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AN EVALUATION OF MAN-MADE DEEP-HOLES OF THE DULUTH-SUPERIOR HARBOR AS POTENTIAL DISPOSAL SITES FOR MAINTENANCE DREDGED MATERIAL

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... Duluth-Superior urban area communities cooperating
in planning and development through a joint effort of the
Northwest Regional Planning Commission and the
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Principal planner and author: Tom Davis
Graphics: Bob Lundberg

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BACKGROUND

During the past several years, the Northwest Regional Planning Commission (NWRPC), through its Metropolitan Interstate Committee (MIC), has been involved in various planning efforts regarding the disposal of maintenance dredged material in the Duluth-Superior harbor. In 1981, these efforts culminated in the completion of a long-range disposal plan for the harbor (MIC 1981). The plan presents suggested disposal methods and sites to be used after the present Erie Pier disposal site is exhausted.

Ultimately, the enactment of the various components of the plan is the responsibility of several state and federal agencies. While these agencies were closely involved in its development, they do not necessarily concur with all aspects of the document, and there is no assurance that they will, in fact, implement any or all of the program. Furthermore, questions remain regarding some of the disposal options, and more information is needed before those components can be adequately evaluated and possibly implemented. Since the useful life of the current disposal facility is projected to end in 1990, the unresolved issues and questions need to be addressed now.

One of the suggested disposal options is the filling of existing or newly created man-made deep-holes in the harbor. The importance that deep-hole disposal may have in future maintenance dredging in the Duluth-Superior harbor is great. Existing deep-holes alone have a volume of approximately 2.5 million c.y. and could hold several years of maintenance dredged material. In addition, the cost of disposal in deep-holes would be appreciably lower than other disposal options. This is due to several factors including the relatively short transport distance from dredging sites to the holes and the inexpensive disposal technique (direct disposal from hopper-dredge into the holes) which could be used. Total savings could be large since every dollar per cubic yard saved would result in an overall savings of over two million dollars if existing deep-holes were filled. The cost of dredged material disposal has always been of concern, but it will become even more important if recent proposals to assign dredging and disposal costs to the user and/or responsible local unit of government are implemented.

While it is apparent that deep-hole disposal of dredged material is highly desirable from an economic standpoint, some issues remain unresolved. These lie in two major areas: potential adverse environmental impacts and legal constraints. This report addresses these issues and is intended to help determine whether deep-hole disposal can or should be implemented in the Duluth-Superior harbor. It also is hoped that the findings will prove useful in assessing the feasibility of using deep-hole disposal in other ports within the state of Wisconsin.

Although the impetus for this study was the desire to determine whether deep-hole disposal is a viable option for maintenance dredged material, other benefits which may be associated with this technique have been assessed also. Of particular interest is the possibility that this technique may have some direct positive impacts on the environment and/or be useful in various habitat enhancement programs which have been proposed for the harbor.

OBJECTIVES OF STUDY

1. To generate and analyze information necessary to resolve environmental and legal issues concerning the filling of man-made deep-holes with dredged material.

2. To fully investigate and define the various aspects and options regarding this disposal technique.

3. To provide information, analysis and staff support necessary to permit or exclude the use of this technique.

4. To provide information which may make the use of this technique possible in other ports.

5. To provide information regarding the need to conduct new sampling of the pollution status of harbor sediments.

APPROACH

The conclusions and recommendations made in this report are primarily based upon a review of pertinent literature, but they also reflect communications with state and federal agency staff and selected individuals with particular expertise related to the study. In addition, a field study was conducted to determine present environmental conditions at two of the existing deep-holes in the harbor - the East Gate Basin hole and the Cross-channel hole (see MAP 1). This effort included collection and analyses of data from the deep-holes and the shallow water areas immediately adjacent to them. Benthos and fish populations, vegetation, dissolved oxygen, water temperature, and sediment characteristics (including grain size and pollutant status) were examined. The on-site studies, conducted from May through August 1983, were performed by the Lake Superior Basin Studies Center, University of Minnesota-Duluth (UMD). For a more detailed description of the methods and results of this work, see Appendix A which contains the full report submitted by UMD.

Supplementary environmental information on the deep-holes was acquired from the Minnesota Department of Natural Resources (MDNR) and the U.S. Army Corps of Engineers (COE). Data regarding fish utilization of the deep-hole near Hearding Island were collected by the Minnesota DNR in July of 1983. This information is presented in the UMD report. Data regarding benthos populations were gathered at the Cross-channel hole by the COE in the spring and fall of 1983. These are given in Appendix B.

Major Publications Pertaining to Deep-hole Disposal

The major publications from which information was obtained are listed at the end of this report. Although there is some overlap, they predominantly fall into three categories: those dealing with dredged material removal and disposal in general, those specifically addressing deep-hole disposal, and those pertaining specifically to the Duluth-Superior harbor. The most extensive source of information is the publications regarding research conducted under the auspices of the U.S. Army Corps of Engineers, Waterways Experiment Station. Of particular relevance is the series of documents published as part of the Dredged Material Research Program (DMRP). This set of publications presents the results of an extensive nationwide research program to examine the effects of dredged material disposal. Technical Report DS-78-1 (Aquatic Dredged Material Disposal Impacts) summarizes that portion of the program most pertinent to deep-hole disposal.

Two other reports were of particular help in assessing potential environmental impacts. They are "A Report on Studies of the Effects of Dredging and Disposal in the Great Lakes with Emphasis on Canadian Waters" (Sly 1977), and "Impacts of Navigational Dredging on Fish and Wildlife: A Literature Review" (Allen and Hardy 1980). The former summarizes the results of dredging impact studies on the Great Lakes prior to 1977. It specifically addresses impacts related to the availability of nutrients and toxic substances and turbidity. The latter is an excellent review of the literature pertaining to dredging and its impacts on fish and wildlife. This work was funded by the U.S. Fish and Wildlife Service and covers the literature up to 1980 including a separate discussion regarding the Great Lakes.

Several references were found which deal specifically with deep-hole disposal. Of particular importance is the work done in the Long Island, New York area. Several studies have been conducted in Long Island Sound including evaluations of deep-holes as disposal sites and pilot studies in which impacts were monitored and various disposal techniques evaluated during actual deep-hole disposal operations. These studies, conducted from 1975 to 1981, were sponsored by the State of New York and the State University of New York, New York Sea Grant Institute. The best summary of this work is given in a letter report made by H. Bokuniewicz of the State University of New York, Marine Sciences Research Center at Stony Brook to the New York District Corps of Engineers (1980). Other noteworthy sources of information on the environmental aspects of deep-hole disposal include: Polis (1973), Murawski (1969), Broughton (1977), and Koo (1973).

Pertinent references dealing specifically with the Duluth-Superior harbor are too numerous to list here. They cover a wide range of topics such as dredging and disposal, natural resources of the area, and sediment pollutants. Especially relevant to this report is a series of documents pertaining to dredged material disposal authored by MIC staff (MIC 1980, 1981, and 1982).

State and Federal Agency Concerns

In addition to the above references, input from state and federal agencies concerned with dredged material disposal and especially potential environmental impacts was sought and received. Agencies from which comments were solicited include: U.S. EPA (Region 5, Dredge and Fill Section, Water Quality Branch), U.S. Army Corps of Engineers (Environmental Analysis Branch, Planning Division, Detroit), U.S. Fish and Wildlife Service (St. Paul Field Office, Ecological Services), Wisconsin DNR (Area Office, Brule, Wisconsin), Minnesota DNR (Region 2 Office, Grand Rapids), and the Minnesota Pollution Control Agency (Permits Section, Division of Water Quality). Minnesota agencies were included in this process since dredged material disposal is a bi-state issue in the harbor and some of the potential deep-hole disposal sites lie in Minnesota waters. Responses were received from all but the MDNR, and they are included as Appendix C.

