of Parks and Recreation is funding the dredging of the East Harbor in Ottawa County and the placement of dredged materials to approximately 30 acres of flat agricultural land. A small hydraulic dredge pumps the material to a booster pump, which then transports the material to the placement site. An agreement is in place to return the land to the owner with a new specified elevation.]*

1. [illegible]

[illegible]

[illegible]

[illegible]

*[Project Team Response: The criticality of finding alternatives to open-lake placement and possible funding will be included in the final Toledo Harbor Sediment Management and Use Plan].* [illegible]

# APPENDIX H

[illegible]

[illegible]

**Toledo Harbor Sediment Management and Use Solutions**

**Stakeholder Forum #2**
[illegible]d [illegible] 19 2012
1 00 [illegible] 00 [illegible]
[illegible]d M r [illegible] r [illegible] r [illegible] d [illegible]
300 r M r [illegible] r [illegible] r r [illegible] d [illegible] 3 0 [illegible]

[illegible]

*Thank you for taking the time to complete this survey. Your feedback is important and will be incorporated into the Toledo Harbor Sediment Management and Use Final Plan. A copy of your completed survey may be included in the final plan. This survey should only take a few minutes to complete.*

1. **Which sector do you represent?**
   - o [illegible] r [illegible] r [illegible] 9
   - o [illegible] d r [illegible] r [illegible] 2
   - o [illegible] r [illegible] 5
   - o [illegible]
   - o [illegible] 5
   - o [illegible] r [illegible] 0

2. **Did you attend the first Toledo Harbor Sediment Management and Use Public Forum on June 16, 2011 at the Toledo Maritime Center?**
   - o [illegible]
   - o [illegible] 1 [illegible]

*If you answered yes, please respond to the following questions:*

**2a. Did you provide ideas at the first forum through participation in the roundtable?**
   - o [illegible]
   - o [illegible] 0 [illegible]

**2b. Topics I discussed at the small group breakout sessions were considered in the sediment management and use options analysis.**
   - o [illegible] r [illegible] r [illegible] 1
   - o [illegible] r [illegible]
   - o [illegible] r [illegible] 1
   - o [illegible] r [illegible] 0
   - o [illegible] r [illegible] r [illegible] 0

*Continued on next page*

**Toledo Harbor Sediment Management and Use Solutions**
**Stakeholder Forum #2**

*Please answer the following questions based on today's forum presentation using the scale below.*

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| **3. The information shared at today's forum was presented in a clear and understandable manner.** | 12 | 10 | 0 | 0 | 0 |
| **4. As a result of today's forum, I am better informed about Toledo Harbor dredging issues and potential management options.** | | 13 | 2 | 0 | 0 |
| **5. A combination of options will be needed to address sediment management needs of Toledo Harbor dredged material.** | | | 2 | | 0 |
| **6. A combination approach using the four options identified in the presentation (agricultural improvements, wetland restoration, beneficial use, and open-lake placement with controls) is a good starting point to address sediment management needs of Toledo Harbor dredged material.** | 3 | 9 | 5 | 5 | 0 |
| **7. Programmatic flexibility that permits the modification of the degree of reliance on any one particular option is important, understanding that with implementation of any option knowledge is gained and unintended consequences (both good and bad) become evident.** | | 11 | | 1 | 0 |
| **8. The initial suggested sediment volumes allocated for each option in the combination approach (wetland restoration – 7M CY; agricultural improvements – 7M CY; beneficial use – 3M CY; open-lake with controls – 13M CY) appears reasonable based on the information provided.** | 2 | | 10 | 3 | 1 |

*Continued on next page*

9. **Please provide any additional questions or comments (if applicable)**

***OPTIONAL***

*Personal information provided below will not be included in the final plan. Your personal information will not be shared with others outside of our project team.*

*If you have any questions or would like to discuss any aspect of this project, please contact the Ohio Lake Erie Commission at 419-621-2040.*

# APPENDIX K

Potential Funding Sources for Sediment Management and Use Options

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# TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE K-1

## POTENTIAL FUNDING SOURCES FOR SEDIMENT MANAGEMENT AND USE OPTIONS

| Potential Funding Source | Description | Funding Amount | Match | Potential Sediment Management and Use Option |
|---|---|---|---|---|
| Ohio Department of Natural Resources (Ohio DNR) Coastal Management Program Coastal Management Assistance Grants (CMAG) | Projects must be within the Ohio Coastal Management Program's boundary and can include a variety of activities including habitat restoration/demonstration of innovative practices, coastal land acquisition, water quality, coastal planning, and research and data collection. | No max. listed, but grants typically range $5,000 to $110,000. | 50% match | All Options – Pilot or Small Study |
| Ohio DNR Division of Wildlife Wetlands Restoration Assistance | Available to individuals and organizations to assist with costs associated with wetland restoration projects on private lands in Ohio. Projects include tile cuts and/or construction of small, low-level dikes to restore or enhance hydrology. | $1,000/acre wetland restored max. | 50% match | • Emergent HRU<br>• Wetland Restoration and Shoreline Protection |
| Ohio EPA Section 319 Program | Ohio EPA is the designated water quality agency responsible for administering the Ohio Section 319 program. Since 1990, Ohio EPA has annually applied for, received, and distributed Section 319 grant funds to correct nonpoint source (NPS) caused water quality impairments to Ohio's surface water resources. Section 319(h) implementation grant funding is targeted to Ohio waters where NPS pollution is a significant cause of aquatic life use impairments. | $200,000-$350,000 | 20% match required, can be in-kind or cash | • Wetland Restoration and Shoreline Protection<br>• Agricultural Field Improvements |

| Potential Funding Source | Description | Funding Amount | Match | Potential Sediment Management and Use Option |
|---|---|---|---|---|
| Ohio EPA Surface Water Improvement Fund (SWIF) | For implementation of specific projects that address non-point source pollution and/or stormwater runoff and result in water quality improvements in Ohio's streams, rivers, and lakes. | up to $100,000 | Not required | • Beneficial Use<br>• Wetland Restoration and Shoreline Protection<br>• Emergent and Submerged HRU<br>• Agricultural Field Improvements |
| Ohio Lake Erie Commission (Ohio LEC) Lake Erie Protection Fund (LEPF) Small Grants | Funding priorities are to assist in implementing at least one of the 84 priorities addressed in the Lake Erie Protection and Restoration Plan, which includes recommendations addressing water quality, pollutant sources, habitat, coastal recreation, boating, fishing, beaches, tourism, and shipping. | $15,000 max. | 25%, in-kind or cash | All Options – Pilot or Small Study |
| Ohio State University Ohio Sea Grant Research Grants Program | One- to three-year research projects on Great Lakes and marine problems with particular significance to Ohio, Lake Erie, the Great Lakes region, and the nation. | Varies; $100,000-$300,000 | None Listed | All Options |
| Ohio State University Ohio Sea Grant Small Grants Program | One- to three-year research projects on Great Lakes and marine problems with particular significance to Ohio, Lake Erie, the Great Lakes region, and the nation. | $10,000 max. | None Listed | All Options – Pilot or Small Study |
| Ohio Water Development Authority (OWDA) Research and Development Grant Program | Qualifying research and development programs. The eligible participants are Local Government Agencies that perform research and/or development. Projects for which grants are awarded must be of such a nature that the benefits to be derived fulfill a general need in the State of Ohio that is within the scope of the powers of OWDA | Grant cannot exceed 50% of the total project cost. Applicant must show exceptional circumstances to request a grant greater than $200,000. | At least 50% | All Options |
| OWDA Water Pollution Control Loan Fund (WPCLF) Linked Deposit Program | Bank loan at a reduced interest rate for implementation of agricultural or forestry best management practices, on-site wastewater disposal systems or other non-point source pollution control. | Max. per bank loan agreement | NA | • Agricultural Improvements |

| Potential Funding Source | Description | Funding Amount | Match | Potential Sediment Management and Use Option |
|---|---|---|---|---|
| Ohio State Infrastructure Bank Loans and Bonds (ODOT) | Purpose is to encourage economic development and public investment in public transportation facilities that contribute to the multi-modal and intermodal transportation capabilities. Qualified public transportation projects include construction, reconstruction, resurfacing, restoring, rehabilitation, or replacement of public transportation facilities within the state; any highway, transit, or other transportation project eligible for financing or aid under any federal act or program; and any project involving the maintenance, repair, improvement, or construction of a public or highway, road, street, parkway, or transit project, any related right-of-way, bridges, tunnels, railroad-highway crossings, drainage structures, signs, guardrails, or protective structures. Costs that are not eligible project costs include preliminary engineering and design, environmental studies, major investment studies, and interchange justification analysis. | Varies. Loans, loan guarantees, letters of credit, leases, interest rate subsidies, debt service, cash reserves, and other forms the Director determines to be appropriate. | Not required | • New CDF<br>• Emergent and Submerged HRU |
| Clean Ohio Brownfield Fund and Brownfield Loan Fund (Ohio Development Services Agency/Jobs Ohio) | Grants and low-interest loans available for brownfield remediation. | Grants up to $1M, low-interest loans | 25% match of total project costs | • Upland placement |

| Potential Funding Source | Description | Funding Amount | Match | Potential Sediment Management and Use Option |
|---|---|---|---|---|
| State Capital Improvement Program (SCIP), Ohio Public Works Commission (working through local District Integrating Committees) | Each Public Works District can slightly modify the program, but SCIP generally funds repair and replacement of existing infrastructure (roadways, bridges, stormwater, sewer, water, and solid waste systems); evaluation criteria focus on the financial need of the governmental entity, the project's strategic importance to the district, and emphasize the repair and replacement of infrastructure rather than new and expanded infrastructure | Funding is provided through grants, loans, and loan assistance or local debt support. There is no minimum or maximum loan amount. | Grants are available for up to 90% of the total project costs for repair/ replacement, and up to 50% for new/expansion. Loans can be provided for up to 100% of the project costs. Grant/loan combinations are also available. | |
| Great Lakes Commission (GLC) Great Lakes Protection Fund (GLPF) | The ultimate criterion used to select projects is the anticipated benefit to the health of the Great Lakes ecosystem. Projects must identify a significant, tangible ecological outcome and a pragmatic plan to achieve it. | Varies | Not required | All Options |
| Sustain Our Great Lakes (SOGL) Community Grants Program | Similar to the SOGL Stewardship grants program but on a smaller scale. Support on the ground habitat restoration and enhancement projects (tens of acres or thousands of stream feet) that improve local habitat conditions and build local conservation capacity. | $25,000-$150,000 | 1:1 or greater will be more competitive | • Wetland Restoration and Shoreline Protection<br>• Emergent and Submergent HRUs |
| SOGL Stewardship Grants Program | Support large-scale (hundreds of acres or tens of stream miles or larger), on the ground habitat restoration and enhancement projects. | $150,001-$1.5M | minimum of $150,001 with 1:1 match helpful | • Wetland Restoration and Shoreline Protection<br>• Emergent and Submergent HRUs |
| US Fish & Wildlife Service (USFWS) Joint Venture Habitat Restoration & Protection Plan | Provides support to state and other partner projects for long-term habitat restoration, enhancement or protection and conservation of native Great Lakes fish and wildlife populations, particularly migratory birds. | $25,000-$290,000 | at least 25% of grant request | • Wetland Restoration and Shoreline Protection<br>• Emergent and Submergent HRUs |

| Potential Funding Source | Description | Funding Amount | Match | Potential Sediment Management and Use Option |
|---|---|---|---|---|
| USFWS Great Lakes Fish and Wildlife Restoration Act | Encourage cooperative conservation, restoration, and management of fish and wildlife resources and their habitat in the Great Lakes basin. | $2,300-$2M with avg. project receiving $102,900 | at least 25% of grant request | • Wetland Restoration and Shoreline Protection<br>• Emergent and Submergent HRUs |
| USFWS North American Wetlands Conservation Act (NAWCA) Small Grant Program | Supports projects in Canada, the United States, and Mexico that involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats. | $75,000 max. | 1:1 | • Wetland Restoration and Shoreline Protection<br>• Emergent and Submergent HRUs |
| USFWS North American Wetlands Conservation Act (NAWCA) Standard Grant Program | Supports projects in Canada, the United States, and Mexico that involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats. | Each fiscal year, available funds have been distributed among projects in the three countries according to a pre-determined percentage within the range of percentages allowable under the Act. | 1:1 | • Wetland Restoration and Shoreline Protection<br>• Emergent and Submergent HRUs |
| U.S. Army Corps of Engineers (USACE) General Investigation (GI) Study | Congress must provide USACE with authority and funds to first accomplish a feasibility study and secondly, to construct the project. Local sponsors share the study and construction costs with the USACE and usually pay for all operation and maintenance costs. GI Studies require specific congressional appropriations and must be in the USACE budget or appropriated through a congressional add | No limit; funds must be approved by Congress | USACE provides the first $100,000 of feasibility study costs. A non-federal sponsor must contribute 50% of the cost of the feasibility study after the first $100,000 of expenditures, 35 %of the cost of design and construction, 50% of the cost of recreational features and 100% of the cost of operation and maintenance. | All options |

| Potential Funding Source | Description | Funding Amount | Match | Potential Sediment Management and Use Option |
|---|---|---|---|---|
| USACE Section 204 of Water Resources Development Authority (WRDA) 1992 | Section 204 of WRDA of 1992 provides authority for USACE to plan, design, and build projects to protect, restore, and create aquatic and ecologically related habitats in connection with dredging of authorized Federal navigation projects. | $5 million project limit | USACE provides the first $100,000 of feasibility study costs. A non-federal sponsor must contribute 50% of the cost of the feasibility study after the first $100,000 of expenditures, 35 %of the cost of design and construction, 50% of the cost of recreational features and 100% of the cost of operation and maintenance. | • Wetland Restoration and Shoreline Protection<br>• Emergent and Submergent HRUs |
| USACE Section 206 of Water Resources Development Authority (WRDA) 1996 | Section 206 of WRDA of 1992 provides authority for USACE to design and build projects to restore aquatic ecosystems for fish and wildlife. | $5 million project limit | USACE provides the first $100,000 of feasibility study costs. A non-federal sponsor must contribute 50% of the cost of the feasibility study after the first $100,000 of expenditures, 35 %of the cost of design and construction, 50% of the cost of recreational features and 100% of the cost of operation and maintenance. | • Wetland Restoration and Shoreline Protection<br>• Emergent and Submergent HRUs |

| Potential Funding Source | Description | Funding Amount | Match | Potential Sediment Management and Use Option |
|---|---|---|---|---|
| USACE Section 217 of WRDA 1996 | USACE may use public-private partnerships in the design, construction, management, or operation of dredged material management facility in conjunction with Federal navigation projects. The Federal government may reimburse the private entity for the disposal of dredged material in the facility through a disposal user fee, which is sufficient to recover the funds contributed by the private entity plus a reasonable rate of return on investment. | No limit; funds must be approved by Congress | The Federal share of the fees is equal to the percentage of the total cost that would otherwise be borne by the Federal government as part of cost-sharing as required pursuant to existing cost sharing requirements. | All options |
| Harbor Maintenance Trust Fund (HMTF) | Established to fund operation and maintenance of ports and harbors. These funds are currently not available for use by Congress. There is pending legislation to make these funds available for use. | unknown | unknown | All options |
| U.S. Department of Agriculture Natural Resource Conservation Service (USDA-NRCS) Commodity Credit Corp. Conservation Innovation Grants (CIG) | Voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging the Federal investment in environmental enhancement and protection, in conjunction with agricultural production | $1 $6 max (Fiscal Year (FY) 2011) | 50% match | • Agricultural Field Improvements |
| Great Lakes Restoration Initiative | Variety of habitat improvement, nutrient reduction and water quality improvement projects are available through 11 federal agencies. | Grants | Typically not required, but helpful in scoring | • Open-lake placement with controls<br>• Wetland Restoration and Shoreline Protection<br>• Emergent and Submerged HRU |

| Potential Funding Source | Description | Funding Amount | Match | Potential Sediment Management and Use Option |
|---|---|---|---|---|
| NOAA Section 309 Plan 2011-2015, as Amended Coastal Zone Enhancement Grants | Provides grants to states to manage and implement their coastal enhancement strategies. | Grants | No match | • Open-lake placement with controls<br>• Wetland Restoration and Shoreline Protection<br>• Emergent and Submerged HRU |
| Other Alternative Funding Sources | Other programs such as license plate fees, stamps, sales tax surcharges, bonds, private foundations, endowment funds, revenue from special assessments and levies could be used to finance options. These programs could be managed at any government level (e.g. local, state, federal) or privately. | Unknown | Unknown | All options |

Notes:

1. The table of potential funding sources is meant to serve as a guide only and is not an exhaustive list. Proposed sediment management and use options have not been screened extensively for each funding source. In some cases, funding may be appropriate to partially fund an option or fund a pilot project.

# APPENDIX L

Refinement of the Agricultural Field Improvement Option
for the Toledo Harbor Sediment Management and Use Plan

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# REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

FOR THE:
**OHIO LAKE ERIE COMMISSION**

**GREAT LAKES RESTORATION INITIATIVE PROJECT**
**USEPA GRANT # GL-E00523**

PREPARED FOR:
**OHIO LAKE ERIE COMMISSION**
**111 SHORELINE DRIVE**
**SANDUSKY, OHIO 44870**

PREPARED BY:
**HULL & ASSOCIATES, INC.**
**3401 GLENDALE AVENUE**
**SUITE 300**
**TOLEDO, OHIO 43614**

**DECEMBER 2012**

# REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

**TOLEDO HARBOR DREDGE TASK FORCE**
**GREAT LAKES RESTORATION INITIATIVE PROJECT**
**USEPA GRANT #GL-E00523**

FOR THE:
**OHIO LAKE ERIE COMMISSION**

**GREAT LAKES RESTORATION INITIATIVE PROJECT**
**USEPA GRANT # GL-E00523**

PREPARED FOR:
**OHIO LAKE ERIE COMMISSION**
**111 SHORELINE DRIVE**
**SANDUSKY, OHIO 44870**

PREPARED BY:
**HULL & ASSOCIATES, INC.**
**3401 GLENDALE AVENUE**
**SUITE 300**
**TOLEDO, OHIO 43614**

**DECEMBER 2012**

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Appendix B Refined Cost Estimates for Agricultural Field Improvement Option Using Different Sized Hydraulic Dredges

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CCME | Canadian Council of Ministers of the Environment |
| CDF | Confined Disposal Facility |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CIDARS | Chemical Information Database and Applicable Regulatory Standards |
| CFR | Code of Federal Regulations |
| COCs | Contaminant of Concerns |
| CY | cubic yard |
| DMRA | Dredged Material Relocation Area |
| ESL | U.S. Environmental Protection Agency Region 5 Ecological Screening Level |
| Federal channel | Toledo Harbor Federal Navigation Channel |
| GLRI | Great Lakes Restoration Initiative |
| HDPE | High-density Polyethylene |
| Hull | Hull & Associates, Inc. |
| ICP | Inductively Coupled Plasma |
| kg | kilogram |
| LM | Lake Mile |
| M | million |
| mg | milligram |
| NA | Not Applicable |
| ND | Not Detected |
| NM | Not Measured |
| ORNL | Oak Ridge National Laboratory |
| Ohio DNR | Ohio Department of Natural Resources |
| Ohio EPA | Ohio Environmental Protection Agency |
| Ohio LEC | Ohio Lake Erie Commission |
| PAHs | Polycyclic aromatic hydrocarbons |
| PCBs | Polychlorinated biphenyls |
| PED | Planning, engineering and design |
| PI | Plasticity Index |
| ppm | parts per million |
| RCRA | Resource Conservation and Recovery Act |
| RM | River Mile |
| RSL | Regional Screening Level |
| SDR | Standard Dimension Ratio |
| SRV | Sediment Reference Value |
| S.U. | Standard Units |
| Task Force | Toledo Harbor Dredge Task Force |
| TEC | Threshold Effect Concentration |
| THSMUP | Toledo Harbor Sediment Management and Use Plan |
| TLCPA | Toledo-Lucas County Port Authority |
| USACE | U.S. Army Corps of Engineers |

## LIST OF ACRONYMS AND ABBREVIATIONS (CONT.)

| | |
|---|---|
| USDA | U.S. Department of Agriculture |
| USEPA | U.S. Environmental Protection Agency |
| VAP | Voluntary Action Program |

# 1.0 PROJECT BACKGROUND AND OBJECTIVES

The Toledo Harbor Sediment Management and Use Plan (THSMUP) was developed to assist the Toledo Harbor Dredge Task Force (Task Force) in identifying and implementing a sediment management and use strategy for the Toledo Harbor Federal Navigation Channel (Federal channel) and commercial/recreational non-federal channel that represents a consensus-based approach of the diverse stakeholders represented by the Task Force. The THSMUP was funded through United States Environmental Protection Agency (USEPA) Great Lakes Restoration Initiative (GLRI) Grant # GL-E00523 to the Ohio Lake Erie Commission (Ohio LEC). Ohio LEC sub-granted the funding to the Toledo-Lucas County Port Authority (TLCPA), who retained the Hull & Associates, Inc. (Hull) technical team (Hull Team) to develop the THSMUP. The Hull Team is comprised of engineering, science, and consensus-building professionals from Hull, Moffatt and Nichol, ARCADIS, Great Lakes Marketing, and Proudfoot Associates.

