Testing and Evaluating Dredged Material for Upland Beneficial Uses:

A Regional Framework for the Great Lakes

Great Lakes Commission des Grands Lacs

Great Lakes Dredging Team

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Second Edition

With references to:

Upland Beneficial Use of Dredged Material Testing and Evaluation Annotated Bibliography

This report is also available online via the Great Lakes Dredging Team website at
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References

All references in this document refer to reference numbers in the *Annotated Bibliography*, which includes a much longer list of potential references to aid in decision making with respect to upland beneficial use.

List of Acronyms

ARCS – Assessment and Remediation of Contaminated Sediments program
ASTM – American Society for Testing and Materials
BOD – Biological oxygen demand
CDF – Confined disposal facility
CFR – Code of Federal Regulations
CLP – Column leaching procedure
COC – Contaminant of concern
CWA – Clean Water Act
DMMP – Dredged Material Management Plan
DTPA - Diethyltriamine-pentaacetic acid
EA – Environmental Assessment
EIS – Environmental Impact Statement
IAC – Illinois Administrative Code or Indiana Administrative Code, depending upon context
MSW – Municipal solid waste
NEPA – National Environmental Policy Act
NR – Natural Resources Code
NYCRR – New York Codes, Rules and Regulations
NYSDEC - New York State Department of Environmental Conservation
OAC – Ohio Administrative Code
ORC – Ohio Revised Code
PAH – Polycyclic aromatic hydrocarbon
PCB – Polychlorinated biphenyl
PCLT – Pancake column leaching test
ppm – parts per million
PUP – Prediction of uptake by freshwater plants
RCRA – Resource Conservation and Recovery Act
RISC – Risk Integrated System of Closure
SBLT – Sequential batch leaching test
SDWA – Safe Drinking Water Act
SLV – Soil leachate value
SRV – Soil reference value
SSG – Soil screening guidance
SSL – Soil screening levels
SVOC – Semivolatile organic compound
TACO – Tiered Approach to Corrective Action
TCLP – Toxicity characteristic leaching procedure
TOC – Total organic carbon
TSCA – Toxic Substance Control Act
U.S. ACE – United States Army Corps of Engineers
U.S. EPA – United States Environmental Protection Agency
VOC – Volatile organic compound
WAC – Wisconsin Administrative Code
WDNR – Wisconsin Department of Natural Resources

1. Overview

A. OBJECTIVES

The *Regional Framework for Testing and Evaluating Dredged Material for Upland Beneficial Uses* presented here and the complementary *Annotated Bibliography* respond to an identified need for such a framework. The lack of adequate regulatory guidance was one of the obstacles to beneficial use of dredged material identified by the Great Lakes Beneficial Use Task Force and described in the final task force report, published by the Great Lakes Commission in 2001.[37] The lack of guidance is particularly acute regarding beneficial use of dredged material in upland environments. The Beneficial Use Task Force report noted that most upland beneficial uses are evaluated on a case-by-case basis using various types of guidance or regulations aimed at solid waste, hazardous waste and sewage sludge. The task force recommended that regional guidance be developed for beneficial use of dredged material. This recommendation became one of the top five priorities for the Great Lakes Dredging Team, which served in an advisory capacity to the Beneficial Use Task Force.

This *Regional Framework* offers a regional risk-based approach for testing and evaluating dredged material for upland uses and provides narrative guidance and detailed references for each step along the way.

This *Regional Framework* brings together and builds on the body of existing case studies, policy, guidance and regulations that have been and are, as of 2004, being used by Great Lakes state regulatory agencies to make decisions regarding beneficial use of dredged material. It also includes relevant rules and regulations implemented by the U.S. Army Corps of Engineers (U.S. ACE) and the U.S. Environmental Protection Agency (U.S. EPA). As such, the *Regional Framework* puts structure around what has been a piecemeal approach to beneficial use decision making.

In general, the *Regional Framework* and *Annotated Bibliography* are intended for use by all those who have some decision making responsibility with respect to dredged material management. In particular, these documents are intended for those who have regulatory authority or responsibility for making risk-based determinations regarding upland beneficial use of dredged material. This document fosters informed decisions by providing a regulatory and technical framework for each stage in the decision making process. In addition, valuable references are cited where applicable to provide access to more information.

This *Regional Framework* was developed by the Great Lakes Commission's Upland Testing and Evaluation Project Management Team — a group of relevant state and federal agency representatives from throughout the Great Lakes region (see Appendix B). As such, the *Regional Framework* and *Annotated Bibliography* build on the knowledge and experience of the region's practitioners.

Dredged Material Management in the Great Lakes

Dredging of Great Lakes waterways began at least 150 years ago. In recent years, about four million cubic yards of sediment have been dredged annually from the Great Lakes' 136 federal harbors and 745 miles of federal navigation channels and from state, municipal, and private marinas.[39] Dredging in the Great Lakes is primarily done to maintain water depths in navigation channels necessary for commercial shipping, but is also used as a means to remediate the large volumes of contaminated sediment that plague many areas of the Great Lakes. In addition, sediment has been dredged for such projects as private and public utility developments and marina development.

> As CDF capacity diminishes and open water discharge of sediment is discouraged or prohibited, upland beneficial use of dredged material becomes increasingly needed.

Beneficial use offers a long-term environmentally sound sediment management alternative. Generally speaking, three primary options are exercised for dredged material management: placement in Confined Disposal Facilities (CDFs); discharge in open water; and relocation of suitable material into nearshore areas (e.g., beach nourishment). However, each of these is facing increasing obstacles. First, Great Lakes CDF capacity is diminishing. With about 50 percent of the Great Lakes' annual dredging volumes being relocated to CDFs, it's expected that most existing CDFs will be near design capacity or full in the near future.[223] New CDFs are difficult to site and expensive to construct. Further, there is controversy surrounding demands to use CDFs for non-navigation material that is more contaminated and cannot be beneficially used, which raises issues about preserving appropriate CDF capacity for the most contaminated dredged material. Open-lake, deep-water disposal is rapidly growing out of favor and is already prohibited in several Great Lakes states.

Traditionally, dredged material has been considered a waste product instead of a resource. However, there is an increasing awareness that dredged material can be a valuable resource for many uses. Dredged material displays a wide variety of physical characteristics. Certain types of dredged materials are better suited for certain uses. Whether from environmentally degraded areas (e.g., Great Lakes Areas of Concern) or navigation channels, large volumes of sediment having lower levels of contamination and/or elevated nutrients may be suitable for a variety of upland applications. Examples of beneficial use include topsoil creation, beach nourishment, aggregate for construction materials, brownfield, agricultural, recreation or other land improvements, and habitat restoration.

> Beneficial use of dredged material can meet needs for fill or raw material for use in a variety of applications, providing a means for preserving and extending the life of existing CDFs.

Most upland beneficial use projects to date have been implemented on a case-by-case basis. The *Regional Framework* presented here and complementary *Annotated Bibliography* are intended to provide the first steps toward a regional and structured approach to facilitate decision making with regard to upland beneficial uses of dredged material.

B. FRAMEWORK

The Beneficial Use Upland Testing and Evaluation Project Management Team created a risk-based framework for evaluating potential upland beneficial use opportunities. This framework, adapted from the technical framework presented in *Evaluating Environmental Effects of Dredged Material Management Alternatives*[55] is shown in Figures 1.1, 3.1 and 3.3. The framework is divided into three main phases as shown in Figure 1.1:

- Screening and preliminary assessment
- Testing and evaluation
- Implementation

The *testing and evaluation* phase contains additional frameworks for evaluating the physical suitability and the chemical/environmental suitability of a dredged material for upland beneficial uses, as shown in figures 3.1 and 3.3 respectively. Use of this framework should expedite the process of selecting appropriate beneficial uses for a given dredged material, while assuring that all important concerns are addressed. This section provides an overview of this framework. The following sections will describe the processes involved in each phase with more detail.

Screening and Preliminary Assessment

Section 2 addresses the first phase of the beneficial use evaluation framework: *screening and preliminary assessment*. This phase begins with the identification of beneficial use needs and opportunities. Creating opportunities to use dredged material beneficially will require early and frequent communication with the other potential stakeholders in the process. Using past cases of beneficial use as examples can lend valuable guidance in this process. Further information about many of these applications is presented in Appendix A. Detailed strategies for identifying opportunities for upland beneficial uses are described in Section 2A.

The next step is to identify and screen logistical and economic constraints. Not all uses will be feasible for all dredged materials. Some uses can be ruled out from the outset based on obvious constraints or prior experience with dredged material management at the same site. Other uses will not be as simple to rule out and a more thorough analysis of the potential constraints involved will be required. The process of identifying and screening these constraints is discussed further in Section 2B. Following a preliminary determination of physical and chemical suitability for each potential use, an evaluation of important socio-economic factors must be made. These factors will include, but are not limited to, transportation costs and alternatives, the condition of the proposed site, including historic and current land use, the use of adjacent lands, and possible benefits to and impacts on the community. Details of how to conduct these evaluations are also described in Section 2B.

The final stage of the *screening and preliminary assessment* phase is the identification of applicable physical and chemical criteria that must be evaluated for each potentially suitable beneficial use. Many of these criteria will vary somewhat from state to state. This stage is described in more detail in Section 2C. For some uses, examples of possible contamination criteria and guidelines are presented in Appendix A. Section C-3 of the *Annotated Bibliography* can also be consulted.

Testing and Evaluation

The second phase of the dredged material beneficial use evaluation framework is *testing and evaluation*. In this phase, a number of tests, evaluations and analyses will be conducted to more fully evaluate the potential of the material to satisfy the requirements of each use that was determined to be potentially suitable in the *screening and preliminary assessment* phase.

The first stage in the *testing and evaluation* phase is to conduct each of the tests that were identified as necessary to screen the material for physical and chemical suitability. All uses that were determined to be feasible in the screening phase should be considered. These test results can then be compared to the standards that were identified to determine if the dredged material has properties compatible with each selected beneficial use. For some applications, dredged material may need to be blended with another material to meet physical requirements. Therefore, testing of multiple mixtures may be necessary.

Following the physical suitability evaluation, the material must undergo evaluation for environmental suitability. This stage of the evaluation ensures that use of the material in the identified manner will not present unacceptable risks to human health or the environment. During this stage, tests for contamination of the material will be conducted and the results will be compared to the standards identified during the first phase for each potential use. In addition, some uses may require a more thorough evaluation of exposure pathways and/or a formal risk assessment to satisfy all relevant environmental concerns. Section 3A describes the relevant physical and chemical testing procedures. Section 3B details the risk assessment process with regard to dredged materials. Figures 3.1 and 3.3 provide detailed outlines of these processes.

When the information from all of the preceding evaluations has been gathered, a cost-benefit analysis will need to be conducted to compare the uses that have not yet been ruled out. Even if only a single potential use remains, an evaluation of its relative costs and benefits is still an important part of its implementation. Based on this cost-benefit analysis, beneficial use alternatives will be ranked in order of preference. The top-ranking alternative should be selected to proceed to the *implementation* phase. A thorough discussion of ranking alternative beneficial uses and selecting the preferred use is presented in Section 3D.

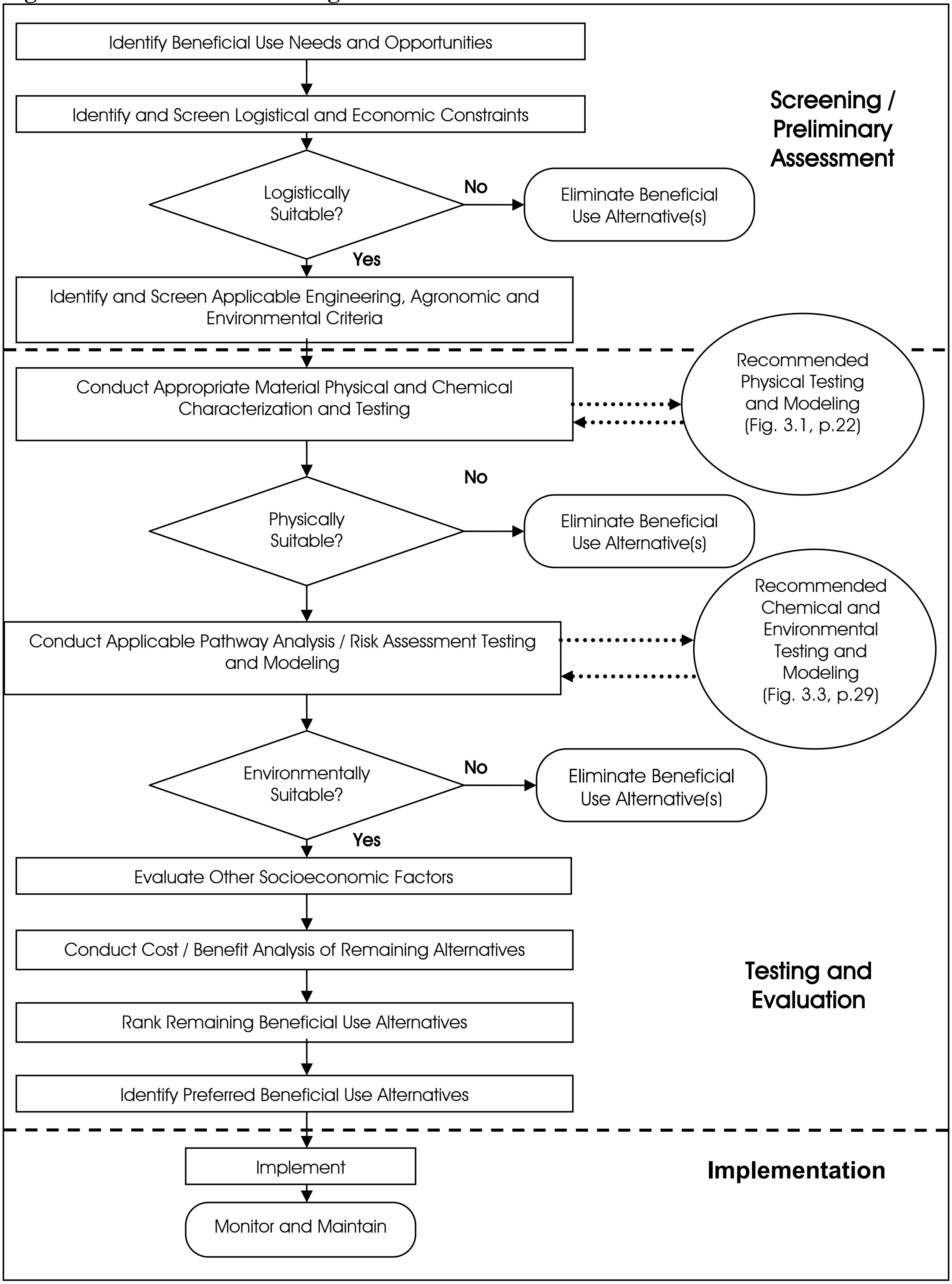
Implementation

The preferred use that is identified during the cost-benefit analysis will proceed to the *implementation* phase. The *implementation* phase consists of all processes necessary to incorporate the material into the chosen application, as well as those required to adequately monitor and evaluate the use of the material after its placement.

Handling of the material, including dewatering and transportation, are covered in Section 4A. Considerations for designing, preparing, and constructing the site for the beneficial use are described in Section 4B. Processes and considerations for material placement at the site and onsite management are described in Section 4C.

After placement of dredged material at its upland beneficial use location, monitoring will ensure the effectiveness of institutional and/or exposure controls, and will provide information from which to evaluate the success of the placement and the need for maintenance. Communication of monitoring and evaluation results is encouraged to provide additional guidance for similar uses. Procedures for effective monitoring are described in Section 4D and evaluation and communication are discussed in Section 4E.

Figure 0-1: Framework for Dredged Material Beneficial Use Evaluations



2. Screening/Preliminary Assessment

A. IDENTIFICATION OF BENEFICIAL USE NEEDS AND OPPORTUNITIES

Identifying opportunities to use dredged material beneficially is not always a simple matter. Lack of dredged material storage space can require a destination to be found quickly. If an appropriate beneficial use is not identified quickly, it is likely that the material will be disposed of by traditional methods that are often less environmentally protective and are more costly in some cases. Finding situations where dredged material can be used beneficially should occur very early in the dredging process when dredging projects are first identified (e.g., by the U.S. ACE). In fact, managers of dredged materials would be well-advised to look for these opportunities on a constant basis. Opportunities can be found in a number of places, including the public and private sectors. Looking for past examples of beneficial use projects, such as those described at the end of this section, is a good way to identify potential new projects and guidance. In addition to those described here, many more examples can be found in Section E of the *Annotated Bibliography*.

Networking to identify beneficial use opportunities

Networking is a great way to find new beneficial use opportunities. One never knows from where or when a new idea or opportunity will come. For instance, at a regional planning commission meeting in Ohio, a park manager happened to mention that a dredge project was coming to completion. An Ohio DOT representative took note and asked if material would be available for several nearby interstate highway “cloverleaf” landscaping projects being planned. Later that year, several hundred cubic yards of dredged material were used beneficially in these highway landscaping projects.

Numerous opportunities for upland beneficial use of dredged material can be found within government programs. Often, the people managing these programs will be unaware of the availability or suitability of dredged material for use in them. It is therefore important for dredged material managers to contact these programs and discuss incorporating dredged material into appropriate beneficial uses. Although opportunities may not be available at the time these discussions take place, informing people of the potential to use dredged material in upland situations can lead to quick identification of opportunities in the future.

One common government program where upland beneficial use opportunities may exist is parks. Local, state, and national parks often require material for landscaping applications and habitat restoration. In addition, many parks are located near the Great Lakes, minimizing transportation obstacles. Another program area with frequent needs for landscaping material is transportation projects, such as highway construction. A third set of government programs where upland beneficial use opportunities might be found are Superfund and brownfields cleanup programs, where dredged material could be appropriate as a fill or cover material, either alone or as part of a mixture. Mineland reclamation programs, such as Pennsylvania's Bark Camp reclamation project,[231, 179] can also benefit from the use of dredged material. Government programs with activities occurring near coastal areas or dredging sites where dredged material can be easily transported hold particular promise for upland beneficial use of dredged material.

In addition to governmental programs, numerous private-sector operations are likely to have potential needs which dredged material may satisfy. Contacting individual businesses, particularly those with operations near the dredging site(s) is an excellent first step. Approaching trade groups (e.g., participating in trade shows) is a good way to inform industries of the availability of dredged material and possible uses for it. Landscape engineers and construction contractors are likely to have frequent need for fill and cover materials. Dredged materials may be ideal for meeting some of these needs. Landfill operators will likely be able to use dredged material as a daily cover, final cover, or closure material. As with many government officials, private-sector representatives may often be unaware that dredged materials are available or suitable for their needs. It is therefore important that dredged material managers take an active role in contacting and informing these groups in order to facilitate these opportunities.

Ohio's innovative strategies for encouraging upland beneficial uses of dredged material

At Ohio Stake Parks, dredged material has been used to create and enhance wetlands, build popular BMX bike courses, and create other bike trails and sledding hills. To promote the use of dredged material with farmers, Ohio has partnered with the USDA to demonstrate on a farm field the benefit of dredged material in growing crops. Also, Ohio has implemented a program to create a "biodredge" potting soil from dredged material from an inland lake, Indian Lake (see description on page 20).

One opportunity to find and incorporate upland beneficial uses on a long-term basis is during the formation and revision of Dredged Material Management Plans (DMMPs). These plans are formed by the U.S. ACE district offices for all deep-draft ports to establish a system for managing dredged materials over a period of 20 years. The Corps works in conjunction with a number of partners, including state agencies and port authorities to formulate these plans, which include an economic analysis of costs and benefits. Considering and planning for upland beneficial use during this process would be efficient because of the diversity of organizations involved and the comprehensiveness of the plans developed. A list of Great Lakes DMMPs and their current status is provided in Table 2-1.

In some cases, the most compelling reason for finding beneficial uses of dredged material will be the potential for substantial cost savings. Although beneficial use is often not the "least cost alternative," in some cases a beneficial use will prove to have a lower cost than other options. As port authorities may be responsible for sharing disposal costs, this can be an important consideration. The federal standard (33 CFR 335.7) requires cost sharing for the portion of costs from any project that exceed the least cost alternative. The nonfederal share of the excess cost varies by type of project (nonfederal funds are needed for 25 percent of the excess cost for restoration and protection projects, 50 percent for beach nourishment, and 100 percent for other uses). In some cases, additional resources can be found to contribute to beneficial use projects, such as grants intended for habitat restoration. Seeking such funds can make some beneficial use projects financially viable, even if they are not the least cost option.

There are a number of strategies that will make the identification of upland beneficial use opportunities more efficient. One important factor is timing. Looking for opportunities well in advance of when they are needed, or even on an ongoing basis, will increase the chances of finding a suitable use. Another important factor is location. Identifying public and private projects near the dredging site can significantly reduce transportation costs, making a project more cost-effective. Active communication with potential users is another important strategy because many people are not aware of the availability of dredged material. If beneficial use opportunities are well-promoted and potential users are well-informed, a number of additional opportunities may become apparent. Creating opportunities to store dredged material temporarily, such as at a dewatering or "staging" site can allow extra time to identify suitable beneficial uses and for the material to solidify. Staging sites also allow for a more stable distribution of material availability over time.