It should be noted that the concerns listed in the letters received from the various agencies are not meant to represent final or formal position statements. They were solicited in order to determine what the agencies consider the most critical environmental issue regarding deep-hole disposal to be. Each agency undoubtedly will have more detailed comments if a specific deep-hole disposal strategy is developed. In the case of those agencies with permit authority, their comments in no way are intended to abrogate their due legal authority.

EXISTING HOLES

Six large, man-made deep-holes exist in the Duluth-Superior harbor. These holes were formed when material was mined for use as fill in various construction projects in the Duluth-Superior metropolitan area. Of these, only four are generally considered feasible disposal sites (See MAP 1). The remaining two, the Allouez Bay site and the 21st Avenue "channel", were eliminated during development of the recommend disposal plan (MIC 1981) for various reasons including difficulty of access and significant environmental concerns. The rationale for excluding these two holes remains pertinent, and they will not receive further consideration in this report.

General information regarding the remaining four holes is presented in Table 1. It is noteworthy that the combined "fillable" volume of these holes, if they were filled to ambient water depths, is 2.3 to 2.5 million cubic yards. Based on recent estimates of annual maintenance dredged material volumes (MIC 1980a), this represents approximately 11 years of all maintenance dredged material.

Because previous work with deep-hole disposal has shown that, from an environmental perspective, it is not desirable to completely fill the holes, the actual "fillable" volume of these holes is somewhat less than 2.5 million c.y. Research conducted in Lake Erie, Lake Ontario, Long Island Sound, and Puget Sound indicates that minimum depths on the floor of the hole immediately adjacent to the sidewall should be at least 13 feet below the surrounding bottom to prevent escape of material during disposal (Bokuniewicz 1980). This estimate assumes that the material is bottom-dumped from a hopper-dredge and that it is released at least 100 meters from the perimeter of the hole. Because this type of disposal results in a cone-shaped deposit centered in the disposal site, the recommended depth at the sideslopes can be maintained while the interior portions of the hole are quite shallow.

Taking all these factors into account, a reasonable estimate of the capacity of the four existing deep holes in the harbor considered potential disposal sites is 2.0 million c.y. This is equivalent to 7-8 years of maintenance dredged material. The lifetime would be considerably longer if only unpolluted material were placed in the holes.

The two holes for which additional information was gathered during this study are the Cross-channel and East Gate Basin holes.

Cross-channel Hole

The Cross-channel hole lies between Interstate Island and the South Channel. It is rectangular in shape and runs from the Burlington Northern Railroad trestle approximately 600 yards westward. The hole was formed when approximately 972,000 c.y. of material was removed for construction purposes. In 1968, 150,000 c.y. which had been removed from the North Channel was placed into the north end of the hole via submerged pipeline, theoretically reducing the volume to 822,000 c.y. Water depths in the hole were checked with sonar this past summer, and it appears that the contours are essentially as given on the 1980 harbor navigation map.

Table 1. Physical characteristics of four deep-holes within the Duluth-Superior harbor considered potential dredged material disposal sites.

SITE	PREDOMINANT DEPTHS	AMBIENT DEPTH	SURFACE AREA	VOLUME
21st Avenue West Hole	20-30 feet	6-7 feet	25 acres	600,000 c.y.
Cross-channel Hole	30-35	4-5	24	822,000
Hearding Island Hole	26-33	2-6	18	485,000
East Gate Basin Hole	20-24	4-8	15	367,000
			82 acres	2,274,000 c.y.

Information gathered in and adjacent to the hole this summer (SEE Appendix A) show the following:

1. The sediments in and adjacent to this hole violate environmental standards (U.S. EPA) for total Kjeldahl nitrogen, zinc, volatile solids, and oil-grease. The pollutant levels are approximately the same in the hole and the adjacent flats, but are appreciably higher in the upper sediment layers than in the lower layers in both areas.

2. Oxygen profiles taken in May and late July indicate adequate oxygen is available (greater than 5.0 ppm) at all depths in the deep-hole throughout the spring and summer (NOTE: recent work by the WDNR indicates there is no oxygen depletion in the deep waters of the harbor during the winter months either).

3. No true thermal stratification occurred in the hole.

4. The deep-hole supports fewer total fish and fewer game fish than the surrounding shallows. No federal or state (Minnesota and Wisconsin) endangered or threatened species were encountered in the hole or the adjacent shallows (NOTE: MDNR data regarding fish use of the Hearding Island deep-hole were similar).

5. There were appreciably more organisms in the hole than in the adjoining flats. However, all of the samples had relatively low biomass and were dominated by small oligochaetes and chironomids. The existing benthic community in the hole is of relatively low fish food value. These findings are supported by the data collected by the COE this past year (SEE Appendix B).

6. No rooted aquatic plants were present in the hole since the bottom lies well out of the photic zone (approximately three foot depth in the harbor).

East Gate Basin

This hole was created in 1961 when approximately 350,000 c.y. of material was mined from the site. The volume as calculated from the most recent harbor navigation chart is 367,000 c.y., although sonar spot checks made during this study revealed that it is deeper then indicated in some areas.

The results of field work conducted this summer are much the same as have been presented regarding the Cross-channel hole. The primary differences regard sediment pollutants. Sediment pollutant levels were somewhat lower than in the area of the Cross-channel hole and, in contrast to the latter site, there was a marked difference between pollutant concentrations in the hole and the surrounding flats. Sediments in the hole violated several federal standards, while pollutant levels in the flats exceeded standards only in the case of zinc which is present in naturally high levels throughout the harbor.

DISPOSAL TECHNIQUES

The following techniques regarding deep-hole disposal have been derived from the work done in the Long Island Sound area (Bokuniewicz 1980). They are advocated as the initial methodology to be used in any deep-hole disposal which may occur in the Duluth-Superior harbor. If, as recommended later in this report, a demonstration project is conducted, modifications/improvements to the following will probably be made.

General

1. The initial dredging should be done with a clam-shell bucket or similar equipment which will create a relatively high-density deposit. This would reduce the amount of material resuspended during disposal and increase the stability of the deposited material.

2. The disposal material should be placed in a bottom-dump scow and subsequently disposed by direct dumping into the hole.

3. The disposal material should be dumped near the center of and a minimum of 100 meters from the perimeter of the hole. This would prevent material from escaping from the hole as it is deposited.

4. The depth of the hole at the perimeter should be at least 13 feet greater than the surrounding shallows. If the techniques described in items 1 through 3 are used, the deposit will form a truncated cone centered in the hole with a trough lying along the perimeter.

5. The deposition should be timed to minimize its impact on the biological community. Since biological activity is lowest during the winter months, this is probably the ideal time for disposal. This would reduce impacts on organisms and give the deposit time to consolidate before the ensuing spring. However, because winter deposition is not practical in the Duluth-Superior harbor, it is recommended that it be done in the late summer or fall. Further information regarding the seasonal variations in benthos populations in the harbor sediments would shed further light on this.