As presented in the THSMUP, and based on recent discussions with Ohio Environmental Protection Agency (Ohio EPA) and other stakeholders, it appears that one of the more sustainable sediment management options is the use of dredged material for agricultural field improvements. The concept of this option is to use the dredged material to raise the elevation of agricultural fields where land would be purchased or rented from the current property owner(s) for the timeframe required to complete the improvements. This option would improve the drainage in the agricultural fields and potentially supply the soil with nutrients. This option is discussed in greater detail in Section 3.1.2 of the THSMUP.

In light of the relative importance of the agricultural field improvement option to the overall program and the recognition that a pilot project would likely be appropriate to gain support from the farm community, several additional tasks were completed to obtain relevant information needed to move this option forward as a potential pilot demonstration project. A pilot project could serve as a model for beneficial use of dredged materials on agricultural fields and demonstrate the implementability of a full-scale project. Results could have significant implications and replication opportunities for the management and beneficial use of dredged material throughout the Great Lakes. Additional activities completed to refine the agricultural field improvement option included:

- Desktop review of agronomic suitability of dredged material, including a review of available dredged sediment data, crop recommendations (e.g. alfalfa, corn),

potential additives (e.g. fertilizer, lime), and the estimated number of growing cycles needed to obtain optimal agronomic and soil conditions for select crops;

- Refinement of design and implementation methods, including project-specific specifications for the implementation of the agricultural field improvement option and a desktop and field review of the agricultural field improvement option currently being completed at East Harbor State Park and other similar projects;
- Refinement of preliminary cost estimates, including a more detailed pump management and maintenance cost, more detailed land rental/acquisition and easement costs, refined anticipated energy costs associated with pumping operations, and refined construction cost estimates for installation of in-water and upland infrastructure; and
- Identification of next steps (e.g. financing, permitting) recommended to move forward with the implementation of the agricultural field improvement option or a pilot demonstration project.

This report summarizes additional activities completed by the Hull Team for the refinement of the agricultural field improvement option identified in the THSMUP.

# 2.0 AGRONOMIC SUITABILITY OF DREDGED MATERIAL

## 2.1 Introduction

Dredged material can be used beneficially to amend marginal lands for agricultural purposes or to improve the productivity of existing agricultural lands by altering the physical and chemical characteristics of soils to render the moisture content, effective porosity, and nutrient levels more favorable for crop production. It is important to understand the physical, chemical, and biologic changes that will occur in the dredged material after it is relocated from an aquatic to an upland environment, along with the potential effects to crops that might be grown in the material. This section provides the results of a desktop review of agronomic suitability of dredged material, including a review of available dredged sediment data, crop recommendations (e.g. alfalfa, corn), potential additives (e.g. fertilizer, lime), and the estimated number of growing cycles needed to obtain optimal agronomic and soil conditions for select crops.

Agricultural land in northwest Ohio generally consists of level to gently sloping areas with loamy and clayey to loamy and sandy soils (U.S. Department of Agriculture [USDA], 1980). Drainage predominately ranges from very poorly drained to somewhat poorly drained. Smaller areas of the Oak Openings region contain sandy soils with moderately to well-drained soils. Toledo Harbor dredged material primarily consists of water, soil particles, and organic matter and might contain small pieces of rock, wood, metal, glass, and other debris. Toledo Harbor sediments are generally weakly acidic to slightly alkaline and comprised predominately of clayey silts and silty clays with varying degrees of organic matter. Traditional contaminants of concern (COCs) in some impacted areas include low levels of heavy metals, phosphorus, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides. However, these COCs are not expected to be present in material dredged from the Federal channel at levels that would present any concerns for agricultural products of row crops. Ohio has not adopted non-site specific regulatory standards for the land application of dredged material, but other standards such as regional screening levels and biosolids limits can be used to screen the suitability of materials for land application. Site-specific and crop-specific agronomic testing could be completed as part of final engineering and design to determine the suitability of dredged material for land application at a specific agricultural field and the need for any amendments.

## 2.2 Considerations for Land Application of Sediment

The suitability of implementing the agricultural field improvement option at a specific site is dependent on the characteristics of the dredged material and the agricultural land on which it is placed. Toledo Harbor dredged material is primarily comprised of fines (a mix of silt and clay), predominately classified as CH (clay with high plasticity or fat clay) with a Plastic Index (PI) of over 50 and a high water retention capacity. Traditional contaminants of concern monitored in sediment samples collected by the United States Army Corps of Engineers (USACE) from the Federal channel include heavy metals, PAHs, pesticides, and PCBs (USACE, 2009). A summary of the maximum reported concentrations of various constituents detected during the USACE's 2010 sampling event of bulk sediment samples from the Federal channel as well as respective sediment quality guidelines is provided in the Toledo Harbor Dredge Sediment Preliminary Risk Evaluation memorandum that is included in Appendix B-2 of the THSMUP.

As discussed in the memorandum, the accumulation of chemicals in the sediment from sources such as storm run-off, point discharges and atmospheric deposition determines the nature of the constituents in the sediment. This affects the suitability of the type of sediment management and use option (e.g. in-water, near-shore, upland, beneficial use) that can appropriately manage the material. The suitability of potential in-water uses (e.g. open-lake placement), near-shore uses (e.g. wetland restoration and shoreline protection), and upland uses (e.g. agricultural field improvement, non-structural fill), were evaluated through a comparison of concentrations of constituents reported in sediment samples collected from the Federal channel in 2010 by USACE to respective sediment screening criteria.

The screening criteria used in the evaluation included the following:

- USEPA Regional Screening Levels (RSLs) for industrial soil;
- USEPA RSLs for residential soil;
- Ohio EPA Voluntary Action Program (VAP) direct contact soil standards for commercial/industrial land use;
- VAP direct contact soil standards for residential land use;
- Ohio EPA sediment reference values (SRVs);
- USEPA Region 5 Ecological Screening Levels (ESLs) for sediments; and

- Threshold Effect Concentrations (TECs) from MacDonald, Ingersoll and Berger (2000).

Table B-1, which is included in the memorandum attached as Appendix B-2 to the THSMUP, provides a summary of the maximum concentrations reported for sediment samples collected from the Federal channel in 2010 as well as respective screening criteria. Based on a comparison of these results to screening criteria, most Toledo Harbor sediments might be appropriately used for upland, nearshore, and in-water uses, with the possible exception of sediments dredged from isolated areas of the Federal channel as discussed in the THSMUP. Additional site-specific biological and toxicity testing might be necessary to determine the suitability of the use of the material from these isolated areas.

Dredged sediments with concentrations below residential soil RSLs may be suitable for upland placement at residential sites. In general, Ohio EPA considers residential soil RSLs to adequately encompass human direct contact exposures in most applications, potentially including recreational land use, mixed land use, and unrestricted land uses (Ohio EPA, 2010). It could be assumed that agricultural land use falls within the category of land uses encompassed by residential soil RSLs. However, the residential soil RSLs do not incorporate assumptions about human consumption and contaminant uptake from soil into food crops, milk and eggs, and livestock; therefore, human exposures based on agricultural use of dredged sediments are not specifically evaluated by comparison to residential soil RSLs.

Generic screening levels based on agricultural use have not been developed by Ohio EPA or USEPA, perhaps attributable to the difficulty of evaluating contaminant uptake into crop plants, the differential distribution of contaminants in the edible and non-edible parts of the plant, and intake rate of produce by consumers. However, the Canadian Council of Ministers of the Environment (CCME) has developed agricultural screening levels for soils (CCME, 2012). The CCME guidance states that assessment of human food consumption is relevant “where consumption of backyard garden food is or is likely to be significant” (CCME, 1999). The CCME generic scenario assumptions based on 50% of the meat and produce and 100% of the milk being consumed by persons is produced on-site (CCME, 1999). Thus, the CCME soil quality guidelines for the protection of environmental and human health based on agricultural land use may not be relevant for the evaluation of the beneficial use of dredged sediments for agricultural field improvements.

Table 1 provides a summary of background metal concentrations reported in Ohio soils collected as part of Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) environmental investigations from 64 sites in 36 of Ohio's 88 counties (Cox and Colvin, 1996) and background concentrations of potassium and phosphorus for Ohio soils (Ohio State University, 2005). The concentrations of metals in soils are the result of the source rocks or sediments from which the soil developed and the result of anthropogenic pollutants. Soils used to characterize Ohio background metals concentrations may have had subtle anthropogenic influence but are not considered to be significantly affected by industrial activity. Although the maximum reported metal concentration in Toledo Harbor sediment was higher than the geometric mean calculated for background concentrations of metals in Ohio soils, the metal concentrations for Toledo Harbor sediments are generally within the range of background concentrations for Ohio soils.

Ohio has not established regulatory standards for acceptable levels of constituents present in dredged material for beneficial use. The requirements of 40 Code of Federal Regulations (CFR) Part 503 for land application of biosolids have been used as a general guideline for determining suitability of the land application of dredged material in some states. The regulatory limits for metal concentrations in biosolids have been established based on research specific to organic material. The chemical characteristics of the dredged material and upland soil, the dredged material application rate, the water and drainage requirements, and the desired crop types and plant bioavailability should also be considered when evaluating the use of dredged material for agricultural use.

Manufactured soil screening tests indicated that fertile topsoil could be blended from dredged material collected from Cell 1 of the Toledo Harbor Confined Disposal Facility (CDF), yard waste, and biosolids (Lee, 1999). Metal concentrations in the manufactured soil were evaluated in relationship to the USEPA 503 regulations for acceptable maximum metal concentrations in agricultural soils receiving biosolid applications. A bench-scale seed-germination and plant growth test was completed on ryegrass, tomato, marigold, and vinca using dredged material collected from Cell 1 of the Toledo Harbor CDF and blended with varying percentages of cellulose, and biosolids. The results from the screening tests indicated that Toledo Harbor dredged amended with cellulose, and biosolids will enhance plant growth. A field demonstration was completed in 1998 that produced 550 cubic yards (CY) of fertile topsoil that was used to landscape the entrance to the University of Toledo and to improve soil beds at the entrance of the Toledo Botanical Gardens.

## REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 1

## COMPARISON OF INORGANIC CONCENTRATIONS REPORTED IN SAMPLES COLLECTED FROM THE TOLEDO HARBOR FEDERAL CHANNEL TO OHIO SOIL BACKGROUND CONCENTRATIONS AND TO REGULATORY LIMITS ESTABLISHED FOR AGRICULTURAL APPLICATION OF CLASS B BIOSOLIDS

| Parameter | 2010 Sediment Results[a] | | Background Metal Concentrations in Ohio Soils[b] | | Agricultural Application of Class B Biosolids (Ohio Administrative Code 3745-40-04) | |
|---|---|---|---|---|---|---|
| | Maximum Detected Concentration (mg/kg) | Location of Maximum Detected Concentration | Geometric Mean (mg/kg) | Range (mg/kg) | Table D-1. Pollutant Ceiling Concentration Limit (mg/kg) | Table D-2. Pollutant Cumulative Pollutant Load Rates (pounds/acre) |
| Aluminum | 48,000 | LM-2 | 8,180 | 2,000 - 16,100 | NA | NA |
| Antimony | 0.51 | LM-2 | NA | 0.97 - 92 | NA | NA |
| Arsenic | 11 | LM-3.5 and RM-2 | 5.72 | 0.5 - 56 | 75 | 36.6 |
| Barium | 190 | RM-2 | 63.4 | 9.3 - 323 | NA | NA |
| Beryllium | 1.2 | RM-2 | 0.377 | 0.10 - 3.15 | NA | NA |
| Cadmium | 2.5 | RM-4 | 0.507 | 0.07 - 4.40 | 85 | 34.8 |
| Chromium | 52 | RM-2 | 12.1 | 2.00 - 80.5 | NA | NA |
| Cobalt | 14 | RM-2 | 6.42 | 1.0 - 53.6 | NA | NA |
| Copper | 61 | RM-4 | 11.8 | 1.2 - 58 | 4,300 | 1,339.9 |
| Iron | 47,000 | RM-2 | 18,400 | 5,150 - 100,000 | NA | NA |
| Lead | 51 | RM-4 and LM-13 | 16.2 | 1.0 - 147 | 840 | 267.9 |
| Manganese | 830 | LM-3 | 459 | 59.0 - 1,750 | NA | NA |
| Mercury | 0.37 | LM-13 | 0.081 | 0.081 - 1.60 | 57 | 15.2 |
| Nickel | 48 | RM-2 | 14.4 | 2.00 - 110 | 420 | 375.1 |
| Phosphorus | 580 | LM-0 | NA | 250 - 750[h] | NA | NA |
| Potassium | 5,300 | RM-2 | 709 | 230 - 2,180 (10,000 - 20,000[h]) | NA | NA |
| Selenium | 1.2 | LM-0.25 and RM-2 | NA | 0.20 - 35.0 | 100 | 89.3 |
| Silver | 0.78 | RM-4 | NA | 0.20 - 14.8 | NA | NA |
| Thallium | 0.83 | LM-0.25 | NA | 0.17 - 0.59 | NA | NA |
| Vanadium | 55 | RM-2 | 17.4 | 4.60 - 71.0 | NA | NA |
| Zinc | 220 | RM-2 | 42.7 | 7.50 - 190 | 7,500 | 2,500.4 |

Notes:
a. 2010 USACE sampling included 39 surface grab samples collected from the Lake Approach Channel (Lake Mile (LM) LM-0 through LM-13) and River Channel (River Mile (RM) RM-1 through RM-7). Only actual measured values are reported for 2010 sediment data. Values reported as not detected at or above the specified minimum detection limit and estimated values reported between the minimum detection limit and reporting limit are not identified. Sediments dredged from RM-1, RM-2, and RM-4 were identified as not meeting Federal guidelines for open-lake placement in the latest round of sediment sampling completed by the USACE (USACE, 2012). Total PAHs were identified as sediment COCs at these sites. All other dredged material was evaluated and determined to be suitable for open-lake placement. NM-Not Measured; ND-Not detected at or above the specified minimum detection limit and reporting limit; NA-Not Applicable; mg-milligram; kg-kilogram
b. "Evaluation of Background Metal Concentrations in Ohio Soils." Cox-Colvin & Associates, Inc. June 21, 1996.
c. "Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites." June 2011.
d. Ohio Administrative Code 3745-300-08(C)(3).
e. VAP Program Chemical Information Database and Applicable Regulatory Standards (CIDARS) database.
f. VAP Program CIDARS database for Residential Child Soil Standard.
g. Not a listed Hazardous Substance.
h. Ohio Agronomy Guide (Ohio State University, 2005).

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Table 1 also provides a summary of established regulatory limits for land application of biosolids. Regulatory limits include the ceiling concentration limit, which is the maximum concentration of each metal allowed in biosolids for land application, and the cumulative pollutant loading rate, which is the maximum amount of a pollutant that can be applied to a site over its lifetime by all applications of biosolids meeting ceiling concentration limits. Maximum concentrations reported for Toledo Harbor sediments are considerably below respective established ceiling concentration limits.

In addition to direct comparisons of total sediment concentrations to screening criteria, considerations should also be given to the physical, chemical, and biologic changes that will occur when the sediment is dredged and placed in an upland environment and the effect the changes will have on contaminant mobilization and bioavailability. As the dredged material dewaters and is exposed to oxygen in the atmosphere, it will dry and oxidize, which will change the mobility, solubility and bioavailability of inorganic and organic compounds present in the material. Contaminant mobilization and bioavailability is primarily dependent on a material's texture, organic matter content, and chemical properties such as acidity and oxidation/reduction status. In general, sandy sediments have little attraction for either toxic metals or synthetic organics (pesticides and PCBs). Fine-grained sediments such as silt and clay generally have a much greater affinity for all classes of contaminants, thereby having an ability to reduce contaminant mobilization. Organic matter in the material usually decreases the mobility of metals and serves as an energy source for sediment microbial populations that assist in organic contaminant degradation of contaminants like PAHs.

An important factor governing the solubilities of various compounds in the exchange reactions that occur between soil and water is pH. In general, the solubility of metals tends to increase in soil solution with decreasing pH, which increases the metal's bioavailability. Sediment pH can also influence the sorption of organic molecules bound to the soil, which affects the leaching potential of the organic compounds. Although no consistent regulatory criteria exists for determining the significance of metal and organic concentrations in soils used to grow plants for direct human or animal consumption, releases of metals in the dredged material should be minimized given that weakly acidic soils are developed and maintained through the use of buffering agents such as lime.

## 2.3 Considerations for Agronomic Suitability

Physical and chemical properties of dredged material and upland soil are significant factors that should be considered in the evaluation of potential sites for land application of dredged material. The nutrient and metal content of the dredged material can affect the amount of material which should be applied to the field and the ideal crop types.

Crops require a specific range of growing conditions, including nutrients, soil structure, and drainage. Proper drainage, or how long soils are saturated at or near the surface during the year, is critical for all crops. Crop success is also dependent on the condition and activities of the root system, which controls uptake of nutrients and water from the soil and supports a microbial environment that helps make nutrients available. Proper drainage is critical to support a healthy root system and ultimately will affect crop success. Soils in northwest Ohio are often modified with drainage improvements to allow soils to drain in order to plant crops earlier and improve root health.

Corn, soybeans, and wheat were evaluated for use in the agricultural improvement option because they are common crops grown in northwest Ohio. Additionally, alfalfa was evaluated due to its high water use, which could further aid in reducing moisture content of the sediment and enhance the soil formation process especially post-application to accelerate dewatering through evapotranspiration. Corn and alfalfa have a much deeper root system than soybean and wheat, as shown in Table 2. Alfalfa requires much more water than wheat and soybeans, while corn requires the least. Alfalfa would be suitable for planting on the agricultural field in order to take up significant moisture that would be contained within the dredged material. Wheat also has a fibrous root system, tolerates wet soils, and is effective at reducing soil erosion. While consideration was given to corn, soybeans, wheat, and alfalfa, other crops such as barley, rye, and radishes could also be considered.

Multiple cropping, or the establishment and harvest of a second crop within the growing season, is common in northwest Ohio. Corn grown for silage following the first cutting of alfalfa, or soybeans after winter wheat, is a common multiple cropping scenario in Ohio; however, many other crop rotations are employed. Alfalfa is sometimes broadcast seeded while the ground is still frozen into smaller grains such as wheat with a primary purpose of weed control. Because of the large amount of water required for a multiple cropping system, it is generally successful in soils with large water supply capacities, adequate drainage, and suitable root zone structure.