Table 2-1: U.S. ACE Dredged Material Management Plans (DMMPs) in the Great Lakes

Site	Start Date	Status
Chicago District		
Michigan City, Ind.	Summer 2003	Detailed analysis of first set of alternatives underway. Stakeholder team is in place.
Calumet Harbor, Ill.	Winter 2003-04	In early stages of identifying first set of alternatives. In process of establishing a stakeholder team.
Waukegan, Ill.*	Continuation of long term project	Plan involves some work on the inner harbor involving dredging both in and outside the channel.
Buffalo District		
Cleveland, Ohio	2003	Nearing completion of Phase I, including preliminary assessment of the need for a CDF within the next ten years, a DMMP scope of work, and agreement with nonfederal sponsor. Following independent technical review, these will be forwarded to Division for potential funding in FY 05.
Toledo, Ohio	Continuation of long term project	Phase I completed in '03, Phase II underway with actual technical investigations and general project management development.
Lorain, Ohio	2003	Phase I completed, now starting Phase II with project management development, including determination of need for Environmental Impact Statement over coming year.
Detroit District		
St. Joseph, Mich.	Continuation of long term project	Upland disposal site selected and nonfederal sponsor identified: Berrien County. Environmental assessment being prepared for pumping material directly from dredging operations, likely starting in FY 05. Geotubes to be used for containment instead of holding pond.
Grand Haven, Mich.	Continuation of long term project	No upland disposal site identified. Working with all stakeholders to find alternative to open lake disposal. Also working with U.S. ACE Vicksburg R&D lab on potential for topsoil creation using local yard waste.
Saginaw, Mich.	Continuation of long term project	Currently evaluating potential upland disposal sites with the State of Michigan.
St. Claire, Mich.		Actively looking for alternative to Dickinson Island as disposal site, ideally in Port Huron/Sarnia area because of haul distance. Working with the State on a plan to deposit sandy material on a park beach at Port Huron.
Oconto, Wis.		Inactive, unfunded
Sebewaing, Mich.		Inactive, unfunded
Duluth, MN – Superior, WI		Completed
Green Bay, WI		Completed
Holland, MI		Completed

B. LOGISTICAL AND ECONOMIC CONSTRAINTS

Beneficial use options should be evaluated in the first stages of a project to assess logistical and economic constraints that may affect the feasibility of the beneficial use. Factors that could hinder the beneficial use of dredged material include the following:

- Distance from the site of dredging to site(s) of beneficial use and associated transportation costs
- Timeframe for availability of the material (including mandated seasonal windows for dredging to minimize environmental impacts) and time constraints for fulfilling project needs (such as a construction schedule)
- Dewatering cost, time and space requirements
- Availability and cost of various transport options (e.g., rail, barge or trucking)
- Local ordinances and community concerns
- Market factors, especially the typical cost and predicted availability of a conventional material, such as aggregate or fill, which the dredged material would be replacing.

It may be evident from the outset that a proposed beneficial use will encounter major obstacles and should be eliminated. However, further physical and chemical data and site information are often needed to fully evaluate logistical and economic feasibility.

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Transportation Costs and Alternatives

Transportation options often determine the feasibility of a beneficial use option. Travel distance and travel time between the point of generation of dredged material and reuse locations has a significant effect on project costs, particularly for large projects. Options for transporting dredged material to its site of use include rail, barge, and trucking. In addition, hydraulic dredges can pump materials up to approximately one mile and can serve as a means of material transport for projects close to the dredging site. Rail and barge transport typically cost the least per mile and their costs are less sensitive to the cost of fuel than trucking. However, rail and barge are less available than trucking. Transportation costs are typically a function of volume or weight and distance. Wet dredged material is heavier and more voluminous, and therefore more expensive to move. Typical costs for moving dredged material by truck range around $1 per cubic yard per mile. More detailed estimates for transportation costs can be found in the RSMeans *Construction Cost Data* series.[239]

The transportation distance for other materials needed at the site, such as fill soil, clay, sand, or gravel must also be considered. In some cases, such as production of bagged or bulk products, the access and transport to markets should be considered as well. For example, one should consider the efficiency of the site for reaching end-users.

Processing dredged material at the site of dredging by dewatering, stabilization or decontamination may facilitate transport by decreasing the volume and weight of dredged material, and in some cases rendering dredged material less contaminated. Some states impose rules on transport of solid wastes, issuing permits or requiring special controls. The need to comply with such rules should be considered in evaluating of beneficial use options.

Condition of Proposed Site and Historic and Current Land Use

At one location, dredged material placement may be considered as disposal of a waste, with negative environmental or socioeconomic impacts. At a different location, placement of the same material may be viewed as a beneficial use, such as for grading fill. After testing and evaluation, some dredged materials may be deemed suitable for unrestricted use based on a minimal potential for impact to human health, biota and natural resources. However, some dredged materials pose some level of risk to human health and the environment if placed in sensitive locations, such as residential developments, schools, parks, forest preserves or wetlands.

When a dredged material may pose a threat to public health or the environment, various controls can be implemented to eliminate or minimize those risks. Direct contact with the material may be prevented through covering with pavement, clean soil or an engineered landfill cap. These engineered controls physically separate the dredged material from a potential receptor. Such controls are often used at brownfield sites, landfills and Superfund cleanup sites. Access controls, such as fencing, may be desirable where beneficial use involves contaminated dredged material. In addition, use and development restrictions can be written into the property deed, and local zoning ordinances that limit types of development and use (e.g. commercial or industrial) can also reduce risks from unacceptable human exposure to contaminants. Where controls are needed, a governing authority should enforce these controls as a condition of beneficial use. The historic use of the proposed site can affect its acceptability. If the quality of dredged material is similar to background levels at the proposed site, opportunities for beneficial use are much more numerous. For example, mildly contaminated dredged material would be more acceptable for use at a former industrial site or another property that has been degraded than at a relatively pristine site.

A further consideration is naturally occurring high levels of metals at the site of beneficial use. Such "background" may already be at or near allowable levels of contamination, thereby reducing opportunities to use material containing the particular contaminant of concern.

Adjacent Land Use

In any evaluation of beneficial use, not only the site of use but also surrounding land use must be considered. The site of beneficial use may be surrounded by residential, agricultural, commercial or industrial properties, or by a protected area such as a forest preserve or wetland. Dredged material placed at a site could impact surrounding properties through wind or water erosion, migration of biota or human trespass. Groundwater could be impacted, affecting nearby public or private water supply wells. Surrounding industrial or commercial uses are more likely to accept dredged material with some contamination because these land uses are more accommodating for exposure controls, either engineered or institutional, and generally have fewer exposure routes as a result. Taking these factors into account is important when determining the appropriateness of a given use.

Community Benefits and Impacts

The above paragraphs discuss some possible effects of beneficial use of dredged material at a given location, each of which may benefit or adversely affect a community. For example, a real or perceived increase of health risks, degradation of natural resources, or loss of aesthetics can lead to loss of property values. Alternately, infrastructure and landscaping improvements associated with some beneficial use projects can enhance property values and improve environmental quality. Project managers might conclude on detailed evaluation that a beneficial use will not result in negative impacts to a community, or that benefits will outweigh impacts. It may then be necessary to win the support of the interested public for a beneficial use of dredged material in a community. In such efforts, effective communication is vital. Project managers should make available to the public the results of risk analysis and impact evaluation, clearly explaining the evaluation process and how conclusions were reached. They should candidly divulge possible problems such as future disturbance and abuse of material and state how the possibility of such problems can be minimized. Managers should emphasize specific economic and social benefits of the beneficial use of dredged material. For example, it can effectively replace a conventional or "virgin" material such as structural fill, aggregate or topsoil. In evaluation of a beneficial use, the project manager should weigh the likelihood of winning community support.

Community involvement should begin in the earliest stages of a project, seeking out and establishing contact with existing community groups and local government. State and federal permitting rules often dictate minimum public outreach, but for effective outreach, project managers may have to go beyond such minimum requirements. U.S. EPA's *Guide for Industrial Waste Management* [215] recommends conducting interviews with local government officials, community organizations, adjacent residents, and other interested or affected groups. Upon assessing the level of community interest and specific concerns, a written plan should be developed for public participation throughout the planning and implementation of the beneficial use project. The written plan should include participation activities appropriate to level of interest and timing of significant project events, plus a well-researched contact and mailing list. U.S. EPA's *RCRA Public Participation Manual* [217] provides detailed instructions for implementing participation activities such as mass mailings, public meetings, press releases, advisory and focus groups, open houses and information offices.

The formation of a committee to bring all interested and affected groups together may be beneficial for a large-scale project. The Holland, Mich. case study (see page 17) is an example of a successful effort to coordinate local government, citizens and the Corps of Engineers through the formation of an advisory committee. These committees can also foster long-term beneficial use in a region or locality where dredging is frequent. A written charter and management plan for the committee is essential. A plan allows for wise and effective responses to beneficial use opportunities, being based upon comprehensive knowledge of community needs and expectations; the alternative is a crisis-by-crisis, haphazard effort to match dredged material availability and feasible uses. A committee of community, scientific, industry and government representatives can administer a program for ongoing beneficial use. *Managing Lakes and Reservoirs* [240] details a seven-step process to development of a management plan for water bodies that can be adapted for dredged material. Along the way to plan development, a management organization is formed to implement the plan. Results are monitored, evaluated, and the plan revisited and fine-tuned. Through a management plan and advisory committee, it is possible to protect the environment and meet community needs while maximizing dredged material use. Many project reports and case studies, such as the *Bark Camp Final Report* [231], will also have descriptions of public outreach efforts.

Local Government Takes Proactive Role in Promoting Beneficial Use

A case study from Holland, Michigan

Holland Harbor is on the eastern shore of Lake Michigan. Historically, the dredged material from the outer harbor channel has been used for beach nourishment and dredged material from the inner harbor has been placed at an upland site provided by the city of Holland, Mich.. These sites, Riverview CDF and Windmill Island, have been filled to capacity and are no longer available. Additional capacity to accommodate a backlog of 183,000 cubic yards of dredged material, plus future maintenance dredging, is required for navigation to continue in Holland Harbor. The city of Holland coordinated efforts with the Corps of Engineers in seeking additional locations for placement of Holland Harbor dredged material. During the selection of a new site, local participants were strong advocates of engineering the site to allow reuse of the material.

Numerous alternatives were investigated for managing the supply of dredged material from Holland Harbor. These included new upland dredged material placement sites, in-water confined disposal facilities (CDFs), modifications to extend the life of existing facilities and beneficial use of dredged material, such as topsoil for landscaping. Tests of the material showed a contamination profile similar to the area's background levels, indicating that beneficial use might be a feasible and low-cost solution.

In 1991, the Holland community formed a task force under the Macatawa Area Coordinating Council called the Holland Harbor Improvement Committee (HHIC). This committee comprised a wide range of local concerns, from township governments to major harbor users and engineering firms. The HHIC was a strong advocate of finding a beneficial use for the dredged material that was both environmentally and economically advantageous. Ten sites were considered and an upland site located within Holland township was subsequently selected by the Corps based on the HHIC's evaluation. The evaluation criteria were engineering suitability, environmental suitability, and cost. The HHIC submitted a resolution to the Township for approval of the site. Holland Township passed a resolution to use the selected site in 1994. The city of Holland purchased the upland site in 1996. The city then transferred the rights-of-way to the State of Michigan (local sponsor) who, in turn, transferred those rights to the Corps. The site has subsequently been cleared and grubbed and is available for receipt of dredged material.

The upland site at Holland Township is intended to be the permanent site for placement of material dredged from the inner harbor. This site, in conjunction with continued use of outer harbor dredged material for beach nourishment, would satisfy maintenance dredging needs in the least costly manner consistent with sound engineering practices and federal environmental standards. The Holland Township site is available to receive dredged material by hydraulic or mechanical dredging methods for more than twenty years. The Corps has recently completed an environmental assessment (August 1995) followed by a Finding of No Significant Impact for this site. The city of Holland plans to reuse the dredged material for beneficial use, in accordance with Michigan Department of Environmental Quality guidance, for general topsoil application, roadside application, or agricultural application. Local support from the HHIC was critical in making the beneficial use possible.

Market Analysis

Many dredged material beneficial use projects occur at a single time and place. However, some beneficial uses may involve ongoing manufacture and distribution of dredged material as a product, such as aggregate or grading fill, or component of a product, such as manufactured topsoil. The feasibility of such beneficial uses depends on whether a market exists for such products. In market demonstrations, dredged material or a dredged material product should be shown to be equivalent to a conventional product. It should also be shown that consumer demand and market prices will ensure a profitable enterprise. A regulatory agency making a determination of beneficial use need not, and should not, provide a warranty of the quality of dredged material versus conventional product, but should review a market demonstration for the purpose of assurance that the material will be used as proposed. In some states, such as New York, there are regulatory requirements for market analysis.[16] For a case study of cost savings using dredged material in lieu of fill for construction and expansion at shoreline airports, see Douglas and Lawson.[147]

Marketing strategies must take into account the nature of the material and the required restrictions and controls on its use. Liabilities would generally reside with the provider unless specifically assigned to the user. With liability comes the need to control use of the material. The provider must assign restrictions and controls for a material, considering the heterogeneity of the material, the uncertainty/variability of sampling, and the quality control in the production of the material. Quality control must be adequate to ensure that contaminant levels do not exceed specifications for designated uses. Handling instructions should be provided for the material to be transported, stored and used in an environmentally safe and protective manner. Responsibilities of all parties in this regard must be clear, so that users are not penalized for using a non-virgin material and adverse environmental effects are prevented. Testing methods may also impact the determined suitability of dredged material for some marketed products. *In situ* contamination results will often be higher than *ex situ* results due to homogenization of the material during dredging. Additional *ex situ* testing may therefore allow additional uses of the material.

Indian Lake Biodredge Project [212]

Indian Lake, a large inland lake in Ohio requires periodic dredging to maintain its use for recreational boating. This project has produced a large amount of dredged material for which disposal costs have been expensive for the Ohio State Parks. By mixing the dredged material with swine manure solids, the parks department was able to make a viable "biodredge" soil material that could be sold. Tests were performed to determine the optimal mixture ratio. Although the production costs were too high for sale as an agricultural amendment, the material was economically competitive for sale as topsoil.

In addition, Ohio State Parks has a giveaway program for dredged material. Local homeowners can load a pickup truck or small dump truck with the material for their landscape beds or vegetable gardens. Local newspapers, park advisory groups, watershed groups and word of mouth are used to market the dredged material. The State Parks also have demonstration garden plots in visible areas with small signs that, for instance, say, "Flowers grown in Indian Lake dredged material."

Bark Camp Mine Reclamation Demonstration Project [231, 179, 233]

An abandoned mineland in Pennsylvania was identified as a suitable site to serve as a demonstration project for reclaiming the natural habitat and natural watershed flow aspects of the mineland through filling the mine with dredged material. The methodology developed for this project involved an admixture of dredged material from the New York / New Jersey harbor with coal fly ash to act as a stabilizer. In all, the project used nearly half a million tons of dredged material. The final report from the project[231] presents a full description of the planning and implementation process which is applicable to many large-scale beneficial use operations in additional to mine reclamation.

C. IDENTIFYING APPLICABLE CRITERIA

This section discusses the criteria that should be considered when determining the suitability of dredged material for upland use. The criteria are dependent on the specific use of the dredged material because certain characteristics may be considered desirable or undesirable for a specified use. These criteria have been divided into three categories: environmental, agronomic and engineering. Agronomic and engineering criteria may not be applicable to every use, but environmental criteria should always be considered in determining the suitability of dredged material for upland use.

Environmental Criteria

Material dredged from the waterways of the United States can range from being virtually contaminant-free or "clean" to heavily contaminated. This document aims to present a framework for using materials that are clean or have relatively low levels of contaminants that can be controlled for.

Agronomic and engineering criteria may not be applicable to every specific use, but environmental criteria should always be considered in determining the suitability of dredged material for upland use.

Environmental criteria include allowable chemical contaminant concentrations in the material and the chemical characteristics of the material (such as pH or salinity). For some beneficial use scenarios, there is clear guidance on contaminant limits in state or federal regulations.

If specific applicable regulations do not exist for the proposed use, limits specified in other regulations with environmental exposure similar to the proposed use may help identify appropriate limits. Indeed, when testing and evaluating dredged material for beneficial use, most Great Lakes states have relied on hazardous waste regulations, solid waste regulations, land application of biosolids, or other similar statutes and rules. Very few states have promulgated specific legislation related to the management of sediments or dredged material with the appropriate testing and evaluation.

In most cases, state regulatory agencies will make the final determination of how each situation will be evaluated. Usually, acceptable concentration limits will vary depending on the proposed use and may also be adjusted if exposure controls are used. If appropriate risk-based contaminant criteria cannot be identified, a full risk assessment may be needed to ensure protection of human health and the environment. Appendix A offers examples of environmental criteria that are potentially applicable to several common beneficial use scenarios. It also includes a discussion of relevant regulations as well as environmental pathways and exposure routes.

Traditionally, concentration limits have been established based upon risk or the best available technology. Best available technology limits are based upon the lowest level that can be achieved by the best treatment technology currently available at the time the regulation is promulgated. The resulting concentration limit may be lower or higher than the limit established based upon risk. Risk assessment generally establishes limits based upon the potential for adverse environmental effects, such as increased cancer risk, or mutagenic, teratogenic or population effects in human, terrestrial and aquatic communities, as appropriate. In risk assessment, factors such as dosage and exposure time are taken into consideration. Although this report does not attempt to evaluate or recommend one method for establishing contaminant criteria, it does set a framework for applying contaminant criteria according to risk, considering exposure routes and the use of exposure controls. The role of risk assessment in dredged material evaluation is further described in Section IIIB.

All states are required to comply with the federal requirements related to hazardous waste contained in Resource Conservation and Recovery Act (RCRA), including the Subtitle D provisions for municipal solid waste, and the Toxic Substance Control Act (TSCA) regulations related to PCBs. Materials not regulated under these statutes may still be regulated by each individual state as a waste. U.S. EPA has recently published guidelines for nonhazardous industrial waste management that propose minimum standards related to siting, engineering controls, operation, monitoring, closure and financial assurance.[215] Although these guidelines are intended for traditional waste products (fly ash, slag, foundry sand, etc.), application to dredged material could be appropriate in some cases.

Although this report does not attempt to evaluate or recommend one method for establishing contaminant criteria, it does set a framework for applying contaminant criteria according to risk, considering exposure routes and the use of exposure controls.

States regulate nonhazardous, non-TSCA, and nonmunicipal waste in a variety of different ways. Some states adopt only the federal requirements, while other states implement more restrictive requirements. If there are no state regulations for waste materials which are not covered by federal regulations, and if a particular material does not fall under regulations for hazardous or municipal solid waste, then there are no handling or use restrictions for the material. Such gaps in the regulatory framework can result in arbitrary contaminant limits. For example, a material that leaches lead at 5.0 mg/l, using the toxicity characteristic leaching procedure (TCLP), is regulated as hazardous waste and must be placed in a landfill that has a double composite liner and leachate collection system, while a material leaching lead at 4.99 mg/l can be used with no restrictions.

In addition to solid waste, hazardous waste and toxic waste regulations, there are numerous other regulations states have used to develop criteria for management of contaminated materials. A popular regulation to base these standards on is the Safe Drinking Water Act (SWDA),[224] which was originally passed in 1974 to protect the nation's drinking water supply. The SWDA sets maximum contaminant levels (primary drinking water standards) for 90 contaminants that must be met by public water systems as well as maximum contaminant level goals (secondary drinking water standards) that systems should attempt to meet. Some states have based their regulations for management of dredged material on the regulatory levels or a multiple of the levels contained in the SDWA. Criteria based on one to 30 times the primary drinking water standards have been used by various states in the past.

Some states have adopted the criteria developed under Part 503 of the Clean Water Act for dredged material to be used for land application. Part 503 was developed for the land application of sludges from municipal wastewater treatment plants (biosolids). This was one of the first major programs to use a risk-based approach to develop criteria that considers potential impacts to various routes of exposure. However, Part 503 criteria were developed based on extensive study of contaminants associated only with biosolids and the use of these biosolids at agronomic rates under a set of prescribed conditions. Because of the difference between the characteristics and use of dredged material and biosolids, Part 503 criteria should not be used for beneficial use of dredged material. Nevertheless, the guidance offered by Part 503 in developing risk-based standards for land application is very valuable.

Another risk-based approach was developed by the U.S. EPA for cleanup of Superfund sites. In 1996, U.S. EPA issued the *Soil Screening Guidance*[67] (SSG) and a companion *Supplemental Soil Screening Guidance*[93] as tools to help standardize and accelerate the evaluation and cleanup of contaminated soils at sites on the National Priorities List. The SSG provides site managers with a tiered framework for developing risk-based, site-specific soil screening levels (SSLs) for the protection of human health.

While the SSG proposes a mechanism to determine the risk associated with contaminants through various pathways, each individual state determines the amount of risk that is acceptable. Many states set their risk based criteria at an allowable cancer rate of between one in ten thousand and one in a million occurrences per lifetime. If a risk based approach is used to set criteria for upland beneficial use of dredged material, the numerical criteria from SSG may be used as a guide and adjusted to meet each individual state's environmental protection standards.

Additional sources of state-specific criteria are listed in section 3-C of the *Annotated Bibliography*. In addition to official government regulations and guidelines, numerous criteria have been developed that may be applicable to some upland beneficial uses of dredged material. Some of these are designed to evaluate impacts in aquatic ecosystems and therefore may not apply directly to many upland beneficial uses. However, they may be appropriate to placements in or near wetlands. One example is the consensus-based sediment quality guidelines developed by MacDonald *et al.*[228] Additional criteria, such as those described for the Great Lakes Assessment and Remediation of Contaminated Sediments (ARCS) program,[229, 47, 43] may also be relevant in cases where aquatic habitat is a consideration (e.g., wetland reclamation). See also the Guidance Manual to Support the Assessment of Contaminated Sediments in Freshwater Ecosystems.[121, 59, 60]

Soil Screening Guidelines

The 1996 Soil Screening Guidelines (SSG) quantitatively address a number of exposure pathways in a residential setting, including:

- direct contact with contaminated soils
- inhalation of volatiles and fugitive dusts from undisturbed soils
- ingestion of groundwater contaminated by the migration of chemicals through site soils

Some states have added additional pathways that must be considered. For example, Michigan considers these additional pathways:

- indoor inhalation of hazardous substance vapors
- groundwater venting to surface water
- groundwater direct contact

Agronomic Criteria

Agronomic criteria are used to predict the ability of the dredged material to grow vegetation. Examples of these criteria include soil classification, alkalinity, acidity, and nitrogen, phosphorus and potassium content. These criteria should be considered whenever the selected beneficial use involves the establishment of vegetation on the dredged material (or dredged material product). An agronomist usually evaluates these criteria. Agronomic criteria may overlap with environmental criteria for various reasons, including the desire to restore an area for conservation purposes.

Dredged material that contains a high percentage of fine materials (i.e. silts and clays) may require mixing with a coarser material in order to be desirable for land application. Where direct land application is an option, the material must usually be land applied at agronomic rates. For example a dredged material containing 2,000 ppm of organic nitrogen and 400 ppm inorganic nitrogen supplies 1.6 pounds available nitrogen per ton of dredged material. This would equate to approximately 100 tons per acre application rate based on crop needs. A project generating 30,000 cubic yards of material a year would require at least 300 acres each year to satisfy this generation rate. A phosphorus concentration of 500 ppm would supply 1.2 pounds of phosphorus (as phosphate) per ton of dredged material, which in many cases would be more limiting than the nitrogen requirements.

Engineering Criteria

Engineering criteria are used to predict the performance of dredged material in a construction project and develop procedures for placement and compaction of the material.