Polluted Materials

If polluted sediments were to be placed in the holes, one additional step would be necessary - a cap of clean material would have to be placed on top of the contaminated material. This would minimize the potential impacts of contaminants present in the underlying deposit. The thickness of the cap should be great enough to prevent pollutants from leaching into the overlying waters and to ensure that burrowing organisms and roots of aquatic plants will not reach the underlying polluted sediments. Several questions would have to be answered in order to properly apply this technique in the harbor (e.g., what organisms would colonize the cap and to what depth would they burrow?). Bokuniewicz recommended a sand cap of three feet in Long Island Sound.

TYPE OF DISPOSAL

Permanent vs. Temporary Disposal

The decision as to whether deep-holes should be used as permanent or temporary disposal sites depends upon several inter-related factors including:

1. The pollutant status of the material to be placed in the holes
2. The suitability of the material for re-use
3. The cost/benefit of removing the material for re-use
4. The environmental impacts of repeated removal of material

If deep-holes are to be used as temporary disposal sites, one of the first considerations must be whether or not there is a demand for the re-use of the disposed material. The potential for re-use of dredged material in the Duluth-Superior harbor was examined previously (MIC 1980b). This report concluded that, due to the size and composition of dredged material in this harbor, the primary potential for re-use is as construction fill. Dredged material has been used for this purpose in the past, and this practice undoubtedly will continue in the future. However, it appears that the demand for fill can be met by the re-use sites recommended in the 1981 MIC disposal plan (i.e., Itasca and Superior Forest sites).

Re-use of material placed in the deep-holes would be considered only if this was deemed a better alternative than the previously recommended sites. This is not the case due to the potential adverse environmental impacts of the repeated in-water transfers of the material (i.e., removal from the holes) which would be required. Although questions regarding the impacts associated with on-land handling and storage of dredged material remain, transfers from land-based stockpiles or sites effectively isolated from the harbor's aquatic system (e.g., Erie Pier) generally are preferred from an environmental perspective.

Although it probably would not be needed for general construction fill, material deposited in deep-holes could be used in habitat and wildlife enhancement projects in the harbor. Of particular relevance is the possible use of dredged material to maintain colonial bird nesting habitat. Portions of three dredged material islands in the lower harbor are being or soon will be managed as colonial bird nesting sites by the MDNR and/or the WDNR. Since the birds prefer bare or sparsely vegetated sandy substrates for nesting habitat, the primary management activity is to keep large portions of the islands clear of vegetation. The vegetation on the islands continually "invades" the cleared nesting areas, and it must be removed and/or covered periodically to maintain the preferred habitat.

One way to maintain bare, sandy habitat on the islands is to bury the vegetation with dredged material. Colonial bird management programs incorporating this technique have proven successful elsewhere in the U.S. (Soots and Landin 1978). This approach is particularly appealing in the Duluth-Superior harbor because two of the proposed deep-hole disposal sites

(Cross-channel and Hearding Island) are located immediately adjacent to Colonial Bird Wildlife Management Area islands. Material could be transferred from the deep-holes to the managed areas quite easily. This would maintain the desired habitat and extend the lifetime of the holes. Approximately 25,000 and 10,000 c.y. would be required on Hearding Island and Interstate Island respectively every three to five years (MIC 1982).

The primary factors to consider before implementing this technique are:

1. If the total cost of disposal in the holes and subsequent transfer of the material to the islands was less than the cost of other available disposal options, the habitat modifications could be done without cost to the managing agencies. Otherwise, it would be quite expensive.

2. This use would require that only uncontaminated material be placed in the holes. Use of polluted material would probably require that the islands be diked in order to prevent contamination of the surrounding waters when material was placed on the islands. This would be expensive and would make the islands less suitable as colonial bird nesting sites.

3. This technique could only be used a limited number of times since the material eventually would accumulate on the islands.

The other potential "re-use" of dredged material placed in deep-holes would be as part of the major enhancement project which has been proposed for the Interstate Island area. The large expanse of shallow water surrounding Interstate Island (approximately 200 acres) is noted in the Duluth-Superior Harbor Land Use and Management Plan (MIC 1978) as a prime site for the creation of several types of wildlife habitat including mudflats, submergent and emergent aquatic vegetation, and small islands. The cross-channel deep-hole lies within this area and offers potential as a temporary holding site for material which would be used in creating the desired habitats. As in the case of the island management scheme, this use of the material would extend the lifetime of the hole as a disposal site. The same cost and pollution considerations would apply as well.

With the exceptions noted, and unless the demand for re-use of dredged material changes dramatically, the major potential for existing deep-hole sites in the Duluth-Superior harbor is as permanent disposal sites.

Existing Holes vs. New Holes

The creation of additional man-made deep-holes for use as disposal sites is not justified at the present time. As in the case of temporary disposal in deep-holes, the creation of new holes would require that there be a demand for the material which would be excavated; and, as was discussed in the foregoing section, there is no great demand for such material.

Even if a demand for the material existed, there are serious environmental concerns regarding the creation of new deep-holes and their subsequent use as

disposal sites. Foremost of these would be the loss of existing habitat, and this probably would be shallow water habitat. The loss of this type of habitat in the harbor is a major concern due to its relatively high productivity, its importance to the fisher, and the major losses which have already occurred.

The remaining deep-hole disposal option - the permanent use of existing holes appears to be feasible. It will be discussed at length in following sections.

ENVIRONMENTAL ISSUES

Since the creation of new deep-holes and the use of existing ones as temporary disposal sites are not considered feasible disposal options at present, only environmental concerns regarding permanent disposal in existing holes are addressed in this section. Impacts associated with dredging are not considered since these will occur regardless of the type of disposal technique used. The environmental evaluation assumes that the techniques described in the foregoing section (DISPOSAL TECHNIQUES) would be used.

To facilitate discussion, environmental impact worksheets similar to those used by the Corps of Engineers in 404(b) Environmental Assessments have been used to summarize the concerns associated with this disposal option. Impact worksheets have been prepared for each of two conditions - disposal of unpolluted material and disposal of contaminated material (Tables 2 and 3). Since the potential impacts associated with each of the four holes are quite similar, composite rather than site-specific worksheets have been used. Any site-specific differences are noted in the discussion.

Wetlands

With the exception of the 21st Avenue hole, no wetlands are present in or adjacent to the four deep holes considered potential disposal sites. Mudflats are present in the shallows adjacent to the 21st Avenue hole, and there is some potential for negative impact on them. The major concern is that disposal material would bury and/or alter the existing habitat. This could occur if a large amount of consolidated material escaped during disposal or if particulates suspended during disposal later settled in the mudflats. Neither of these appears to be a serious concern. Essentially no consolidated material would be expected to escape from deepwater to the shallows during disposal (Bokuniewicz 1980) and only 1-3% of the disposal material would be re-suspended in the water column (Barnard 1978). Furthermore, the flow of Miller Creek would tend to carry suspended material away from the mudflat area and into the North Channel.

The other potential negative impact on the mudflats regards disposal of polluted material. If contaminated material were placed in the hole, it might increase pollutant levels in the adjoining shallows. Pollutants could be released from the disposal material both during (resuspension) and after (leaching) disposal. The possible increase in bio-available contaminants is of special concern since the mudflats are used as a feeding site by both migrant and resident waterfowl, shorebirds, gulls, and terns. More information regarding the bio-availability of sediment pollutants in the Duluth-Superior harbor is needed before this impact can be adequately assessed (see following discussion of Water Quality impacts).