The agricultural field improvement option could utilize a multiple cropping system, which would also reduce soil and nutrient runoff by keeping residue on the field. Selection of specific crops and varieties for a growing season depends on many factors including weather and soil conditions, soil fertility, and drainage conditions. Many of the crops discussed above would be suitable for growing on an agricultural field amended with dredged material. Further evaluation of suitable crops and potential rotations should be completed on a field-specific basis. Best management practices should be employed to ensure proper erosion controls, drainage management, and invasive species management. Ultimately, crop type and rotation will and be up to the farmer and/or landowner following completion of dredged material placement activities.

**REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 2**

**TYPICAL SOIL AND DRAINAGE CONSIDERATIONS FOR SELECT CROPS[1]**

| Crop | Soil Conditions | pH | Typical Root Depth[2] | Water Requirement[3] | Usual Plant Date | Usual Harvest Date[4] |
|---|---|---|---|---|---|---|
| Alfalfa | Well-drained | 6.5-6.8 | 3-4 feet | High | 4/1-5/1 or 8/1-8/15 | 5/25-9/11 |
| Corn | Well-drained | 6.0-7.5 | 3 feet[5] | Low | 4/24-5/24 | 10/11-11/20 |
| Soybean | Well-drained | 6.0-6.5 | 1 foot | Medium | 5/3-5/30 | 9/30-10/31 |
| Wheat | Well-drained | 6.0-6.5 | 1 foot[6] | Medium | 10/2-10/25 | 8/2-8/17 |

Notes:

1. Source is the Ohio Agronomy Guide (Ohio State University, 2005), unless otherwise noted. pH reported in Standard Units (S.U.).
2. Depth reported is the zone for most of the root growth. Taproots cab reach much deeper than depths listed.
3. Low = less than 400 pounds of water per pound dry crop; Medium = 400-700 pounds of water per pound dry crop; High = greater than 700 pounds water per pound dry crop; Source: North Dakota State University, 2009. *Crops and Water Use.*
4. USDA. 2010. *Field Crops and Usual Planting and Harvesting Dates*. Agricultural Handbook Number 628.
5. Rhodes, F.M. and Yontes, C.D. 1991. *Irrigation Scheduling for Corn - How and Why*. National Corn Handbook, NCH 20.
6. Beuerlein, J. 2001. *Relay Cropping Wheat and Soybeans.* The Ohio State University Extension. AGF-106-01.

Crop growth is dependent on the bioavailability of 16 essential nutrients with different forms of each nutrient taken up by the plant at various concentrations. Table 3 presents the sixteen essential nutrients, their symbol, and form taken up by plants. Thirteen of the essential nutrients are extracted from the soil and can be categorized as primary macronutrient, secondary macronutrient, and micronutrients. Primary macronutrients, including phosphorus, nitrogen, and potassium, are nutrients required in the largest quantity while secondary macronutrients are required in lesser amounts. Finally, micronutrients are those nutrients required by plants in an even lesser amount. Crops also remove these nutrients from soil as they grow and are

harvested. In general, alfalfa removes the most nitrogen, phosphorus, and potassium followed by corn, soybean, and wheat (Vitosh, M.L. et al. 2007).

**REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE 3**

**ESSENTIAL NUTRIENTS, ELEMENT SYMBOL, AND CHEMICAL FORM TAKEN UP BY PLANTS[1]**

| Element | Element Symbol | Form Taken Up |
|---|---|---|
| Carbon | C | $CO_2$ |
| Hydrogen | H | $H_2O$ |
| Oxygen | O | $H_2O$ |
| **Primary Macronutrients** | | |
| Nitrogen | N | $NH_4$+ and $NO_3$- |
| Phosphorus | P | $H_2PO_4$- and $HPO_4^{2-}$ |
| Potassium | K | K+ |
| **Primary Macronutrients** | | |
| Calcium | Ca | $Ca^{2+}$ |
| Magnesium | Mg | $Mg^{2+}$ |
| Sulfur | S | $SO_4^{2-}$ |
| **Micronutrients** | | |
| Iron | Fe | $Fe^{2+}$ and $Fe^{3+}$ |
| Manganese | Mn | $Mn^{2+}$ |
| Boron | B | $H_3BO_3$ |
| Chlorine | Cl | Cl- |
| Zinc | Zn | $Zn^{2+}$ |
| Copper | Cu | $Cu^{2+}$ |
| Molybdenum | Mo | $MoO_4^{2-}$ |

Notes:

1. Adapted from the Ohio Agronomy Guide (Ohio State University, 2005).

The Tri-State Fertilizer Recommendations outline optimum soil test values for most crops in Ohio, as reported in Table 4. Data from the USACE's routine sampling of Toledo Harbor is reported as total concentrations of a parameter, while the Tri-State Fertilizer Recommendations are based on availability of the specific nutrient. Therefore, a direct correlation cannot be made between reported values from USACE and the optimum value as recommended by the Tri-State Fertilizer Recommendations (Ohio State University, 2005). However, where available, parameter concentrations reported for dredged material was compared to respective optimum soil test total values for Ohio soils.

## REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

### TABLE 4

### OPTIMUM SOIL TEST VALUES FOR SELECT INORGANICS FOR MOST CROPS IN OHIO AND TOLEDO HARBOR FEDERAL CHANNEL SEDIMENT CONCENTRATIONS

| Soil Test Parameter[1] | Optimum Soil Test Value | Dredged Sediment Parameter | 2010 Toledo Harbor Federal Channel[3] |
|---|---|---|---|
| pH[2] | 6.3 to 7.0 S.U. | pH | Not Reported |
| Available Phosphorus | 15-40 ppm | Total Phosphorus | 406 ppm |
| Exchangeable Potassium | 100-200 ppm | Total Potassium | 3,565 ppm |
| Exchangeable Calcium | 200-8,000 ppm | Total Calcium | 47,384 ppm |
| Exchangeable Magnesium | 50-1,000 ppm | Total Magnesium | 13,268 ppm |
| Available Manganese | 10-20 ppm | Total Manganese | 649 ppm |
| Available Boron | 0.25 ppm | Total Boron | Not Reported |
| Available Zinc | 1.5 ppm | Total Zinc | 129 ppm |

Notes:

1. Adapted from the Ohio Agronomy Guide (Ohio State University, 2005).
2. Assumes mineral soil.
3. Maximum parameter concentration reported for 39 surface grab samples collected from the Lake Channel (LM-0 through LM-13) and River Channel (RM-1 through RM-7) by the USACE in 2010 (USACE, 2012).

It is important to note that Tri-State Fertilizer Recommendations for phosphorus are based on the colorimetric Bray-Kurtz P1 soil test method. Many Ohio soil laboratories measure phosphorus, as well as other nutrients (e.g. potassium, calcium, magnesium, etc.), using the inductively coupled plasma (ICP) spectroscopy method Mehlich-3-ICP. While the Bray-Kurtz P1 and the Mehlich-3-ICP test methods measure plant-available phosphorus, only total phosphorus concentrations were identified in sediment samples by EPA Method 6000/7000 during USACE's 2010 Federal channel sampling event. The 2010 average total phosphorus concentration in dredged material from the Federal channel is 405 parts per million (ppm), or mg/kg. This average is within range of total phosphorus in Ohio soils, which varies from 250-750 ppm (Ohio State University, 2005). It is important to note that not all of this phosphorus is bioavailable, or available for plants to utilize.

Soil pH of a soil impacts the success of various crops. For example, the recommended pH range for alfalfa is 6.5 to 6.8 Standard Units (S.U.) while small grains (e.g. wheat, rye) are 6.0 to 6.5 S.U. (Vitosh, M.L. et al. 2007). Liming is recommended when the pH range of a soil is between 0.2 to 0.3 S.U. below the recommended level. While pH values for the dredged material are not available, it is anticipated that the pH is within the range suitable for most crops, as reported in Table 4.

Total potassium in Ohio soils range from 10,000 to 20,000 ppm, with only a small portion available to the plant (Ohio State University, 2005). While Toledo Harbor dredged material appears to have potassium levels below this range, potash could be added when additional potassium is required. While calcium and magnesium availability are tied to pH, Ohio soils with a pH above 5.5 S.U. are rarely deficient in these nutrients (Vitosh, M.L. et al. 2007).

Micronutrients such as manganese, boron and zinc are also highly pH dependent and can be toxic if present in elevated levels. For example, alfalfa and soybeans are highly sensitive to high manganese levels. Based on the average reported values in 2010 dredged material, macronutrients and micronutrients are generally within the range reported in Ohio soils. Agronomic testing could be completed as part of final engineering and design to determine if any amendments are necessary to ensure optimum soil nutrient conditions for specific crops at specific locations.

# 3.0 REFINEMENT OF AGRICULTURAL FIELD IMPROVEMENT OPTION DESIGN, IMPLEMENTATION METHODS, AND COST

## 3.1 Introduction

The projected relative costs and assumptions discussed in Section 6.0 of the THSMUP were developed to achieve the same level of comparison among all options while completing cost estimates with a similar level of detail. Once an option is selected for further design, the option would need to be further refined to determine the most economical and beneficial methods. Based on recent discussions with Ohio EPA and other stakeholders, it appears that one of the more sustainable sediment management options identified as part of work completed for the THSMUP is the beneficial use of dredged material for agricultural field improvements.

Since the THSMUP comparative scoring analysis identified the agricultural field improvement option as a preferred option that can be implemented relatively quickly and used to manage dredged material over the long-term, additional refinement of the design and costs were completed to better position the option for a pilot project or for consideration for full-scale implementation. Detailed costs and associated calculations are discussed in the following sections and are provided in Table 5 and Tables B-1 through B-4, which are included in Appendix B. These tables provide a refinement of the agricultural field improvement option preliminary costs presented in Section 6.0 and Tables H-1, H-4, and H-5 of the THSMUP. Only cost element categories that are applicable to the agricultural field improvement option are presented in this table. Table 5 provides the estimated total costs for various dredging methods and includes major cost element categories (e.g. Item 2.0) used to derive the estimated total costs. Tables B-1 through B-4 detail the sub-components of each major cost element category (e.g. Item 2.1, Item 2.2). Cost element categories may not be comparable with those in the THSMUP.

The refined costs were based on a re-evaluation of the major design components, including the most economical dredging and operational methods available, and a better defined site-specific potential placement location. A review of implemented agricultural field improvement projects was also completed to assist in refinement of the design and cost-estimates. While the refined cost estimates are closer to a final opinion of probable costs, they should not be used for potential funding values. The steps and procedures involved in developing the refined cost estimates are discussed below.

## 3.2 Results of Similar Agricultural Field Improvement Projects

Previous studies and implementation projects have documented potential benefits associated with applying dredged materials to improve agricultural soils resulting in increased water-holding capacity, enhanced crop growth (tilth), and increased hydraulic conductivity to improve drainage.

Fine-grained dredged material collected from a former dredged material management facility in Toledo, Ohio, known as Penn 7, has been demonstrated to increase agricultural production when mixed with marginal, coarser-textured, agricultural soils (Gupta, 1978). USACE conducted greenhouse experiments to determine agricultural suitability of dredged material collected from Penn 7 and from other locations in the United States. Growth studies were completed in a greenhouse for ryegrass and barley using dredged material, a marginal soil collected near the Toledo Express Airport, various mixtures of dredged material and marginal soil, and reference soils collected from a productive agricultural field in Minnesota. The yield of ryegrass and barley plants grown on the dredged material was greater than on the productive Minnesota control soils, marginal soil, and the dredged material and marginal soil mixtures. USACE attributed the increased yields on the fine-textured dredged material to greater nutrient availability, to greater available water contents, or to a combination of both. Penn 7 dredged material contained slightly higher amounts of zinc, copper, nickel, and cadmium than the majority of dredged materials evaluated in the study; however, plant growth did not appear to be affected by uptake of these metals.

Application of dredged material on a 500-acre agricultural field was completed in Springfield, Illinois, with only site-grading and a drainage ditch for dewatering. Dredging was completed in two phases over a three-year period. Over 3.2 million (M) CY of sediment was dredged over a three-year period and placed on the field at an average depth of 6 feet. A drainage ditch was installed and the site was grubbed, graded, and planted with corn three years after the end of dredging. The first planting of corn resulted in a relatively low yield in comparison to the Sangamon County average. Corn yields remained slightly less than average county yields during subsequent normal growing seasons, and the field was planted with soybeans. Soybean yields exceeded the Sangamon County average. The difference between corn and soybean yields is attributed to less subsurface moisture impact to the shallow-rooted soybeans than to the deeper-rooted corn (Agricultural Watershed Institute, 2005). The Illinois study also showed soybean yields higher than the county average during periods of drought, which is attributed to

the moisture retaining capacity of the fine-grained dredged material. Since residual moisture content affected crop yields of agricultural fields amended with fine-grained dredged material in Illinois, a Toledo Harbor agricultural field improvement option will include a subsurface drainage to enhance drainage and improve tilth.

Between 2000 and 2005, approximately 450,000 CY of silty, uncontaminated, freshwater dredge material was removed from the Potomac River near Washington, DC. Dredged material was used to create a productive agricultural soil in Charles City County, Virginia and placed on previously reclaimed sand and gravel mine (Daniels et al., 2007). Dredged material was dewatered for one year, amended with varying rates of yard waste compost, and planted with winter wheat in the fall of 2001 and corn in the spring of 2002 and 2003. The dredged material was converted to suitable agricultural soil within two years after placement and corn and wheat crop yields grown on this agricultural field were at or above county averages from 2002 through 2006.

In addition to the studies above, Ohio Department of Natural Resources (Ohio DNR) Division of Parks and Recreation is placing material dredged from East Harbor at East Harbor State Park on agricultural fields. Material is being hydraulically dredged and pumped through a temporary pipeline and booster pump into a dredged material relocation area (DMRA) on an agricultural field. The DMRA consists of four cells separated by dikes approximately 9.5 feet in height. An adjustable box weir and perimeter ditches are being used to control discharge water through the cells. Over the course of four to five years, a total of approximately 250,000 CY of material will be placed into the cells. Once placement of dredged material is complete, the DMRA will be graded as agreed upon by the landowner and Ohio DNR. The final use of the property is up to the landowner but could include future use as a fruit farm or potential development. A memorandum summarizing the placement of dredged material in the DMRA and photographs, as discussed during a site visit by Ohio DNR and Hull, is provided as Attachment A.

## 3.3 Potential Candidate Locations for Implementation

A review of local property public records and field-scouting identified two to three property owners and six to nine potentially suitable property parcels for implementation of this option. These parcels would be capable of handling 10.5M CY of dredged material over 30 years. Locations for placement sites and infrastructure development were driven by and a visual record was made documenting the feasibility of implementation. The locations are all rural zoning lots

with topographic characteristics capable of supporting this option, have an average parcel size of approximately 150 acres, and are within five miles of the potential location of the main near shore booster pumping station. Landowners could lease their land to allow for site development in exchange for the benefits of owning an enhanced agricultural property. They would also receive compensation for their land (assumed at a rental cost of $300 per acre per year) for the farmland that would not be able to produce the normal cash crop during the development, placement, dewatering and replenishing periods. The parcels are located in eastern Lucas County and offer relatively easy access for the on-land pipelines through public road right-of-ways and minimal 90-degree turns and minimal road crossings. During the field-scouting it was determined that the pipeline could be located within the public utility easement. If existing unidentified utilities and/or ditches occupy the area, the purchase of additional land might be required. It was assumed that a thirty foot wide strip of land for the full length of pipe (seven miles was assumed) would be purchased at a cost of $6,000 per acre for the easement.

Independently of which dredging and operation methods are used, as described in Section 3.6, a system would need to include a centralized pumping station on land and additional upland pipelines leading to the agricultural field site(s). The main booster pump facility would be located onshore, near Maumee Bay State Park at a cost of $25,000 (not including the pump). The facility would provide a mechanical connection with a permanent underwater pipeline originating near the center of gravity of historic dredging operations (see Figure 1). The booster pump would be appropriately sized to handle the discharge volume that results from the hydraulic dredge or the pump-out system. The booster pump may initially be rented, but for the purpose of the refinement cost it was assumed that the pump would be purchased and maintained for the 30-year option for an initial purchase cost of $250,000 for each pump. It was assumed that each booster pump would have a life of ten years before it would need a major maintenance overhaul or replacement. The permanent booster pump would range between 16 inches and 24 inches and would be operated by an electrical engine, ranging between 465 kilowatt and 640 kilowatt capacity, to reduce cost and noise. The operational cost of $0.15 per kilowatt-hour was applied to the required pumping time. It was assumed the permanent booster pump would be housed inside an all-weather building and fenced in for security. One additional booster pump and facility would likely be required depending on the final pumping distance and the size of pump(s) selected during the detailed design/planning phase. It is anticipated that sites within a five-mile radius will be sufficient for the initial phases of this option and seven miles of buried pipeline would be installed. However, sites further than five miles could be

needed earlier based on the overall acceptance and success of this option, and the relative reliance on this option as part of the overall strategy. Costs associated with the site development are identified by Item 5.0 of Tables B-1 through B-4, provided in Appendix B.

## 3.4 Pipeline Requirements

The pipeline required for this option (including the hydraulic dredge discharge line, the underwater pipeline, and the upland pipeline) would be high-density polyethylene (HDPE) material, with Standard Dimension Ratio (SDR) of 11. The SDR is a direct relation between the pipe outside diameter and wall thickness, where the lower the SDR, the thicker the pipe wall. HDPE is a very resistant material that provides significant physical flexibility and is relatively simple to install. It is commonly used in fine-grained slurry applications where abrasion from large-size particles is not a concern. SDR 11 is the lowest SDR readily available in the market as it is a standard stocking item and would be adequate for this application.

The installation of an underwater conveyance system to transport the dredged material from an area near the center of gravity to a booster pumping station on land would be required for all operations. The dredged material would be pumped through a permanent HDPE SDR 11 underwater pipeline varying in size between 16 inches and 24 inches. This pipeline would be installed at an adequate depth to allow vessels to pass over and not cause a navigational hazard. The installed price range between $180 and $345 per lineal foot was used for the permanent underwater pipeline. Costs associated with the conveyance system are identified by Item 7.0 of Tables B-1 through B-4, provided in Appendix B. The upland pipeline would be between 12 inches and 24 inches and the installed price ranges between $50 and $115 per lineal foot.