Soil classification, permeability, compactibility, the potential for settlement, and bearing capacity are examples of engineering criteria. These are determined through standard soil testing methods prescribed by regulations or established by national organizations such as the American Society for Testing and Materials (www.astm.org) and the American Association of State Highway and Transportation Officials (www.aashto.org). Depending on the type of project and use of the material, state or federal regulations, local building codes and standard engineering practices will be used to determine the suitability of dredged material in upland construction projects.

The environmental, agronomic and engineering criteria may be used to determine the suitability of the dredged material for the intended use or develop treatment or placement procedures (e.g., exposure controls) to ensure the success of the project. Because the criteria are dependent on location and type of use, research must be done for each project to identify the applicable regulations, and develop site-specific criteria for the upland use of dredged material. The *Annotated Bibliography* identifies some sources of criteria that may be applicable to a specific situation. Appendix A, which reviews a number of beneficial use scenarios, gives some examples of possible criteria sources.

3. Testing and Evaluation

A. PHYSICAL AND CHEMICAL TESTING

Thorough characterization of a material proposed for beneficial use is a necessary component of the beneficial use evaluation to assure that the material meets application specifications and environmental criteria. Characterization typically involves physical and chemical testing appropriate to the proposed placement and use. The type of use and location will dictate engineering requirements, environmental pathways, and potential human and ecological exposure routes.

Generally, physical tests can be conducted more rapidly and at less cost than chemical analyses. Therefore, unnecessary analytical costs may be avoided if the material is first screened for the proposed use based on physical suitability. The physical data may also lead to strategies for compositing samples for contaminant testing. Numerous references are available containing information pertinent to testing for beneficial use applications. The *Upland Testing Manual* [56], although developed to address upland disposal (rather than beneficial use) of dredged material, contains relevant guidance with respect to dredged material testing. Several documents produced by the U.S. ACE in recent years were developed specifically to address material recovery and beneficial use evaluations, including the *Determining Recovery Potential of Dredged Material for Beneficial Use* series from the Dredging Operations and Environmental Research program.[101, 102, 103] Additional references are cited in these documents as well as the *Annotated Bibliography*.

Material Characterization and Physical Testing

Acceptable grain size and contaminant levels are determining factors for most, if not all, beneficial uses. As a result, material characterization will generally include a particle size distribution analysis and bulk chemical contaminant analysis. Testing of other parameters may also be important, depending upon the beneficial use material specifications. These include clay and moisture content, liquid and plastic limit, and permeability. Structural applications would likely require compaction and shear strength testing. Nonstructural placements will require an estimate of the initial placement volume and changes in volume that will occur over time. Depending upon the method of placement, this information may be obtained from column settling tests and consolidation testing (see Table 3.1). Nutrient analysis, salinity and pH tests might be appropriate if the material will be used as a soil amendment or landscaping material. This is not an exhaustive listing; other tests may be indicated for each specific application. Figure 3.1 illustrates the steps of an effective process for evaluating the physical suitability of dredged material for beneficial use. Table 3.1 provides a list of some common geotechnical tests and approximate costs.

Figure A-1: Evaluating Physical Suitability of Dredged Material for Beneficial Use

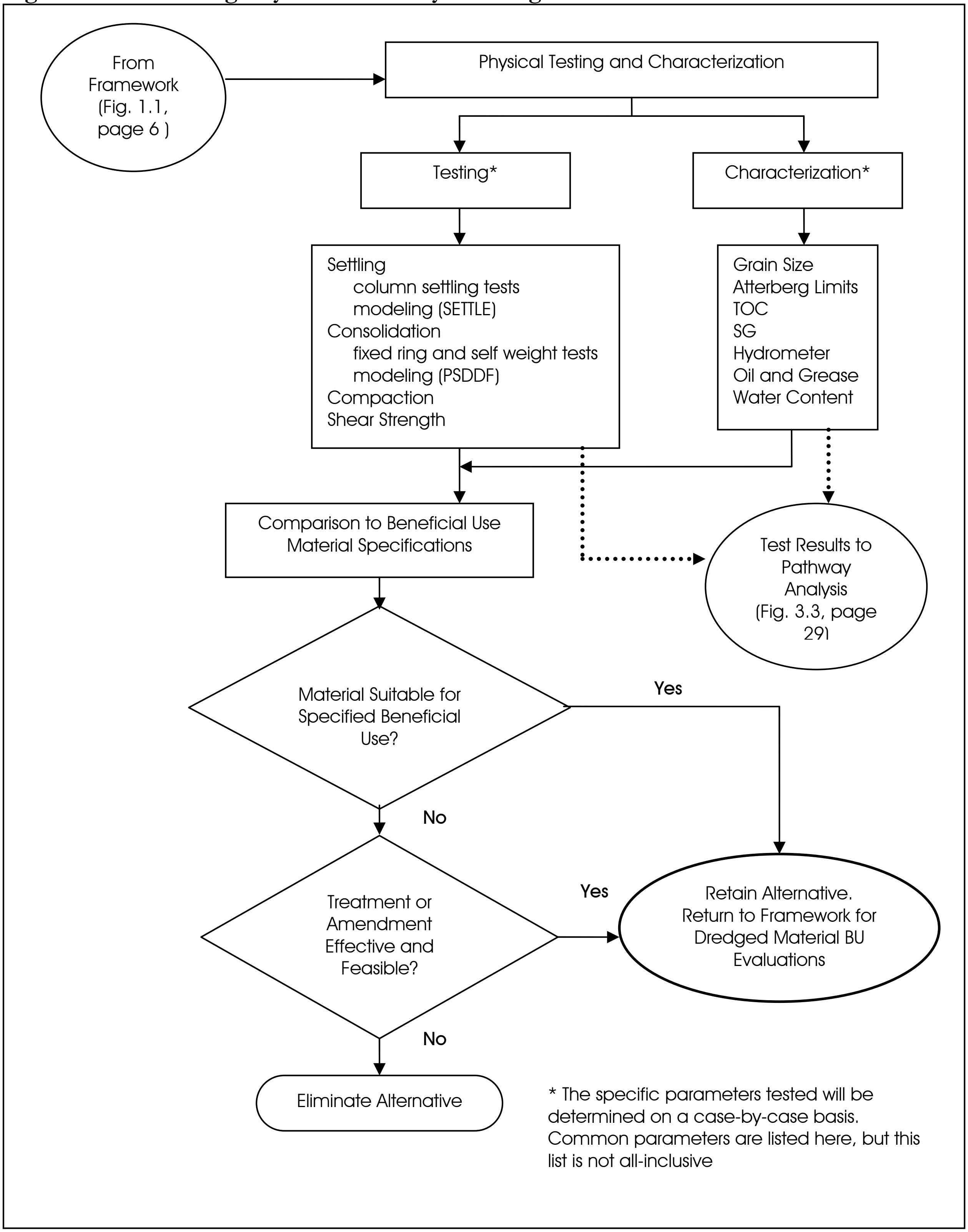


Table 3-1: Geotechnical Tests

Test	Description	Material Required (kg)	Cost (USD)
ASTM D 2488	Visual classification & water content	0.1-1.0	30
ASTM D 2974	Organic content (loss on ignition)		40
ASTM D 422 ASTM D 1140	Sieve analysis & soil classification	0.1-1.1	20-450
ASTM D 422	Hydrometer analysis		50
ASTM D 4318	Atterburg limits		100-200
ASTM D 854	Specific gravity	0.02-0.1	50-70
ASTM D 698[a]	Density		450-750
ASTM D 2216	Water content	0.1-1.0	20
ASTM D 5084	Hydraulic conductivity	0.4-1.6	600
ASTM D 2435	Consolidation	0.6	500-600
TR GL-86-13	Consolidation (self weight)	7.0	1,200
ASTM D 3080	Direct shear	1.0	550-660
ASTM D 2166	Unconfined triaxial compression		100-250
ASTM D 2850	Triaxial compression	1.0-4.0	275-460
a: Also ASTM D 1557, ASTM D 1883, ASTM D 4253 and ASTM D 4254			

Chemical Characterization and Testing

Design of the chemical testing approach requires consideration of all available information regarding the contaminant history of the material, including possible contaminant input from area industries and previous contaminant analysis conducted on materials from the same location. A broad suite of analytes (substances that are tested for) should be identified initially that will capture the range of contaminants that might reasonably be expected to be present. Subsequent testing, if required, may be narrowed to those contaminants that are found to be present in the initial screening. Some typical analyses and representative costs for sediments dredged from navigation channels are listed in Table 3.2. The per sample cost is typically higher for a small number of samples, which require the same set up and instrument calibration effort as a large number of samples. Alternatively, the laboratory may charge a one-time setup fee. Atypical analytes may be very costly as the laboratories able to handle them will be more limited and may have to demonstrate or "prove" the method before the analysis can be done. For additional information on chemical testing, see also *Dredged Material Characterization Tests for Beneficial Use Suitability* [54] and the associated case studies,[185] the *Guidance Manual to Support the Assessment of Contaminated Sediments in Freshwater Ecosystems*,[121, 59, 60] the *Great Lakes Dredged Material Testing and Evaluation Manual* [58] and Section C of the *Annotated Bibliography*.

If a bulk material is found to be unsuitable for the identified beneficial use, a more comprehensive characterization might be useful to determine whether some type of treatment, amendment or site management (i.e., controls) would permit its use for the proposed application. Material blending might be needed to improve engineering or agronomic characteristics. If the bulk material is too contaminated, a contaminant distribution analysis may indicate that a portion of the material is suitable. Alternatively, treatment through removal or immobilization of contaminants may be feasible. Effectiveness and cost of such efforts must be balanced against the expected benefit. Particle separation is relatively inexpensive and effective at separating coarser sandy material from finer clays which have higher contaminant content. Many treatments are expensive and this will prohibit their use for some applications. Choice of an appropriate treatment method will vary widely from case to case. Dredged material treatment is discussed in numerous other sources.[37, 47, 38, 196, 48]

Table 3-2: Chemical Analyses

Method	Analyte	Cost (USD/sample)[1]
SW846 6010/6020 and SW8467060A/6020	Metals (PP or Michigan Metals)[2] Metals (Individual)	195-225 30-35
SW846 7471A	Mercury	30-35
SW846 7740	Selenium	15-30
SW846 9010	Cyanide	50-75
EPA 350.1	Ammonia	25-40
SW846 8081	Organochlorine Pesticides	165-225
SW846 8141	Organophosphorus Pestcides	
SW846 8082	PCBs (Aroclors) PCBs (Congeners)	125 250
SW846 8260B	Volatile Organic Compounds (VOCs)	225-235
SW846 8270C	Semivolatile Organic Compounds (SVOCs)	465
SW846 8440	Total Recoverable Petroleum Hydrocarbons (TRPH)	100
SW846 9060	Total Organic Carbon (TOC)	60

1. Lab setup, digestion/extraction and filtering fees may be in addition to the analytical costs listed here. Analytical costs for sediments versus aqueous samples may differ due to sample preparation requirements. The costs given here are representative cost ranges for analysis of sediment samples, but may vary depending upon location, specific analytes selected and total number of samples submitted for processing at any one time. For example, PAHs are a subset of the semivolatiles. PAH analysis can be obtained for approximately $195/sample. The entire list of PP organic compounds can be obtained for approximately $880/sample.
2. Priority pollutant or Michigan metals groups

If possible, applicable criteria should be identified for each beneficial use alternative before samples are obtained or any testing is conducted. These criteria will determine the structure of the testing and the type and volume of samples required. When definitive contaminant criteria are not available, or contaminant concentrations exceed the specified criteria, a risk assessment may be required to further evaluate the potential environmental impacts attributable the proposed use. The need for data to support a risk assessment should be considered at the same time that the physical and chemical characterization effort is developed. It is often more cost-effective to obtain samples sufficient to support all anticipated testing than to conduct a second sampling effort. This allows testing and analysis to be conducted in a stepwise fashion, as information needs dictate. The number of samples required to adequately characterize a site will vary with the size of the site and the amount of material to be dredged. Some general guidance on this topic is offered in Table 3.3. The degree of uncertainty associated with dredged material assessment techniques can be kept to a minimum by following thorough quality assurance and quality control techniques.[90, 88] Risk assessment can also help reduce uncertainties, and lead to better understanding where they lie.

Table 3-3: Suggested Minimum Core Sample Numbers for Site Characterization

Volume of Sediment to be Used (cubic yards)	Approximate Number of Core Sample Sites to Characterize the site.
1 – 10,000	<3
10,000 – 30,000	3
30,000 – 100,000	5
100,000 – 500,000	6
500,000 – 1,000,000	8

From Wisconsin's Draft Guidance for Applying Chapter NR347 WAC to Dredging Projects in Surface Waters.[53] Because variation in grain size can vary greatly over short distances, a dredging project area may require greater sample density.

B. RISK ASSESSMENT

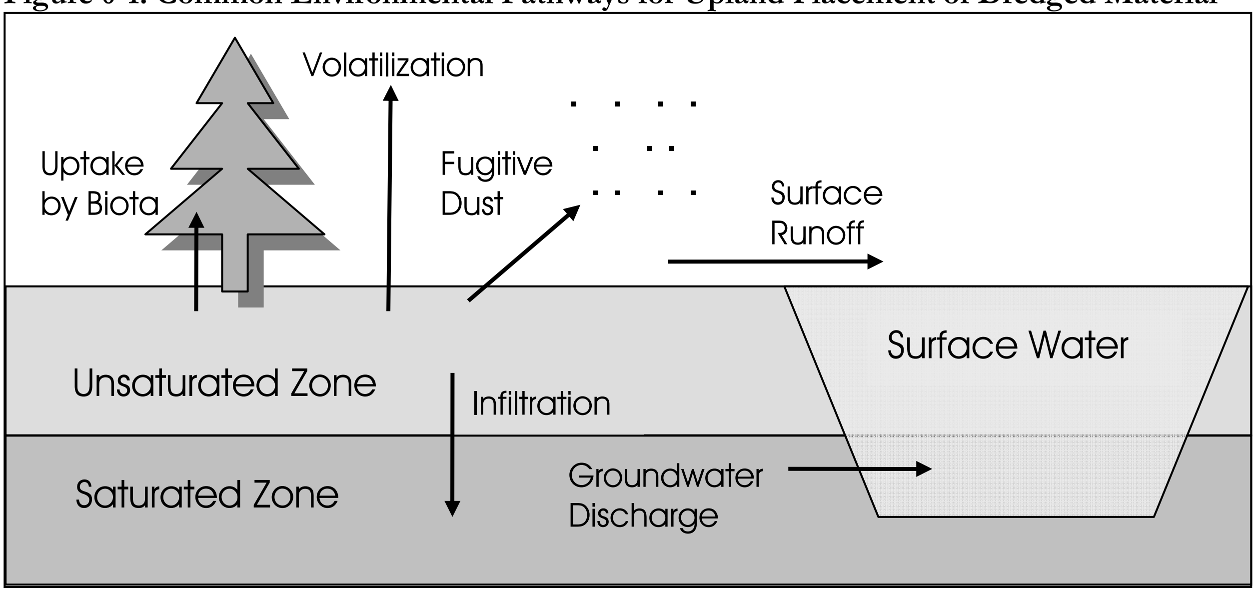
Although risk assessment as a formal process for dredged material evaluations has only emerged in recent years, much of the customary testing and analysis conducted prior to dredged material disposal is inherently risk-based. For example, water quality criteria are based on effects levels established in biological studies. The potential for exceedance of water quality criteria during dredged material disposal and following placement is a key component of the pathway analysis conducted prior to a dredging and disposal action. However, in cases where applicable criteria do not exist or are not met, a formal risk assessment is often necessary to justify a beneficial use action. U.S. ACE's *Use of Risk Assessment in Dredging and Dredged Material Management* [219] is a valuable resource for the basic concepts of risk assessment for dredged materials. In many cases, ecological risk, as well as human health risk must be considered. Conducting an ecological risk assessment is similar to a human health risk assessment. Ecological endpoints, such as mortality or impairments to species and effects on food-web dynamics, are considered rather than cancer risk. Some criteria have been developed for assessing such impacts. The complexity of the ecological risk assessment will vary with the complexity of the ecosystem the dredged material is being introduced into. U.S. EPA has several guidance documents available on this topic, including *Proposed Guidelines for Ecological Risk Assessment* [226] and *Ecological Risk Assessment Guidance for Superfund*.[227] Driscoll *et al.* [111] present a methodology that incorporates both ecological and human health risk assessment into dredged material management decisions.

Evaluation of environmental pathways for an upland beneficial use of dredged material may be modeled after the analysis typically conducted for upland dredged material disposal, with necessary or appropriate modifications (as described in the *Upland Testing Manual*).[56] The environmental pathways customarily evaluated with respect to contaminant transport for upland placement include volatilization, effluent from hydraulically placed material, runoff, leachate and uptake by plants and animals. Figure 3.2 depicts these common environmental pathways. The proposed placement should be evaluated with a focus on pathways that are likely to provide a contaminant exposure route. See Figures A-1 and A-2, Appendix A pages 54 and 55, for additional discussion of environmental pathways and exposure routes.

All of the pathways listed above are potentially of concern. Their significance will be a function of contaminant type, level and mobility, site accessibility and type, sensitivity of receptors and other factors. The magnitude of contaminant release anticipated for the identified pathways may be estimated based on partitioning analysis and bench scale testing. These analyses are intended to be conservative and to overestimate the expected contaminant release. If predicted releases or exposures are determined to be below applicable criteria, environmental impacts are considered to be acceptable. If predicted releases are greater than applicable criteria, there are no applicable criteria, or a definitive answer cannot be obtained due to data limitations, then formal risk assessment may be employed to make a final determination regarding the proposed placement or action.

There are numerous testing and analysis procedures that can be used to analyze the volatilization, runoff, leachate and effluent pathways. The volatilization pathway may be evaluated based on contaminant levels in the material and volatilization characteristics of the contaminant. Predicted releases at the placement site may be compared to an inhalation reference dose to determine whether adverse effects might result from a given exposure duration. A more detailed assessment would include evaluation of transport from the site and expected off-site concentrations. Use of on-site concentrations is a conservative assumption.

Figure 0-1: Common Environmental Pathways for Upland Placement of Dredged Material



Similarly, the effluent pathway may be evaluated based on predicted solubility of contaminants and assumptions regarding mixing and equilibrium of pore water with carrier water (water entrained with the sediment during dredging and discharged as effluent), and mixing in the receiving water. The partitioning analysis is often supported with the modified elutriate test,[230] which involves mixing of sediment with site water for a specified period of time, followed by measurement of resulting contaminant concentrations in the water. Runoff concentrations may be relatively well represented by the effluent concentrations. Most metals become more mobile as material dries and oxidizes, and separate partitioning analysis and runoff testing is advisable where metals are a concern.[130, 167] The Simplified Runoff Procedure (SLRP)[220] is a bench scale testing protocol that involves analysis of synthetic "runoff" produced with wet and dry sediment, with and without chemical oxidation. Leachate concentrations may be estimated based on pore water concentrations. A more definitive analysis will also take into account partitioning to foundation materials at the placement site, and mixing with groundwater within a specified zone. Additional bench scale testing such as the pancake column leaching test (PCLT) ,[56, 138] sequential batch leaching test (SBLT) ,[56, 61] column leaching procedure (CLP)[68] and the toxicity characteristic leaching procedure (TCLP)[138] may also be conducted. The state of Washington's *An Assessment of Laboratory Leaching Tests for Predicting the Impacts of Fill Material on Ground Water and Surface Water Quality* [72] is a comprehensive reference for information on leaching tests. Figure 3.3 illustrates the steps of an effective process for conducting a risk-based analysis of the chemical suitability of dredged material for an upland beneficial use.

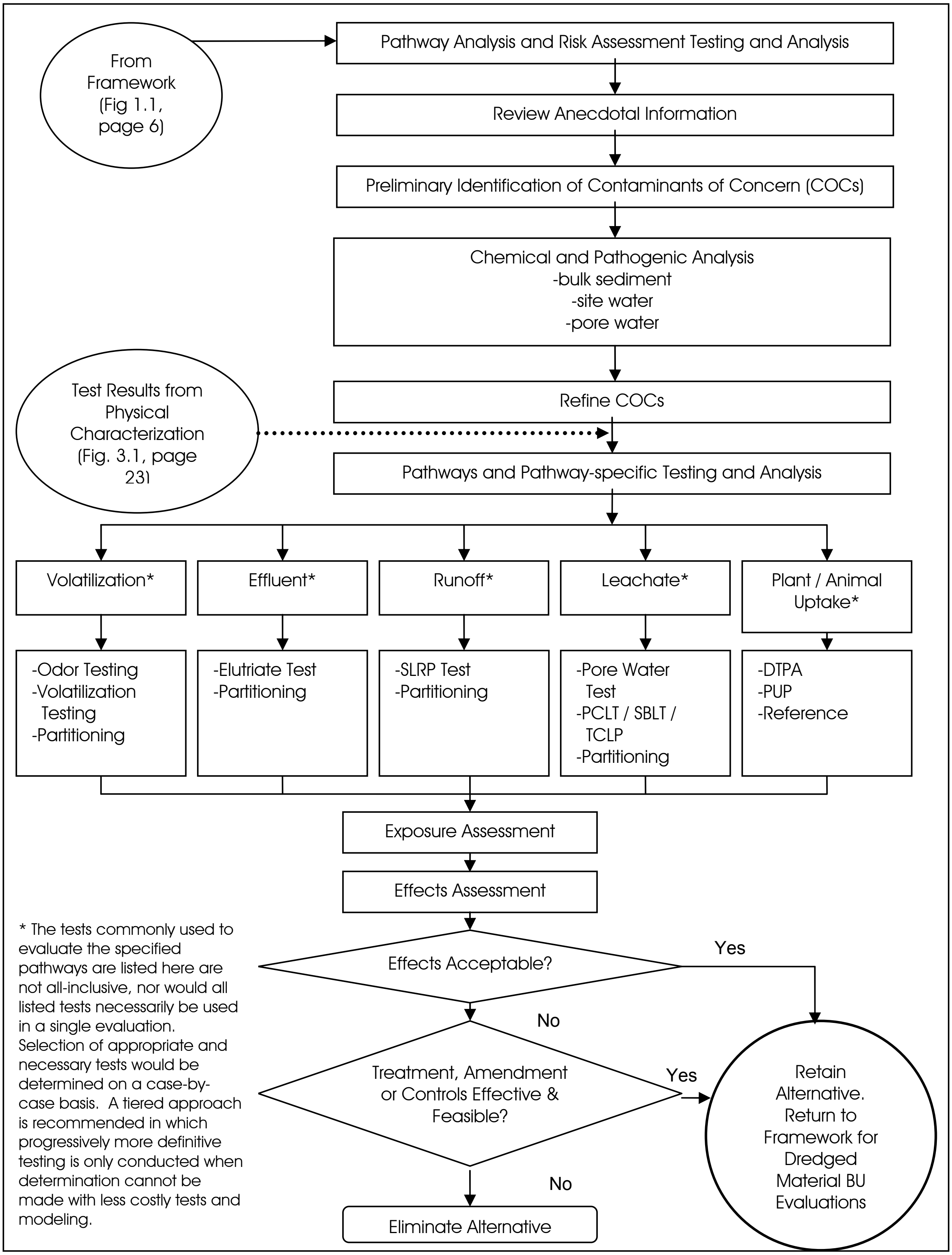
Although the major consideration presented here is for chemical risks, biological risks associated with presence of pathogens in dredged material should also be considered and formally evaluated in some cases. Although most dredged material does not contain appreciable amounts of pathogenic material, dredged material taken from some areas, particularly near sewage outfalls, may contain pathogens at a level that could pose risk. The U.S. ACE has produced guidance for evaluating such contamination, where appropriate.[201]

There are presently few criteria available for evaluation of plant and animal uptake. Preliminary evaluations may be conducted comparing sediment contaminant concentrations to published reference values, or criteria such as those developed for land application of biosolids. However, contaminant partitioning in biosolids and sediments is likely to be very different due to inherent differences in these materials. Values developed for other materials should be used with caution. Bench scale tests and models are also available to predict and measure plant uptake. These include the diethyltriamine-pentaacetic acid extraction (DTPA) and, a model for prediction of uptake by freshwater plants (PUP) (see www.wes.army.mil/el/elmodels/).