The long-term impacts on wetlands could be positive since various wetland types could eventually be established in portions of some of the filled holes. The requisite feature would be a shallow or emergent substrate comprised of material which could support the desired vegetation. Historic losses of

TABLE 2. SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH DISPOSAL OF UNPOLLUTED DREDGED MATERIAL IN EXISTING DEEP-HOLES OF THE DULUTH-SUPERIOR HARBOR.

ENVIRONMENTAL CONSIDERATION	NO IMPACTS	POTENTIAL IMPACTS							
		NEGATIVE IMPACTS				POSITIVE IMPACTS			
		SHORT TERM		LONG TERM		SHORT TERM		LONG TERM	
		Minor	Major	Minor	Major	Minor	Major	Minor	Major
WETLAND								X	
WATER QUALITY		X						X	
MUNICIPAL WATER SUPPLIES	X								
FISHERY RESOURCES		X							X
SHELL FISH	X								
WILDLIFE		X						X	
BENTHOS		X						X*	
SUBMERGED VEGETATION								X	
RECREATION		X						X	
AESTHETICS		X							
COMMERCIAL FISHING		X							
ENDANGERED and THREATENED SPECIES	X								

TABLE 3. SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH DISPOSAL OF POLLUTED DREDGED MATERIAL IN EXISTING DEEP-HOLES OF THE DULUTH-SUPERIOR HARBOR.

ENVIRONMENTAL CONSIDERATION	NO IMPACTS	POTENTIAL IMPACTS							
		NEGATIVE IMPACTS				POSITIVE IMPACTS			
		SHORT TERM		LONG TERM		SHORT TERM		LONG TERM	
		Minor	Major	Minor	Major	Minor	Major	Minor	Major
WETLAND		?		?				X	
WATER QUALITY		X		?				?	
MUNICIPAL WATER SUPPLIES	X								
FISHERY RESOURCES		X	?	?					X
SHELL FISH	X								
WILDLIFE		X		?				X	
BENTHOS		X		?				X	
SUBMERGED VEGETATION								X	
RECREATION		X						X	
AESTHETICS		X							
COMMERCIAL FISHING		X		?					
ENDANGERED and THREATENED SPECIES	X								

wetlands in the harbor have been large, and the creation of new ones would be considered a major positive impact. The use of dredged material to create wetlands has proven successful in other parts of the U.S. (U.S. Army Corps of Engineers 1978b).

The potential for establishing wetlands by filling existing deep-holes is limited. The most likely candidate for this type of activity is the 21st Avenue hole. By filling it to ambient depths, the existing mudflats could be expanded. This would require that the uppermost deposition be compatible with the existing substrate. The remaining holes are subject to wave action which would prevent establishment of wetlands or are in areas used by recreational boats, thus eliminating them as acceptable wetland development sites.

Water Quality

Potential water quality impacts which have been associated with in-water disposal and therefore deep-hole disposal of dredged material include: release of contaminants and/or toxic organics, increase in suspended solids (i.e., turbidity), release of nutrients and biostimulants, direct destruction of plankton or nekton, and depletion of dissolved oxygen (Allen and Hardy 1980). The potential impacts are markedly lower in well-mixed waters such as those of the harbor (Wright 1978), and most are short-term in nature.

Concerns regarding the release of contaminants are primarily restricted to disposal of polluted material in the deep-holes. The resuspension of contaminated material during disposal could result in the release of pollutants to the water column. Of particular concern are ammonia, manganese, and iron because these components are more readily released from particulates than others (Burks and Engler 1978) and all three have been found in the sediments of the harbor at levels considered moderately or, in a few instances, heavily polluted by the EPA (U.S. EPA 1975, 1976, 1977a). Other pollutants which must be considered because they have been found in unacceptable concentrations in some sediments of the Duluth-Superior harbor include: PCB's, mercury, lead, and oil-grease.

Although the major potential for increased contaminant levels in the water column would be the release of pollutants due to resuspension of contaminated disposal material, release caused by resuspension of the polluted sediments already present in the holes could occur also. The mechanism would be entrainment by the disposal material as it impacts the bottom. However, given the fact that less than 5% of the disposal material, which would traverse the entire water column during its descent, would be expected to escape the hole due to resuspension, the amount of entrained bottom material which would be resuspended and subsequently escape the hole would probably be inconsequential.

To date, studies of the role of resuspended sediments in the distribution and bio-availability of pollutants have yielded varying results. It appears that the phenomenon may be quite site-specific. Because of this and the fact that much of the work has been conducted in saltwater regimes, these studies may not be directly applicable to the Duluth-Superior harbor. It is apparent that

more information is needed before the potential impact of disposing polluted materials into deep-holes can be properly assessed.

Concern regarding the release of nutrients and biostimulants also is greatest with respect to disposal of polluted materials because polluted sediments usually have higher levels of these materials. The primary issue is the potential for algal blooms and accompanying problems (e.g., oxygen depletion). Release of phosphorous and nitrogen are of greatest importance in this regard, and, since phophorous and nitrogen levels in harbor sediments often exceed EPA guidelines, a stimulatant effect could result during disposal of polluted sediments in the holes. However, this type of impact is of greatest concern in poorly mixed waters, and the deep-hole sites and the harbor in general are well-mixed thus lessening this possibility. As in the case of toxicants, this phenomenon is not fully understood as it applies to the Duluth-Superior harbor.

Disposal of dredged material, whether clean or contaminated, in the holes would cause a temporary increase in turbidity. In general, the longer the duration of elevated particulate levels, the higher the potential for impact is. For this reason, turbidity is or greater concern in fresh softwater systems (less than 200 mg/l total dissolved solids) where it can be quite persistent (Wechsler and Cogley 1977). The waters of the Duluth-Superior harbor are hard, thereby reducing the potential for long-lasting turbidity. Since polluted material is usually finer than clean material, turbidity would last longer if disposing contaminated sediments. However, the impact would be short-lived in either case and is considered minor.

"Post-disposal" resuspension and erosion of materials placed in the holes is unlikely to occur. The work done in Long Island Sound indicates that currents of 35-40 cm/second are required to resuspend silty dredged material such as would be placed in the holes. Calculated velocities in areas near the proposed deep-hole disposal sites are considerably less than this (Stortz and Sydor 1980). In fact, velocities in the channels near these sites, where maximum flow occurs, rarely exceed this figure.

The primary mode of resuspension would probably be the passage of ships, i.e., prop wash. Unless the holes were filled to elevations significantly higher than the surrounding flats, the additional amount of material resuspended due to filling the holes would be inconsequential. If the holes were filled to levels above the surrounding flats, ship passage would probably reshape the deposit in a short time. This would be of concern if the upper deposition layers were polluted, but the recommended technique incorporates only clean material in the upper strata of the deposit.

Oxygen depletion during in-water disposal operations is seldom considered a major problem (Slotta 1974). Any impact noticed is usually short-lived and occurs primarily near the point of impact on the bottom (Stern and Stickel 1978). Long-term depletions or anoxia can occur if highly organic material is being discharged, but even then it usually is not a problem in well-mixed waters such as those of the Duluth-Superior harbor.

Municipal Water Supplies

None of the disposal sites is near a municipal water supply and no impact is foreseen.

Fishery Resources

The impacts on the harbor fishery resources would include both positive and negative elements. During the initial disposal, there would be an increase in turbidity. This would be short-term, but could result in disorientation and, in some instances, death of fish in the disposal area. In the case of polluted material, toxicants levels in the water might be temporarily increased during the disposal operation (see discussion of Water Quality Impacts), and this could have various impacts on fish in the area. Since fish use of the deep-hole sites in the harbor is relatively low, these are not serious impacts.