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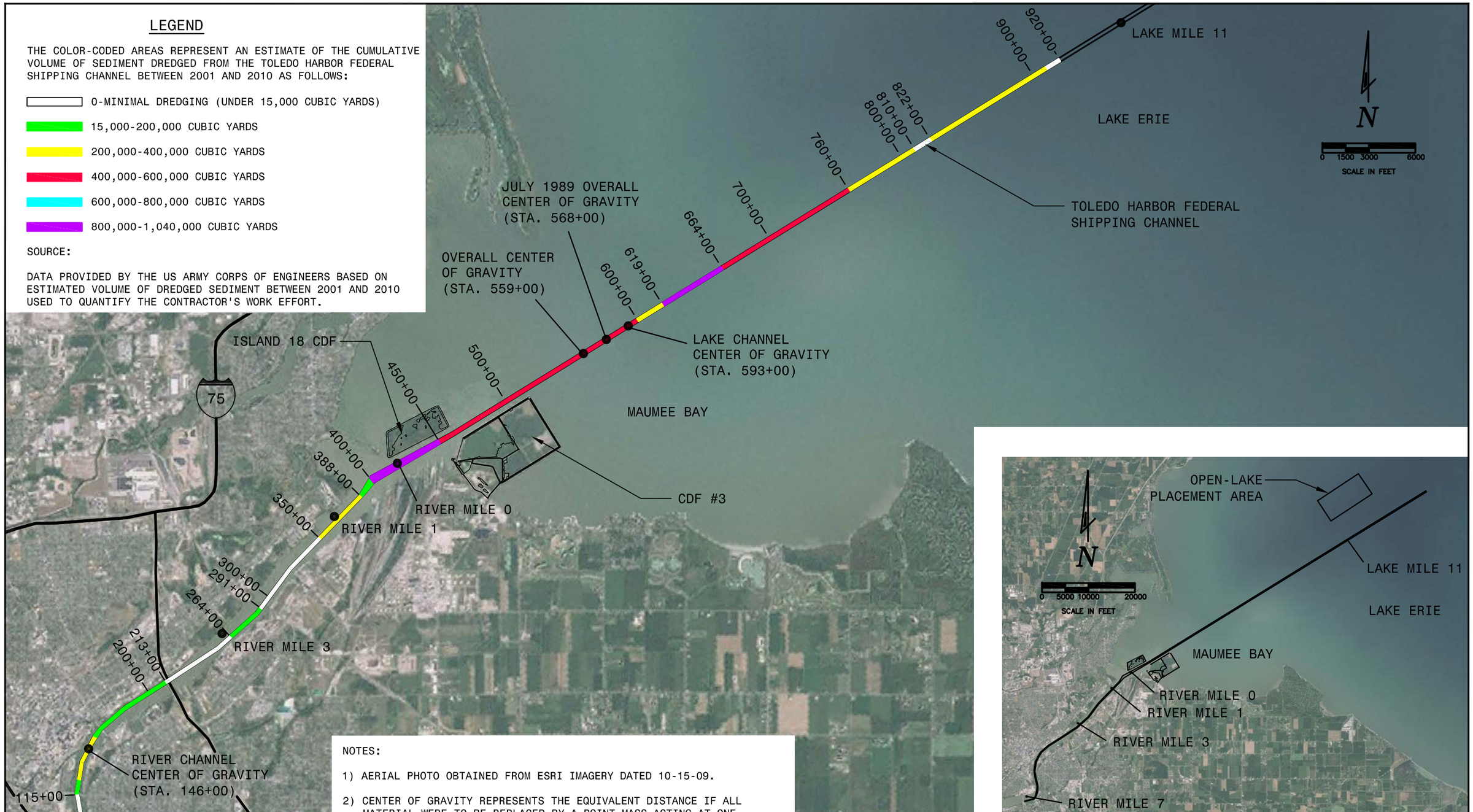
## LEGEND

THE COLOR-CODED AREAS REPRESENT AN ESTIMATE OF THE CUMULATIVE VOLUME OF SEDIMENT DREDGED FROM THE TOLEDO HARBOR FEDERAL SHIPPING CHANNEL BETWEEN 2001 AND 2010 AS FOLLOWS:

- 0-MINIMAL DREDGING (UNDER 15,000 CUBIC YARDS)
- 15,000-200,000 CUBIC YARDS
- 200,000-400,000 CUBIC YARDS
- 400,000-600,000 CUBIC YARDS
- 600,000-800,000 CUBIC YARDS
- 800,000-1,040,000 CUBIC YARDS

SOURCE:

DATA PROVIDED BY THE US ARMY CORPS OF ENGINEERS BASED ON ESTIMATED VOLUME OF DREDGED SEDIMENT BETWEEN 2001 AND 2010 USED TO QUANTIFY THE CONTRACTOR'S WORK EFFORT.




NOTES:

1) AERIAL PHOTO OBTAINED FROM ESRI IMAGERY DATED 10-15-09.

2) CENTER OF GRAVITY REPRESENTS THE EQUIVALENT DISTANCE IF ALL MATERIAL WERE TO BE REPLACED BY A POINT MASS ACTING AT ONE LOCATION. IT ESSENTIALLY REPRESENTS THE CENTER OF WHERE DREDGING HAS OCCURRED BETWEEN 2001 AND 2010 BY VOLUME OF SEDIMENT.

3) THE JULY 1989 OVERALL CENTER OF GRAVITY WAS REPORTED IN THE "EVALUATION OF WOODTICK PENINSULA RESTORATION AND RECREATIONAL HILL/UPLAND DISPOSAL ALTERNATIVES USING TOLEDO HARBOR DREDGE SPOIL MATERIAL", PREPARED BY HULL & ASSOCIATES, INC., DATED JULY 1989, USING DATA BETWEEN 1984 AND 1988.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GREAT LAKES RESTORATION INITIATIVE PROJECT
EPA GRANT #GL-00E00523-0
TOLEDO-LUCAS COUNTY PORT AUTHORITY AND THE OHIO LAKE ERIE COMMISSION

FIGURE 1
TOLEDO HARBOR DREDGING
CENTER OF GRAVITY, 2001-2010
MAUMEE RIVER/LAKE ERIE, OHIO

| | |
|---|---|
| PROJECT NO.: TPA044 | SUBMITTAL DATE: DECEMBER 2012 |
| CAD DWG FILE: TPA044.100.0001 | PLOT DATE: 12/3/12 |

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## 3.5 Dewatering and Structural Controls

Because the dredged material will be delivered to the site as a slurry mix, the sediment will need to be dewatered. This will be accomplished via the installation of weirs in the containment dikes. The weirs, which regulate the decanted water discharged from within the containment structure, will be installed in the higher levels of the dikes and in opposite locations from the inlet relative to the site layout to allow the dredged material to settle in the bottom prior to the water reaching the weirs and being discharged. The underground drainage lines will also help in dewatering as it will drain the water-laden sediment.

A series of interior trenches and drainage piping could be installed, at a cost of $3 per lineal foot, to assist the dewatering process during placement of material and allow for future drainage at the completed agricultural field. Water would be collected and gravity drained by perforated tile drainage pipe to an internal “edge of field” sub-drain filter system which would outlet to a perimeter “edge of field” buffer strip and controlled drainage structure outfall. The “edge of field” system would be implemented on up to ten percent of the overall placement site, depending on field configuration and property proximity to surface water features, for a cost of $6,075 per acre of the edge of field system. This system would minimize runoff from the agricultural field and serve as a best management practice for nutrient management, and coincidentally would be the only practical way that passive treatment of tile discharge could occur using a perimeter system approach in many areas of northwest Ohio due to the relative lack of a topographic relief and reliance on constructed drainage ditches. Costs associated with the site development are identified by Item 5.0 of Tables B-1 through B-4, provided in Appendix B.

## 3.6 Evaluation of Overall Dredging and Relocation Operation

Different dredging methods and conveyance systems were evaluated to determine the most cost-effective and feasible means of implementing the agricultural field improvement option. A mechanical dredge with a pump-out area and various sized hydraulic dredges, all with a conveyance system are discussed in the sections below.

### 3.6.1 Mechanical Dredge with Pump-out Area

One option to relocate the dredged material to the selected final site(s) is to construct a pump-out area located near the overall center of gravity of dredging operations. This option would include the continuation of current USACE mechanical dredging methods and hauling the material to the pump-out area and releasing the material from the bottom of the scow. A re-

handling area would be dredged to the required size and depth, which allows the scow to have appropriate mobility. There the material would be collected by a pump-out system, which would include a series of pumps and/or manifolds to collect the dredged material as well as a sufficient amount of water to pump the slurry mix. The development cost for this system would include the purchase of pumps, pumping costs, docking structures and other miscellaneous improvements.

The estimated cost for an alternative considering the current dredging methods and the pump-out area is $11.10/CY (2012 dollars) and is inclusive of all the required development in-water, upland, and at the agricultural sites. The capital cost is based on the management 10.5M cut CY over an initial 30-year period. The cost per CY would be reduced as the volume of cut CY managed through the system is increased due to the fixed cost to develop the pump-out area. The major cost component categories for the mechanical dredge evaluation are identified in Table 5. Refined unit cost calculations for mechanical dredge and pump-out area are included in Attachment B. The sub-components of the cost categories are identified in Table B-4, where appropriate.

### 3.6.2 Hydraulic Dredge with Conveyance System

Another option to relocate the dredged material to the selected final site is to use a hydraulic dredge, which would eliminate the need of a fixed pump-out system. The discharge line for the hydraulic dredge would consist of a HDPE pipe varying in size between 16 inches and 24 inches, which would be dependent upon the size of the hydraulic dredge used. For cost estimating purposes and to provide an understanding of the range of options for a hydraulic dredge, the use of a large dredge and a small dredge were evaluated considering the use of a permanent underwater conveyance pipeline, as discussed below in sections 3.6.2.1 and 3.6.2.2, respectively.

Another possible temporary option is to use a hydraulic dredge with a floating discharge line that would extend from the center of gravity to the on-shore booster facility. This would eliminate the need of a pump-out area and possibly reduce the extent of a permanent underwater pipeline. Measures would need to be taken to ensure that the discharge pipeline would not disturb recreational and shipping vessels, which would increase the dredging cost and associated mobilization/demobilization costs. The material would then be pumped through the additional

pipelines and to the constructed agricultural field locations as previously discussed above in Sections 3.3 and 3.4.

#### 3.6.2.1 Large Hydraulic Dredge

The largest hydraulic dredge that would reasonably be used in this application is a 24-inch dredge. This type of hydraulic dredge could pump an estimated range of 700 and 1,000 cut CY of dredged material per hour for an additional cutting depth range of two to four feet below the channel. Based on an annual cut amount of 350,000 CY dedicated to this option, and a 24-hour a day dredging operation, the required time period for dredging would be between 14 and 21 days. The estimated cost to operate the hydraulic dredge is between $6.00/CY and $9.50/CY based on the daily productivity above and a fuel cost of $4.00 per gallon.

#### 3.6.2.2 Small Hydraulic Dredge

The smallest hydraulic dredge that would reasonably be used in this application is a 16-inch dredge. This type of hydraulic dredge could pump an estimated range of 300 and 500 cut CY of dredged material per hour for an additional cutting depth range of two to four feet below the channel. Based on an annual cut amount of 350,000 CY dedicated to this option, and a 24-hour a day dredging operation, the required time period for dredging would be between 29 and 49 days. The estimated cost to operate the hydraulic dredge is between $6.50/CY and $10.50/CY, based on the daily productivity above and a fuel cost of $4.00 per gallon.

The use of a hydraulic dredge appears to be more economically and logistically feasible than the current methods and a pump-out area. However, hydraulic dredges have not been used in the Toledo Harbor since 2006, and it could be a challenging to find a hydraulic dredge that meets the current federal procurement requirements (e.g., U.S. flag vessel, small business, etc.). If, during the planning/design period, it is determined that the use of a hydraulic dredge is not feasible, the pump-out area concept can be used instead of the hydraulic dredge.

The refined estimated cost for the hydraulic dredging methods and transport through a conveyance system ranges between $10.10 and $11.50/CY (2012 dollars) and is inclusive of all the required development in-water, upland and, at the agricultural site.

The capital cost is based on the management 10.5M cut CY over an initial 30-year period. The cost per CY would be reduced as the volume of cut CY managed through with the dredge is increased due to the fixed cost to either purchase the dredge or the mobilize/demobilize cost associated with contracting on a yearly basis. The major cost component categories for the hydraulic dredge evaluation are identified in Table 5. Refined unit cost calculations for each hydraulic dredge size evaluated are included in Attachment B. The sub-components of the cost categories are identified in Tables B-1 through B-3, where appropriate.

## REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN

## TABLE 5

## COMPARISION OF RELATIVE UNIT COSTS OF THE REFINED AGRICULTURAL FIELD IMPROVEMENT OPTION USING DIFFERENT DREDGING AND RELOCATION METHODS[1,2,3,4]

| | | Overall Dredging and Relocation Operation Method | | | |
|---|---|---|---|---|---|
| **Item #** | **Description** | **16" Hydraulic Dredge** | **18" Hydraulic Dredge** | **24" Hydraulic Dredge** | **Mechanical Dredge and Pump-out Area** |
| 2.0 | Containment Structure (Dike) | $0.20 | $0.20 | $0.20 | $0.20 |
| 5.0 | Habitat/Site Development | $1.10 | $0.90 | $0.90 | $0.90 |
| 7.0 | Pump-out Area and/or Conveyance System | $0.60 | $0.70 | $0.90 | $1.50 |
| **Subtotal 1** | | **$1.90** | **$1.80** | **$2.00** | **$2.60** |
| 9.0 | Mobilization and Demobilization (8% of subtotal 1)[5] | $0.20 | $0.10 | $0.20 | $0.20 |
| **Subtotal 2** | | **$2.10** | **$1.90** | **$2.20** | **$2.80** |
| 12.0 | Planning, Engineering, and Design (10% of subtotal 2)[6] | $0.20 | $0.20 | $0.20 | $0.30 |
| **Subtotal 3** | | **$2.30** | **$2.10** | **$2.40** | **$3.10** |
| 14.0 | Dredging Method | $6.80 | $6.00 | $6.80 | $5.80 |
| **Subtotal 4** | | **$9.10** | **$8.10** | **$9.20** | **$8.90** |
| 15.0 | Contingency (25% of subtotal 4)[7] | $2.30 | $2.00 | $2.30 | $2.20 |
| **Relative unit costs ($/CY)** | | **$11.40** | **$10.10** | **$11.50** | **$11.10** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks
**Checked by:** Fernando Camargo

Notes:

1. This table provides a refinement of the agricultural field improvement option preliminary costs presented in Section 6.0 and Table H-1 of the THSMUP. Only cost element categories that are applicable to the agricultural field improvement option are presented in this table.
2. Detailed assumptions for each option and major cost elements are presented in Section 3.0.
3. Cost elements are reported as $/CY in 2012 dollars (unless otherwise noted) and are rounded to the nearest $0.10. Costs per CY assume each option would accommodate 10.5 M CY.
4. Unit cost calculations are included in Tables B-1 through B-4.
5. Cost for mobilization and demobilization was assumed to be 8% of all construction costs, not including the baseline dredging cost.
6. Planning, engineering, and design (PED) was assumed to be 10% of all additional costs implemented to the baseline dredge cost, including the mobilization and demobilization.
7. A contingency was assumed to be 25% of all costs, including the baseline dredge cost. The contingency is related to additional project requirements and associated costs that were not determined during this preliminary evaluation. These requirements and associated costs will be included in a detailed design.

## 3.7 Conceptual Phasing for Implementation

The actual volume of dredged material is unknown and assumptions were made based on historical data and projected consolidation rates to determine the required capacity. In order to project actual consolidation rates, additional sample collection and testing will be required. The current volume assumed is based on cut CY, which are inclusive of the buoyant forces acting on the sediment prior to removal from the lake. Once the sediment is removed from the lake, the water is removed and the overall volume is reduced. For other the agricultural field improvements option, additional consolidation will occur and the overall volume will be reduced further when the sediment is placed into the containment area. It was assumed that an estimated 60% volume reduction will occur after dewatering and evapotranspiration. An evaluation of the projected consolidation should be completed prior to the design and to help determine the final option or combination of options.

The agricultural field improvement option would most likely need to be implemented in a phased approach. As discussed above, the average site is 150 acres, and based on an average minimum fill of four feet, it can manage approximately 1.4M cut CY of dredged material. Each site will be comprised of four cells where each cell would receive approximately 350,000 cut CY of dredged material per year. The cells will be constructed of clay or on-site material and be of sufficient construction to contain the dredge material and water slurry. It will take approximately four years to fill the entire site. Each site is subdivided into four cells to allow the property owner, or lessor, to use the undisturbed areas while filling operations are being completed in the constructed cell. Costs associated with the containment structures are identified by Item 2.0 of Tables B-1 through B-4, provided in Appendix B.

The following is a conceptual phasing for a typical 150-acre site:

- Year 1: construct Cell 1 (1/4 of the total site) and fill with dredged material; continue farming the remaining 3/4 of the site.
- Year 2: construct Cell 2 (1/4 of the total site) and fill with dredged material; dewater and plant land cover crop in Cell 1; continue farming the remaining 1/2 of the site.
- Year 3: construct Cell 3 (1/4 of the total site) and fill with dredged material; dewater and plant land cover crop in Cell 2; till Cell 1; continue farming the remaining 1/4 of the site.

- Year 4: construct Cell 4 (1/4 of the total site) and fill with dredged material; dewater and plant land cover crop in Cell 3; till Cell 2; begin farming Cell 1.
- Year 5: dewater and plant land cover crop in Cell 4; till Cell 3; begin farming Cell 2 and continue farming Cell 1.
- Year 6: till Cell 4; begin farming Cell 3 and continue farming Cells 1 and 2.
- Year 7: begin farming Cell 4 and continue farming Cells 1, 2, and 3.

Depending on the site's physical characteristics and the agreement with the property owner, subsequent layers may be applied to the field in a similar phasing plan raising the improvement height above four feet. The increase in height would improve the drainage in the agricultural field and allow the owner to access the areas earlier than the previous elevations did. Planting the field earlier would be of great benefit to allow the crops to take advantage of the spring rain and advance the growth prior to the typically drier conditions encountered during the summer. The agricultural field improvement option will reduce re-suspension of sediments and long-term nutrient loadings to surface water and will complement the 4R Nutrient Stewardship initiative, which encourages farmers to adopt production guidelines that decrease the impact of agricultural nutrients (primarily dissolved phosphorus) entering streams and water resources. The 4R Nutrient Stewardship concept promotes using the right fertilizer source, at the right rate, at the right time, with the right placement (Fertilizer Institute, 2012).

# 4.0 SUMMARY AND NEXT STEPS

The THSMUP identifies and prioritizes practicable, implementable, economically sound, and environmentally acceptable options, which could be implemented by federal, state, municipal, and private entities that must dredge areas of the Toledo Harbor to maintain safe conditions for marine commerce, recreational navigation, and other purposes.

The agricultural field improvement option was one of several options ranked and prioritized through a comparative scoring analysis, which focused on general physical attributes, logistics, geographic attributes, historic and projected dredging volumes, habitat areas, initial cost estimates, and stakeholder input on the relative importance of six major categories of technical criteria. These criteria included feasibility, ecological benefits/effects, environmental benefits/effects, human benefits/effects, economic benefits/effects, and implementation cost. The goal of the comparative scoring analysis was to complete a fair, equitable evaluation of options that can be very dissimilar in both overall design goal and implementation.

The next steps for this option include the following:

1. Pilot study – perform a pilot study to demonstrate the suitability of the agricultural field improvement option as a viable sediment management and use option for Toledo Harbor dredged material; and

2. Contact potential site property owners and secure legal agreements; determine sequencing plan for the sites.

If Steps 1 and 2 are successful, the steps below would be completed. Note that these steps can be performed concurrently for different sites if dredging operations allow.

3. Permitting/easements and design of the infrastructure – pumping and pipeline system for Site 1;

4. Permitting and design of Site 1 – containment dikes, inlet/outlet structures, drainage tiles, and structural controls;

5. Bid, contract, and construction activities for Steps 3 and 4 above;

6. Begin filling Site 1; and

7. Follow Steps 3 through 6 above for next site in the sequencing plan and so forth.

Potential locations for the implementation of a pilot agricultural field improvement project include the City of Toledo-owned and Port-owned parcels, as well as other readily available plots along the Maumee River and Bay. A small-scale project using methods similar to that described in Section 3 could be implemented on a relatively small parcel (less than 10 acres) to demonstrate the feasibility and implementability of this option. Figure 1 shows a conceptual layout for a pilot agricultural field improvement project. Several cells could be used to test various conditions and methods. For example, different cells could be used to place material at varying depths to test factors such as dewatering time, soil structure, and crop success. Potential amendments (e.g. lime to adjust pH) could be added during this time to allow sufficient time for the soil to assimilate. Additionally, the pilot project could include local universities to incorporate edge of field studies related to nutrient runoff and best management practices.