Results obtained for the pathway testing may then be used to support an exposure and effects assessment. As noted earlier, exposure routes can vary considerably depending on the proposed beneficial use. Some potential exposure routes of concern include ingestion, inhalation and dermal contact. If risk is determined to be acceptable based on this assessment, which may involve a full risk assessment, then the proposed alternative is considered to be environmentally acceptable. If the risk is found to be unacceptable, treatment or controls may be considered, or the alternative must be eliminated. For further information on risk assessment, see *Use of Risk Assessment in Dredging and Dredged Material Management*[219].

It should be noted that there may be environmental effects associated with a proposed beneficial use other than those attributable to the presence of contaminants. These must also be taken into account before an alternative is determined to be feasible. This would likely be done as part of the environmental assessment, or environmental impact statement, if applicable. The role of EA/EIS in dredged material evaluations as defined under the National Environmental Policy Act (NEPA) [(Pub. L. No. 91- 190) (42 U. S. C. 4321 et seq.)] is discussed in the *Technical Framework*.[55] Additional guidance pertaining to ecological risk assessment may also be found in the *Wildlife Exposure Factors Handbook* [237, 236] the *Proposed Guidelines for Ecological Risk Assessment,*[226] the *Ecological Risk Assessment Guidance for Superfund,*[227] and *Priorities for Ecological Protection*.[235]

Figure 0-2: Evaluating Chemical and Environmental Suitability of Dredged Material for Beneficial Use



C. RANKING AND SELECTION OF ALTERNATIVES

As described above, selecting the most appropriate upland beneficial use of dredged material in a given situation requires thorough evaluation of the physical and chemical characteristics of the material, how the dredged material can be successfully and safely used, and the socio-economic characteristics involved. Grain size, water content, contaminant concentration, cost, and public acceptance become critical criteria during the decision process. These factors will be determinants of both the likelihood of receiving regulatory approval and the desirability of the project from a dredged material manager's perspective. Some states may already have regulations that require submission of this information as part of a permitting process. The relative importance placed on each of these factors depends upon the intended use of the material.

Use Alternatives

The range of upland options for dredged material includes: beach nourishment, habitat development, construction material, manufactured soil, agricultural use, landfill cover and landfill disposal, among others. The order listed here suggests a use hierarchy from highly beneficial to disposal (not acceptable for beneficial use). Material specifications will vary from one use to another. Each of these alternatives is evaluated below based on the importance of material characteristics and other factors in determining their suitability.

Beach and Littoral Nourishment

The use of dredged material for beach and littoral nourishment is a commonly accepted practice for repairing or replacing beach material that has naturally eroded from the shoreline. The placement of materials to create a shoreline generally requires clean sandy material making the grain size and contaminant concentrations the most important factors in determining suitability of the dredged material. Most dredged material used for beach nourishment is pumped directly onto the beach to naturally dewater or in the littoral zone where dewatering is not an issue. The cost of the project will be impacted if material must be pumped long distances or if it is necessary to transport dewatered material from another location. Although beach nourishment is a common practice, public acceptance will vary depending on the final use of the project site and other factors involved.

Habitat and Parkland Development

Habitat and parkland development may vary from creation of wetlands to creation of open space for active or passive recreational activities. Dredged material used for such development must be suitable in terms of physical (particularly grain size) and chemical (salinity, nutrients, and contaminants) characteristics. The grain size and agronomic characteristics must be compatible with planned plantings and activities. If the desired use of the area is wetland development, then a fine-grain-size material is necessary to hold the water that creates the wetland. If the desired use is a recreational site, such as an athletic field, then a coarser material may be needed to encourage drainage and withstand foot traffic. In both cases, the contaminant concentrations of the material are critical in determining suitability. The degree of dewatering required will vary depending upon the application, but is generally driven by placement and transportation requirements rather than selected site use. While creation of open space or a recreational area may be a desired alternative, these uses must be developed with public input and will suffer if not accepted by the public. On the other hand, if the location of the project area is remote, public interest may be minimal.

Construction Material

Dredged material can be used as a construction material for structural or for non-structural fill. The use of the material in either of these activities typically requires the dredged material to be dewatered. The engineering characteristics of the material will take precedence in this application. Dredged material that will be placed under a building or a highway must be capable of withstanding the imposed loads. In some cases this may require blending of dredged material with other materials. The dewatering or blending with other materials could increase the cost of the project. In those cases where dredged material is used for construction of open space or recreational areas, the engineering characteristics may not be as critical. For many construction activities, the dredged material will be covered by a building or paved over during the construction of the project. Material with low levels of contamination can sometimes be utilized in these applications. However, potential for migration of contaminants via particulate transport, runoff, leachate or other potentially applicable pathways must be considered and evaluated.

Drain Fields are Possible Beneficial Use Application

Sandy dredged material could be used for engineered drain fields in coastal areas near dredging sites. This beneficial use could reduce nearshore pollution from failed septic systems, a common problem with older cottages along the Great Lakes.

Manufactured Soil

Dredged material can be blended with other materials to make a manufactured soil to be used as topsoil or potting soil. Grain size is important in these applications. Because, the dredged material will be blended with other materials, particle size can generally be controlled by the mixture components as well as the dredged material. If the intent is to manufacture topsoil, the dredged material may be blended with leaf and yard compost or biosolids. Contaminant concentrations may not be as critical when using manufactured soil for restoration of a brownfields site. In all cases, the dredged material must be dewatered prior to blending. Required dewatering and blending costs will need to be weighed for this alternative. Public acceptance is important not only where the material will be used or marketed, but also may need to be addressed when blending activities occur.

Agricultural Use

In some circumstances, dredged material may be used as a soil conditioner or a soil additive in agricultural applications. While similar to soil manufacturing, this should be considered a separate alternative as the dredged material may be applied directly to the land surface and incorporated into existing soil. As with manufactured soil, the dredged material must be dewatered for this use. The contaminant concentrations are a critical consideration if the material will be used for food crop production. This factor may not be as important if the material will be used for restoring barren sites that will be planted with vegetation where there is not as great a concern for plant or animal uptake. However, potential surface and groundwater impacts due to contaminant transport will always be a consideration. Grain size may be an important factor if the dredged material will be used as a soil conditioner. Adding a sandy material to a soil with a high clay content is an example. Cost of dewatering and transportation from the point of generation to where the material will be used may be an important factor. In addition, the importance of public acceptance will depend on where and how the material will be used.

Landfill Cover / Land Disposal

The last two alternatives are at the bottom of the use hierarchy, as they both will occur at disposal sites. Landfill cover will obviously require the material to be dewatered. Grain size specifications need not be as stringent as for other beneficial uses, but the material must be workable and stable enough to remain in place and be useful in control of blowing litter, odors, and fires at a landfill. The cost factor would have to take into consideration the dewatering as well as transportation. Since most landfills have liners to collect leachate for treatment, and have ground water monitoring, the contaminant concentrations are not as critical as for most beneficial uses, but will enter into the evaluation. Dredged material with contaminant concentrations high enough to classify it as hazardous waste will require disposal in a permitted facility. Public acceptance would not be expected to be problematic for such applications, but must always be taken into consideration.

Land disposal is not a beneficial use. It may or may not require dewatering. The dredged material may be disposed in a confined disposal facility that acts as a dewatering impoundment. The *Upland Testing Manual* [56] was developed specifically to guide decision-making for upland disposal of dredged material and should be consulted. The design and location of the disposal area would have to take contaminant concentrations into consideration. Cost in this instance would be a major factor because a disposal area would require engineering design and, depending upon evaluation of contaminant levels and transport potential, ground water monitoring could be required. Disposal in a permitted landfill typically requires that the material meet the paint filter test. The grain size may be a significant factor in designing disposal site and operations, as fine grained dredged material may require considerably more time and effort to dewater and stabilize. As with any alternative where land disposal is the option of choice, public acceptance is an important consideration.

Weighing Alternatives

Because of the wide diversity of possible upland applications, it may be difficult to weigh them using a single method. The types of benefits and impacts presented by each can vary widely. The physical and chemical testing processes can be used to rule out unsuitable applications for the material. Alternatives remaining at this point must be evaluated based on the cost of implementation relative to the expected social or environmental benefits to be derived. There are numerous systems for weighing benefits and impacts that can be adapted for the decision in question. Table 3.4 shows an example of one possible method of organizing such an evaluation. Depending on the projects being considered, additional categories may need to be added or existing categories subdivided for better specificity. The relative weights for each category will need to be determined by the dredged material manager based on the constraints of their situation and their institutional priorities. For each project, each criterion can be scored on a scale, such as -5 to +5 or -10 to +10, with negative numbers indicating adverse impacts and positives indicating benefits. These scores can then be multiplied by each criterion's relative weight and added together to determine the overall score for each use. It is advisable to also record a justification for each score for future reference. This is just one possible evaluation system. Managers are encouraged to explore other decision making frameworks that may better suit their individual needs. Nonbeneficial use alternatives can be evaluated concurrently to provide a comparison of costs and benefits.

Table 3-4: Sample Evaluation Criteria Table for Upland Beneficial Use Selection

	Criterion	Weight	Option 1	Option 2	Option 3	Option 4	Non-beneficial use
Economic	Immediate cost to agency						
	Long-term cost to agency						
	Immediate external costs						
	Long-term external costs						
	Immediate economic benefits						
	Long-term economic benefits						
Social	Human health impacts						
	Human health benefits						
	Aesthetics						
	Social perceptions						
	Public support / opposition						
	Other social impacts / benefits						
Environmental	Toxicity to terrestrial species						
	Toxicity to aquatic species						
	Impact on water quality						
	Impact on terrestrial habitat						
	Impact on aquatic habitat						
	Impact on wetlands						
Other							
	Sum						

4. Implementation

A. MATERIAL HANDLING AND PROCESSING

Material handling may involve dewatering, debris or oversize material removal, blending, stabilization, containment and transportation. Material handling requires selection of suitable equipment for any necessary processing, identification of feasible transport methods and consideration of the logistics for field operations. Operational interfaces, containment, residuals management and quality control are all important elements of material handling.[129] If dredging and material processing are to take place concurrently, dredging operations should not be planned independently of planning for effective pre-treatment, staging, moving/storage and treatment. If the interdependence of dredging, processing and transport is not considered and anticipated, material may accumulate or costly delays may be introduced to some part of the process. In most cases, a staging area plan should be developed to define locations for the placement of material awaiting storage. If the production rates of dredging and processing do not match, the plan has to address points where material will accumulate. In some cases, staging areas can be reused or considered semipermanent.

Dewatering

The intended use of the material and the proximity to the dredging location will determine the need for dewatering before transport. Some uses may permit direct placement of mechanically dredged material. However, with the exception of nearshore placement where dewatering and placement could occur simultaneously, hydraulically dredged material will require an intermediate dewatering step.

There are several dewatering techniques. Placement of material in a settling or dewatering basin allows solids to settle and surface waters to runoff or evaporate. Dewatering in a settling basin may require a year, or even several years, depending upon the characteristics of the material, depth of placement and on-site management practices. Deeper lifts will require longer periods of dewatering. The Bayport CDF in Green Bay, Wisc. was constructed with an underdrain system to expedite dewatering. In instances where underdrains are not available or would not be effective, tilling or mounding of the material will reduce dewatering times. Volume and density of material dewatered in a settling basin can be estimated using consolidation analysis (see PSDDF at www.wes.army.mil/el/elmodels/). Depending on the quality of the material, measures may need to be taken to contain any water discharged during dewatering or staging.

Mechanical dewatering may be employed at the time the material is dredged. Solids contents of 45 percent to 60 percent are possible with mechanical dewatering processes such as belt filter presses and plate and frame presses. Such options are sometimes employed in remediation dredging to reduce the volume and weight of material to be transported. Although this would be a benefit in beneficial use applications, the processing cost may outweigh the reduction in transportation costs. For further discussion concerning volume reduction and cost comparisons for different processing options, see *Planning level cost-benefit analysis for physical separation at confined disposal facilities*.[221]

Geotextile tubes are another option for dewatering dredged material. Dredging is conducted hydraulically and the slurry is pumped into the tubes. Water is forced out of the bags while dredged material remains inside. Weight may be placed on top of the bags to expedite consolidation. After dewatering, the bags may be split open and the dredged material removed and transported for use at another location. Geotextile tubes can remain in place for nearshore beneficial uses such as erosion control. Use of geotextile tubes for dewatering may not be suitable for all types of dredged material. An advantage of this method is that the filtrate can be very clear and require little treatment. Flocculant may be needed to prevent excessive loss of fines. The dewatering site may need a lined pad for the geotextile tubes, along with pumps, piping, manifolds and flocculant feeds.

Upland beneficial use sites may allow the material to be spread over an area exposed to the atmosphere for some months or years. This takes advantage of the drying and shrinkage effects of evaporation of pore water from settled solids. Experience has shown that dredged material can be dried sufficiently under this type of operating plan to allow it to be excavated by construction equipment. Excavation might have to be limited to taking off horizontal layers, to allow newly exposed material to dry, shrink, and attain soil-like structure. Drying dredged material in this process avoids the costs of mechanical or chemical dewatering or stabilization and can prepare dredged material for subsequent beneficial use. Volatilization may be a concern where the dredged material contains high levels of volatile organic compounds (VOCs). Where this is a concern, monitoring should take place during the drying period.

In some instances trenches, berms, or other structures will need to be constructed at the placement site to control the movement of the dredged material and released water and suspended solids. Even material dredged via mechanical means still contains 50 percent to 80 percent water and will tend to flow. Dredged material transported to the placement site as a slurry contains a volume of water approximately seven times the volume of the dredged material and requires an extensive effort to deal with the carriage water. Hydraulically transported dredged material requires a much larger placement site and a considerably longer dewatering time compared to mechanical dredging. Regardless of the placement method, dredged material undergoes a considerable amount of consolidation as it dries out. Fracturing also occurs as the material dries. Many beneficial uses require dewatering and/or solidifying dredged material into a damp, nonflowing solid that can be stacked and handled by earthmoving equipment. Both gravity settling and mechanical dewatering (such as by running the sediment through a filter-press to squeeze out water) can create material that is sufficiently solid and stable. The major trade-off in deciding between gravity and mechanical dewatering is between time and space requirements versus equipment, energy and cost requirements. In addition, separating the material or amending it might be desired prior to its placement at the site. Dewatering, separation and amendment options are described in section IV-A, *Material Handling and Processing.*

Separation and Amendment

In addition to dewatering, removal of debris or oversize material will likely be required for many beneficial uses. Debris may consist of such objects as cables, chunks of concrete, coal, tires, wood pilings and even auto bodies. Depending upon the grain size distribution specified for the beneficial use application, processing may also be required separate oversize or undersize materials from the desired product. Dry materials can be processed through a grizzly, trammel or dry shaking screen, but water spray is typically required to remove fines from coarse materials if a very clean coarse product is required. Attachments are also available for backhoes and front-end loaders that allow screening of soil during excavation and handling. For additional discussion regarding removal of debris from dredged material, see *Determining recovery potential of dredged material for beneficial use - Debris and trash removal*.[222] Commercial equipment available for material handling and processing are described in *Physical Separation for Volume Reduction of Contaminated Soils and Sediments*.[129]

Some applications may require that the dredged material be amended in some manner to achieve physical or chemical characteristics. This may be addressed by blending or stabilization. Stabilization may refer to the amendment of the dredged material with substances that will help to immobilize contaminants, or it may refer to the addition of cementitious or other materials to improve structural characteristics. For example, dredged material has been mixed with cement, fly ash, lime and/or chemicals to create soil aggregates. This mixing binds the small particles into larger aggregates with improved physical and chemical characteristics that can allow the material to be used beneficially.[37] Studies have been conducted by the Los Angeles Region Task Force and others to evaluate both types of stabilization. Results of those studies can be found in Chian *et al.* (2002)[225] and Dermatas *et al.* (2002) .[232] In addition to stabilization, the addition of calcerous, reactive materials such as lime, pozzolanic fly ash, cement kiln dust and Portland cement, has a long history of use in dewatering soils.

Transportation

The mode or combined modes of transportation will be case-specific. However, getting the material to land will involve either barge or pipeline. If the beneficial use site is not on or near the shore, truck or rail transport could then be utilized. Availability will be the primary determining factor of transportation choice, followed by relative cost. Potential transportation methods should have been considered when screening for logistic constraints (see section II-B). Containment of seepage and dust control may be issues during loading, transport and offloading of materials. Worker safety and necessary personal protective equipment (PPE) must be considered. Provision for cleaning of trucks or rail cars may need to be addressed at loading and offloading areas.

B. SITE DESIGN, PREPARATION AND CONSTRUCTION

The diversity of local geography, geology, and regulations coupled with particular end use needs leads to a wide array of considerations for implementing the site design and for, preparation and construction of beneficial use projects. The range of scenarios is too wide to describe them individually. Instead, this section focuses on the site design, preparation, and construction elements of beneficial use scenarios that resemble waste management and disposal operations and which require extensive engineering and site preparation activities and are likely to incur the heaviest regulation. Such operations could include handling facilities, where material would be prepared for beneficial use, as well as final placement at a particular location. Many beneficial use projects will not require such large planning and implementation efforts. For additional engineering discussion concerning dredged material, see U.S. ACE's dredged material *Engineering and Design* reports.[41, 42]

State and Local Regulations

Dredged material is categorically defined or regulated as solid waste in some states. There are also waivers and exceptions to this definition depending on test results and end uses. Where exceptions do not exist, the material is subject to some or all solid waste rules and regulations for processing, storage and public distribution. Solid waste regulations are based primarily on design concepts for containment of wastes and leachate, and on provisions for protection of groundwater quality such as at landfills. Applicants should become familiar enough with their state's regulatory process to determine whether the beneficial use must comply with solid waste requirements and whether there are exemption processes or guidance documents specific to dredged material or to the given beneficial use. Appendix A describes the regulatory framework in the Great Lakes states for several beneficial uses.

Depending on the state regulatory process, beneficial reuse may be subject to dredging regulations or discharge permit regulations, rather than solid waste regulation. The format and language of these regulations may differ among the various regulations, and the applicant must determine which design requirements apply and demonstrate that they are environmentally protective. Regardless of the regulatory umbrella, an applicant will be required to demonstrate that the action is environmentally protective.

Concentrations of contaminants, location and regulatory requirements for groundwater protection heavily influence choices in design of facilities. Locational and performance standards for disposal facilities (and similar beneficial use placements) are usually set by state regulatory agencies, occasionally with additional requirements by local agencies. Locational standards are often listed in regulatory codes as setback distances from homes, private or public water supply wells, roads, and public buildings or property. These standards can be set either at the state level or by local ordinances. Performance standards are often expressed as requirements for compliance with groundwater standards, surface water discharge standards, air standards and protection of wetlands and critical habitat.

For some beneficial uses, dredged material is expressly exempt from many requirements if it is sufficiently uncontaminated. In other cases, exemption may be requested if it can be demonstrated that the material will not be injurious to the environment or human health in the specified placement. Because such demonstration (e.g., a full risk assessment) is difficult and costly, successful siting is often based on complying with location and performance standards.

Site Selection

For many beneficial use projects, siting decisions will be inherent in the choice of the project, such as for landscaping in a state park or beach nourishment on a portion of shoreline. For daily and final cover uses, the landfill siting process has already occurred. For other projects, a site will need to be found. In some cases, such as production of a topsoil product, the site will be temporary. In other cases, projects will resemble large-scale construction or earthwork projects and will require an appropriately large amount of space. There are a number of tools and exercises that can be used to find a placement site. Knowledge of the area is a valuable asset. The siting process must take into consideration both the physical features of a location and the social and political influences imposed by people and businesses around the location. A comprehensive suitability assessment approach for siting beneficial use applications is shown in Gregorkovich *et al.* (2003)[233] and could be applied to meet large-scale dredged material management needs.

Transportation costs will be a major factor in selecting a site. These costs are affected by the distance from the dredged material source, as described in section II-B and IV-A, and available transportation alternatives. Project location is another important cost consideration. Location in an urban area is more likely to be successful if the municipality has plans for remediation or renovation of lands that have fallen into disuse (i.e., there is a need for a project to utilize dredged material). Rural areas with large parcels of open or unoccupied land with fewer restrictions due to past use may be more likely locations for clean fill or landscaping amendment. Suburban lands offer a mix of the advantages and disadvantages of each. Because most dredging operations take place in urbanized waterways or harbors, use of rural or suburban locations may pose higher transportation costs.