The major potential for positive impact on the harbor's fishery is the creation of additional shallow and/or moderate depth habitat. The loss of shallow water areas has been a major natural resources problem in the harbor, primarily because they are considered valuable fish habitat. One of the concerns expressed by the U.S. Fish and Wildlife Service, and MDNR, and the WDNR with respect to the recently proposed Harbor Improvement Project has been the loss of shallow and moderately deep water habitats adjacent to the shipping channels which would occur (U.S. Army Corps of Engineers 1982). Estimated losses associated with the improvement project would be less than 24 acres. Filling the proposed deep-holes sites would convert approximately 80 acres of non-productive, polluted, deep-water habitat to this more productive shallow or moderately deep habitat. Of course, merely filling the holes would not ensure that they become valuable fish habitat, but the newly created habitat certainly would be more valuable than the existing deep-holes appear to be.

Wildlife

The potential negative impacts on wildlife would be minor and short-term. There would be temporary interruptions in the use of adjacent shallow waters as feeding areas by migrant and resident waterfowl, gulls, terns, and shorebirds due to the presence of disposal equipment and turbidity. The Hearding Island and 21st Avenue holes are of primary concern in this regard since both lie adjacent to waterbird feeding areas. These areas are used by large numbers of birds - especially during migration. The impact would be minimal since the disposal equipment would only be at the holes for brief periods of time.

If it was deemed necessary to reduce even the minmal impact expected, disposal could be limited in these two holes during the peaks of migration. Since the recommended disposal period includes the fall, avoiding fall migrants would be

the main concern. The peak of the fall waterbird migration lasts for about four weeks from late September to early October.

Benthos

Potential impacts of deep-hole disposal on the benthos are probably greater than those associated with water quality. They include: burial and/or suffocation of organisms, long-term changes in species composition and biomass, uptake of pollutants (including toxic organics and heavy metals), changes in water circulation, and changes in sediment characteristics and stability (Allen and Hardy 1980). The pollutant status of the disposal material is of primary importance.

The foremost concern, which is restricted to disposal of polluted materials in the holes, is the possible influx of contaminants into the aquatic food chain and the adverse effects that it could have on organisms. Since the actual uptake and toxicity of contaminants common in the harbor's sediments are not well understood, predicting these impacts is difficult.

This concern is mitigated by the fact that the sediments in the deep-holes are already polluted. Furthermore, it is likely that any polluted dredged material placed in the holes would contain the same pollutants as are present now, although perhaps at different concentrations. Therefore,the primary impact of initial disposal of contaminated material would probably be the burial of organisms. Depending upon the deposition schedule, it is likely that the benthic community would essentially be lost during the several years required to fill the holes. This is not considered significant since the loss of present benthos populations is not felt to be critical.

The eventual impact on the benthos probably would be positive, whether clean or polluted material were placed in the holes. The recommended practice for disposal of polluted materials in deep-holes is to place a protective cap of clean material on top. This presumably would prevent contaminants from entering the aquatic food chain. The end result would be a substrate that would be both cleaner and at a depth more likely to support a "valuable" benthic community than the present substrate. The "new" substrate would be similar to the adjoining shallows, and it is likely that it would be re-colonized by organisms from these areas. The exact thickness of the cap which would be required to effectively isolate the polluted materials, both in terms of long-term leaching and availability to burrowing organisms is not known, but is probably near three feet.

If only clean material was placed in the holes, it is even more probable that the long-term impact would be positive. In addition to the aforementioned positive changes in the benthic community, by the time the holes were filled, several feet of unpolluted sediments would have been placed on top of the existing polluted bottoms. There is little doubt that this would effectively remove the pollutants from the aquatic system.

The probability that filling the deep-holes would change water circulation patterns and/or cause movement of existing sediments is low. Velocities in the area of the potential disposal sites are low or non-existent (see discussion under Water Quality Impacts), and it seems highly unlikely that filling the holes, which presently constitute incongruities in the bottom topography, to the depth of surrounding areas would substantially change even those flow patterns which do exist.

Submerged Vegetation

Since no submerged vegetation is present in or immediately adjacent to the deep-hole sites, no negative impacts are foreseen. Depending upon the final water depth, it is possible that submerged vegetation would establish itself in the shallows created by filling the holes.

Recreation

There would be both positive and negative impacts on recreation in the harbor. Minor, short-term disruptions in general recreational boating in the waterway and reduced angling activity would be caused by the presence of disposal equipment and turbidity. Since none of the proposed disposal sites is a preferred recreational area, these impacts would be minor.

One additional concern, which applies only to the East Gate Basin hole, regards a further potential conflict with recreational boating. If this hole were filled to depths much shallower than the surrounding flats, it could pose a hazard to recreational traffic which presently uses the area. This should not be done. The remaining holes lie in areas which are already quite shallow and/or are not used by small watercraft.

One indirect but positive recreational impact of filling the holes would be a probable increase in fishery potential due to the creation of additional moderate to shallow depth habitat.

Aesthetics

The primary impacts on the aesthetics of the harbor would be those associated with turbidity and the presence of disposal equipment. These would be minor, short-term impacts.

Commercial Fishing

Since commercial fishing in the harbor is quite limited, there is little potential for impact. Only Sivertson Fisheries Inc. consistently fishes the area, and their operation is limited to a few pond nets. The nets are operated in the early spring during the smelt run. One of the usual net locations is near Hearding Island, and there is some possibility that turbidity associated with disposal in the Hearding Island deep-hole would reduce catch success in this net. This possibility could be eliminated by not allowing disposal to take place during the short time the net is operated.

Endangered and Threatened Species

No state (Minnesota and Wisconsin) or federal endangered or threatened species are known to exist in or adjacent to the deep-holes being considered for disposal.

Summary of Environmental Assessment

There are several unresolved issues concerning the environmental consequences of disposing polluted materials in deep-holes within the Duluth-Superior harbor. These include: the role of resuspended sediments as sources and/or sinks of nutrients, heavy metals, and organic pollutants, and the bio-availability and toxic effects of sediment pollutants. Until these issues are adequately addressed, this option cannot be recommended for implementation in future disposal plans. Minnesota Sea Grant researchers have just begun a three-year study in which they will be examining these topics. This work will be conducted in the harbor and near-shore areas of Lake Superior and ultimately will evaluate the environmental impacts of in-water disposal of polluted dredged material. This study should provide much if not all of the information needed to properly assess the environmental impacts of deep-hole disposal.

It appears that disposal of clean material in deep-holes could take place in an environmentally acceptable manner. The potential negative impacts are short-term and of minor importance. Several potential long-term positive impacts may result.

SEDIMENT POLLUTANTS

Additional information is needed regarding the pollutant status of the harbor's sediments and especially the potential environmental impacts existing sediment pollutants may have. Although a large number of sediment samples have been analyzed during the past decade, the majority of these have been taken from the navigation channels and in particular from shoals which are interfering with normal vessel traffic. Relatively little work has been done with respect to the bio-availability of the pollutants and the effect that resuspension of the sediments has on this.