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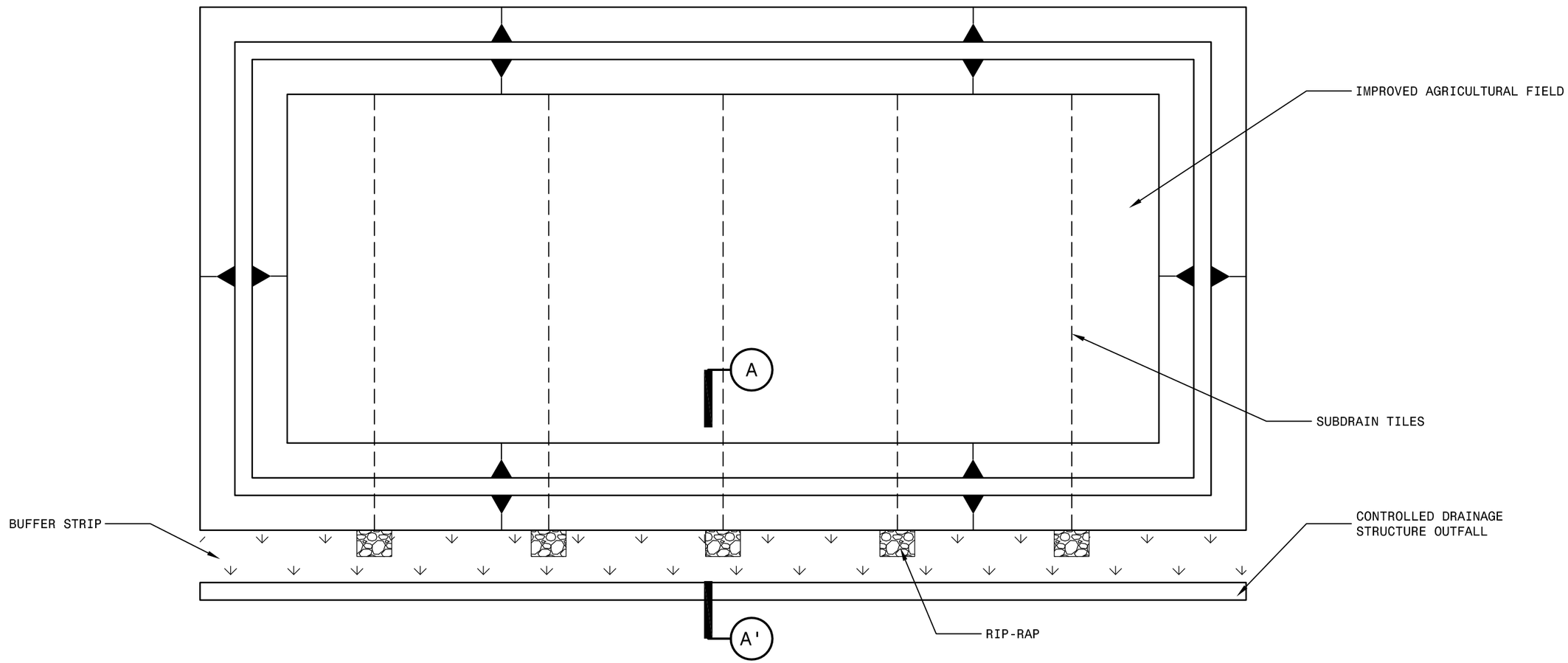
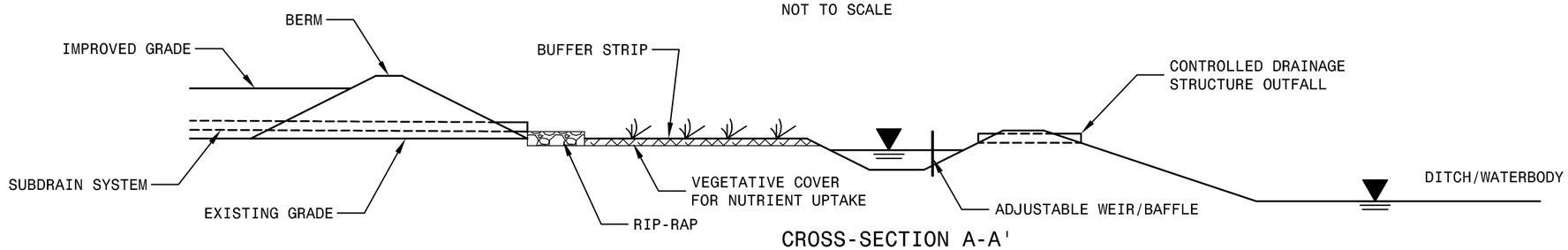



PLAN

NOT TO SCALE




CROSS-SECTION A-A'

NOT TO SCALE

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GREAT LAKES RESTORATION INITIATIVE PROJECT
EPA GRANT #GL-00E00523-0
TOLEDO-LUCAS COUNTY PORT AUTHORITY AND THE OHIO LAKE ERIE COMMISSION

FIGURE 2

CONCEPTUAL PLAN AND CROSS-SECTION FOR AGRICULTURAL FIELD IMPROVEMENT OPTION

MAUMEE RIVER/LAKE ERIE, OHIO

| | |
|---|---|
| PROJECT NO.: TPA044 | SUBMITTAL DATE: DECEMBER 2012 |
| CAD DWG FILE: TPA044.100.0012 | PLOT DATE: 12/3/12 |

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The physical characteristics of the dredged material are similar to naturally productive, fine textured agricultural soils in northwest Ohio. With the construction of proper engineered controls to facilitate dewatering and proper handling, tillage, and fertility treatments, the dredged material can develop into a productive agricultural soil.

Concentrations reported for some metals and organics in sediments collected from several areas of the Federal channel are somewhat elevated compared to other areas of the channel and to background values for terrestrial soils in the area. Although no consistent regulatory criteria exists for determining the significance of metal and organic concentrations in soils used to grow plants for direct human or animal consumption, releases of metals should be minimized given that weakly acidic soils are developed and maintained using buffering agents such as lime as necessary. The dredged material's organic content will be beneficial to interim retention and in-situ biologic degradation of residual organics and will develop a microbial community capable of anaerobic degradation of organic compounds. Additional research into specific plant uptake of metals and organics might be evaluated prior to implementation at a specific site and using dredged material from a specific reach of the channel.

Prior to land application of dredged material, it is expected that property owners would require a demonstration that the dredged material are as follows:

- Contaminants that might be present do not pose an unacceptable risk to human health and the environment;
- Nutrients and texture is compatible with current field conditions;
- Traditional farming practices and equipment can be employed after material is land-applied and returned to the farmer;
- Level of effort for maintenance of ditches, tiles, and structural controls.

The agricultural field improvement option is a viable, cost-effective sediment management and use option for material dredged from Toledo Harbor. A pilot project of this option could serve as a model for beneficial use of dredged materials on agricultural fields and demonstrate the implementability of a full-scale project.

# 5.0 REFERENCES

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# APPENDIX A

Summary of East Harbor State Park Upland Placement of
Dredged Material Site Visit Memorandum

Hull & associates, inc.

3401 Glendale Avenue, Suite 300 ◆ Toledo, Ohio 43614 ◆ (419) 385-2018 ◆ (419) 385-5487 fax

# Memorandum

TO: John Hull, P.E.

FROM: Philip A. Hicks, P.E. and Kristin Gardner, Hull & Associates, Inc.

DATE: November 15, 2012

RE: Summary of East Harbor State Park Upland Placement of Dredged Material Site Visit; OLE001.100.0003

---

Introduction

This memorandum has been prepared to provide a summary of the current practice and management of the upland dredge material relocation area (DMRA) being implemented at East Harbor State Park, located in Lakeside-Marblehead, in Ottawa County, Ohio. The park is comprised of three sections: West Harbor, Middle Harbor, and East Harbor. Several marinas are located within the East Harbor portion of the park and periodic dredging is required to maintain access to Lake Erie. Ohio Department of Natural Resources (ODNR) Division of Parks and Recreation is funding and managing the dredging of portions of East Harbor and the placement of dredged materials on an upland farm field, which is approximately 30 acres of flat agricultural land. ODNR Division of Parks and Recreation has designed the current dredging and placement process, coordinated permitting associated with the project, and is managing the implementation of the project. This memorandum documents discussions regarding the placement of dredged material at East Harbor State Park during a site visit conducted on November 13, 2012 by ODNR and Hull & Associates, Inc. The dredging and upland placement locations and layout of the DMRA are included in Attachment A. Photographs 1-14, included in Attachment B, were taken during the site visit and illustrate major components of the implementation of the project.

Site Description and Project Overview

East Harbor is approximately 800 acres and has an average depth of 5 to 6 feet. In order to provide adequate access for recreational boaters, a 100 foot channel is being hydraulically dredged an additional 4 feet, to a total channel depth of approximately 9 feet. The hydraulically dredged material is transported through a pipeline and booster pump system to the DMRA. The project is estimated to take 4 to 5 years and will place approximately 224,000 cubic yards (CY) of dredged material into the DMRA.

The dredged material consists mainly of silts and clays with isolated areas having higher percentages of sand. These sandier areas are not being used for beach nourishment due to the impracticality of separating and transporting this relatively small volume separately from the rest of the material being placed into the DMRA. Prior to implementation, two soil samples from the DMRA and five sediment samples from the harbor were collected and analyzed for a suite of parameters (e.g. polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs),

metals) to ensure the material was appropriate for the end-use and also to establish baseline conditions. Sediment results were evaluated based on available sediment quality guidelines.

ODNR coordinated Section 401 and 404 permitting with the U.S. Army Corps of Engineers (USACE), Buffalo District. ODNR also completed additional coordination with the Ohio EPA, Ohio Historical Preservation Office and U.S. Fish and Wildlife Service was completed, including a Phase I archaeological survey and an endangered species evaluation. This project was authorized under a Nationwide 16 permit, which allows for the release of return water into East Harbor from the upland dredge material placement location. The permit specifies that no in-water work can take place from April 15th and June 30th to reduce impacts to fish spawning, nursing, and feeding. Since the issuance of the permit, ODNR was granted a waiver to allow dredging during the environmental window. This will allow ODNR to reduce costs and compress the schedule duration.

Dredging Operations

A 475 horsepower (HP) hydraulic suction dredge with a 12 inch by 10 inch pump excavates the dredged material and transports it approximately 3,500 feet through a temporary 12-inch high-density polyethylene (HDPE) pipeline to an upland booster pump (Photos 1 and 2). The pipeline is marked with orange buoys every 100-200 feet and floats in the water at East Harbor. The upland booster pump is a 12-inch slurry pump driven by a 425 HP diesel engine. The booster pump transports the material through a 12-inch HDPE pipeline overland to the DMRA, which is located approximately 4,000 feet inland (Photos 3 and 4). Although ODNR believes the pipeline is designed and operated to avoid leakage, a portion of the pipeline is encased in a 16-inch metal casing and buried approximately one foot below ground surface to accommodate one property owner's concerns.

The DMRA is designed as four separate cells. Each cell is contained by dikes, approximately 9.5 feet in height. The dikes are designed in accordance with the Ohio Revised Code Section 1521.06 Construction permits for dams or levees required – exceptions. A dam is defined by a certain height, width, and/or storage capacity behind an embankment. If a design does not meet the exceptions, the regulations and permit requirements may increase due to safety concerns (e.g. flooding and potential loss of life, etc.) associated with the volume of water stored behind a dam. Dike/dam heights are measured from the lowest ground elevation at the outside limit of the dike/dam to the top of the dike/dam. A "bowl" was excavated within the cell to hold more dredged material, and the material excavated from the "bowl" was used to build the dikes. Each single cell will be filled to capacity prior to discharging dredged material to the next cell (Photos 5-9). The filled cell must be breached prior to placing dredged material, in order to eliminate the cells capability of having a water storage capacity. Since the cells share a common dike, if one cell is not breached, the combined storage capacity would classify the dikes as a dam. It is expected that material in the first cell will consolidate while material is being placed in the following cells, potentially allowing additional material to be placed into the first cell. The consolidation of the material was not included in the original design capacity.

Water within the cell flows through a silt curtain to an adjustable box weir, which is used to control the discharge of water runoff within each cell (Photos 10 and 11). Water within each cell is discharged through the box weir to a perimeter ditch containing check/filter dams (Photos 12-14). This perimeter ditch discharges to the existing open ditch that eventually discharges water back into East Harbor. Maintenance of the ditches may be required over the project duration.

Right of entry was required where the pipeline crossed private properties and roads. ODNR leased rights to two properties and was provided free passage through one property. Since the 12-inch HDPE pipeline needed to cross State Route 163, ODNR worked with Ohio Department

of Transportation (ODOT) to install the pipeline under the road. ODOT assisted in the installation of the pipeline to ensure the pipeline did not adversely affect the stability of the road,

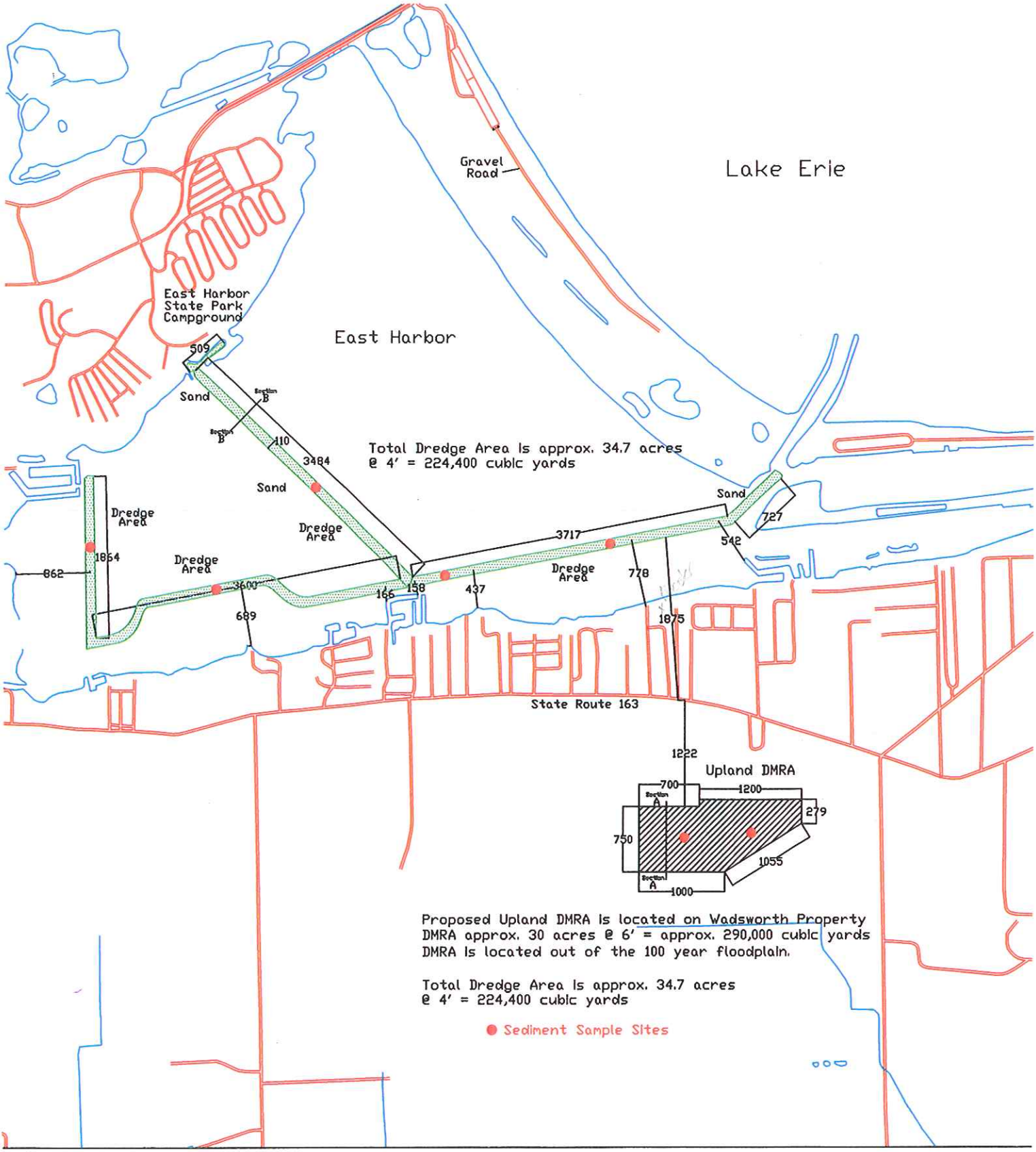
ODNR and the DMRA landowner have a contractual agreement which specifies that the property be returned at a specific elevation at the completion of the project. This might require re-grading of the site after final placement to achieve the specified elevations. The end use of the property is unknown, but could include agricultural use, future development, or mining for sale of topsoil/fill. At project completion, ODNR will remove the booster pump and pipeline and coordinate with State and federal agencies as necessary during removal activities.

Current Status and Summary

The first and second cells of the DMRA have been constructed, and ODNR is currently dredging and placing material into the first cell. Approximately 60,000 CY has been dredged, with plans to dredge around 250,000 CY in the next 4 years. Areas of the first cell where material was placed last year have recently become vegetated with dense stands of phragmites. ODNR staff indicated that the plant growth started within the last few months. While ODNR staff hope that final grading of the site will address the phragmites growth, no invasive species management plan exists for the DMRA.

If projects similar to the East Harbor project were implemented, ODNR recommends that the public be kept informed on project activities. For example, ODNR invited the public to watch the dredging and board the dredging vessel during East Harbor project activities. ODNR also recommended that site access controls be established to minimize potential trespassers and public safety concerns.