Other factors to be considered during the selection process include the following:

- Sites with firm, compact soils and substantial depths to groundwater are usually more developable. Sites with soft soils, high groundwater, or complex geology represent greater challenges to development, which can result in higher costs.
- Local opposition can slow or stop projects, especially for those projects resembling waste disposal (see section II-B).
- Beneficial use often involves some degree of staging. Land area may have to be devoted to this as well as to processing.
- Access to utilities, including water, sewer, electricity, phone and natural gas will be a requirement for some beneficial use sites.
- If the water generated from a beneficial use application (including during processing or staging) is considered contaminated, discharge to a sewage treatment plant or to an onsite dedicated treatment plant will likely be necessary.

Site Access

Access to a site through existing road networks is an important consideration. Even in situations where rail or barge access will be available, truck transport is often more versatile and may be more efficient. However, there may be seasonal load limits on public roads, particularly in rural locations. Existing roads may have to be upgraded to accommodate the loading from large construction vehicles. Access controls may also be needed.

Site Preparation

The initial activities associated with site preparation are not usually done on the site. These include land sale and acquisition, transfer of title, securing access or easements, determining road limits due to season or pavement limits, and obtaining local or state licenses or permits for the preferred transportation route. Initial activities also include satisfying regulatory requirements for preparation of plans and obtaining permits or approvals, which often include specific conditions or limitations to be incorporated into the construction activities.

There are a number of additional site preparation tasks:

- *Contracts* usually have to be let out for bid and selection for earthwork contractors. Specialty subcontractors for a wide variety of services may be necessary. Specialty work can include installation of geosynthetics, piping, electrical equipment and power lines, concrete work, tank installation, and a wide variety of other equipment or structures. Most are partly or wholly dependent on completion of earthwork activities.

- *Initial surveying and site investigation* may be necessary to lay out controls for the construction of facilities and to determine whether and to what degree the in-field conditions differ from those advertised.
- *Remediation activities*, such as removal of old tanks or contaminated soil, may be needed at historic or current industrial properties. Some degree of land clearing and grubbing is necessary at any site.
- *Runoff and erosion controls* are usually required to be in place before major land clearing starts.
- *Utilities* may need to be installed or upgraded, including electricity, communications, water, sewerage/septic, and natural gas or fuel oil.
- *Auxiliary facilities* are often needed. These might include a construction office, parking, lab or monitoring support facilities, maintenance or vehicle servicing, and engineering and field inspector workspace.
- *Staging area* for stockpiling dredged material, topsoil, subsoils, or other soils to be used in construction is usually required in any construction plan involving earthwork.

Site Design Considerations

Design elements are often determined by a need to control flow and loss of water, which is often the dominant pathway for contaminant loss. Impacts to both surface and groundwater quality and hydrology are both of concern. Beneficial uses that involve creating a permanent site will require geological and hydrogeological investigation to define groundwater table, groundwater gradients, stratigraphy of soil layers, elevation and hydrogeology of bedrock, condition of bedrock, and soil properties. Contaminant concentrations in the dredged material and hydrogeologic information about the site usually have to be assessed to determine the potential for groundwater or surface water contamination. State environmental regulations often require design features, such as liners, and location restrictions which avoid situations that commonly lead to groundwater contamination. In many cases, containment structures will be required to prevent the material or water from running freely on or off the site.

When not explicitly regulated, degree of containment is a matter of choice, based on perceived needs. The need for hydraulic containment (preventing surface or groundwater from moving off the site to neighboring sites or to aquifers) becomes increasingly likely as contaminant concentration of dredged material increases. Hydraulic containment might even be necessary for dredged material that is relatively clean if excessive water leakage to subsoils would affect nearby water tables, wetlands, building foundations or basements, etc. Additionally, control of suspended solids in surface water is always a potential concern. There is a range of complexity in design concepts for hydraulic containment. In most beneficial reuse situations, containment concepts will be simpler than those required for disposal sites. A number of containment options are discussed in the next section, *Material Placement and Onsite Management.*

Site Construction

A project manager is necessary in the construction process. This person can be an employee of the owner, or a hired consultant or contractor but must be someone familiar with construction processes and technology. The project manager represents the client and watches for schedule compliance and problems, conflicts, delays, compliance with owner's plans, need for changes, and the budget. Consultant services are typically needed for surveying, recordkeeping and construction quality assurance work. This involves conducting tests and recording data to determine if construction activities met project specifications. Construction documentation may be required for regulatory approval. Assembling this data and report is often assigned to engineering consultants. It is common for additional design efforts to be required of design consultants to accommodate changed conditions or materials, or to incorporate decisions made after the construction activities have started.

Depending upon the relative composition (sand, clay and organics), material with a solids content of approximately 35 percent by weight will have the consistency of a thick mud. Dredged material with approximately 45 percent to 55 percent solids by weight will resemble damp, soft soil and may be handled with conventional earthmoving equipment. Some beneficial use activities utilize construction equipment similar to that used in site construction, although often smaller and less powerful. The ground pressure exerted by wheeled and tracked equipment can become a significant limitation when equipment has to traverse a soft surface. Depending on the consistency of the dredged material, the operator may have to use low-ground-pressure equipment, which uses wide tracks or flotation tires to distribute the weight of the machine and avoid sinking or losing traction.

C. MATERIAL PLACEMENT AND ONSITE MANAGEMENT

Dredged material is typically transported to an upland site either through mechanical placement or as a hydraulic slurry. For direct placement of hydraulically dredged material, the receiving location would have to be capable of handling large amounts of water and slurry. Mechanical dredging results in soft solids with high water content that may require handling similar to hydraulically dredged material. Even when saturated, some materials have enough physical integrity to be piled up without flowing under gravity.

Containment and Liners

The area fill method is one common and fairly simple means of containing dredged material. This method provides physical confinement of solids without decanting or removing water. The lagoon-style site design uses embankments to confine water and flowable solids. These types of containment areas are filled with hydraulically dredged material or mechanically dredged material that is not otherwise dewatered. If water is to be drained from the containment area, a decant structure may be needed. In some cases, water drained from a containment area may need to be treated prior to release from the containment area. No specific provisions are made to prevent infiltration of groundwater. This approach may be appropriate for dewatering material that does not present contamination concerns.

A decant structure may be needed to drain water off settled solids and gather precipitation. In some cases, the drained water must be treated prior to being released. This can involve discharge to sewer and a sewage treatment plant, or onsite treatment. Material characteristics, location, state and local regulations, and cost will dictate what is necessary. On-site treatment and discharge operations must comply with suspended solids, contaminants, and nutrients standards. Discharge of decant water after treatment is usually subject to water quality standards and other restrictions in state-administered discharge permits. More complex containment design concepts tend to mimic solid waste landfill designs, and landfill regulations might be required. Engineered landfill containment technology is fairly well advanced and has been demonstrated to be effective in protecting groundwater quality, although expensive and complex to construct.

Containment Options

As most beneficial uses will involve using only uncontaminated material or mildly contaminated material with controls, beneficial use projects should generally not require this extent of containment. However, if control over loss of contaminants is necessary, containment site design can incorporate some or all of the following:

- *Recompacted clay soil liners* with 2-5 feet total thickness are acceptable in some States for nonmunicipal solid wastes. A clay liner is usually constructed in a sequence of 6-9 inch lifts and compacted by earthwork machinery to meet predefined limits on moisture content and density. These limits are imposed to assure that the compacted clay attains low permeability. Clay soil engineering properties and borrow sources are usually subject to investigation and review prior to construction to define construction specifications.
- *Single composite liners* with 2-4 feet of recompacted clay covered by a geomembrane are acceptable in some states for municipal solid wastes and sometimes required for nonmunicipal solid wastes. The clay component would generally be constructed using the same requirement as required for clay liners. The geomembrane component would be subject to specifications for material properties and construction quality that are set by published specifications and state rules.
- *Double liner and double composite liner* designs are required in state and federal rules for hazardous waste landfills and in some states for solid waste landfills, using two or more feet of recompacted clay and geomembranes, possibly supplemented by geocomposite clay liners for the clay component in the primary liner. The secondary collection system between the liners allows documentation of the performance of the primary liner and significantly reduces overall loss of leachate and contaminants from the site.
- *A leachate collection system* is usually necessary, regardless of liner design, to drain off water and reduce hydraulic pressures on the liner. The collection system can also accelerate the consolidation and drainage of pore water. The drainage system is typically a one-foot layer of sand or gravel placed over the top of the liner, supplemented by drain pipes, sumps, and pumps to extract water released from the dredged material.

Construction Material

Great Lakes dredged material can vary widely in grain size from site to site. If material is being transported off-site for use as fill material, such as road fill or construction fill, typical contract specifications dictate that the fill material must be less than 15 percent fine-grained. This requirement stems from a desire to make the material easily graded and to reduce settling. Due to the high amount of fine-grained and organic material in dredged material, its use for construction material has been limited. At the Erie Pier Confined Disposal Facility in Duluth, Minn. the dredged material is washed to separate the coarse-grained material from the fine-grained material and organics. The coarse, sandy material is typically much less contaminated than the fine and organic phases. Since the material taken off-site is required to contain less than 15 percent fines, the contractor is not required to conduct chemical monitoring of the material that is taken off-site. Where there is a coarse carbon fraction present, such as hard carbon (e.g., coal) or soft carbon (e.g., leaf litter, wood chips), higher contamination may sometimes be found in the sand fraction than in the fine fraction. Adequate characterization must be done to confirm the assumption that the coarse fraction is clean, and that chemical monitoring is not needed. A single thorough characterization may be adequate where there is a single source of dredged material used for multiple projects, such as a CDF mining.

> Allowing higher levels of fines will likely require some type of chemical testing to determine appropriate uses and necessary exposure controls.

Dredged material placed at sites where settling is not as critical, such as for landscaping highway embankments, might allow the use of fill containing more than 15 percent fines. Material with a higher percent of fines might also be useful in capping brownfield sites where only a thin layer (one foot or less) of material is being placed. However, as stated earlier, allowing higher levels of fines will likely require some type of chemical testing to determine appropriate uses and necessary exposure controls.

Landscaping/Topsoil Creation

Dredged material can be used directly (after dewatering) or may be combined with other media, such as manure, wood chips or biosolids to create topsoil that can be used for public parks, golf courses, and garden areas. Mixing the dredged material with other media to create composting conditions can improve biodegradation of organic contaminants. Dredged material can be composted to create topsoil at a disposal site, where space is available, and then be transported for use or mixing and final application. The growth of undesirable vegetation and invasive plant species is an important consideration. Where this occurs, a control strategy may need to be implemented.[245] Exposure controls will not be possible during use of a topsoil product that is widely distributed (such as to the public). Such applications may, therefore, require more stringent contamination criteria than large-scale landscaping projects where exposure control may be possible.

> **Considerations for Selling or Giving Away Material**
>
> Material sold or given away in bulk for use by the private sector should be characterized and a permit issued accordingly, except where uses are unrestricted. For uses in the private sector without controls, extra care should be exercised, taking into account uncertainties associated with characterization, treatment and processing. There are limitations to the degree of quality control that can be exercised in such cases.

The U.S. ACE has successfully conducted composting demonstrations at the Milwaukee CDF.[119, 117, 139] In this case, the dredged material is first dewatered in windrows prior to mixing with the other media. The mixing phase can be completed with large-scale machinery such as the SCAT Turner. In order to ensure consistent product quality, such parameters as biological oxygen demand (BOD), total organic carbon (TOC), dissolved oxygen, temperature, and nutrients should be monitored during the mixing process.

Habitat Creation

Fine-grained dredged material contains large amounts of organic material, including seeds, and rapidly vegetates under favorable conditions. In those instances where the dredged material is not contaminated it may provide a valuable asset in the creation of upland, wetland, or in-water habitat. The Minnesota Department of Natural Resources is currently evaluating the use of Duluth-Superior Harbor dredged material for creation of a wetland in a mine tailings pond in northern Minnesota. Pilot scale studies have shown that dredged material is comparable to commercial topsoil for the creation of wetland habitat.

U.S. ACE is also evaluating the use of dredged material to cap moderately contaminated sediments at the 21st Avenue location in the Duluth Harbor. Dredged material would be spread or slurried over the existing sediments to create a shallow water habitat.

One problem seen with wetland habitat creation projects has been the potential for seeds of invasive plant species (e.g., purple loosestrife, *Lythrum salicaria*) to be present in the dredged material. Care must be taken in any habitat creation project to ensure that viable invasive plant seeds are not present in the dredged material.[61]

Closure and Long-term Care

Closure and long-term care activities apply to disposal-like beneficial use sites. Long-term care requirements are defined by regulations, expected post-closure use of the property, and development plans. Beneficial reuse projects involving processing activities are usually closed out as processing of dredged material ceases. For mass fill or other one-time use projects, closure activities are incorporated into the reuse function. For disposal sites, some degree of closure activities and post-closure care are usually necessary. The magnitude of those activities is determined by the need to prevent exposure to contaminants, the physical condition of the dredged material, and associated regulatory requirements. Effluent treatment, drying, solidifying, and grading issues to be addressed in closing disposal-like sites are discussed in section IV-B.

Final cover designs encompass a range of concepts, varying in complexity, achievement of hydraulic containment and cost. The surface of the dredged material can be left exposed and seeded or allowed to directly vegetate. In many cases, dredged material vegetates vigorously on its own, once the rooting zone desaturates. Although inexpensive, this may allow direct contact with the dredged material by biota and humans, which may not be considered acceptable if it is contaminated. A clean soil cover can be placed to prevent direct contact. However, dredged material must dry sufficiently to support the construction activities associated with placing the soil.

A landfill-style engineered multilayered cap can be constructed to control infiltration, leachate generation, and gas and odor. Both design and construction are complex. The cover has to be constructed and survive over a low strength, high water content waste mass subject to considerable settlements and strains placed on the cap. This cover design may require specialty features such as drain layers below the capping layer and geosynthetic reinforcement at the base of the cap. Any site that was designed with a liner will have an obligation for continued extraction and treatment of leachate.

D. IMPLEMENTATION AND MONITORING OF EXPOSURE CONTROLS

Engineering and/or institutional controls should be maintained for as long as necessary to prevent unacceptable exposure. If, at some time, the dredged material no longer poses a human or ecological health risk, engineering or institutional controls may be discontinued. States should use existing programmatic regulations to make such determinations, if possible. Property owners are generally responsible for maintaining engineering controls. Local and state governments usually enforce and monitor institutional controls. At a minimum, all institutional or engineering controls should be able to be demonstrated by the property owner through periodic reviews of maintenance plans and appropriate land use designations.

Engineering controls are physical controls that prevent exposure to contaminated media or prevent environmental chemicals of concern (COCs) from migrating further. Any physical treatment method that provides an appropriate barrier, but does not permanently and irreversibly decrease COC concentrations to closure levels throughout the environmental media, is considered an engineering control. Construction of a cap to prevent infiltration into a source area is considered an engineering control. Examples of engineering controls which can reduce or eliminate exposure pathways include clay and geosynthetic capping layers in cover structures; vegetative covers; hard-surfaced covers such as paved parking lots; migration controls such as slurry walls; interception trenches and extraction wells; and fencing. Ongoing repair and maintenance of these existing structures may be necessary. If the control permanently and irreversibly decreases COC concentrations to closure levels, then it is considered treatment. Treatment is beyond the scope of this document.

Institutional controls are nonengineered, administratively and legally enforceable measures that limit human exposure to COCs. Institutional controls can serve several purposes, including:

- Notifying current and future owners about the environmental conditions of the property
- Limiting use of the land to prevent activities that could result in unacceptable human or wildlife exposures to contaminants

Institutional controls are used when contamination levels exceed thresholds for that use and exposure to the remaining contamination must therefore be prevented. Whenever institutional controls are used, an environmental notice should be recorded so that a reasonably diligent inquiry into a property would uncover the existence of the control. Examples of institutional controls are land-use restrictions, deed restrictions, deed notices, and declarations of environmental restrictions.

A common method of recording an institutional control is the deed notice or environmental notice. Under certain circumstances, a local ordinance can substitute for an environmental notice. This includes ordinances restricting the use of groundwater. The primary criteria for an institutional control are that it (1) provide legal notice to current and potential future property owners of the nature and extent of the restrictions, (2) be permanent, and (3) be legally valid.

An institutional control is required for the following situations:

- An activity restriction used as part of a remedy
- An engineering control used as part of a remedy

Monitoring to ensure the effectiveness of institutional controls will be needed at some dredged material beneficial use sites. In other cases, this will not be required. The need for such monitoring will be determined by the type of operation in question, the characteristics of the dredged material (such as level of contamination) and the regulatory framework for the beneficial use. Inspections can be an effective means of monitoring and reporting on the condition of the property and maintenance of the institutional and/or engineering controls. Such reports may include:

- The date and time of the inspection
- The name and employer of the inspector
- Any changes in land use since the remedy or last report period
- Activities being performed on the property by employees, contractors, or the public
- Any construction activity that has taken place since the remedy closure or previous report period
- A discussion of the effectiveness of the engineering or institutional controls and their effectiveness in preventing exposure to environmental or human health hazards
- A discussion of the soundness of the financial assurance instrument, if applicable

In some cases, monitoring activities beyond what is required may be advisable to ease ongoing public concerns.

For uses involving placement in a landfill or similar site, such as for daily cover or final cover (Scenarios 1 and 4 from Appendix A), monitoring requirements for the beneficial use will likely be fulfilled by the facility's existing monitoring plan. In these cases, monitoring of institutional controls is guided by the applicable solid waste regulations. Closure and post-closure requirements include deed restrictions, ongoing maintenance and monitoring, and financial assurance. These help to ensure that the property is adequately cared for, and that all institutional controls are maintained.

Some restricted uses of dredged material as a fill or cover material (Scenarios 5B, 5C and 7 from Appendix A) may require limited monitoring and inspection. The greater the degree of contamination remaining in the dredged material, the more likely exposure controls will be needed and monitoring required. Periodic evaluations of actual land usage and financial assurance (as through inspections) may also be appropriate to ensure continued validity of land usage exposure assumptions.

For beneficial uses involving relatively uncontaminated material that has been approved for use with few restrictions, little or no monitoring will likely be required. Beach nourishment, compost or topsoil manufacture, cover for residential use and unrestricted fill (scenarios 2, 3, 5A and 6 from the Appendix A) are uses where no restrictions are placed on the dredged material, no institutional controls are needed, and therefore no monitoring would be necessary.

E. PROJECT EVALUATION

Evaluating a project after its completion is an important step in ensuring that all goals have been met and in applying lessons learned toward future projects. Sharing of evaluation outcomes with coworkers and colleagues is encouraged to help build knowledge and experience concerning beneficial use projects within the region. There are a number of possible evaluation mechanisms. Periodic (e.g., annual or five-year) reports is one option. Case studies, such as those published by the Great Lakes Dredging Team on its website (www.glc.org/dredging/). In addition, publishing in journals or newsletters, presenting at conferences or other public forums, and publishing information on organizational websites are effective means of communicating results and recommendations. The following is a list of questions to be considered upon the completion and during periodic review/evaluation of a project:

- Did the reuse project provide a legitimate use of the material? Was it more than just disposal?
- Did it provide a comparable substitute product or even a superior product? Did that substitute product lead to a cost savings, or was it cost-competitive to other alternatives?
- Was the reuse project environmentally sound based on risk-based procedures?
- What standards and criteria were used in the risk assessment process?
- From a natural resource management standpoint, was the public better off in terms in resource usage? Was it a wise overall use of our natural resources?
- Was the project a workable and commonsense approach to beneficially reusing dredged material? Include consideration of impacts from not reusing the dredged material (e.g., disposing of it in a CDF, dumping in the open water) and tradeoffs with respect to using a different source material instead of the dredged material for the beneficial use
- Was the procedure for testing and evaluating the dredged material easy to understand and follow? Can it be replicated for similar uses?
- Were there specific threshold pollutant values that allowed one to quickly make a decision on the environmental viability of this project? Which ones?
- Did the costs of this alternative handling procedure support the economic viability of upland disposal over confined disposal/landfilling?
- Did the project lead to less dependence on confined disposal facilities and thus did the project provide a means of extending the life of a particular disposal site in the Great Lakes region?
- Did the project make sense in terms of regional sediment management needs and alternatives?
- Did the project contribute to the body of written material that can provide guidance to aid in decision making regarding upland use of dredged material? For example, habitat creation/restoration, agricultural amendments, capping, landscaping, and use of dredged material in the manufacture of aggregate for construction materials?
- Did the project produce some key lessons learned or changes that would be made if the project were to be repeated?

- Were institutional or engineering controls used? Were they effective? Who was responsible for implementing, enforcing and monitoring these controls?
- Did the project require ongoing monitoring at the site? What are the objectives of the monitoring? For what period of time will monitoring be undertaken? If so, what are the cost and benefit implications of this monitoring, both in terms of actual expenditures and information gathered that can be of long-term use?

Appendix A: Case Studies of Upland Beneficial Use

INTRODUCTION

This appendix was developed based on information gathered from the Upland Testing and Evaluation Project Management Team, comprised of representatives of the eight Great Lakes states and relevant federal agencies (see Appendix B). State members of the team were asked to evaluate how their state would handle evaluating several beneficial use scenarios. Members were further asked to identify any applicable rules or regulations; contaminant criteria that would or could apply in evaluating materials; and routes of exposure and contaminant pathways considered in establishing such criteria.

Table A-1: Scenarios Evaluated

1. Daily cover at licensed municipal solid waste landfills
2. Beach nourishment
3. Compost/topsoil manufacture
   a. Unrestricted
   b. Bagged
   c. Restricted
4. Final cover at licensed municipal solid waste landfills
5. Cover at Superfund/brownfield sites to meet
   a. Residential Use
   b. Industrial Use
   c. Commercial use
6. Unrestricted fill
7. Restricted fill
8. Aggregate (i.e., bonded by lime, asphalt or cement)

Each state has its own regulatory system to address contaminated materials, such as soils, hazardous wastes, and municipal solid wastes. Some states have regulations that explicitly address dredged material and/or particular beneficial uses. Others have laws that broadly cover this area and which can be applied, either directly or by analogy, to the scenarios presented. In most instances, states will consider each case on its own merits, or reserve the right to do so. Examples of regulations given here should be considered as examples of how state agencies *might* treat a given scenario, not how they *will* treat the scenario. In some instances, states have never evaluated the case scenarios presented here.

Determination of exact criteria often involves details that are unique to each situation. The criteria provided in this document are meant to be suggestive of the level of contamination that would generally be allowed in each scenario. Actual criteria applied in a given situation could differ dramatically from these in some instances.