Essentially no information regarding the pollutant status and physical properties of harbor sediments was available prior to 1970. Since that time, however, several sampling programs have been conducted. The Corps of Engineers has performed most of the sediment sampling in the harbor. Since this work has been conducted as part of the Corps' congressional mandate to maintain navigable channels in the harbor, the samples deal almost exclusively with sediments which must be dredged to maintain the shipping channels. Within this confine, the COE sampling has been extensive (e.g., 60 samples analyzed in 1977). The COE uses the test results to determine the pollutant status of those sediments to be dredged and therefore the appropriate dredging and disposal techniques.

Additional sediment data have been collected by various state and federal agencies and researchers. As in the case of the COE work, the primary concern has been the status of sediments in the shipping channels, and, with the exception of site-specific analyses performed in response to permit applications for in-water work, few data are available regarding sediments outside the channels. With some exceptions, the number of samples involved in these programs has been relatively small. The U.S. Environmental Protection Agency (EPA) sampled sediments in 1970 (15 sites), 1973 (6 sites), 1975 (33 sites), and 1976 (6 sites). The EPA considered the 1975 survey comprehensive, but the Minnesota Pollution Control Agency later questioned the adequacy of this survey. This resulted in the additional EPA analyses in 1976. Further sediment analyses have been performed by National Biocentrics (1972-73, 16 sites), the University of Wisconsin - Superior (1973, 36 sites and 1977-78, 6 sites), and the University of Wisconsin - Madison (1973, 6 sites).

Of the sediment samples taken from the harbor, most have been analyzed via bulk sediment chemistry, although a large number has been subjected to elutriate tests also. With the exception of the UWS work performed in 1977-78 and the samples analyzed by the EPA in 1976, essentially no bioassay work has been performed.

In recent years, the adequacy of bulk sediment chemistry in determining the potential environmental impacts of sediment pollutants has been questioned (Plumb 1981). It now appears that pollutant concentrations as determined by bulk sediment chemistry do not necessarily reflect the biological availability of these chemicals (i.e., actual potential for environmental impacts). This test has been used extensively because of the relatively simple procedures and lower cost. Elutriate tests are considered a far better measure of potential

impact since they determine the mobility of pollutants from the sediments to the water column. This is perhaps the most important consideration in assessing the potential impacts of dredged material removal and disposal.

Because most recent sediment work has included elutriate analyses, knowledge regarding the pollutant status of harbor sediments in the shipping channels is improving. However, several important considerations remain. The first is that, due to reduced pollutant inputs into the river, recent sediment depositions are probably cleaner than in the past. This means that conditions may be changing fairly rapidly in the harbor and that extensive sampling should continue in order to maintain an accurate picture of the pollution status of the sediments. The second point follows from the first. If more recent clean materials are now "covering up" older polluted sediments, how fast is this occurring and how deep must the clean overlying layers be to effectively remove the polluted materials from the harbor's aquatic system? The latter question includes several factors such as how deep benthos organisms burrow and the depth at which polluted materials no longer "leach" into the overlying waters.

The final point is that additional work is needed to fully understand the role that resuspended sediments play in the bio-availability of pollutants and therefore the potential environmental impacts associated with this phenomenon. The relative contribution and importance of the various mechanisms of resuspending sediments (e.g., prop wash, dredged material removal, and storms) should also be examined. This is of great importance in assessing the true impacts of dredged material removal and in-water disposal.

LEGAL CONSIDERATIONS

The regulatory considerations related to in-water disposal, and therefore deep-hole disposal, in the harbor were previously discussed in the long-range disposal plan (MIC 1980). Since few changes have occurred since then, the following account is merely an updated version of the information given in that report.

Disposal of dredged material is governed by all three levels of government with the States playing the most significant role. The Federal government through the Corps of Engineers issues permits for disposal in navigable waters. For this purpose, the Corps uses pollution guidelines established by the Environmental Protecton Agency. Usually the Corps will abide by State concerns on a permit and will generally wait for the State to issue a permit before issuing its own. The Corps issues permits under authority found in the Rivers and Harbors Appropriation Act and Section 404 of the 1977 Amendments to the Federal Water Pollution Control Act.

Each state issues permits under its own authorities as well as under Section 404 of the FWPCA. Neither state has a separate body of law governing dredging and disposal, but rather relies on the interaction of several different statutes and rules. In Wisconsin, the Department of Natural Resources operates under the following statutes:

1. 30.11 Wis. St. - Bulkhead line)
2. 24.39 Wis. St. - Lakebed lease) These two are used in combination. A city must first establish a legally described bulkhead line, which the state must then approve. Once this is done, the state can then lease to the city the right to place material upon the bottom of the lake behind the bulkhead line.

3. 30.19 Wis. St. - Waterway alterations

4. 30.12 Wis. St. - Structures in navigable waters

5. 144.26 Wis. St. - Navigable Waters Protection Law

6. 144.04 & 144.444 - Solid Waste Facility Approval

7. 147 Wis. St. - Pollution discharge elimination

The primary laws are Chapters 30.12 and 147, with the former being the most important with respect to in-water disposal. Chapter 30.12 defines what types of structures may be placed into the waters of the state and under what circumstances. Interpretation of this law has precluded the deposition of unconfined dredged material into lakes and rivers (the Wisconsin Attorney General in 39 O.A.G. 230 stated that the law "specifically distinguishes between deposit of materials and the erection of structures" and that "the term 'structure' should be extended to any artificial creation which has a utility because of its form as opposed to a mere pile or dump of materials"). Under this opinion and subsequent WDNR administration of regulations,

unconfined islands and disposal areas have not recieved permits. The second statute, in accord with federal law, defines dredged material as a pollutant whose discharge into water must be regulated. The fact that a permit is required under Chapter 147 does not mean that all in-water disposal is prohibited. A permit could be issued for disposal if it can be shown that there will not, in fact, be any degradation of the waters of the state.

As noted above, Chapters 30.11 and 24.39 are combined to permit filling of public waters that in some cases would otherwise be prohibited by Chapter 30.12. In no circumstances could these chapters be used to negate Chapter 147.

In issuing permits, the WDNR is required to make these findings:

1. The project must be in the public interest.

2. The project must not materially injure the rights of any riparian owner.

3. The use must be a harbor facility.

4. The project is to cause no environmental pollution.

In addition, the WDNR has been acting under two general policies. First, no disposal is to be permitted in the open waters of Lake Superior. Second, the continued loss of biologically productive shallow water areas is unacceptable.

Because Chapters 144 and 147 define dredged material as a pollutant, disposal sites can be defined as solid waste disposal facilities which require approval. NR 180 is the set of regulations which implements these provisions. Under this code all disposal sites for the harbor will be governed by the regulations, but variances are available. Variances can be obtained for all locational criteria except two: potential detrimental effect on any surface water and potential detrimental effect on groundwater quality. That is, all sites must satisfy these two guidelines.

Under the auspices of the Coastal Task Force on Dredging and Disposal, the WDNR is reviewing its rules and policies and will be issuing new policies clarifying the issuance of disposal permits. Preliminary discussions indicate that one result will be a more liberal interpretation of the existing rules allowing for more in-water disposal than before.

Minnesota splits its permitting authority between the Pollution Control Agency (water quality) and the DNR (state waters, habitat, etc.). The MDNR operates under authority of MSA 105.42 as administered under Minnesota Rules 6 MCAR Sections 1.5020 to 1.5023. The general policy regarding fill as stated in the rules is "to limit the placement of fill material into public waters in order to preserve the natural character of public waters and their shorelands, and maintain suitable aquatic habitat for fish and wildlife."