# ATTACHMENT A



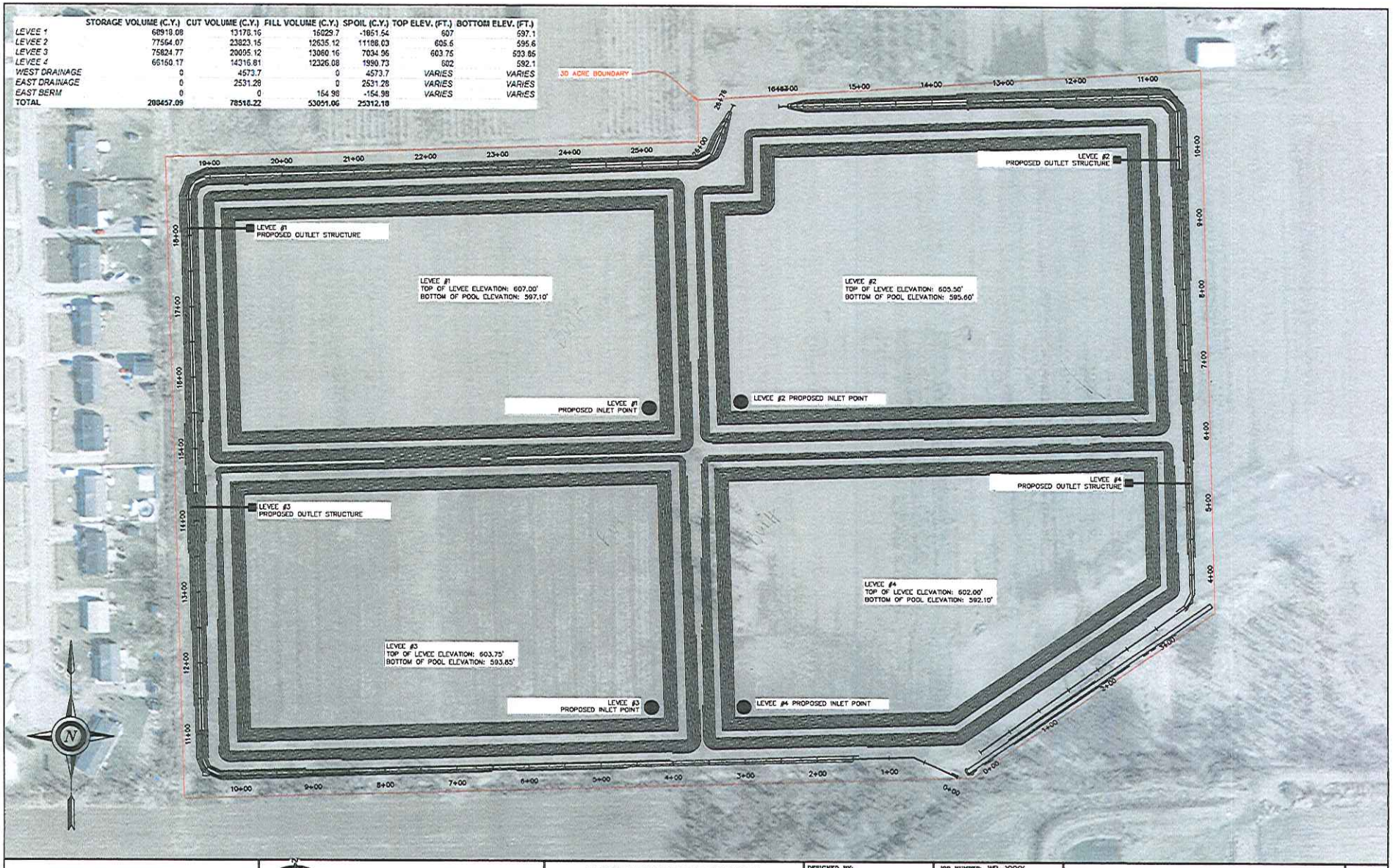

C o Department of Natural Resources
Division of Parks and Recreation

Scale:1"= 1500'

NORTH

Proposed Activity: Maintenance Dredge
Waterway: East Harbor State Park
Address: 1169 N. Buck Rd., Lakeside-
County: Ottawa. Marblehead, Oh 43440
Date: January 2009

| | STORAGE VOLUME (C.Y.) | CUT VOLUME (C.Y.) | FILL VOLUME (C.Y.) | SPOIL (C.Y.) | TOP ELEV. (FT.) | BOTTOM ELEV. (FT.) |
|---|---|---|---|---|---|---|
| LEVEE 1 | 60918.08 | 13178.16 | 15029.7 | -1851.54 | 607 | 597.1 |
| LEVEE 2 | 77564.07 | 23823.15 | 12635.12 | 11188.03 | 605.6 | 595.6 |
| LEVEE 3 | 75824.77 | 20095.12 | 13060.16 | 7034.96 | 603.75 | 593.85 |
| LEVEE 4 | 66150.17 | 14316.81 | 12326.08 | 1990.73 | 602 | 592.1 |
| WEST DRAINAGE | 0 | 4573.7 | 0 | 4573.7 | VARIES | VARIES |
| EAST DRAINAGE | 0 | 2531.28 | 0 | 2531.28 | VARIES | VARIES |
| EAST BERM | 0 | 0 | 154.98 | -154.98 | VARIES | VARIES |
| TOTAL | 280457.09 | 78518.22 | 53051.06 | 25312.18 | | |




ENGINEERING
Ohio Department of Natural Resources

**EAST HARBOR DMRA**
**OTTAWA COUNTY**

| | | | |
|---|---|---|---|
| DESIGNED BY: | | JOB NUMBER: | WR-XXXX |
| DRAWN BY: | | SCALE: | 1"=120' (11X17) |
| CHECKED BY: | | DATE: | 10/04/2010 |
| APPROVED BY: | | REVISED: | DD/MM/YYYY |

**DMRA SITE PLAN**

1/4

# ATTACHMENT B

PHOTO 1: Material is hydraulically dredged from the channel and travels through a 12-inch HDPE pipeline (far right).

PHOTO 2: Dredged material travels through the pipeline and booster pump.

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East Harbor State Park
Upland Placement of Dredged Material

Site Photographs

Middle Harbor and Upland Placement Site
Ottawa County, Ohio

Date:
November 2012

Project Number: OLE001
File Name:
OLE001.100.0002.XLS

PHOTO 3: Dredged material travels south through the pipeline toward the upland placement area. While the pipeline is designed to avoid leakage, a portion of the pipeline is encased and buried to address one landowner's concerns.

PHOTO 4: 12-inch HDPE pipeline traveling south to the upland placement area.

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PHOTO 5: Dredged material is pumped into a cell of the dredged material relocation area.

PHOTO 6: Empty constructed cell and dike of the dredged material relocation area.

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PHOTO 7: Cell currently being filled at the dredged material relocation area.

PHOTO 8: Dredged material was placed in this portion of the cell last year and became vegetated within the last few months.

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PHOTO 9: Water depths vary in the cell currently being used to place dredged material.

PHOTO 10: A silt curtain reduces the flow of water and quantity of sediment in the water before it enters a box weir .

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Ottawa County, Ohio

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PHOTO 11: A box weir is used to control discharge of water from the cell into the perimeter ditch.

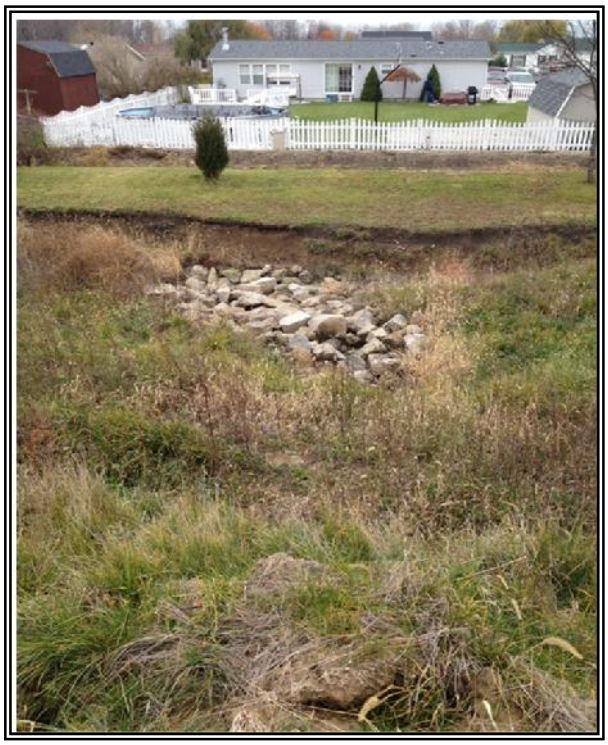

PHOTO 12: Water discharges from the outlet structure through erosion protection (rip-rap) prior to entering the perimeter ditch.

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East Harbor State Park
Upland Placement of Dredged Material

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Middle Harbor and Upland Placement Site
Ottawa County, Ohio

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November 2012

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PHOTO 13: Perimeter ditch along the dredged material relocation area.

PHOTO 14: The perimeter ditch contains check/filter dams to reduce turbidity.

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Upland Placement of Dredged Material

Site Photographs

Middle Harbor and Upland Placement Site
Ottawa County, Ohio

Date:
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Project Number: OLE001
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OLE001.100.0002.XLS

# APPENDIX B

Refined Cost Estimates for Agricultural Field Improvement Option
Using Different Sized Hydraulic Dredges

**REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE B-1**

**REFINED UNIT COST CALCULATIONS FOR THE AGRICULTURAL FIELD IMPROVEMENT OPTION USING A 16" HYDRAULIC DREDGE[1]**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)[2]** | | | | | | | | | |
| 2.1 | Interior - Berms / Containment Structures[3] | 5,000 | LF | 1.2 | CY/LF | 6,000 | CY | $10 | $60,000 | $0.04 |
| 2.2 | Exterior - Berms / Containment Structures[4] | 10,000 | LF | 2.4 | CY/LF | 24,000 | CY | $10 | $240,000 | $0.17 |
| | | | | | | | | **Subtotal Cost per Site[22]** | **$300,000** | **$0.20** |
| | | | | | | | | | x 7.5 Sites | |
| | | | | | | | | **Subtotal - 2.0 Containment Structure (Dike)** | **$2,250,000** | **$0.20** |
| **5.0** | **Habitat/site development[5]** | | | | | | | | | |
| 5.1 | Drain Tiles[6] | 135 | AC | 872 | LF/AC | 117,720 | LF | $3 | $353,160 | $0.25 |
| 5.2 | Secondary Controls[7] | 1 | SITE | 15 | AC/SITE | 15 | AC | $6,075 | $91,125 | $0.07 |
| 5.3 | Misc. Improvements / Access[8] | 1 | SITE | 1,200 | LF/SITE | 1,200 | LF | $22 | $26,400 | $0.02 |
| 5.4 | Pump Operations (electric)[9] | 2900 | HR | 930 | KW | 2,697,000 | KWH | $0.15 | $404,550 | $0.29 |
| 5.5 | Above Grade HDPE Pipe[10] | 1 | SITE | 1,200 | LF/SITE | 1,200 | LF | $50 | $60,000 | $0.04 |
| 5.6 | Management/placement/pumping[11] | 2900 | HR | 3 | MEN | 8,700 | MH | $50 | $435,000 | $0.31 |
| 5.7 | Land Rental[12] | 150 | AC | 3 | YR | 450 | AC-YR | $300 | $135,000 | $0.10 |
| 5.8 | Land Cover (alfalfa)[13] | 135 | AC/SITE | 1 | SITE | 135 | AC | $100 | $13,500 | $0.01 |
| | | | | | | | | **Subtotal Cost per Site[22]** | **$1,518,735** | **$1.10** |
| | | | | | | | | | x 7.5 Sites | |
| | | | | | | | | **Subtotal - 5.0 Habitat/Site Development** | **$11,390,513** | **$1.10** |
| **7.0** | **Conveyance system[14]** | | | | | | | | | |
| 7.1 | Booster Pump Facility[15] | 3 | EA/LOCATION | 2 | LOCATION | 6 | EA | $25,000 | $150,000 | $0.01 |
| 7.2 | Pump Cost[16] | 3 | EA/LOCATION | 2 | LOCATION | 6 | EA | $225,000 | $1,350,000 | $0.13 |
| 7.3 | Dredging for Pipeline[17] | 1 | CY/LF | 10,000 | LF | 10,000 | CY | $15 | $150,000 | $0.01 |
| 7.4 | In Water HDPE Pipe[18] | 1 | EA | 10,000 | LF/EA | 10,000 | LF | $180 | $1,800,000 | $0.17 |
| 7.5 | Below Grade HDPE Pipe[19] | 7 | MI | 5,280 | LF/MI | 36,960 | LF | $60 | $2,217,600 | $0.21 |
| 7.6 | Easement Cost[20] | 7 | MI | 3.6 | AC/MI | 25 | AC | $6,000 | $152,727 | $0.01 |
| | | | | | | | | **Subtotal - 7.0 Conveyance system** | **$5,820,327** | **$0.60** |
| **14.0** | **Dredging operation** | | | | | | | | | |
| 14.1 | 16" Cutter-Suction Dredge[21] | 350,000 | CY/YR | 30 | YR | 10,500,000 | CY | $6.75 | $70,875,000 | $6.75 |
| | | | | | | | | **Subtotal - 14.0 Dredging Operation** | **$70,875,000** | **$6.80** |
| | | | | | | | | **Total** | **$90,335,840** | **$8.70** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

1. This table provides a refinement of the agricultural field improvement option preliminary costs presented in Section 6.0 and Tables H-4 and H-5 of the THSMUP. Only cost element categories that are applicable to the agricultural field improvement option are presented in this table. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10.
2. The containment structure (dike) items are based on one site that has a capacity of 1,400,000 cut cubic yards of dredged material.
3. This item is based on an interior berm used to divide a 150-acre site in four cells. The volume is determined by the length, width and height of four feet.
4. This item is based on a square 150-acre site consisting of a perimeter containment berm with a volume determined by the perimeter length and height of five feet.
5. The habitat/site development sub-items are based on one site with a capacity of 1,400,000 cut cubic yards of dredged material.
6. This item includes a 4"-6" drain tile installed approximately 12" deep with a collection header discharging to an existing drainage ditch.
7. This item includes the cost to install a 50-foot wide buffer strip and a controlled drainage system with outfall.
8. This item includes the cost to develop an access point to the placement area for labor and maintenance crews, which consists of a 15' x 1,000' aggregate base access road, culvert and security gate.
9. This item is based on typical local electrical rates to operate the booster pumps with minimal labor effort at a rate of 465 KW/HR (each) at an approximate dredging rate of 480 CY/HR.
10. This item includes a 16" HDPE SDR 11 pipe required to transfer material throughout the 150-acre placement area at a distance of 1,200 feet or half of the overall length.
11. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 480 CY/HR.
12. This item includes the cost to rent the land at a local agricultural land value of $300 per acre per year during, an improvement period of three years.
13. This item includes the cost to plant a cover crop one time to establish vegetation and introduce organics into the new soil.
14. The conveyance system sub-items are based on the management of 10,500,000 cut CY of dredged material.
15. This item includes the cost to install and maintain a 20' x 15' booster pump facility with utility service at two locations for protection, maintenance and noise reduction.
16. This item includes the cost to purchase and maintain two 465 kW (625 HP) booster pumps that will transport the dredged material from the in-water discharge line to the placement area.
17. This item includes the cost to dredge below the lake bottom to install the discharge pipe in an area within 2,000 feet of the federal channel to the discharge point on land, at an average rate of $15/CY to dredge and place the material.
18. This item includes installation of a 16" SDR 11 HDPE pipe at an increased cost due to working in and/or below water, in an area within 2,000 feet of the federal channel to the discharge point on land.
19. This item includes the 16" SDR 11 HDPE pipe required to transfer the dredged material from the in-water discharge line to the placement area, at a distance of 7 miles of pipe for two or three potential sites to accommodate the overall area required.
20. This item includes the cost to purchase easement property 30 feet wide by the length of the below grade discharge line (7 miles) at a local land value of $6,000 per acre.
21. This item is based on typical operation and production of a 16" cutter-suction hydraulic dredge at an average depth of four feet and rate of 480 CY/HR.
22. A site is a 150-acre parcel with 135 acres of land available for material placement due to containment dikes and other infrastructure items in the perimeter of the parcel. To accommodate 10.5 million CY of material, 7.5 sites will be required.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE B-2**

**REFINED UNIT COST CALCULATIONS FOR THE AGRICULTURAL FIELD IMPROVEMENT OPTION USING A 18" HYDRAULIC DREDGE[1]**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment structure (dike)[2]** | | | | | | | | | |
| 2.1 | Interior - Berms / Containment Structures[3] | 5,000 | LF | 1.2 | CY/LF | 6,000 | CY | $10 | $60,000 | $0.04 |
| 2.2 | Exterior - Berms / Containment Structures[4] | 10,000 | LF | 2.4 | CY/LF | 24,000 | CY | $10 | $240,000 | $0.17 |
| | | | | | | | | **Subtotal Cost per Site[22]** | **$300,000** | **$0.20** |
| | | | | | | | | | x 7.5 Sites | |
| | | | | | | | | **Subtotal - 2.0 Containment Structure (Dike)** | **$2,250,000** | **$0.20** |
| **5.0** | **Habitat/site development[5]** | | | | | | | | | |
| 5.1 | Drain Tiles[6] | 135 | AC | 872 | LF/AC | 117,720 | LF | $3 | $353,160 | $0.25 |
| 5.2 | Secondary Controls[7] | 1 | SITE | 15 | AC/SITE | 15 | AC | $6,075 | $91,125 | $0.07 |
| 5.3 | Misc. Improvements / Access[8] | 1 | SITE | 1,200 | LF/SITE | 1,200 | LF | $22 | $26,400 | $0.02 |
| 5.4 | Pump Operations (electric)[9] | 1800 | HR | 1,100 | KW | 1,980,000 | KWH | $0.15 | $297,000 | $0.21 |
| 5.5 | Above Grade HDPE Pipe[10] | 1 | SITE | 1,200 | LF/SITE | 1,200 | LF | $65 | $78,000 | $0.06 |
| 5.6 | Management/placement/pumping[11] | 1800 | HR | 3 | MEN | 5,400 | MH | $50 | $270,000 | $0.19 |
| 5.7 | Land Rental[12] | 150 | AC | 3 | YR | 450 | AC-YR | $300 | $135,000 | $0.10 |
| 5.8 | Land Cover (alfalfa)[13] | 135 | AC/SITE | 1 | SITE | 135 | AC | $100 | $13,500 | $0.01 |
| | | | | | | | | **Subtotal Cost per Site[22]** | **$1,264,185** | **$0.90** |
| | | | | | | | | | x 7.5 Sites | |
| | | | | | | | | **Subtotal - 5.0 Habitat/site development** | **$9,481,388** | **$0.90** |
| **7.0** | **Conveyance system[14]** | | | | | | | | | |
| 7.1 | Booster Pump Facility[15] | 3 | EA/LOCATION | 2 | LOCATION | 6 | EA | $25,000 | $150,000 | $0.01 |
| 7.2 | Pump Cost[16] | 3 | EA/LOCATION | 2 | LOCATION | 6 | EA | $250,000 | $1,500,000 | $0.14 |
| 7.3 | Dredging for Pipeline[17] | 1 | CY/LF | 10,000 | LF | 10,000 | CY | $15 | $150,000 | $0.01 |
| 7.4 | In Water HDPE Pipe[18] | 1 | EA | 10,000 | LF/EA | 10,000 | LF | $225 | $2,250,000 | $0.21 |
| 7.5 | Below Grade HDPE Pipe[19] | 7 | MI | 5,280 | LF/MI | 36,960 | LF | $75 | $2,772,000 | $0.26 |
| 7.6 | Easement Cost[20] | 7 | MI | 3.6 | AC/MI | 25 | AC | $6,000 | $151,200 | $0.01 |
| | | | | | | | | **Subtotal - 7.0 Conveyance system** | **$6,973,200** | **$0.70** |
| **14.0** | **Dredging operation** | | | | | | | | | |
| 14.1 | 18" Cutter-Suction Dredge[21] | 350,000 | CY/YR | 30 | YR | 10,500,000 | CY | $6.00 | $63,000,000 | $6.00 |
| | | | | | | | | **Subtotal - 14.0 Dredging Operation** | **$63,000,000** | **$6.00** |
| | | | | | | | | **Total** | **$81,704,588** | **$7.80** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

1. This table provides a refinement of the agricultural field improvement option preliminary costs presented in Section 6.0 and Tables H-4 and H-5 of the THSMUP. Only cost element categories that are applicable to the agricultural field improvement option are presented in this table. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10.
2. The containment structure (dike) items are based on one site that has a capacity of 1,400,000 cut cubic yards of dredged material.
3. This item is based on an interior berm used to divide a 150-acre site in four cells. The volume is determined by the length, width and height of four feet.
4. This item is based on a square 150-acre site consisting of a perimeter containment berm with a volume determined by the perimeter length and height of five feet.
5. The habitat/site development sub-items are based on one site with a capacity of 1,400,000 cut cubic yards of dredged material.
6. This item includes a 4"-6" drain tile installed approximately 12" deep with a collection header discharging to an existing drainage ditch.
7. This item includes the cost to install a 50-foot wide buffer strip and a controlled drainage system with outfall.
8. This item includes the cost to develop an access point to the placement area for labor and maintenance crews, which consists of a 15' x 1,000' aggregate base access road, culvert and security gate.
9. This item is based on typical local electrical rates to operate the booster pumps with minimal labor effort at a rate of 550 KW/HR (each) at an approximate dredging rate of 780 CY/HR.
10. This item includes a 18" HDPE SDR 11 pipe required to transfer material throughout the 150-acre placement area at, a distance of 1,200 feet or half of the overall length.
11. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 780 CY/HR.
12. This item includes the cost to rent the land at a local agricultural land value of $300 per acre per year during, an improvement period of three years.
13. This item includes the cost to plant a cover crop one time to establish vegetation and introduce organics into the new soil.
14. The conveyance system sub-items are based on the management of 10,500,000 cut CY of dredged material.
15. This item includes the cost to install and maintain a 20' x 15' booster pump facility with utility service at two locations for protection, maintenance and noise reduction.
16. This item includes the cost to purchase and maintain two 550 kW (735 HP) booster pumps that will transport the dredged material from the in-water discharge line to the placement area.
17. This item includes the cost to dredge below the lake bottom to install the discharge pipe in an area within 2,000 feet of the federal channel to the discharge point on land, at an average rate of $15/CY to dredge and place the material.
18. This item includes installation of a 18" SDR 11 HDPE pipe at an increased cost due to working in and/or below water, in an area within 2,000 feet of the federal channel to the discharge point on land.
19. This item includes the 18" SDR11 HDPE pipe required to transfer the dredged material from the in-water discharge line to the placement area, at a distance of 7 miles of pipe for two or three potential sites to accommodate the overall area required.
20. This item includes the cost to purchase easement property 30 feet wide by the length of the below grade discharge line (7 miles) at a local land value of $6,000 per acre.
21. This item is based on typical operation and production of a 18" cutter-suction hydraulic dredge at an average depth of four feet and rate of 780 CY/HR.
22. A site is a 150-acre parcel with 135 acres of land available for material placement due to containment dikes and other infrastructure items in the perimeter of the parcel. To accommodate 10.5 million CY of material, 7.5 sites will be required.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE B-3**