Similarly, the contaminant criteria shown should be considered examples of what criteria a state agency *might* apply. Determination of exact criteria often involves details that are unique to each situation. The criteria provided in this document are meant to be indicative of the level of contamination that would generally be allowed in each scenario. Actual criteria applied in a given situation could differ. For example, for organic and metal contaminants that are ionized (such as arsenic and zinc), solubility (and therefore bio-availability) will vary with pH. Some regulations and guidelines, such as Indiana's Risk Integrated System of Closure (RISC)[74] contain criteria that are applicable to a neutral pH, but may not apply in situations where source or destination soils are non-neutral. In addition to applicable criteria, the background concentration of each contaminant in the area can also effect the decision to allow or not allow a particular beneficial use. If background levels at a site already exceed the contaminant criteria, similar exceedances may be allowable for the dredged material. Conversely, placement of a dredged material may be undesirable, even if all contaminant criteria are met, if the material is considerably more contaminated than the background. The contaminants presented in the tables (arsenic, lead, zinc, benzo(a)pyrene, PCBs, and benzene) are only selected examples of a potentially much broader array of contaminants that might be present in dredged material for which testing would be required. The references provide guidelines on additional contaminants.

FEDERAL LAWS AND REGULATIONS

In addition to state regulations, numerous federal regulations apply to upland uses of dredged material. Indeed, many of the state regulations respond directly to federal requirements. Following is an overview of some of the most pertinent federal regulations as they apply to upland uses. The Great Lakes Dredging Team's *Decision Making for Dredged Material Management* [195] can be consulted for more detailed information on these and additional laws that may apply.

Clean Water Act

Section 404 of the Clean Water Act (CWA)[2] requires permits to be obtained for discharges of any dredged material into waters of the United States, making it directly applicable to beach nourishment cases or placement in a wetland. Section 404 permits are also required for waters (i.e., effluent) from upland sites. This program is designed to protect a number of human health and ecological endpoints. In addition, CWA Section 401[1] requires permits to be obtained from state agencies whenever a section 404 permit is required. Section 401 permits ensure compliance with state water quality criteria.

National Environmental Policy Act and Endangered Species Act

The National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA) respectively require consideration of adverse environmental impacts and specific impacts on threatened or endangered species. These acts apply to all federal agency actions, including permit issuance. For NEPA, potential impacts will need to be considered and in their absence a formal statement or Finding of No Significant Impact will need to be issued. If there is cause for concern, a formal environmental assessment or environmental impact statement will need to be conducted.

Resource Conservation and Recovery Act & Toxic Substances Control Act

The Resource Conservation and Recovery Act (RCRA) and the Toxic Substances Control Act have a number of requirements regarding the handling, transport, and disposal of wastes. Depending on the level of contamination, different provisions of these acts may (or may not) apply. If a dredged material qualifies under any of the criteria of these acts, some or all beneficial uses may be precluded.

Coastal Zone Management Act

The Coastal Zone Management Act established the national Coastal Zone Management Program (CZMP)-- a federal-state partnership dedicated to comprehensive management of the nation's coastal resources. Administered by the National Oceanic and Atmospheric Administration, the CZMP provides financial and technical assistance to states to develop and implement their own coastal zone management programs. Seven of the Great Lakes states have a Coastal Zone Management Program in place. (Illinois does not participate in the federal program.) A unique aspect of the CZMA is "federal consistency" which ensures that federal actions that are reasonably likely to affect any land or water use or natural resource of the coastal zone will be consistent with the enforceable policies of a coastal state's or territory's federally approved coastal zone management program. All seven of the Great Lakes state coastal management programs are "networked" programs, which means that the program does not have its own set of rules and regulations, but rather integrates all relevant existing state programs and policies that impact coastal development, protection and resource management under the rubric of a single coordinated program. The CZMA gives states broad flexibility for coastal resource management and protection, which can be used as a mechanism to promote beneficial use of dredged material or to reject federal dredged material management decisions if they are inconsistent with the state's CZMP.

State Cleanup Regulations

Following are some examples of Great Lakes state comprehensive risk-based cleanup programs:

Illinois' Tiered Approach to Corrective Action (TACO) standards:[73]
Illinois' TACO system has been designed for uses such as brownfield remediation and RCRA closure. However, it also provides a framework that could potentially be applicable to some beneficial uses of dredged material, such as topsoil manufacture or cover material. Tier 1 of the system uses conservative, risk-based contamination criteria classified by end-use of the property. Tiers 2 and 3 provide guidance for determining situation-specific criteria for material that fail to meet the Tier 1 guidelines. Although the criteria and methods contained in TACO are not designated for evaluating dredged material placement, they can be used as guidance for the type of evaluation the state would likely make in some beneficial use cases. Illinois EPA has determined that TACO standards are for comparative purposes only. Failure to meet the appropriate TACO standard may only indicate that further analysis is required.

Minnesota's Soil Reference Values (SRVs) and Soil Leachate Values (SLVs):[193, 194]
The SRVs and SLVs are designed to represent acceptable soil concentrations for specific exposure scenarios, which could be used as guidance in many cases for evaluation of dredged material for beneficial use. Tier 1 values represent a conservative screening approach. Compliance with these values would likely make the material acceptable for a variety of uses. Tier 2 provides generalized, site-specific criteria that account for the property's end use. Compliance with certain Tier 2 criteria may qualify a dredged material for some specific uses. In addition, a Tier 3, case-specific evaluation can be made for material that fails to meet the appropriate Tier 1 or 2 criteria.

Indiana's Risk Integrated System of Closure (RISC):[74]
Indiana has developed the RISC system to provide a framework for evaluating remediation criteria for a wide range of applications. As with similar systems developed by other states, RISC provides a convenient set of guidelines that may apply to many beneficial uses of dredged material. RISC provides default tables of contaminant criteria based on the end-use of the property. In addition a framework has been developed to support case-specific, risk-based evaluation of contaminants.

STATE LAWS AND REGULATIONS

Regulations regarding beneficial use of dredged material vary widely from state to state. States have considerable control over the dredging process bases on four authorities, Clean Water Act section 401 certification, Coastal Zone Management Act consistency determinations, state solid-waste regulations, and environmental dredging windows determination. In most states, regulations specifically addressing beneficial use of dredged material do not exist. Rules and regulations that cover similar uses or similar materials may be applied. Some classes of potentially applicable state regulations are listed below.

Use-specific Regulations

In some cases, states will have regulations that specifically address the qualities of a material to be used for certain applications. For example, Michigan's Operational Memo 115-10[184] defines the contaminant limits for a landfill daily cover material. Pennsylvania has a general permit that allows dredged material to be used in road applications if certain criteria are met.[209, 211] Both Michigan and Wisconsin have regulations specifying grain size of dredged material that can be used for beach nourishment. Some states may also have regulations that prohibit a given use outright. For example, New York does not allow reuse of contaminated materials for residential cover or unrestricted fill, without risk review.[16, 97] Where they exist, use-specific regulations can facilitate beneficial use planning by clarifying which applications are allowable and which are not.

Wisconsin's NR 538 and byproduct classification

Natural Resources Code 538 places reusable materials into 5 categories based on contamination levels. The rule is not directly applicable to dredged material but can be used as guidance. A major limitation of the rule is the absence of limits for several organic contaminants. A dredged material can be categorized under this system based on its contaminant profile. These categories are approved for specific beneficial uses as follows:

- *Category 5*: Raw material for manufacturing, waste stabilization, energy recovery (fuel source), and landfill daily cover (including internal structures). This is the most restrictive category
- *Category 4*: All those above plus confined geotechnical fill and encapsulated transportation facility embankments
- *Category 3*: All those above plus capped transportation facility embankment and unconfined geotechnical fill
- *Category 2*: All those above plus bonded or unbonded surface course, decorative stone and cold weather road abrasive
- *Category 1*: All those above plus additional uses that meet exposure assessment requirements under NR 720.19(5). This is the least restrictive category

General Reuse Regulations

Several states have regulations that govern the reuse of industrial by-products or other wastes. These regulations exempt materials from being considered as waste if they meet certain qualifications and are destined for a given set of uses. New York has a process by which a beneficial use determination can be made, thereby making dredged material exempt from solid waste requirements.[37, 51] New York also has metal contaminant limits that qualify a material for two sets of reuse applications.[97] Wisconsin's NR 538 contains a sophisticated system of classifying waste materials into five levels of contamination with varying limits on their reuse options. Pennsylvania's clean fill rule allows general reuse of materials as well, as described on page 71.

Soil Cleanup Regulations

Another class of regulations that could be applied to dredged material for some beneficial uses are state soil cleanup criteria. States have developed such criteria to determine the level of soil contamination that is an appropriate endpoint for cleanup of brownfield or superfund sites. These programs specify different criteria based on the desired end use of the property (such as residential or industrial). In general, these programs are based on very thorough risk-based considerations of human and wildlife exposures through a number of pathways and exposure routes (see following section on "Routes of Exposure and Contamination Pathways", p.53). For that reason, they are a good precedent for what level of contamination can be considered safe for use as topsoil or cover material. They may also be appropriate for uses with fewer exposure routes than topsoil. However, care should be taken to avoid this type of application if the material is significantly different than soils at the receiving site. Sections II-C and III-B of this document discuss this consideration in greater detail.

The Canadian Environmental Quality Guidelines

Another suite of guidelines that are utilized to evaluate potential placements of dredged material in the Great Lakes basin are the Canadian Environmental Quality Guidelines[246] (EQGs), a suite of contaminant criteria for a wide range of environmental media that are set to be protective of human health and the environment. These guidelines have also been used by Great Lakes states in evaluating the safety of material placement, particularly for open-lake disposal. Among media that are covered by the EQGs are air, water, sediments and soils. For upland placements of dredged material, the soil criteria are the most likely among these to be applicable. These could be referred to in situations where the dredged material will replace a soil. The soil EQGs are divided into categories of agricultural, residential and parklands, commercial, and industrial. Determining which set is most applicable will largely depend on the intended use of the placement site.

Environmental Review Regulations

Many states will subject most permit decisions to some form of comprehensive environmental review to determine compliance with federal regulations such as NEPA and (ESA) as well as state regulations that may be present for purposes such as preservation of natural areas or features such as wetlands. Illinois' Comprehensive Environmental Review

Program (at http://dnr.state.il.us/orep/nrrc/cerp.htm) and Endangered Species Consultation Program (http://dnr.state.il.us/orep/nrrc/brief.htm) provide examples of such state review processes.

Sewage Sludge Regulations

Where dredged material would be applied to land, whether for agricultural use or otherwise, sewage sludge land application regulations might provide appropriate guidance. Such regulations would be particularly appropriate in cases where sludge is mixed with dredged material to formulate topsoil. At the federal level, 40 CFR 503, passed pursuant to CWA Section 405 governs uses of sludge. Many states, such as Ohio,[22] have additional rules that coincide with Section 503. One major difference to consider is that many sewage sludge regulations have provisions to prevent biological contamination, which will be less of a concern with dredged sediments. Additionally, organic content of sewage sludge and dredged material may be very different in character. Mobility of contaminants in low organic content dredged material may be higher than in sewage sludge, depending upon the type of carbon present in the sediments.

ROUTES OF EXPOSURE AND CONTAMINANT PATHWAYS

"Routes of exposure" refers to ways in which a contaminant comes into contact with or enters the body. Examples are ingestion, inhalation, and dermal contact. "Contaminant pathways" refers to a mechanism by which contaminants move from their original medium (such as dredged material) into the broader environment. Contaminant pathways can generally be measured and monitored, whereas exposure routes cannot. Examples include leaching to ground or surface waters, volatilization and fugitive dust (see also Section III-B, page 22, and Figure 3.2). Each of the scenarios beginning on page 56 will include a list of specific exposure routes and/or contamination pathways that should be considered when determining the appropriateness of the particular beneficial use. Possible exposure routes and pathways are described briefly below.

Figure A- 3: Common Dredged Material Exposure Routes

Human - Dermal

Human dermal exposure occurs when the contaminated material contacts a person's skin. In addition to the concentration of the contaminant in the material, important determinants of exposure from the dermal pathway include the area of skin contacted by the material, the availability of the contaminants and the ability of the contaminant to cross the skin barrier.

Human - Ingestion

Humans inadvertently consume considerable amounts of dirt. This happens when materials, including hands, which have dirt on them touch the mouth. Children are at highest risk from this pathway because of their increased soil ingestion rate (as much as 250 mg/day, compared to 50 mg or less for an adult).

Human - Inhalation

Inhalation exposure occurs when material that has volatilized or become suspended as particulate matter enters the body though the mouth or nose. Most gasses and small particles will enter the lungs following inhalation. Larger particles will primarily enter the gastrointestinal system.

Biota (land) – Ingestion

Material placed at a beneficial use site will often grow vegetation, which will be eaten by animals. Where contaminants of concern are taken up from the soil by the plants, there is opportunity for exposures among the area's biota.

Biota (land) - Bioaccumulation

In the course of their passage through the food chain, many contaminants will become increasingly concentrated at the higher levels of the food chain. This is due to the lipophilic nature of these contaminants, which causes them to be excreted in only very small quantities relative to their rate of ingestion due to retention in the organism's fatty tissues. The potential for this phenomenon should be considered when considering exposures to biota.

Plant toxicity

Contamination of soils can result in plant toxicity. The ability of a soil product to support vegetation can be evaluated by greenhouse-based tests on germination and growth.

Figure A- 4: Common Dredged Material Contamination Pathways

Volatilization

Volatilization involves the movement of contaminants from a solid or liquid medium into the air in a gaseous form. The amount of loss by this pathway will be highly dependent upon the type of compound. Most volatile or semivolatile compounds are organic. Mercury is a volatile inorganic compound that is often encountered in sediments.

Fugitive Dust

Fugitive dust is the release of contaminants to the air in a solid form. It is the result either of wind or other disturbances of the material (e.g., people or animals walking). Both the rate of escape and the distance of travel will be dependent upon the particle size. Factors such as vegetative cover can diminish migration through this pathway, as can minimizing disturbance by other means.

Runoff

Runoff results in the movement of contaminants from the land to surface water. Engineered controls can greatly minimize or eliminate this contamination pathway.

Leaching and Infiltration

Material with contaminants bound to it will pass some portion of these contaminants into water that passes through the material. The amount of leaching of these contaminants will vary depending on the contaminant in question and the physical and chemical properties of the material and the water. Following leaching, these contaminants may move with the water as it passes downward through the unsaturated zone into groundwater, which can result in contamination of groundwater. Beneficial uses involving landfills (Scenarios 1 and 4) require special barriers to eliminate these pathways.

Groundwater Discharge

If leaching and infiltration of the material result in contamination of groundwater, these contaminants may also move into surface waters to which the underlying aquifer discharges.

Plant and Animal Uptake

Contaminants may be taken up by plants, and subsequently consumed by foraging animals. Burrowing animals and soil dwelling organisms may also ingest dredged material directly, which may then be passed up the food chain.

CASE SCENARIOS:

Scenario 1: Daily Cover at Licensed Municipal Solid Waste Landfill

Daily cover at a municipal solid waste (MSW) landfill is one potential upland beneficial use. Landfills use daily cover to prevent odor and litter from escaping the landfill. It is a thin layer of material, typically six inches, laid over the waste in the landfill each day. Often, use of daily cover is mandated by state regulations. Materials that are appropriate for use as daily cover include most grades of sand and soil. Some landfills will purchase daily cover if another source is not available. Landfills may accept dredged material at a reduced tipping fee. At a minimum, the material will need to be dewatered. Amendment of the material may also be required prior to use as daily cover. If the sediment is contaminated, the water taken from it will likely need to be sent to a wastewater treatment plant. Because of limited direct routes of exposure from a landfill and the presence of protective barriers to either prevent exposure or eliminate contamination pathways, daily cover might allow a higher level of contamination than many other beneficial uses.

Contaminated vs. Toxic

Although dredged material may contain contaminants, most dredged material does not qualify as toxic waste. Contamination is a matter of containing a foreign or abnormal substance, which may or may not pose harm. Toxic implies a known cause of illness or death. Although dredged material may contain substances that can be toxic, toxicity is dependant on the degree of exposure to the substance. There are several regulations that control the transport, use and disposal of materials that contain harmful substances at toxic levels. RCRA and TSCA contain precise definitions of what qualifies as a "toxic substance" or "hazardous waste" under these acts. Qualification of a dredged material under these definitions would require strict management of the material according to the provisions of these laws. Most upland beneficial uses of the material will therefore be prohibited if the material qualifies as a toxic or hazardous waste.

Exposure Routes and Pathways

At a minimum, the following pathways should be considered for landfill daily cover projects:

- Volatilization
- Fugitive Dust
- Runoff
- Leachate

Applicable Rules and Regulations

At a minimum, compliance with the federal Clean Water Act (CWA) will be required. Municipal solid waste landfills that operate under Subtitle D of RCRA have permits that limit contaminant concentrations of the material that is placed in them. Parameters that have to be monitored for materials disposed in landfills include paint filter test (moisture), reactive sulfides, Toxicity Characteristic Leachate Procedure (TCLP), and ignitability. Disposal of waste subject to TSCA regulations (e.g., high levels of PCBs) is not permitted in

Subtitle D landfills. Additional state regulations and guidelines that may apply are discussed below.

Illinois: Contaminant criteria would need to be made on a case-by-case basis following the risk based procedures outlined in 35 Illinois Administrative Code (IAC) 742.[5] As guidance, the TACO Tier 1 industrial contaminant criteria[73] could be referred to.

Indiana: As this use is consistent with the landfill placement requirements of Indiana Administrative Code (IAC) 10-2-174(a)(6)(B), it is an appropriate beneficial use of dredged materials which qualify as solid wastes under this act. Although non-binding, the industrial RISC guidelines[74] would likely apply in this case.

Michigan: Criteria for landfill cover can be found in Operational Memorandum 115-10.[13] These criteria are based on modeling to determine the 10^{-6} cancer risk to a Maximally Exposed Individual (a person spending a 70 year lifetime at the site boundary). The sample criteria given are based on a one-acre exposed area of material that is 100 feet from the site fenceline.

Minnesota: Soil Reference Values (SRVs) from the Risk-Based Guidance for the Soil – Human Health Pathway[96] may be applied. If Tier 1 standards are not met, Tier 2 industrial chronic or worker subchronic would be appropriate. Additional appropriate evaluation criteria are Tier 2 Soil Leaching Values (SLVs),[194] TCLP values, hazardous waste characterization results, and specific landfill permit requirements.

New York: Beneficial use for solid wastes, approved in advance by the New York State Department of Environmental Conservation (NYSDEC) for use as daily cover, were promulgated in 6 New York Codes, Rules and Regulations (NYCRR) Part 360-1.15(b)(10).[16] Contaminant criteria for this use will be determined on a case-specific basis with an overall goal that RCRA hazardous materials are excluded. In the draft *Suggested Metals Limits for General Reuse Options* [97] reuse category B limits reflect, in part, screening values to avoid failure of the TCLP, and can be consulted.

Ohio: If the dredged material meets the definition of a soil, contaminant criteria may not apply. If the location where the dredged material is obtained is a known hazardous waste problem, characterization of the material under Chapter 3745-51 of the Ohio Administrative Code (OAC) may be indicated. Other relevant sections are Chapter 3734 of the Ohio Revised Code (ORC), Chapter 3745-27 of the OAC, especially Section 3745-27-19(F) (for daily cover requirements).

Pennsylvania: Information on use as a landfill daily cover is contained in Chapter 25 of the Pennsylvania Code (§271.231 and §273.232, in the municipal waste management regulations).

Wisconsin: Beneficial use as a daily cover is defined in NR 538.10(4).[29] According to NR 538.10(1),[29] use in this application, if it can be shown to substantially eliminate leaching or emission of contaminants, would likely require a Category 5 or better industrial byproduct as defined in NR 538.08.[29] The qualification for this classification is that the material is not a hazardous waste as defined in NR 600.03(98). Additional Wisconsin rules and regulations that could impact use of dredged material for daily cover include NR 506.05,[32] which requires MSW landfills to use a daily cover of six inches, NR 506.055,[32] which allows approved alternative materials to be used for this purpose, NR 500.08(5)[30], which allows exemptions from solid waste regulations to allow for beneficial reuse of materials and §289.43(8), Stats, which allows the DNR to make exemptions for low hazard wastes.

A Note about the Contaminant Criteria Tables

The tables of contaminant criteria presented here are intended to represent criteria that are *potentially* applicable to a particular beneficial use and that *might* be applied by the state regulatory agency. Relevant state agencies will evaluate each individual case on its own merits and may or may not adopt the approach used here. The particular beneficial use of dredged material has not occurred in some states, so there is no precedent. Values with less confidence are shown in *italics*. Those criteria that have been applied in preceding cases or that have relatively firm regulatory support are in plain text. The contaminant criteria listed are based on the regulations that are most relevant to the type of beneficial use. The criteria source is noted in the last row of each table.

Contaminant Criteria

Table A-2: Criteria for Scenario 1, Daily Cover at an MSW Landfill

Contaminant	IL[a]	IN[b]	MI[c]	MN[d]	NY[e]	OH[f]	PA[g]	WI[h]
Arsenic	*0.05**	*20*	5.8	*25*	41	*12*	--	--
Lead	*0.0075**	*230*	3,333	*700*	4	*600*	--	--
Zinc	*7,500*	*10000*	466667	*70000*	n/a	*360*	--	--
PCBs	*1*	*5.3*	16	*8*	n/a	*33*	50	50
Benzo(a)pyrene	*0.8*	*1.5*	n/a	*4*	n/a	*0.7*	--	--
Benzene	*0.03*	*0.67*	0.102	*4*	n/a	*5*	--	--
Criteria Source	Cleanup – Industrial	Cleanup – Industrial	Use-specific regulations	Cleanup – Industrial	Reuse – Specific	Soil Quality – Industrial	Non-TSCA	Non-TSCA

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 industrial tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for an industrial soil.[74]

c: Michigan criteria are based on sample values from Operational Memo 115-10.[184]

d: Minnesota criteria are based on SRV Tier 2 chronic industrial standards.[96]

e: New York criteria are based on the Suggested Metal Limits for General Reuse Options.[97]

f: Ohio values are adapted from the Canadian Environmental Quality Guidelines for soil at an industrial location.[246]

g: Pennsylvania requires that dredged material be dewatered enough to pass the paint filter test. It must also be shown to not fail the TCLP (cannot be a hazardous waste) nor be a TSCA waste. The state would prefer nondetect for regulated organics like VOCs, PCBs, dioxin/furan, or PAHs.

h: For Wisconsin, the material cannot be a hazardous waste as defined in NR 600.03(98). Additionally, it must pass the paint filter test and TCLP tests and be less than 15 percent silt and clay (P200). The requirement of 50 ppm PCBs is based on the definition of TSCA wastes, which are prohibited. The WDNR can set criteria on a case-by-case basis and would prefer non-detect levels for regulated organics like VOCs, PCBs, dioxin/furan, or PAHs.