In accord with this policy, the rules permit fill in only a handful of circumstances. Wharves are permitted, if no other alternative is available, but creating land for development is not. The preference is to have dredged material deposited in upland sites but "[d]redge spoils may be placed below the ordinary high water mark when the Department determines that one or more beneficial public purposes will be enhanced." Recreational and habitat improvements usually are considered public purposes under this policy. The DNR also would allow in-water disposal if the particular sites and techniques to be used were adopted as part of a local harbor management plan which has been approved by the state (i.e., DNR).

The Minnesota Pollution Control Agency regulates water quality and issues disposal permits where there could be impacts upon surface or ground waters. The PCA operates under MSA 115, 116 and 116B; the applicable administrative rules are 6 MCAR 4.8014-15, 4.8024-25 and 4.8022.

The general policy of the PCA is to oppose in-water disposal of dredged material on the basis that the discharge of this material usually violates water quality standards or effluent limitations. In the case of violations, the applicant can seek a variance which must be acted upon by the PCA Board after a hearing before the state office of the Hearing Examiner. For the Duluth-Superior harbor, the PCA's preference for disposal sites has been contained upland facilities.

At the local level, the City of Duluth adopted Chapter 51 of its city code to govern floodways, shorelands and wetlands. The intent of the chapter is to protect water resources within the city. Fill activities are a special use under the floodways and shorelands sections of the code. The City policy is to minimize the amount of fill and to prevent adverse impacts on the carrying capacity of the floodway.

Attesting to the fact that in-water disposal is acceptable in Minnesota under appropriate conditions is a project in the harbor of Warroad, Minnesota. In this case, maintenance dredged material will be placed in a near-shore area of Lake-of-the-Woods and be used to create an island. It is hoped that the island will serve as nesting habitat for colonial birds. Theoretically, this type of project could be done in Wisconsin also through the combined use of statutes 30.11 (bulkhead line) and 24.39 (lakebed lease).

The implications of the various regulations regarding deep-hole disposal in the Duluth-Superior harbor are:

1. Deep-hole disposal in Wisconsin waters is probably not feasible at the present time. The WDNR would likely deny the necessary permits under the premise that material placed in the holes would not constitute a legitimate structure. Since the two deep-holes lying in Wisconsin waters (East Gate Basin and Cross-channel) are both within the harbor line, the lakebed lease and bulkhead line provisions could not be exercised. It is unlikely that the WDNR would grant permits for a demonstration program either.

2. Deep-hole disposal in Minnesota waters is feasible, although the MPCA might deny the necessary permits based on their preference for on-land disposal and possible water quality violations. The water quality violations would be minor if clean material was disposed, and the MPCA would be more likely to grant permits under this condition. Deep-hole disposal would probably occur only if one of the two following conditions were met: its use is stipulated in an approved local harbor management plan, or, it is shown to be legitimate wildlife/habitat enhancement activity. A demonstration project in Minnesota waters would be possible, especially if only clean material were disposed and a comprehensive research and monitoring program were implemented as part of the project.

SUMMARY

1. Disposal of maintenance dredged material in deep-holes could be an important option in future disposal plans for the harbor and should be given serious consideration. Of existing holes, four appear suitable as disposal sites. These sites alone could hold on the order of 7-8 years of material. The cost of disposal in deep-holes would be appreciably lower than other disposal techniques. This may be even more important than in the past if dredging costs must be borne by the users and/or the responsible governmental units.

2. The creation of additional man-made deep-holes in the harbor for use as disposal sites is not justified at the present time. The creation of new holes presumes a need for the material removed during formation of a new hole. At present there is no great demand for such material. There are serious environmental concerns with this option also. They include: the loss of existing habitat (probably shallow water habitat), and water quality impacts during the creation of new holes and subsequent disposal into them). Should the demand for material increase in the future, this option could be re-assessed, but it would still require careful scrutiny due to the potential environmental problems.

3. It appears that disposal of unpolluted maintenance dredged material in existing deep-holes could be done in an environmentally sound manner and that filling of the holes may actually be beneficial to the aquatic system. Existing deep-holes in the Duluth-Superior harbor were not found to have any exceptional natural resource value. The sediments consist of fine material and are moderately to heavily polluted, fish use is low, no rooted aquatic vegetation is present, and the benthos population is low and of relatively low value as fish food. Filling these holes could effectively remove the contaminants from the aquatic ecosystem and provide more productive shallow water habitat.

Since previous studies of deep-hole disposal indicate that, following recommended techniques, less than 5% of the disposed material escapes from the hole, the primary impacts associated with this option would be temporary water quality impacts (e.g., turbidity) and changes in benthos due to substrate modification and initial burial of organisms. These impacts are short-term. The duration of turbidity relates primarily to grain-size of the disposal material (coarser material settles faster). Since this option would use unpolluted materials which are predominantly coarser, sandier sediments, turbidity should not be major problem.

The remaining questions regarding this technique primarily revolve around the applicability of methods developed in other parts of the country to the Duluth-Superior harbor. These questions can best be addressed via a pilot disposal program which would include a comprehensive research and monitoring effort.

4. Disposal of contaminated maintenance dredged material does not appear advisable at the present time. Although this option may prove feasible in the future, additional information is needed before it can be given serious consideration. Several environmental questions would have to be answered including: environmental impacts of resuspending contaminated sediments, the stability of clean "caps" which would be placed on top of polluted material placed in the holes, and the availability of buried contaminants to the food chain. Two research projects, dealing directly with these issues, will be initiated this year as part of a Minnesota Sea Grant research program. These are proposed three-year projects and should answer most, if not all, of the remaining environmental questions regarding deep-hole disposal of contaminated material.

5. Under present conditions, deep-holes should be considered for permanent, not temporary, disposal. The same considerations and concerns delineated regarding creation of new deep-holes apply to the use of existing holes a temporary disposal sites (i.e., lack of demand for material and environmental concerns associated with repeated transfer of material in the aquatic regime). The one exception may be the use of unpolluted material placed in the holes for habitat enhancement programs on the Hearding Island and Intersate Island Wildlife Management Areas. Both islands lie immediately adjacent to existing holes, and clean material could be used to maintain the desired sandy habitat.

6. Additional data regarding the pollutant status of sediments in the harbor and the bio-availability of these pollutants are needed. To date, almost all pollutants analyses have assessed contaminant levels in the shipping lanes and in particular in areas of shoaling where dredging is necessary. Other than site-specific analyses done in response to permit applications, essentially no information is available for the remainder of the harbor. The actual impacts that existing polluted sediments have on the harbor's aquatic system need to be determined. This should include assessments of the role that resuspension of these sediments has in this regard. These Sea Grant projects mentioned in item #4 include plans to examine these issues.

RECOMMENDATIONS

1. A pilot/demonstration deep-hole disposal project should be initiated in the Duluth-Superior harbor.

   a. The project should utilize only unpolluted maintenance dredged material.

   b. Due to legal restrictions in Wisconsin, the project would be most easily conducted in Minnesota waters. The Hearding Island deep-hole appears to be the optimum site.

   c. A comprehensive research/monitoring program should be conducted in association with the pilot project. This program should be designed with the input of technical staff from the concerned state and federal agencies including: U.S. Fish and Wildlife, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, and Minnesota Pollution Control Agency. The goal of the program would be to fully assess the environmental impacts of test disposals in the selected deep-hole and to make recommendations regarding modifications or improvements in technique or cessation of the pilot program.

   d. Since Minnesota Sea Grant has just initiated a research program to examine various environmental issues regarding dredged material disposal in the Duluth-Superior harbor, these efforts should be coordinated with any pilot disposal project initiated. If a pilot project is begun, serious consideration should be given to expanding the Sea Grant program to include work elements desired in the research/monitoring program.