**REFINED UNIT COST CALCULATIONS FOR THE AGRICULTURAL FIELD IMPROVEMENT OPTION USING A 24" HYDRAULIC DREDGE[1]**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment Structure (Dike)[2]** | | | | | | | | | |
| 2.1 | Interior - Berms / Containment Structures[3] | 5,000 | LF | 1.2 | CY/LF | 6,000 | CY | $10 | $60,000 | $0.04 |
| 2.2 | Exterior - Berms / Containment Structures[4] | 10,000 | LF | 2.4 | CY/LF | 24,000 | CY | $10 | $240,000 | $0.17 |
| | | | | | | | | **Subtotal Cost per Site[22]** | **$300,000** | **$0.20** |
| | | | | | | | | | x 7.5 Sites | |
| | | | | | | | | **Subtotal - 2.0 Containment Structure (Dike)** | **$2,250,000** | **$0.20** |
| **5.0** | **Habitat/Site Development[5]** | | | | | | | | | |
| 5.1 | Drain Tiles[6] | 135 | AC | 872 | LF/AC | 117,720 | LF | $3 | $353,160 | $0.25 |
| 5.2 | Secondary Controls[7] | 1 | SITE | 15 | AC/SITE | 15 | AC | $6,075 | $91,125 | $0.07 |
| 5.3 | Misc. Improvements / Access[8] | 1 | SITE | 1,200 | LF/SITE | 1,200 | LF | $22 | $26,400 | $0.02 |
| 5.4 | Pump Operations (electric)[9] | 1320 | HR | 1,280 | KW | 1,689,600 | KWH | $0.15 | $253,440 | $0.18 |
| 5.5 | Above Grade HDPE Pipe[10] | 1 | SITE | 1,200 | LF/SITE | 1,200 | LF | $105 | $126,000 | $0.09 |
| 5.6 | Management/placement/pumping[11] | 1320 | HR | 3 | MEN | 3,960 | MH | $50 | $198,000 | $0.14 |
| 5.7 | Land Rental[12] | 150 | AC | 3 | YR | 450 | AC-YR | $300 | $135,000 | $0.10 |
| 5.8 | Land Cover (alfalfa)[13] | 135 | AC/SITE | 1 | SITE | 135 | AC | $100 | $13,500 | $0.01 |
| | | | | | | | | **Subtotal Cost per Site[22]** | **$1,196,625** | **$0.90** |
| | | | | | | | | | x 7.5 Sites | |
| | | | | | | | | **Subtotal - 5.0 Habitat/Site Development** | **$8,974,688** | **$0.90** |
| **7.0** | **Conveyance System[14]** | | | | | | | | | |
| 7.1 | Booster Pump Facility[15] | 3 | EA/LOCATION | 2 | LOCATION | 6 | EA | $25,000 | $150,000 | $0.01 |
| 7.2 | Pump Cost[16] | 3 | EA/LOCATION | 2 | LOCATION | 6 | EA | $275,000 | $1,650,000 | $0.16 |
| 7.3 | Dredging for Pipeline[17] | 1 | CY/LF | 10,000 | LF | 10,000 | CY | $15 | $150,000 | $0.01 |
| 7.4 | In Water HDPE Pipe[18] | 1 | EA | 10,000 | LF/EA | 10,000 | LF | $345 | $3,450,000 | $0.33 |
| 7.5 | Below Grade HDPE Pipe[19] | 7 | MI | 5,280 | LF/MI | 36,960 | LF | $115 | $4,250,400 | $0.40 |
| 7.6 | Easement Cost[20] | 7 | MI | 3.6 | AC/MI | 25 | AC | $6,000 | $152,727 | $0.01 |
| | | | | | | | | **Subtotal - 7.0 Conveyance System** | **$9,803,127** | **$0.90** |
| **14.0** | **Dredging Operation** | | | | | | | | | |
| 14.1 | 24" Cutter-Suction Dredge[21] | 350,000 | CY/YR | 30 | YR | 10,500,000 | CY | $6.75 | $70,875,000 | $6.75 |
| | | | | | | | | **Subtotal - 14.0 Dredging Operation** | **$70,875,000** | **$6.80** |
| | | | | | | | | **Total** | **$91,902,815** | **$8.80** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

1. This table provides a refinement of the agricultural field improvement option preliminary costs presented in Section 6.0 and Tables H-4 and H-5 of the THSMUP. Only cost element categories that are applicable to the agricultural field improvement option are presented in this table. Subtotal unit cost elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10.
2. The containment structure (dike) items are based on one site that has a capacity of 1,400,000 cut cubic yards of dredged material.
3. This item is based on an interior berm used to divide a 150-acre site in four cells. The volume is determined by the length, width and height of four feet.
4. This item is based on a square 150-acre site consisting of a perimeter containment berm with a volume determined by the perimeter length and height of five feet.
5. The habitat/site development sub-items are based on one site with a capacity of 1,400,000 cut cubic yards of dredged material.
6. This item includes a 4"-6" drain tile installed approximately 12" deep with a collection header discharging to an existing drainage ditch.
7. This item includes the cost to install a 50-foot wide buffer strip and a controlled drainage system with outfall.
8. This item includes the cost to develop an access point to the placement area for labor and maintenance crews, which consists of a 15' x 1,000' aggregate base access road, culvert and security gate.
9. This item is based on typical local electrical rates to operate the booster pumps with minimal labor effort at a rate of 640 KW/HR (each) at an approximate dredging rate of 1,055 CY/HR.
10. This item includes a 24" HDPE SDR 11 pipe required to transfer material throughout the 150-acre placement area at, a distance of 1,200 feet or half of the overall length.
11. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 1,055 CY/HR.
12. This item includes the cost to rent the land at a local agricultural land value of $300 per acre per year during, an improvement period of three years.
13. This item includes the cost to plant a cover crop one time to establish vegetation and introduce organics into the new soil.
14. The conveyance system sub-items are based on the management of 10.5M cut CY of dredged material.
15. This item includes the cost to install and maintain a 20' x 15' booster pump facility with utility service at two locations for protection, maintenance and noise reduction.
16. This item includes the cost to purchase and maintain two 640 kW (860 HP) booster pumps that will transport the dredged material from the in-water discharge line to the placement area.
17. This item includes the cost to dredge below the lake bottom to install the discharge pipe in an area within 2,000 feet of the federal channel to the discharge point on land, at an average rate of $15/CY to dredge and place the material.
18. This item includes installation of a 24" SDR 11 HDPE pipe at an increased cost due to working in and/or below water, in an area within 2,000 feet of the federal channel to the discharge point on land.
19. This item includes the 24" SDR 11 HDPE pipe required to transfer the dredged material from the in-water discharge line to the placement area, at a distance of 7 miles of pipe for two or three potential sites to accommodate the overall area required.
20. This item includes the cost to purchase easement property 30 feet wide by the length of the below grade discharge line (7 miles) at a local land value of $6,000 per acre.
21. This item is based on typical operation and production of a 24" cutter-suction hydraulic dredge at an average depth of four feet and rate of 1,055 CY/HR.
22. A site is a 150-acre parcel with 135 acres of land available for material placement due to containment dikes and other infrastructure items in the perimeter of the parcel. To accommodate 10.5 million CY of material, 7.5 sites will be required.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

**REFINEMENT OF THE AGRICULTURAL FIELD IMPROVEMENT OPTION FOR THE TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN**

**TABLE B-4**

**REFINED UNIT COST CALCULATIONS FOR THE AGRICULTURAL FIELD IMPROVEMENT OPTION USING A MECHANICAL DREDGE AND PUMP-OUT AREA[1]**

| Item # | Description | Quantity per Unit | Unit | Quantity per Unit | Unit | Quantity per Unit | Unit | Unit Cost | Total Cost | Dredging Unit Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.0** | **Containment Structure (Dike)[2]** | | | | | | | | | |
| 2.1 | Interior - Berms / Containment Structures[3] | 5,000 | LF | 1.2 | CY/LF | 6,000 | CY | $10 | $60,000 | $0.04 |
| 2.2 | Exterior - Berms / Containment Structures[4] | 10,000 | LF | 2.4 | CY/LF | 24,000 | CY | $10 | $240,000 | $0.17 |
| | | | | | | | | **Subtotal Cost per Site[27]** | **$300,000** | **$0.20** |
| | | | | | | | | | x 7.5 Sites | |
| | | | | | | | | **Subtotal - 2.0 Containment Structure (Dike)** | **$2,250,000** | **$0.20** |
| **5.0** | **Habitat/Site Development[5]** | | | | | | | | | |
| 5.1 | Drain Tiles[6] | 135 | AC | 871 | LF/AC | 117,612 | LF | $3 | $352,836 | $0.25 |
| 5.2 | Secondary Controls[7] | 1 | SITE | 15 | AC/SITE | 15 | EA | $6,075 | $91,125 | $0.07 |
| 5.3 | Misc. Improvements / Access[8] | 1 | SITE | 1,200 | LF/SITE | 1,200 | EA | $22 | $26,400 | $0.02 |
| 5.4 | Pump Operations (electric)[9] | 1600 | HR | 1,100 | KW/HR | 1,760,000 | KWH | $0.15 | $264,000 | $0.19 |
| 5.5 | Above Grade HDPE Pipe[10] | 1 | SITE | 1,200 | LF/SITE | 1,200 | FT | $65 | $78,000 | $0.06 |
| 5.6 | Management/placement/pumping[11] | 1600 | HR | 3 | MEN/HR | 4,800 | HR | $50 | $240,000 | $0.17 |
| 5.7 | Land Rental[12] | 150 | AC | 3 | YR | 450 | AC-YR | $300 | $135,000 | $0.10 |
| 5.8 | Land Cover (alfalfa)[13] | 135 | AC/SITE | 1 | SITE | 135 | AC | $100 | $13,500 | $0.01 |
| | | | | | | | | **Subtotal Cost per Site[22]** | **$1,200,861** | **$0.90** |
| | | | | | | | | | x 7.5 Sites | |
| | | | | | | | | **Subtotal - 5.0 Habitat/Site Development** | **$9,006,458** | **$0.90** |
| **7.0** | **Pump-out Area and Conveyance system[14]** | | | | | | | | | |
| 7.1 | Booster Pump Facility[15] | 3 | EA/LOCATION | 2 | LOCATION | 6 | EA | $25,000 | $150,000 | $0.01 |
| 7.2 | Pump Cost[16] | 3 | EA/LOCATION | 2 | LOCATION | 6 | EA | $250,000 | $1,500,000 | $0.14 |
| 7.3 | Dredging for Rehandling Basin[17] | 6,000 | CY/VF | 20 | VF | 120,000 | CY | $15 | $1,800,000 | $0.17 |
| 7.4 | Dredging for Pipeline[18] | 1 | CY/LF | 12,000 | LF | 12,000 | CY | $15 | $180,000 | $0.02 |
| 7.5 | In Water HDPE Pipe[19] | 1 | LF | 12,000 | LF | 12,000 | LF | $225 | $2,700,000 | $0.26 |
| 7.6 | Docking Structure (mounting pump)[20] | 1 | EA/PUMP | 3 | PUMP | 3 | EA | $750,000 | $2,250,000 | $0.21 |
| 7.7 | Pump Cost[21] | 3 | EA/LOCATION | 3 | LOCATION | 9 | EA | $100,000 | $900,000 | $0.09 |
| 7.8 | Pump Operations (labor)[22] | 10,500,000 | CY | 900 | CY/HR | 11,667 | HR | $125 | $1,458,333 | $0.14 |
| 7.9 | Pump Operations (diesel)[23] | 37 | GPH | 11,667 | HR | 431,667 | GAL | $4 | $1,726,667 | $0.16 |
| 7.10 | Below Grade HDPE Pipe[24] | 7 | MI | 5,280 | LF/MI | 36,960 | FT | $75 | $2,772,000 | $0.26 |
| 7.11 | Easement Cost[25] | 7 | MI | 3.6 | AC/MI | 25 | AC | $6,000 | $152,727 | $0.01 |
| | | | | | | | | **Subtotal - 7.0 Pump-out Area and Conveyance System** | **$15,589,727** | **$1.50** |
| **14.0** | **Dredging Operation** | | | | | | | | | |
| 14.1 | Clamshell Mechanical Dredge[26] | 350,000 | CY/YR | 30 | YR | 10,500,000 | CY | $5.75 | $60,375,000 | $5.75 |
| | | | | | | | | **Subtotal - 14.0 Dredging Operation** | **$60,375,000** | **$5.80** |
| | | | | | | | | **Total** | **$87,221,185** | **$8.40** |

**Estimated by:** Moffatt & Nichol/Hull & Associates, Inc. **Calculated by**: Peter Kotulak/Philip Hicks **Checked by:** Fernando Camargo

Notes:

AC - Acres CY - Cubic Yards EA - Each FT - Feet GAL - Gallons GPH - Gallons per Hour HR - Hours KW - Kilowatt KWH - Kilowatt-Hour
LF - Lineal Feet MH - Man-Hours MI - Miles MO - Month PUMP - Pump SF - Square Feet SM - Square Mile TON - Tons VF - Vertical Feet YR - Years

1. This table provides a refinement of the agricultural field improvement option preliminary costs presented in Section 6.0 and Tables H-4 and H-5 of the THSMUP. Only cost element categories that are applicable to the agricultural field improvement option are presented in this table. Subtotal unit co elements are reported as $/CY (unless otherwise noted) in 2012 dollars and are rounded to the nearest $0.10.
2. The containment structure (dike) items are based on one site that has a capacity of 1,400,000 cut cubic yards of dredged material.
3. This item is based on an interior berm used to divide a 150-acre site in four cells. The volume is determined by the length, width and height of four feet.
4. This item is based on a square 150-acre site consisting of a perimeter containment berm with a volume determined by the perimeter length and height of five feet.
5. The habitat/site development sub-items are based on one site with a capacity of 1,400,000 cut cubic yards of dredged material.
6. This item includes a 4"-6" drain tile installed approximately 12" deep with a collection header discharging to an existing drainage ditch.
7. This item includes the cost to install a 50-foot wide buffer strip and a controlled drainage system with outfall.
8. This item includes the cost to develop an access point to the placement area for labor and maintenance crews, which consists of a 15' x 1,000' aggregate base access road, culvert and security gate.
9. This item is based on typical local electrical rates to operate the booster pumps with minimal labor effort at a rate of 550 KW/HR (each) at an approximate dredging rate of 780 CY/HR.
10. This item includes a 18" HDPE SDR 11 pipe required to transfer material throughout the 150-acre placement area at, a distance of 1,200 feet or half of the overall length.
11. This item includes a 3-man crew, at a rate of $50 per hour per man, to operate the discharge pipe during the placement process at an approximate dredging rate of 780 CY/HR.
12. This item includes the cost to rent the land at a local agricultural land value of $300 per acre per year during, an improvement period of three years.
13. This item includes the cost to plant a cover crop one time to establish vegetation and introduce organics into the new soil.
14. The conveyance system sub-items are based on the management of 10.5M cut CY of dredged material.
15. This item includes the cost to install and maintain a 20' x 15' booster pump facility with utility service at two locations for protection, maintenance and noise reduction.
16. This item includes the cost to purchase and maintain two 550 kW (735 HP) booster pumps that will transport the dredged material from the in-water discharge line to the placement area.
17. This item includes the cost to dredge an area of 1,600 square feet to allow scows to maneuver in and out of the pump-out area at an average rate of $15 per cubic yard to dredge and place the material.
18. This item includes the cost to dredge below the lake bottom to install the discharge pipe to the center of gravity of the federal channel to the discharge point on land, at an average rate of $15/CY to dredge and place the material.
19. This item includes installation of a 18" SDR 11 HDPE pipe at an increased cost due to working in and/or below water, in an area within 2,000 feet of the federal channel to the discharge point on land.
20. This item includes the purchase of a vessel to transport the pump, installation of a docking structure to accommodate the pumps, tie off a purchased vessel and barges and/or provide lighting, etc.
21. This item includes the cost to purchase and maintain three 12" diesel pumps that will collect the dredged material released from the scow/barge and transport the material to the booster facility.
22. This item includes a 1-man crew, at a rate of $125 per hour, to operate a vessel and the pumps 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 900 cubic yards per hour.
23. This item is based on typical local fuel rates to operate the three 12" diesel pumps at a rate of 37 gallons per hour 12 hours per day and 30 days per month, during the placement process at an approximate dredging rate of 900 cubic yards per hour.
24. This item includes the 18" SDR11 HDPE pipe required to transfer the dredged material from the in-water discharge line to the placement area, at a distance of 7 miles of pipe for two or three potential sites to accommodate the overall area required.
25. This item includes the cost to purchase easement property 30 feet wide by the length of the below grade discharge line (7 miles) at a local land value of $6,000 per acre.
26. This item is based on typical operation and production of a clamshell mechanical dredge at an average depth of four feet and rate of 900 CY/HR.
27. A site is a 150-acre parcel with 135 acres of land available for material placement due to containment dikes and other infrastructure items in the perimeter of the parcel. To accommodate 10.5 million CY of material, 7.5 sites will be required.