Scenario 2: Beach Nourishment

Beach nourishment is currently the most common beneficial use in the Great Lakes region. Manmade structures, such as piers and breakwaters, interfere with the natural patterns of littoral drift which move and replenish the sand supply on beaches. Where those structures exist, there is often no source of sand to replace that which is lost and beaches get "starved" of sand. Sandy dredged material is often placed on beaches in strategic locations to offset this deficiency by providing a source of additional sand. Because of the high likelihood of both human and wildlife exposures, as well as the high potential for leaching into nearshore waters, contamination limits are often strict. In some cases, the background levels measured at the site of use might be applied as a benchmark. Coarser sandy phase is usually less contaminated than the finer phases. Accordingly, some state regulations waive contaminant testing requirements for materials that are mostly sandy (e.g. >80 percent or >95 percent). These waivers are intended to expedite the use of available and appropriate sediments for beach nourishment, which carries numerous socioeconomic and ecological benefits. Sandy material may also be required for aesthetic reasons.

Exposure Routes and Pathways

Littoral nourishment projects at public beaches present a high potential for human exposure. At minimum, the following exposure routes should be considered:

- Human - dermal
- Human - ingestion
- Human - inhalation
- Biota (land) – ingestion
- Biota (land) – bioaccumulation

Applicable Rules and Regulations

Beach nourishment operations must comply with state water quality regulations, pursuant to section 401 of the CWA[1]. Section 404 of the CWA[2] and the Coastal Zone Management Act will also apply. Several Great Lakes states will have regulations that apply to this scenario.

Illinois: The water quality standards under 35 IAC must be met during beach nourishment operations. The Illinois EPA's dredge and fill rules under 35 IAC Chapter II, Part 395,[5] provide that sediment testing of the material prior to placement must confirm that the material is less than 20 percent passing a #230 U.S. sieve. In addition, the material must be relatively uncontaminated (for example, meeting TACO Tier 1 standards[73] for contamination). In Illinois, additional testing for asbestos may be required prior to beach nourishment.

Indiana: At a minimum, the material must not qualify as a solid waste under IAC 10-2-174(a)(6)(B), which might require landfill placement[7]. It is likely that more restrictive criteria would be applied as well. For example, the residential RISC guidelines[74] might be applied in this case.

Michigan: If the sediments are 95 percent sand or greater, the material is considered to be clean and can be used for beach nourishment. Exemption from solid waste regulations is contained in Rule 110 of Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451 (NREPA),[13] as amended.

Minnesota: SRVs from the *Risk-Based Guidance for the Soil – Human Health Pathway* [96] may be applied. If Tier 1 standards are not met, Tier 2 recreational chronic standards may be appropriate. However, when public risk of exposure is high, such as at a public beach, Tier 1 standard will likely be enforced. Tier 1 or 2 SLVs[194] would also be applicable, as would other Soil Quality Guidelines that would be protective of wildlife and vegetation.

Definition of "Sandy" and Sieve Tests

Soils are classified in part based on the grain size of the material of which they are composed. Sand is a relatively large-grained material (as opposed to silt and clay). The grain size distribution often provides an indicator of the expected behavior of the soil, including affinity for binding certain contaminants and tendency to become airborne. Testing soil grain size involves passing the material through sieves of precisely defined sizes. For example, a #200 sieve has openings of 0.074 mm. Requirements for material with a certain grain distribution are specified by requiring a certain amount of the material to pass or be retained by a certain sieve size. Sand or sandy soil under the USGS is characterized by 50% or more being larger than the P200 sieve. Clean sand is not clearly defined in standards but usually defined by specifications such as little or no silt or clay fines, less than 5 percent fines, no organic fraction, or having uniform gradation.

New York: Beneficial use determination regulations for uncontaminated soil were promulgated in 6 NYCRR Part 360-1.15(b)(7).[16] Guidelines for obtaining case-specific beneficial use determinations (BUD), which would be required in this case are found in 6 NYCRR Part 360-1.15(d).[16] The proposal submitted for such a beneficial use will be required to contain:

i) a description of the solid waste under review and its proposed use;
ii) chemical and physical characteristics of the solid waste under review and of each type of proposed product;
iii) a demonstration that there is a known or reasonably probable market for the intended use of the solid waste under review and of all proposed products; and
iv) a demonstration that the management of the solid waste under review will not adversely affect human health and safety, the environment, and natural resources.

Among the criteria the NYSDEC might use to evaluate this use are those in the Technical and Administrative Guidance Memorandum (TAGM) No. 4046[98]

Ohio: Rules and regulations that could apply to beach nourishment projects include ORC chapter 6111[25] Water Pollution Control, OAC Chapter 3745-1[26] Water Quality Standards, and OAC Chapter 3745-32,[24] which governs section 401 certification. The Ohio DNR has made littoral nourishment a priority use for sediments that are suitable for this purpose.[23]

Wisconsin: Beach nourishment is allowed only for Great Lakes locations, not inland waters. The relevant rule is NR 347.07(4).[33] Placement is restricted to be above the ordinary high water mark. Water regulation case law prohibits disposal of dredged material in waters of the state, which effectively prohibits placement of fill below the ordinary high water mark.

Contaminant Criteria

Table A-3: Criteria for Scenario 2, Beach Nourishment

Contaminant	IL[a]	IN[b]	MI	MN[c]	NY[d]	OH	PA	WI[e]
Arsenic	*0.05**	*3.9*	Must be >95% sand	*12*	*7.5*			Grain size and color requirements
Lead	*0.0075**	*81*		*400*	*Background*			
Zinc	*7,500*	*10000*		*1,242***	*20*			
PCBs	*1*	*1.8*		*1.2***	*1*			
Benzo(a)pyrene	*0.09*	*0.5*		*1.0***	*0.061*			
Benzene	*0.03*	*0.034*		*0.034***	*0.06*			
Criteria Source	Cleanup – Residential	Cleanup – Residential	Use-specific regulation	Cleanup – recreational	Cleanup – General			Use-specific regulation

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 residential tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for an residential soil.[74]

c: Minnesota criteria are based on SRV Tier 2 chronic recreational standards,[96] except for **, which are from SLV Tier 1 standards.[194]

d: New York criteria are based on Department of Environmental Remediation Technical and Administrative Guidance Memorandum 4046: Determination of Soil Cleanup Objectives and Cleanup Levels.[98]

e: The Wisconsin code lists only two explicit criteria, grain size and color. Risk to beach users is addressed qualitatively by limits placed on the source of beach nourishment material. Grain size is limited by requiring the P200 fraction to be no more than 15% of the average fines content (silt and clay, or P200 fraction) of the native beach material. Color is required to be a close match to existing beach soil color.

Scenario 3: Compost and Topsoil Manufacture

When mixed with other components, some dredged material has the potential to become quality sources of compost or topsoil. Admixtures for this purpose include yard waste, manure, sawdust, scrap paper, drinking water sludge and sewage sludge, among others. Use of sludge can present biohazard concerns, which can usually be avoided if the material is allowed to aerate for a period prior to application. A manufactured soil testing screen can be performed on a material to determine the additional components that will produce the best soil.[104, 242] Greenhouse tests can be conducted on the resulting soil to test seed germination and plant growth.[165, 188, 189, 158] Excellent Great Lakes examples of this beneficial use scenario are the production of topsoil from dredged material reclaimed from a CDF in Toledo, Ohio,[185, 165, 158, 177, 154, 155] and in Wisconsin.[119, 117, 139] Other notable examples include projects at New York / New Jersey Harbor,[185, 188, 187] and Mobile, Ala.[189] There is an accumulating body of evidence suggesting that composting dredged material with organic carbon sources is an effective way to remove organic contaminants, such as PCBs and PAHs.[117, 143, 123, 190]

Exposure Routes and Pathways

The following routes and pathways should be considered:

- Runoff
- Leachate
- Volatilization / particulate transport
- Plant and animal uptake
- Human exposure routes
    - direct contact

- ingestion
- inhalation (including particulates)

- Biota exposure routes
  - direct contact
  - ingestion
  - bioaccumulation

Applicable Rules and Regulations

Illinois: 35 IAC 830 Subpart E: "Quality of End Use Compost"[5] could be used as guidance for use in developing compost mixture specifications. For bagged compost the Illinois EPA would also look at the uptake of the biochemicals into garden produce.

Indiana: If the sediment is contaminated, it is regulated as a solid waste under IAC 10-2-174(a)(6)(B) and landfill placement may be required. Although non-binding, the residential RISC guidelines[74] would likely apply for all topsoil manufacture and compost scenarios.

Michigan: Compost criteria are based on draft rules for Part 115.[13]

Minnesota: Soil Reference Values (SRV)[96] could be applied. If SRV Tier 1 contaminant criteria are not met, various SRV Tier 2 criteria might be applicable depending on the intended use of the resulting soil mixture. Soil Leaching Values (SLVs),[194] either Tier 1 or 2, would also be applied.

New York: Two sets of criteria may be appropriate. For use of dredged material as topsoil or in a manufactured topsoil of which dredged material is the primary ingredient, a similar evaluation to that for unrestricted fill (Scenario 6) is necessary. Department of Environmental Remediation Technical and Administrative Guidance Memorandum (DER TAGM) 4046, Determination of Soil Cleanup Objectives and Cleanup Levels,[98] can be consulted as a starting point for evaluating whether dredged material can be used in an unrestricted manner. Case-specific health and ecological risk assessment may be necessary in order to obtain a beneficial use determination (BUD) for dredged material as topsoil, under 6 NYCRR Part 360-1.15(d).[16] If dredged material is considered a limited-volume soil amendment or conditioning product, 6 NYCRR Part 360-5,[16] "Composted Materials", may be applicable.

Ohio: Chapter 6111 of the ORC[25] "Water Pollution Control" contains potentially useful information for this application. Chapter 3745-40[22] of the OAC, Ohio's sewage sludge land application rules, may also be used as guidance.

Pennsylvania: Wastes meeting the definition municipal waste are described in 25 Pa. Code Chapters 271-285. Wastes meeting the definition of residual waste (nonhazardous industrial waste) are described in Chapters 287-299. General permits are used to authorize the beneficial use of wastes. These regulations may be found at 25 Pa. Code §271.801-852 and §287.601-652. Dredged material is defined as a residual waste and represents the largest volume waste stream the state deals with for general permitting (beneficial use) purposes. General permits are also used for permitting these wastes for beneficial use purposes. These vary depending on the individual permit application so there can be differences among general permits issued for the same type waste stream. Drinking water sludge is managed as residual waste that is used in bagged soil products as well as leaf and wood mulch products.

Wisconsin: Wisconsin has no specific rules for topsoil manufacture, but does have rules that address composting, mostly aimed at yard waste and other organic wastes, NR 502.12[35]. Composting of other wastes is addressed under NR 502.08.[35] Reuses can be addressed by the state's low hazard waste exemption authority, §289.43(8), Stats. If the dredged material has any contamination at all, it might be allowed to be beneficially used under the low hazard waste statute, but it would still be considered a regulated solid waste. Dredged material should be dewatered enough to pass the paint filter test for effective composting. Gross requirements are that it must also be shown to not fail the TCLP (cannot be a hazardous waste) nor be a TSCA waste (i.e., PCB concentration >50 ppm). The state would prefer non-detect for regulated organics like VOCs, PCBs, dioxin/furan, or PAHs. The state also prefers that the dredged material be a granular material (>50 percent sand and larger particle sizes). NR 538[29] addresses beneficial reuse of high volume industrial waste. It contains tables of values for leach test and bulk solids concentrations for several parameters, with variations depending on beneficial use. It is not directly applicable to dredged material, but can be used as a reference.

Scenario 3a: Compost and Topsoil Manufacture - unrestricted use

"Unrestricted-use" implies the material is appropriate for the widest range of applications. This increases the range of potential exposure routes and pathways and therefore generally demands more stringent contaminant criteria.

Contaminant Criteria

Table A-4: Criteria for Scenario 3a, Compost or topsoil, unrestricted use

Contaminant	IL[a]	IN[b]	MI[c]	MN[d]	NY[e]	OH[f]	PA	WI[g]
Arsenic	*0.05**	*3.9*	7.6	*10*	7.5	*41*		*0.042*
Lead	*0.0075**	*81*	400	*400*	Background	*300*		*50*
Zinc	*7,500*	*10000*	65	*1,242***	Background	*2,800*		*4,700*
PCBs	*1*	*1.8*	1.2	*1.2*	*1.0*	--		--
Benzo(a)pyrene	*0.09*	*0.5*	2	*1.0***	*0.061*	--		*0.0088*
Benzene	*0.03*	*0.034*	0.1	*0.034***	*0.06*	--		--
Criteria Source	Cleanup – Residential	Cleanup – Residential	Use-specific regulation	Cleanup – Residential	Specific reuse and general cleanup	Sludge rules		Reuse – General

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 residential tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for a residential soil.[74]

c: Michigan compost criteria are based on draft rules[183] for Part 115.[13]

d: Minnesota criteria are based on SRV Tier 2 chronic residential standards,[96] except for **, which are from SLV Tier 1 standards[194].

e: New York criteria are based on DER TAGM.[98] Background can be a site or regional background, as appropriate. Compost values in 6 NYCRR Part 360-5[16] may apply if the dredged material is used as a limited component.

f: Ohio values are based on monthly average limits contained in Ohio's sewage sludge rules[22]. There are additional limits for a single application and a total lifetime loading limit.

g: Wisconsin criteria are based on NR 538, Appendix 1, Table 1B. These criteria qualify the material as Category 1, allowing its application in nearly all beneficial uses.

Scenario 3b: Compost and Topsoil Manufacture – Bagged Use

Bagged use of topsoil generally involves application of relatively small amounts, such as in residential gardens. Workers producing the material would be exposed to large amounts and may be the focus of the risk assessment. There is significant potential for contact with human skin during bagged use. This can occur both during application and afterward. If the material is used in a vegetable garden, there is the potential for ingestion.

Contaminant Criteria

Table A-5: Criteria for Scenario 3b, Compost or topsoil, bagged use

Contaminant	IL[a]	IN[b]	MI[c]	MN[d]	NY[e]	OH[f]	PA	WI[g]
Arsenic	*0.05**	*3.9*	7.6	*10*	7.5	*41*		*0.042*
Lead	*0.0075**	*81*	400	*400*	Background	*300*		*50*
Zinc	*7,500*	*10000*	170000	*1,242***	Background	*2,800*		*4,700*
PCBs	*1*	*1.8*	1.2	*1.2*	*1.0*	--		--
Benzo(a)pyrene	*0.09*	*0.5*	2	*1.0***	*0.061*	--		*0.0088*
Benzene	*0.03*	*0.034*	180	*0.034***	*0.06*	--		--
Criteria Source	Cleanup – residential	Cleanup – residential	Use-specific regulation	Cleanup – recreational	Specific reuse and general cleanup	Sludge rules		General reuse

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 residential tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for a residential soil.[74]

c: Michigan compost criteria are based on draft rules[183] for Part 115.[13]

d: Minnesota criteria are based on SRV Tier 2 chronic recreational standards,[96] except for **, which are from SLV Tier 1 standards.[194]

e: New York criteria are based on DER TAGM.[98] Background can be a site or regional background, as appropriate. Compost values in 6 NYCRR Part 360-5[16] may apply if the dredged material is used as a limited component.

f: Ohio values are based on monthly average limits contained in Ohio's Sewage Sludge Rules.[22] There are additional limits for a single application and a total lifetime loading limit.

g: Wisconsin criteria are based on NR 538, Appendix 1, Table 1B. These criteria qualify the material as category 1, allowing its application in nearly all beneficial uses.

Scenario 3c: Compost and Topsoil Manufacture – Restricted Use (or bulk use)

Restricted use of a manufactured compost or topsoil can be approved for particular applications. Criteria and pathway considerations will vary somewhat depending on the intended use. Criteria may be less restrictive if the use is limited to sites that have industrial use designations or that have on-site exposure controls.

Contaminant Criteria

Table A-6: Criteria for Scenario 3c, Compost or Topsoil, Restricted Use

Contaminant	IL[a]	IN[b]	MI[c]	MN[d]	NY[e]	OH[f]	PA	WI[g]
Arsenic	*0.05**	*3.9*	7.6	*25*	7.5	*41*		*0.042*
Lead	*0.0075**	*81*	400	*700*	Background	*300*		*50*
Zinc	*7,500*	*10000*	227	*70000*	Background	*2,800*		*4,700*
PCBs	*1*	*1.8*	1.2	*8*	*1.0*	--		--
Benzo(a)pyrene	*0.09*	*0.5*	2	*4*	*0.061*	--		*0.0088*
Benzene	*0.03*	*0.034*	1	*4*	*0.06*	--		--
Criteria Source	Cleanup – residential	Cleanup – residential	Use-specific regulations	Cleanup – industrial	Specific reuse and general cleanup	Sludge rules		General reuse

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 residential tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for a residential soil.[74]

c: Michigan compost criteria are based on draft rules[183] for Part 115.[13]

d: Minnesota criteria are based on SRV Tier 2 chronic industrial standards.[96]

e: New York criteria are based on DER TAGM.[98] Background can be a site or regional background, as appropriate. Compost values in 6 NYCRR part 360-5[16] may apply if the dredged material is used as a limited component.

f: Ohio values are based on monthly average limits contained in Ohio's Sewage Sludge Rules.[22] There are additional limits for a single application and a total lifetime loading limit.

g: Wisconsin criteria are based on NR 538, Appendix 1, Table 1B. These criteria qualify the material as category 1, allowing its application in nearly all beneficial uses. Less restrictive criteria may be applicable following evaluation by the WDNR.

Scenario 4: Final Cover at a Municipal Solid Waste Landfill

In some cases, an attractive placement option for dredged material is use as final cover at a MSW landfill. Final cover is used during the landfill closing procedure to provide an additional barrier between the landfill contents and the surface. Determination of contaminant criteria for this use may be dependent upon the intended use of the property after closure. In addition, physical requirements for this use may be stringent. Landfill covers typically require a thick layer of a clay material, which offers very low water permeability. This reduces the surface water infiltration into the landfill and therefore the leaching of the landfill contents. Dredged material of the right consistency can perform this function very well and may be a desirable material for this purpose.[171, 176] In some cases, mixture with another material, such as ash, will further decrease permeability. In addition to the impermeable layer, landfill caps often contain other layers, such as a sandy layer and a vegetated topsoil layer. Dredged material may also be used for these portions of the cap. A case study of testing procedures for use as a landfill cap is available for a project in Mobile, Ala.[185]

Exposure Routes and Pathways

The purpose of a final cover at a landfill is to prevent exposure to contaminants that may be in the landfill and to eliminate pathways for escape of contaminants. Therefore, the cover material obviously must not be a significant source of contaminant exposure itself. There are a number of potential exposure routes and pathways that would likely be considered in this application. Exposure to contaminants could occur via volatilization, fugitive particle release, surface runoff, leaching to groundwater, as well as ingestion. The potential for each of these will depend on the post-closure use of the site.

Applicable Rules and Regulations

Illinois: The criteria determination would be similar to the criteria for unrestricted fill (i.e. uncontaminated)

Indiana: At a minimum, the material must not qualify as contaminated under IAC 10-2-174(a)(6)(B), which would classify it as a solid waste and might require landfill placement. In addition, more stringent standards may be applied, such as the industrial RISC guidelines.[74]

Minnesota: The Soil Reference Values could be applied. If SRV Tier 1 contaminant criteria[96] are not met, some SRV Tier 2 criteria might be appropriate depending on the intended future use of the site. Additional appropriate evaluation criteria are Tier 2 Soil Leaching Values (SLVs),[194] TCLP values, hazardous waste characterization results, and specific landfill permit requirements.

New York: Beneficial use determination regulations for landfill final cover system components were promulgated in 6 NYCRR Part 360-1.15(b)(10).[16] In addition, case-specific beneficial use determination for final cover applications can be applied for under 6 NYCRR Part 360-1.15(d).[16] Criteria applied to dredged material used under an impermeable barrier, such as a flexible membrane, will be less stringent than material used above the barrier, which may be required to meet criteria similar to unrestricted fill (Scenario 6).

Ohio: Rules and regulations affecting final cover use include ORC Chapter 3734,[18] OAC Chapter 3745-27,[19] especially Section 3745-27-19(H) (final cover requirements). If the location where the dredged material is obtained is a known hazardous waste problem, characterization of the material under Chapter 3745-51[20] "Identification and Listing of Hazardous Wastes," of the OAC may be indicated to ensure it can be used safely for this purpose. Applicable contaminant requirements might include those for an "exceptional quality sludge" contained in OAC 3745-40-05(F).[22]

Wisconsin: At a minimum, the free liquids restriction of NR 506.13,[32] and the low hazard waste exemption would apply on a case-by-case basis, §289.43(8), Stats. Gross requirements are that it must also be shown to not fail the TCLP (cannot be a hazardous waste) nor be a TSCA waste (i.e., PCB concentration of 50 ppm). The state would prefer non-detect for regulated organics like VOCs, PCBs, dioxin/furan, or PAHs. It would also be preferred that the dredged material be a granular material (>50 percent sand and larger particle sizes), with a broad gradation that would support vegetation growth. To allow less restrictive uses of the property, Category 3 standard under NR 538[29] might need to be met for portions of the landfill cap that are unconfined and Category 4 standards for confined portions of the cap.

Contaminant Criteria

Table A-7: Criteria for Scenario 4, Final Cover at a MSW Landfill

Contaminant	IL[a]	IN[b]	MI	MN[c]	NY[d]	OH[e]	PA	WI[f]
Arsenic	*0.05**	*20*		*25*	Varies	*41*		*21*
Lead	*0.0075**	*230*		*700*		*300*		--
Zinc	*7,500*	*10000*		*70000*		*2,800*		--
PCBs	*1*	*5.3*		*8*		--		--
Benzo(a)pyrene	*0.8*	*1.5*		*4*		--		*4.4*
Benzene	*0.03*	*0.67*		*4*		--		--
Criteria Source	Cleanup – Industrial	Cleanup – Industrial		Cleanup – Industrial		Sludge rules		Reuse – specific

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.
a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 industrial tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.
b: Indiana values are based on the RISC tables for an industrial soil.[74]
c: Minnesota criteria are based on SRV Tier 2 chronic industrial standards.[96]
d: Criteria applied to dredged material used under an impermeable barrier, such as a flexible membrane, will be less stringent than material used above the barrier, which may be required to meet criteria similar to unrestricted fill (Scenario 6)
e: Ohio values are based on monthly average limits contained in Ohio's sewage sludge rules.[22] There are additional limits for a single application and a total lifetime loading limit.
f: Wisconsin criteria are based on Table 2B in NR 538 Appendix A, qualifying the material as Category 3 and appropriate for use in many geotechnical applications. If barriers are present, Category 4 material, having less stringent standards may be applicable. Criteria for pollutants that are not represented in the table may be enforced by the WDNR.

Scenario 5: Cover at a Superfund or Brownfield Site

Remediation of sites that are actually or potentially contaminated by a past use, industrial or otherwise, often require placement of clean soil material over the existing soil to eliminate exposure to contaminants. As with daily landfill cover (Scenario 1), dredged material, either alone or in mixture with other materials, could be an appropriate material for this purpose. In most cases, contaminant limitations will vary depending on the intended use of the property and existing or background contaminant levels already at the site. Residential use, because of the high probability of chronic exposure, will be the most restrictive. U.S. EPA's Soil Screening Guidance[67, 93] is a valuable background reference for risk assessment regarding this use.

Exposure Routes and Pathways

The pathways for use as a cover material would be very similar to those for use as topsoil (Scenario 3). Exposure parameters for contact, ingestion, and inhalation will depend on the intended use of the property. Exposure from pathways involving leaching to groundwater or surface water will be independent of this use designation. These pathways might be reduced somewhat by the presence of natural barriers, such as clay soil, or the installation of engineered barriers, such as pavement or sheet piling.

Applicable Rules and Regulations

Illinois: Contaminant criteria would need to be determined on a case-by-case basis following the risk based procedures outlined in 35 IAC 742.[5] Although they were not developed for use with dredged material, the TACO[73] standards might be applied in these situations.

Indiana: If the sediment is contaminated, it is regulated as a solid waste under IAC 10-2-174(a)(6)(B) and landfill placement may be required. Although nonbinding, the RISC guidelines[74] would likely apply in these cases. The residential guidelines would be applicable in situations where residential use of the property is intended. For industrial or commercial uses, the industrial RISC guidelines would be applicable.

Minnesota: SRV criteria[96] could be applied. If SRV Tier 1 contaminant criteria are not met, various SRV Tier 2 criteria might be applicable depending on the intended use of the cover. SLV criteria,[194] either Tier 1 or 2, are also appropriate.

New York: Suggested Metals Limits for General Reuse Options[97] lists residential applications as falling under the Universal Reuse Prohibitions for contaminated fill materials. The universal prohibitions also include surficial applications of contaminated fill. Subsurface fill could be allowed as an industrial or commercial fill application, under Reuse Category A criteria for metals, with site-specific organic contaminant criteria.[16, 98]

Ohio: Potentially applicable regulations include those used to evaluate an "exceptional quality sludge" in OAC 3745-40-05(F).[22]

Wisconsin: A number of beneficial uses are defined in NR 538.10.[29] Surface cover is not identified in this section and would therefore likely require a Category 1 material, based on NR 538.12(3) and an exposure assessment in conformance with NR 720.19(5) would need to be conducted on the usage. The requirements for material category 1 are defined NR 538.08(1) and in NR 538 Appendix 1, tables 1A and 1B.[29]

Scenario 5a: Cover to Meet Residential Use

Residential use, because of the high probability of chronic human exposure, will be the most restrictive.

Contaminant Criteria

Table A-8: Criteria for Scenario 5a, Cover to Meet Residential Use

Contaminant	IL[a]	IN[b]	MI	MN[c]	NY[d]	OH[e]	PA	WI[f]
Arsenic	*0.05**	*3.9*		*10*	Use prohibited	*12*		*0.042*
Lead	*0.0075**	*81*		*400*		*140*		*50*
Zinc	*7,500*	*10000*		*1,242***		*200*		*4,700*
PCBs	*1*	*1.8*		*1.2*		*1.3*		--
Benzo(a)pyrene	*0.09*	*0.5*		*1.0***		*0.7*		*0.0088*
Benzene	*0.03*	*0.034*		*0.034***		*0.5*		--
Criteria Source	Cleanup – residential	Cleanup – residential		Cleanup – residential and general	Use-specific regulation	Soil quality – residential		Reuse – general

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 residential tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for a residential soil.[74]

c: Minnesota criteria are based on SRV Tier 2 chronic residential standards,[96] except for **, which are from SLV Tier 1 standards.[194]

d: This use is explicitly precluded in Suggested Metals Limits for General Reuse Options[97] for contaminated soils.

e: Ohio values are adapted from the Canadian Environmental Quality Guidelines for soil at a residential location[246].

f: Wisconsin criteria are based on NR 538, Appendix 1, Table 1B. These criteria qualify the material as category 1, allowing its application in nearly all beneficial uses.

Scenario 5b: Cover to Meet Industrial Use

Contaminant Criteria

Table A-9: Criteria for Scenario 5b, Cover to Meet Industrial Use

Contaminant	IL[a]	IN[b]	MI	MN[c]	NY[d]	OH[e]	PA	WI[f]
Arsenic	*0.05**	*20*		*25*	14.5	*41*		*0.042*
Lead	*0.0075**	*230*		*700*	150	*300*		*50*
Zinc	*7,500*	*10000*		*70000*	2,480	*2,800*		*4,700*
PCBs	*1*	*5.3*		*8*	10	--		--
Benzo(a)pyrene	*0.8*	*1.5*		*4*	0.061	--		*0.0088*
Benzene	*0.03*	*0.67*		*4*	0.06	--		--
Criteria Source	Cleanup – industrial	Cleanup – Industrial		Cleanup – Industrial	Reuse – Specific	Sludge rules		Reuse – general

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 industrial tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for an industrial soil.[74]

c: Minnesota criteria are based on SRV Tier 2 chronic industrial standards.[96]

d: New York metal criteria are based on Suggested Metals Limits for General Reuse Options,[97] category A; surficial use of contaminated material prohibited. Organic criteria based on DER TAGM 4046.[98]

e: Ohio values are based on monthly average limits contained in Ohio's sewage sludge rules.[22] There are additional limits for a single application and a total lifetime loading limit.

f: Wisconsin criteria are based on NR 538, Appendix 1, Table 1B. These criteria qualify the material as Category 1, allowing its application in nearly all beneficial uses. Less restrictive criteria may be applicable following evaluation by the WDNR.

Scenario 5c: Cover to Meet Commercial Use

Contaminant Criteria

Table A-10: Criteria for 5c, Cover to Meet Commercial Use

Contaminant	IL[a]	IN[b]	MI	MN[c]	NY[d]	OH[e]	PA	WI[f]
Arsenic	*0.05**	*20*		*25*	14.5	*41*		*0.042*
Lead	*0.0075**	*230*		*700*	150	*300*		*50*
Zinc	*7500*	*10000*		*70000*	2480	*2800*		*4700*
PCBs	*1*	*5.3*		*8*	10	--		--
Benzo(a)pyrene	*0.8*	*1.5*		*4*	0.061	--		*0.0088*
Benzene	*0.03*	*0.67*		*4*	0.06	--		--
Criteria Source	Cleanup – industrial	Cleanup – industrial		Cleanup – industrial	Reuse – specific	Sludge rules		Reuse – general

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 industrial tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for an industrial soil.[74]

c: Minnesota criteria are based on SRV Tier 2 chronic industrial standards.[96]

d: New York metal criteria are based on Suggested Metals Limits for General Reuse Options,[97] category A; surficial use of contaminated material prohibited. Organic criteria based on DER TAGM 4046.[98]

e: Ohio values are based on monthly average limits contained in Ohio's sewage sludge rules.[22] There are additional limits for a single application and a total lifetime loading limit.

f: Wisconsin criteria are based on NR 538, Appendix 1, Table 1B. These criteria qualify the material as category 1, allowing its application in nearly all beneficial uses. Less restrictive criteria may be applicable following evaluation by the WDNR.

Scenario 6: Unrestricted Fill

In many cases, dredged material can be appropriate for use as a fill. Fill projects have a diversity of physical requirements (such as compaction and permeability), while dredged materials have a wide range of physical properties. The physical quality of the dredged material must match the project needs. To be used with no restrictions, the material must be relatively clean. Relatively uncontaminated materials might be approved with no use restrictions depending on the specifics of the site. Evaluation of a fill material is very similar in most cases to the process for evaluation of a topsoil mixture (Scenario 3). The difference is that use of a dredged material for fill would require criteria to apply to the dredged material itself, whereas in a topsoil mixture, the criteria would apply to the resultant mix of materials.

Exposure Routes and Pathways

Because the material may be used with no restrictions or exposure controls, all potential environmental pathways and exposure routes must be considered for this scenario. Known site conditions may eliminate some contaminant pathways and exposure routes (e.g., impermeable clay may eliminate infiltration). However, because the use is unrestricted, knowledge of site and/or use conditions is not required. Due to the extent of uncertainties concerning the material's use, conservative assumptions should be made in assessing potential exposures and risks.

Applicable Rules and Regulations

Illinois: Contaminant criteria would need to be determined on a case-by-case basis following the risk based procedures outlined in 35 IAC 742.[5]

Indiana: If the sediment is contaminated, it is regulated as a solid waste under IAC 10-2-174(a)(6)(B) and unrestricted fill will likely be prohibited. Landfill placement may be required. Although non-binding, the residential RISC guidelines[74] would likely apply in this case.

Michigan: The standards contained in Act 307 Type B Cleanup Criteria for Groundwater and Soil[182] could be applied.

Minnesota: The Soil Reference Values[96] and Soil Leaching Values[194] could be applied. SRV and SLC Tier 1 contaminant criteria are appropriate for this use. Due to the lack of restrictions on this material, qualification for this designation will be quite strict.

New York: Dredged material cannot be used as an unrestricted fill in New York. Suggested Metals Limits for General Reuse Options[97] lists universal reuse prohibitions for surficial application, residential applications, playgrounds, wetlands, 100-year floodplains, arable land, and mineland reclamation. However, if dredged material can be shown to be uncontaminated through material knowledge, or minimally contaminated by comparison to health-based risk criteria such as DER TAGM 4046,[98] it could be used as an unrestricted fill, on case-by-case review.

Pennsylvania's Clean Fill Rule

Pennsylvania has announced a new "clean fill" regulation. This rule will allow for use of soil-like materials, including dredged material, as fill if it meets the state cleanup standards contained in the Land Recycling and Environmental Remediation Standards Act.[216] The criteria to be met will depend on the end use of the property. In addition, permits-by-rule can be obtained for material not qualifying as clean fill". Such materials, termed "regulated fill," can be permitted for specific projects if safety can be demonstrated. The following general exceptions apply to use of a regulated fill:

- Cannot be used on a residential property
- Cannot be placed on a "greenfield" with no development plans
- Must be used beneficially (as in an approved construction project; cannot be "dumped")
- Property must be vegetated or otherwise stabilized immediately after material placement

Pennsylvania: The rule governing "regulated fill" would expressly permit use of dredged material to "to bring an area to grade, to control runoff, and to limit infiltration of water" if it met given contaminant criteria.[218] Additional restrictions are also listed in the rule. Separate criteria are given for residential and nonresidential uses.

Wisconsin: Use as unrestricted fill is presumed to fall within the dredged material exemptions in NR 500.08(3).[30] In that case, use as fill would not be regulated by solid waste program requirements. Disposal/reuse would be addressed by Chapter 30 permits and NR 347 project regulation. To fall under the code exemption, dredged material would have to be from an inland water body that was not known to be treated by arsenical compounds or influenced by industrial or municipal contamination (sewer outfalls, etc.) or be less than 3,000 cubic yards of dredged material from listed waterways (Lakes Superior and Michigan and certain major rivers). There are no explicit numerical criteria. In essence, the intent is to allow disposal or reuse to the extent that dredged material resembles native soils in contamination quality. Unrestricted uses are limited in terms of not allowing use to fill wetlands or critical habitat areas or to cause a violation of surface water quality or groundwater quality.[31]

Contaminant Criteria

Table A-11: Criteria for Scenario 6, Unrestricted Fill

Contaminant	IL[a]	IN[b]	MI[c]	MN[d]	NY[e]	OH[f]	PA[g]	WI
Arsenic	*0.05**	*3.9*	*5.8*	*10*	7.5	*12*	41	
Lead	*0.0075**	*81*	*400*	*400*	Background	*70*	450	
Zinc	*7,500*	*10000*	*65*	*1,242***	Background	*200*	12,000	
PCBs	*1*	*1.8*	*1*	*1.2*	1	*0.5*	Various	
Benzo(a)pyrene	*0.09*	*0.5*	*0.33*	*1.0***	0.061	*0.1*	2.5	
Benzene	*0.03*	*0.034*	*1*	*0.034***	0.06	*0.05*	0.13	
Criteria Source	Cleanup – residential	Cleanup – residential	Cleanup	Cleanup – general	Use-specific regulation	Soil quality	Use-specific regulation	

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.
a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 residential tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.
b: Indiana values are based on the RISC tables for a residential soil.[74]
c: Michigan criteria are based on Act 307 Type B Cleanup Criteria for Groundwater and Soil.[182]
d: Minnesota criteria are based on SRV Tier 1 standards,[96] except for **, which are from SLV Tier 1 standards.[194]
e: Preclusion of uses for contaminated dredged material as a fill in residential and several other applications are contained in the Suggested Metal Limits for General Reuse Options,[97] but where appropriate, comparison to DER TAGM 4046[98] criteria may indicate minimal contaminant levels which may pose no adverse impact if material is used in an unrestricted manner (further case-specific review will be necessary).
f: Ohio values are adapted from the Canadian Environmental Quality Guidelines for soil based on the most stringent value.[246]
g: Pennsylvania criteria are for the regulated fill rules[218] for residential use. PCB criteria are given separately for 7 congeners.

Scenario 7: Restricted Fill

Exposure Routes and Pathways

The exposure routes and environmental pathways to be considered under this scenario will vary depending on the nature and stringency of the use restrictions and site conditions. Use restrictions or exposure controls in a given application may reduce the need for considering certain routes or pathways. For example, approval of the material for use as fill under roadways may eliminate the fugitive dust pathway, except during material placement when worker exposure to dust may be a consideration.

Applicable Rules and Regulations

Illinois: Contaminant criteria would need to be determined on a case-by-case basis following the risk based procedures outlined in 35 IAC 742.[5]

Indiana: If the sediment is contaminated, it is regulated as a solid waste under IAC 10-2-174(a)(6)(B) and landfill placement may be required. Although nonbinding, the industrial RISC guidelines[74] would likely apply in this case.

Minnesota: SRVs from the Risk-Based Guidance for the Soil – Human Health Pathway[96] may be applied. If Tier 1 standards are not met, Tier 2 standards might be applied with various levels of restrictions. Tier 2 Soil Leaching Values are also applicable for this use.

New York: Suggested Metals Limits for General Reuse Options[97] lists fill for residential fill as falling under Universal Reuse Prohibitions for contaminated materials. Fill involved in industrial and commercial applications are listed as falling under category A, as is use as a subbase in transportation applications.

Ohio: Potentially applicable regulations would include those used to evaluate an "exceptional quality sludge" in OAC 3745-40-05(F).[22]

Pennsylvania: The proposed rule governing regulated fill would expressly permit use of dredged material to "to bring an area to grade, to control runoff, and to limit infiltration of water" if it met given contaminant criteria.[218] Additional restrictions are also listed in the rule. Separate criteria are given for residential and nonresidential uses.

Wisconsin: A number of fill types are defined in NR 538.10(5-8),[29] including confined geotechnical fill and encapsulated transportation facility embankment, which require at least category 4 material, and unconfined geotechnical fill and capped transportation facility embankment, which have the more stringent requirement of Category 3 material. The requirements for these material categories are defined NR 538.08(3-4) and in NR 538 Appendix 1, tables 2-3.[29]

Contaminant Criteria

Table A-12: Criteria for Scenario 7, Restricted Fill

Contaminant	IL[a]	IN[b]	MI	MN[c]	NY[d]	OH[e]	PA[f]	WI[g]
Arsenic	*0.05**	*20*		*25*	Case-by-case determination	*41*	53	21
Lead	*0.0075**	*230*		*700*		*300*	450	--
Zinc	*7,500*	*10000*		*70000*		*2,800*	12,000	--
PCBs	*1*	*5.3*		*8*		--	various	--
Benzo(a)pyrene	*0.8*	*1.5*		*4*		--	11	4.4
Benzene	*0.03*	*0.67*		*4*		--	0.13	--
Criteria Source	Cleanup – industrial	Cleanup – industrial		Cleanup – industrial	Reuse – general	Sludge rules	Use-specific regulation	Reuse – specific

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.
a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 industrial tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.
b: Indiana values are based on the RISC tables for an industrial soil.[74]
c: Minnesota criteria are based on SRV Tier 2 chronic industrial standards.[96]
d: New York criteria will be determined on a case-by-case basis.
e: Ohio values are based on monthly average limits contained in Ohio's sewage sludge rules.[22] There are additional limits for a single application and a total lifetime loading limit.
f: Pennsylvania criteria are for the proposed regulated fill rules[218] for nonresidential use. PCB criteria are given separately for 7 congeners.
g: Wisconsin criteria are based on Table 2B in NR 538 Appendix A, qualifying the material as Category 3 and appropriate for use in many geotechnical and transportation-based applications. If barriers are present, Category 4 material, having less stringent standard may be applicable. Criteria for pollutants that are not represented in the table may be enforced by the WDNR.

Scenario 8: Aggregate (i.e., bonded by lime, asphalt or cement)

Dredged material may be suitable for addition to asphalt or cement as aggregate for construction materials. The appropriateness of this use will depend on the physical characteristics of the dredged material. Materials that have high proportions of sand may be suitable for direct use as an aggregate. In other cases, the sandy phase of the material will need to be separated out prior to use. Binding sediments into an asphalt or concrete has been considered as an attractive use for mildly contaminated sediments because it immobilizes many of the contaminants, especially metals, and prevents their leaching into soil and water. A similar beneficial use that has been explored with some success is the manufacture of bricks from dredged sediments.[185, 150, 151, 241] Although still in the research phase, manufacture of Portland cement from sediment is also being explored and may be an attractive use for sediments with high levels of organic contaminants.[192, 191]

Exposure Routes and Pathways

In situations where the dredged material is tightly bound by the cement or asphalt, the contaminant would be largely immobilized and exposures during the use of the product would be minimized. Tests to confirm the strength of this binding and the lack of leaching may be necessary. In this case, the major exposures to consider are those incurred while producing the product, including inhalation, dermal contact, and ingestion. Potential for exposure at the end of the constructed products life, such as during demolition, should also be considered.

Applicable Rules and Regulations

Illinois: Contaminant criteria would need to be made on a case-by-case basis following the risk-based procedures outlined in 35 IAC 742.[5]

Indiana: If the sediment is contaminated, it is regulated as a solid waste under IAC 10-2-174(a)(6)(B) and landfill placement may be required. Although nonbinding, the industrial RISC guidelines[74] would likely apply in this case.

Minnesota: SRVs from the *Risk-Based Guidance for the Soil – Human Health Pathway* [96] may be applied. If Tier 1 standards are not met, Tier 2 industrial chronic or worker sub-chronic may be appropriate. Because leaching will likely not be a route of concern due to immobilization of contaminants, Soil Leaching Values[194] might not be considered.

New York: *Suggested Metals Limits for General Reuse Options* [97] lists incorporation into asphalt products, Portland cement, or concrete as falling under category B. Organic contaminant limits will be evaluated on a case-specific basis,

Pennsylvania: 25 Pa. Code Chapter 287, Subchapter H. The residual waste management regulations allow the Department of Environmental Protection (DEP) to issue general permits for processing and/or beneficial use of residual waste other than coal ash (for coal ash, there is a separate law that allows beneficial use without requiring a permit). These permits can be issued for statewide or region-wide application. Applicants follow DEP-prescribed application process. Regulations allow DEP also to issue these permits for statewide or region-wide application. Once a general permit is issued, another person can apply to use that general permit by one of the two processes, registration or determination of applicability. Dredged material is managed as residual waste and, as such, qualifies for a general permit for use as an aggregate material.

A general permit, # WMGR072, has already been issued for the beneficial use of dewatered dredge waste for use as road bed material in roadway construction. The permit requires that dredged material comply with the chemical quality standards shown below and the applicable Pennsylvania Department of Transportation specifications covering its proposed use.

Wisconsin: According to NR 538.10(1) ,[29] use in this application, if it can be shown to substantially eliminate leaching or emission of contaminants, would likely require a category 5 or better industrial byproduct as defined in NR 538.08.[29] The qualification for this classification is that the material is not a hazardous waste as defined in NR 600.03 (98).

Contaminant Criteria

Table A-13: Criteria for Scenario 8, Aggregate

Contaminant	IL[a]	IN[b]	MI	MN[c]	NY[d]	OH	PA[e]	WI[f]
Arsenic	*0.05**	*20*		*25*	41		41	--
Lead	*0.0075**	*230*		*700*	4		200	--
Zinc	*7,500*	*10000*		*70000*	--		1,000	--
PCBs	*1*	*5.3*		*8*	--		5	--
Benzo(a)pyrene	*0.8*	*1.5*		*4*	--		0.6	--
Benzene	*0.03*	*0.67*		*4*	--		0.8	--
Criteria Source	Cleanup – industrial	Cleanup – Industrial		Cleanup – Industrial	Reuse – specific		Use-specific regulation	Non-haz. waste

All units are in milligrams per kilogram (mg/Kg) of material except * in milligrams per liter (mg/L) of leachate.

a: Illinois values are based on the most restrictive exposure route for that contaminant from the TACO Tier 1 industrial tables.[73] For ionizable contaminants, a soil pH of 7.0 is assumed for the groundwater ingestion route.

b: Indiana values are based on the RISC tables for an industrial soil.[74]

c: Minnesota criteria are based on SRV Tier 2 chronic industrial standards.[96]

d: New York criteria are based on the *Suggested Metal Limits for General Reuse Options* [97] Category B. Organic limits will be determined on a case-by-case basis.

e: Pennsylvania values are based on General Permit No. WMGR072.

f: For Wisconsin, the material cannot be a hazardous waste as defined in WAC NR 600.03(98).

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