*Conceptual plans and associated calculations were completed by engineers and checked by a peer reviewer prior to inclusion. Cost estimates based on the conceptual ideas were prepared by and reviewed under the supervision of professionals who are competent in construction cost estimating, possess a working knowledge of construction, and are capable of making professional determinations based on experience. The prepared estimates are not an opinion of probable costs and should not be used for potential funding values. However, they are of sufficient detail to fulfill the requirements of the QAPP and suitable for relative comparison.*

# APPENDIX M

Toledo Harbor Task Force Comments

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**US ARMY CORPS OF ENGINEERS, BUFFALO DISTRICT**

**REVIEW COMMENT SHEET**

**Document Title:** TOLEDO HARBOR SEDIMENT MANAGEMENT AND USE PLAN (DRAFT)

**Date Transmitted:** November 23, 2012

| COMMENT NUMBER | SECTION REFERENCE | REVIEWER'S COMMENTS |
|---|---|---|
| 1 | General comment | This planning document, while it lays out a clear set of options at the conceptual level, really lacks important details that could/should be explored at this level of planning which may significantly impact the rating scores across the board. With the overall scores being similar for half of the options (i.e., within a 30 point range), more plan details could result in fewer options rising to the top or some being eliminated completely. |
| 2 | Executive Summary, Page i, first paragraph | It is indicated that approximately one million cubic yards of sediment is dredged annually from Toledo Harbor's Federal and non-Federal navigation channels. Based on the information contained in Table 2, the average volume annually dredged (2001-2010) from the harbor's Federal navigation channels amounts to 659,443 cubic yards. Together, this implies that, on average, about 340,000 cubic yards are annually dredged from the port by non-Federal interests. This is inconsistent with the non-Federal annual average dredging of 53,000 cubic yards indicated in Section 1.1 (assumed to be based on data from Table 3). |

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| 3 | Executive Summary, Page i, third paragraph | We are unaware that U.S. Environmental Protection Agency (USEPA) has a "position that continued open-lake placement in its current form is an unacceptable practice as it re-suspends nutrients, potentially increasing algae and contributing to overall turbidity." The major basis of determining whether a given dredged material meets Federal guidelines (including compliance with applicable State water quality standards [WQSs]) is based on the protocols and guidelines contained in the 1998 Great Lakes Dredged Material Testing and Evaluation Manual. This guidance, which is pursuant to Section 404 of the Clean Water Act, was prepared by USEPA and USACE. Also, please see attached USEPA letter dated May 9, 2009, which does not object to the placement of Toledo Harbor dredged material in the open-lake.<br><br>Scientific evidence provided to OEPA over many years, and existing weight-of-the-evidence, indicate that nutrient resuspension and increases in turbidity resulting from the placement of Toledo Harbor dredged material in the Western Basin of Lake Erie (Basin) are minute in comparison to what typically occurs from bottom sediments throughout the shallow Basin. Without considering relative phosphorus availability, the total phosphorus added to the Basin water column by open-lake placement (630 mg P/kg suspended solids [SS] X 1.45 metric tons [MT] SS/yr = 913 MT P/yr) is less than 10% of the estimated total phosphorus added annually by external loads (~7,000 MT P/yr) plus wind-driven resuspension (~6,100 MT P/yr). However, when considering availability, the ultimate available phosphorus in the dredged sediments (not unlike Maumee River sediments) is on the order of 30% of the total phosphorus. Moreover, open-lake placed sediments also settle out of the water column long before most of the bioavailable phosphorus has actually been released as soluble reactive phosphorus (SRP, which is used as a measure of immediately available phosphorus) to the water column during the settling process. Elutriate test data, which measure the release of dissolved total phosphorus from the sediments to the water column during open-lake placement, are consistent with such low phosphorus bioavailability. |

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| 3 (cont'd) | Executive Summary, Page i, third paragraph | Regarding turbidity, the vast majority of material being placed in the Basin is being dredged from the Lake Approach Channel within the same aquatic ecosystem. Therefore, placement activities constitute an internal relocation of the material within the lacustrine system, rather than external loading. Turbidity associated with the placement of this dredged material should be viewed within the framework of the amount of sediments within the system and entering the Basin from other sources. The amount of Toledo Harbor dredged material annually relocated in the lacustrine system (for this exercise, the amount used is 1,250,000 cubic yards (CY) or an estimated 1,450,000 MT) is less than one percent of the estimated annual resuspended sediment load (150,000,000 to 300,000,000 MT) in the Basin, and is less than that contributed by the Maumee River every year (an estimated 1,500,000 CY). Therefore, the open-lake placement of Toledo Harbor dredged material results in short-term, temporary turbidity, and does not represent widespread or substantially increased background turbidity in the Basin.<br><br>This information strongly suggests that if open-lake placement of this dredged material ceased, no net improvement to Basin ecology would be observed.<br><br>We are also unaware that OEPA has "limited future open-lake placement of dredged sediments" for the reasons alleged above. However, we recognize that it is OEPA's desire and policy to eliminate the placement of Toledo Harbor dredged material in the Basin.<br><br>Please note that under Section 404 of the Clean Water Act and 33 CFR 337, the USACE is responsible for determining whether the open-water placement of material dredged from USACE civil works projects is environmentally acceptable. The State's regulatory role under Section 401 of the Clean Water Act is to certify whether that proposed discharge of dredged material complies with applicable State WQSs. |

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| 3 (cont'd) | Executive Summary, Page i, third paragraph | The opinion that the open-lake placement of Toledo Harbor dredged material "re-suspends nutrients, potentially increasing algae and contributing to overall turbidity" is mentioned throughout the draft report. However, we are unaware of any specific reference, scientific literature or data that supports that the placement of Toledo Harbor dredged material in the Basin significantly "re-suspends nutrients, potentially increasing algae and contributing to overall turbidity." As noted above, this assertion is inconsistent with existing weight-of-the-evidence. |
| 4 | Executive Summary, Page i, third paragraph | Note that any dredged material determined to meet Federal guidelines (including applicable State WQSs) for open-lake placement cannot be placed in Federal confined disposal facilities (CDFs) because USACE policy and Public Law (PL) 94-587 requires USACE to utilize and encourage the utilization of management practices to extend the capacity and useful life of CDFs such that the need for new facilities is kept to a minimum. |
| 5 | Executive Summary, Page iv, thirteenth paragraph | While the bulk concentration of a chemical in sediment provides a single line of evidence, it provides no information on the bioavailability of that contaminant which is the key driver in sediment toxicity. It is generally accepted that sediment screening criteria (like sediment quality guidelines or criteria) should be used for screening purposes, and should not be used alone for decision-making. Sediment screening criteria should be used in tandem with other lines of evidence, such as bioassay and bioaccumulation data. |
| 6 | Executive Summary, Page iv, thirteenth paragraph | Partially for reasons relating to Comment 5, suggest revising this sentence as follows: "With the exception of material dredged from River Channel Miles 1, 2 and 4, the USACE has determined that all Toledo Harbor Federal navigation channel dredged material is suitable for in-water use (i.e., open-lake placement) based on chemical, elutriate and bioassay testing, and water quality and bioaccumulation modeling. This determination is based on existing USEPA/USACE protocols and guidelines pursuant to Section 404 of the Clean Water Act." |
| 7 | 1.1, second paragraph | Of the up to 800,000 cubic yards dredged annually, a portion of that may be placed in the Federal CDF depending on the required harbor dredging. |
| 8 | 1.1, second paragraph | Please see Comment 3. Replace "standards" with "guidelines." |

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| 9 | 2.0, third paragraph | This reads "Average annual suspended sediment decreased approximately 7% between the timeframes of 1992-1996 and 2002-2006, from 743,894 metric tons to 801,600 metrics tons (Baker, 2007)." As presented, this implies an increase in the average annual sediment load, rather than a decrease. |
| 10 | 2.0, third paragraph | The last sentence fails to consider the fact that the vast majority of the sediment that is placed in the Basin is dredged from the Lake Approach Channel in the Basin and as such, does not represent external loading like the other sources of sediment discussed earlier in this section. Unlike soil/sediment runoff from the Maumee River and Basin tributary watersheds, open-lake placement of Toledo Harbor dredged material does not result in a net increase (or input) to the Basin. |
| 11 | 3.1.1 | This reads "Successive Acts increased the authorized depth from 15 feet in 1875 to 25 feet below low water depth (LWD) in 1936 (USACE, 1995)." "Depth" should be "datum." |
| 12 | 3.2 | Note that most Toledo Harbor material is dredged is from the Lake Approach Channel (and not the River Channel). |
| 13 | 3.2.1, first paragraph | In the case of Toledo Harbor where no special dredging operation controls are necessary, USACE contractors select the method of dredging. Note that USEPA/USACE guidance focuses on the toxicological impacts of aquatic placement of dredged material. |
| 14 | 3.2.1, second paragraph | Non-Federal dredging usually occurs in the Maumee River adjacent to the Federal River Channel. In such areas, sediments are typically much more contaminated than those in the harbor's Federal navigation channels, which is a major reason why the dredged material would not meet existing Federal guidelines for open-lake placement. This is a driving factor as to why non-Federal dredged material is typically placed upland, and use of special dredging equipment may be required. This should be clarified. |
| 15 | 3.3, first paragraph | Tiers 1 through 4 involve site-specific testing/data. Tier 2 involves the collection of additional data as well as modeling, and evaluation. Tier 3 involves biological effects-based testing and evaluation. In last sentence, "unsuitable" should be "unacceptable." |

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| 16 | 3.3, third paragraph | This reads, "A decision on the suitability of open-lake placement is currently made based on:<br>1. Compliance with Clean Water Act Section 404(b)(1) guidelines;<br>2. Clean Water Act Section 401 WQC, which is issued by Ohio EPA; and<br>3. Coastal Management Program (CMP) Consistency, which is issued by Ohio DNR."<br><br>Note that the suitability of dredged material for open-lake placement is determined through compliance with Clean Water Act Section 404(b)(1) Guidelines, which includes compliance with applicable State water quality standards and consistency with the State CMP. The Clean Water Act Section 401 WQC or CMPC Determination Concurrence/Non-Concurrence do not determine, per se, whether the material is suitable for open-lake placement. |

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| 17 | 3.3, fourth paragraph | The statement that "Incorporation of a revised sediment evaluation approach into the Federal Standard could impact the evaluation and management of Toledo Harbor sediment by allowing for the incorporation of risk management strategies (e.g. engineering controls) in order to mitigate environmental concerns" is not accurate. The existing Clean Water Act Section 404(b)(1) process currently allows engineering controls to mitigate impacts to human health and the aquatic environment. Risk management strategies are routinely used under the existing law and guidance. These risk management strategies do include sequencing of work, selection of equipment, use of environmental windows, etc. For example, various strategies are currently being used throughout North America to protect threatened and endangered species (e.g., sea turtles, manatees, sturgeon, etc.) when it has been determined to be necessary based on the biology of the species and an assessment of exposure and impacts. In the case of the Great Lakes, risk management strategies are either not used or are often used inappropriately.<br><br>An important point being missed is that any risk to the aquatic ecosystem needs to be clearly identified before a risk management strategy can be implemented. Updates to current guidance will provide additional clarity on the importance developing conceptual site models that incorporate both an assessment of the potential for exposure, and the potential for effects. The integration of these two assessments (potential exposure and effects) is what characterizes risk or, using language from the Clean Water Act, "potential impacts to human health and the aquatic ecosystem." Within any assessment of risk and risk management plan, the potential for risk/impacts must be evaluated within the context of background conditions and how dredging activities modify the existing risk to human health and the aquatic ecosystem. |

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| 18 | 3.3, fourth paragraph | In 2008, USACE initially proposed the concept to investigate any potential links between phosphorus originating from the open-lake placement of Toledo Harbor dredged material and HABs in the Basin. At the time, OEPA agreed with the approach to the study proposed by USACE. However, in a letter dated April 15, 2010, OEPA indicated that they would no longer support such an investigation because it was already evident that there were adverse impacts. This position was not based on weight of the evidence and lacked relevant data to form any theoretical basis. Existing information strongly suggests that runoff resulting from agricultural practices in the Maumee River watershed transport bioavailable phosphorus (i.e., SRP) into the Basin and likely drive late summer HABs. Weight of the evidence strongly suggests that the placement of Toledo Harbor dredged material in the Basin has little potential to influence HABs. |
| 19 | 3.3.2, fourth paragraph | Please see Comment 5. |
| 20 | 3.4 and 3.4.1 | Please see Comment 14. |
| 21 | 3.4.1.2 | Island 18 was last used for the disposal of dredged material in 2007. The dike breached after use and a temporary repair was completed in 2007. |
| 22 | 4.1 | It appears that the assumption has been made that the placement of Toledo Harbor dredged material in the Basin, as currently performed, is not environmentally sustainable. USACE does not agree with such an assumption because it is not based on weight of the evidence. Therefore, USACE recommends including open-lake placement as a baseline. We recommend providing relevant references, scientific literature or data that support the position that the placement of Toledo Harbor dredged material in the Basin, as currently performed, is environmentally unsustainable. Please see Comment 3. |

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| 23 | 5, first paragraph | Regarding the "open-lake placement with controls" and "open-lake placement in a new location" In-Water options, USACE recommends explaining the scientific basis (e.g., relevant references, scientific literature, empirical data) of such restrictions. In other words, explain the unacceptable risks resulting from open-lake placement as it is currently performed based on relevant studies/data , which should provide the rationale for any risk management strategies. Please see Comment 3. |
| 24 | 5.2.1 | This reads "a dike height 4 ft. above LWD would be required." How was this height determined? |
| 25 | 5.2.1 | This reads "a dike height 4 ft. above LWD would be required." How was this height determined? |
| 26 | 5.3 | In the last sentence, it reads "reduces the nutrient loadings caused by the current open-lake placement process." USACE recommends explaining the scientific information (e.g., relevant references, scientific literature, empirical data) that support this statement. Please see Comments 3 and 10. |
| 27 | 5.3.1, second paragraph | This reads "a dike height 10 ft. below LWD would be required." How was this determined, especially before a wave climate study is completed? |
| 28 | 5.3.1, second paragraph | This reads "a dike height 3 ft. below LWD would be required." How was this determined, especially before a wave climate study is completed? |
| 29 | 5.3.2, second paragraph | This reads "a dike height 30 ft. above LWD would be required." How was this determined, especially before a wave climate study is completed? |

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| 30 | 5.3.2, second paragraph | This reads "a dike height 12.5 ft. above LWD would be required." How was this determined, especially before a wave climate study is completed? |
| 31 | 5.3.3.1, first paragraph | The stakeholder concerns cited are inconsistent with weight of the evidence. Large amounts of sediments are resuspended in the shallow Basin and the primary source of those sediments is the bottom sediment pool, which is deeply influenced by the Maumee River sediment load. The existing open-lake placement area, including the dredged material placed there, represents a tiny fraction of that pool. Moreover, the vast majority of the dredged sediments placed at this area are already within in the Basin system. Please see Comment 3. The concern that dredged material placed at the open-lake area re-enters the Federal navigation channel, thus resulting in "double handling," is unsubstantiated. A 2009 investigation indicated that bottom sediments both in-place and placed at the existing open-lake placement area move in a net northeasterly direction (approximately parallel with the Lake Approach Channel) or tend to stay in the area. According to Figure 2, no maintenance dredging of the Lake Approach Channel is required lakeward of Station 920+00, which also indicates that material that may migrate from the open-lake placement area (located north of Lake Mile 11) to the Lake Approach Channel does not require maintenance dredging. |

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| 32 | 5.3.3.1, second paragraph | This reads "The new open-lake placement option evaluated under this plan would continue with the current dredging and placement methods, but re-locate the placement area approximately 15 miles from the center of gravity of the dredging work, so that the open lake placement area is in deeper water and has less potential to be re-suspended and transported back to the Federal and non-federal channels. Appendix G-7 shows the conceptual location and relative size of area required to place all 30M CY of material. It is assumed this location would have a greater depth and less current impacts than the existing location to minimize the environmental impacts and minimize sediment from reentering the channel." Please see Comment 31.<br><br>While the model in the LimnoTech (2010) report suggests that material placed at the existing dredged material open-lake placement area generally moves in a net southeast direction, the study also used a short time scale (e.g., two years). A 2009 study on a longer time scale (e.g., decadal) indicated that the material moves in a net northeasterly direction. Note that the movement of bottom sediments in the Basin is generally more of a function of wind direction, speed and shear, and fetch, rather than depth. |
| 33 | 5.3.3.2, first paragraph | In the first sentence, it reads "that addresses the impacts of nutrient availability resulting from resuspension." USACE recommends explaining the scientific information (e.g., relevant references, scientific literature, empirical data) that support this statement. This option overall implies that a significant amount of phosphorus is released from the dredged material and that open-lake placement substantially increases turbidity. Please see Comment 3. |
| 34 | 5.3.4, first paragraph | Please see Comment 4. Any dredged material determined to meet Federal guidelines (including applicable State WQSs) for open-lake placement cannot be placed in Federal CDFs based on USACE policy and public law. |
| 35 | 5.4.4, first paragraph | Please see Comment 4. Any dredged material determined to meet Federal guidelines (including applicable State WQSs) for open-lake placement cannot be placed in Federal CDFs based on USACE policy and public law. |
| 36 | 6.1.2, first paragraph | Assuming a single cell containment structure for the life of the project doesn't appear realistic when evaluating how to manage approximately 50 years of dredge material. This should be developed further in the evaluation because it could significantly influence the cost, feasibility and ecologic benefits of the use. |

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| 37 | 6.1.4, first paragraph | This reads "It was assumed that from that point on, nature would take over and continue to provide the area with adequate revegetation." Adaptive management and invasive plant species control should be considered for habitat types where this is a problem, such as in emergent zones that have a strong potential to become colonized and overrun by *Phragmites*. |
| 38 | 7, general comment | USACE recommends including the current open-lake placement option as a baseline with application of the same technical criteria used to score other sediment management and use options. |
| 39 | 7, Table 7 | With respect to the "new open-lake placement area without controls" and "open-lake placement with controls" options, the "planktonic and benthic community/habitat" and "fish and aquatic invertebrate species habitat" criteria should be scored "3" rather than "2." Weight of the evidence with respect to these criteria indicate minimal effects resulting from the open-lake placement of dredged material. For example, regarding fish, the open-lake placement of Toledo Harbor dredged material has a very low likelihood of causing turbidity-related adverse effects, including commercially and recreationally important species such as walleye (*Sander vitreum*) and yellow perch (*Perca flavescens*). A 2012 laboratory study found that suspended Maumee Bay sediment exposures to walleye eggs mimicking sediment resuspension during dredging did not result in significantly reduced hatching success or evidence any sublethal effects through gross morphological observation. The study concluded that walleye eggs are relatively tolerant of suspended sediment concentrations likely to be encountered during dredging and open-lake placement of dredged material in the Great Lakes region. Regarding benthos, a 2003 benthic community investigation on the Toledo Harbor open-lake placement area concluded that the diversity and abundance of macroinvertebrates within the area were similar to other reference areas in the Basin. This study also showed that there was no association among sampling areas in relation to their proximity to the placement area, indicating that the placement of dredged material had no measurable long-term effect on the benthic community within or outside the area. |

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| 40 | 7.2.3, Table 8 | In this table, there are duplicate "hydro-dynamic effects" criteria rows across the sediment management and use options. With respect to the "new open-lake placement area without controls" option, the "hydro-dynamics effects" criterion should be scored "3" rather than "1." What scientific information is used to support a negative overall effect with a high level of effort required to overcome? For the purposes of this study, isn't it assumed that the location of this area would allow for less sediment resuspension and reduce the potential for placed sediment to re-enter the Lake Approach Channel? With respect to the "new open-lake placement area without controls" option, the "surface water quality" criterion should be scored "3" rather than "1." What scientific information is used to support a negative overall effect with a high level of effort required to overcome? Elutriate test data across a spectrum of contaminants on Toledo Harbor dredged material indicate that discharge of the material at the current open-lake placement area in the Basin complies with applicable Ohio WQSs, suggesting the same result would occur at the new area. With respect to the "open-lake placement area with controls" option, the "surface water quality" criterion should be scored "3" rather than "4." What scientific information is used to support significant adverse effects such that a positive effect with a moderate degree of benefit would result from the controls (please see Comment 21)? |
| 41 | 7.2.4, Table 9 | In this table, there are duplicate "recreational opportunity" criteria rows across the sediment management and use options. With respect to the "new open-lake placement area without controls" option, what is the basis of a "human health risk" criterion score of "2" rather than "3?" What scientific information is used to support a negative effect to human health with a moderate level of effort required to overcome? |
| 42 | 7.2.5, Table 10 | With respect to the "new open-lake placement area without controls" option, what is the basis of a "tourism" criterion score of "4" rather than "3?" What scientific information or documentation is used to support relocation of the open-lake area, yielding a positive effect with a moderate degree of benefit to tourism? |
| 43 | 8.2.1 | With respect to the "open-lake placement with controls" option, the new open-lake site would be designated and evaluated by USACE under Clean Water Act Section 404(b)(1) Guidelines. This area would be coordinated with OEPA in terms of evaluating whether the proposed discharge of dredged material at the site would comply with applicable WQSs. |

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| 44 | 10.1 | Explain the scientific basis for requiring "hydraulic dredging with permanent discharge lines" for environmental impact purposes. |
| 45 | 10.2 | Explain the scientific basis for requiring open-lake placement controls for environmental impact purposes. Please see Comment 3. |
| 46 | 11.1.1 | Based on weight of the evidence, no open-lake placement controls are necessary to reduce the resuspension of nutrients or turbidity associated with the open-lake placement of Toledo Harbor dredged material. |
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