2. The findings of the Sea Grant program and the research and monitoring program conducted as part of any pilot deep-hole disposal project should be used to assess the feasibility of disposing polluted material in deep-holes. If, at that time, it appears that this option is environmentally sound, the pilot project should be expanded to include polluted material. This would require the design and implementation of a revised research and monitoring program.

3. The plans of Minnesota Sea Grant researchers to document existing sediment conditions in the harbor should be examined and possible expansion of their program considered.

4. The State of Wisconsin should continue to evaluate its rules and policies concerning in-water disposal of dredged material. The MIC feels that a more liberal interpretation of present law or changes in the law which would allow deep-hole disposal to occur when it can be demonstrated that the environmental impacts are minimal and/or positive should be given consideration. Specifically, statute 30.12 and the interpretation of the term "structure" as used in that law should be reviewed. The impact of present interpretation is that in-water disposal of dredged material is not allowed, not because of environmental concerns, but because it is has no "utility because of its form".

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APPENDIX A

REPORT BY UNIVERSITY OF MINNESOTA - DULUTH

Regarding

PRESENT ENVIRONMENTAL CONDITIONS AT CROSS-CHANNEL AND EAST GATE BASIN DEEP-HOLES

A PHYSICAL, CHEMICAL, AND BIOLOGICAL COMPARISON OF TWO DREDGED DEEP HOLES AND ADJACENT FLATS IN THE ST. LOUIS RIVER ESTUARY

Submitted to:

Metropolitan Interstate Committe
and
Arrowhead Regional Development Commission

by:

Robert Cook, Ph.D.
Philip Devore

Lake Superior Basin Studies Center
University of Minnesota, Duluth
217 Research Laboratory Building
Duluth, Minnesota 58512

The University of Minnesota is committed to the policy that all persons shall have equal access to its programs, facilities and employment without regard to race, creed, color, sex, national origin or handicap.

Introduction

This study was contracted as part of a larger study examining the use of deep holes in the Duluth-Superior Harbor as temporary or permanent storage sites for maintenance dredged material. The sites to be examined were the deep holes adjacent to Interstate Island, the East Gate Basin, and the relatively shallow flats adjacent to these holes. The work program included collection, identification, and enumeration of benthos and fish population, grain size analysis of the sediments, dissolved oxygen profiles, and determination of the pollutant status of the sediments.

Methods

Chemical - A sediment core was collected from each of the deep holes adjacent to Interstate Island and East Gate Basin as well as each of the adjoining shallows. Cores were collected using a ten-foot Benthos gravity corer with a 2 1/2-inch polycarbonate core liner. Water was siphoned off in the field and the cores with liner were returned to the lab. Cores were split in half along the long axis for the visual core description. Undisturbed portions of the cores were halved at a depth of 30.5 cm. Chemical analyses were performed on homogenous mixtures from 0-30.5 cm and 30.5-61 cm. Percent water was determined by overnight drying at 125°C. Volatile solids were determined by further heating to 550°C in a muffle furnace. Hg, Zn, and Pb were dissolved from the dried sediment samples and analyzed using atomic absorption spectrophotometry. Total Kjeldahl nitrogen and total phosphorus were determined by

extraction and colorimetric analyses. Dissolved oxygen and temperature profiles were taken using a Yellow Springs Instrument Company dissolved oxygen meter.

Biological - All fish were collected using 24 hour sets with experimental gill nets. The nets were 250 feet long with five square mesh sizes of 0.5, 0.75, 1.0, 1.5, and 2.0 inches. All fish were measured and identified in the field. Gill netting was conducted on June 8-10 and July 26-28. During each of the two sampling periods two lifts were made from each deep hole and each of the flats adjoining the deep holes. The gill net used by the Minnesota DNR (in the deep hole adjacent to Hearding Island) was of the same size and type.

Benthic samples were collected at each of the four sites on June 9, 1983. Three replicate samples were taken using an Ekman grab sampler. All samples were preserved in the field and sorted and identified in the lab.

Discussion

Chemical - Pollutant levels were generally higher in the vicinity of Interstate Island than in the East Gate Basin area. The surface sediments in both deep and shallow sites around Interstate Island were similar with 4 and 5 pollutant concentrations, respectively, exceeding EPA standards for bulk sediments (Tables 1 and 2). Surface sediments in the deep hole adjoining the East Gate Basin exceeded EPA standards for four pollutants (Table 3), though concentrations were lower than those around Interstate Island. The only pollutant exceeding federal standards in the flats around East Gate Basin was zinc (Table 4).

Zinc levels are naturally high in the Duluth-Superior area and many undisturbed samples exceed federal standards.

Disposal of unpolluted sediments in the deep holes could be beneficial as existing pollutants would be sealed in place. This assumes that there would not be significant resuspension due to the disposal process. Another observation is that a silt-clay sediment (as in the deep holes) is a much more effective barrier against movement of pollutants into deeper sediments than is sand (note the higher pollutant levels in subsurface sediments in the shallow as opposed to the deep site at East Gate Basin).

Oxygen and temperature profiles in the two deep holes show adequate oxygen levels extending to the bottom (Table 5). There is no true thermal stratification due to river discharge and Lake Superior seiches. The more upstream site at Interstate Island has more depressed levels, due probably to low river dischage, warm water temperatures, and better mixing with Lake Superior waters in the East Gate Basin deep hole. None of these dissolved oxygen levels are below state standards.

Biological - Catch data from the gill net sets were consistent with past results from sampling in dredge channel areas. These deep areas commonly harbor fewer game fish and fewer total fish. Combined June and July catches from this study produced 6.0 game fish and 17.2 total fish per gill net lift in the deep holes and 36.4 game fish and 47.9 total fish per lift in the flats (Table 6). No endangered or uncommon species were encountered in the deep holes that did not occur in equal or greater numbers in shallow areas (5-10 feet). A winter gill net

assessment conducted by the Wisconsin DNR in 1978 also indicated a lower preference for deep water habitats. It therefore does not seem likely that filling of these deep holes to depths similar to those already existing in the area would have any adverse impacts on fish populations. Such filling could, in fact, be beneficial as it would create more habitat of preferred depths.

Benthic samples contained significantly more total organisms in the deep holes than in adjoining flats (Table 7). None of the samples contained a large biomass, however, as they were dominated by small oligochaetes and chironomids (84-95% in all samples). The larger number of organisms in the deep holes is probably the result of: 1) much larger quantities of fine silt, clay, and organic muck in sediments in the deep holes, 2) a deeper bite by the grab sampler in the soft muck, and 3) fewer fish feeding on the benthic organisms. The generally low biomass and the relatively low fish food valve of existing benthic organisms do not indicate that filling of the deep hole areas would affect unusual or uncommon species or have a significant impact on the food web.

Rooted aquatic plants did not occur within the deep holes. Maximum depth for rooted macrophytes within the estuary is approximately 1 meter due to poor light transmission through the darkly colored water.

Table 1. Sediment core data from the deep hole adjacent to Interstate Island (latitude: 4644.75, longitude: 9207.17). The 67 cm long core was collected on July 6, 1983, at a water depth of 33 feet.

VISUAL CORE DESCRIPTION

Interval (cm)	Remarks
0 - 52	Uniform sandy clay Gas bubbles, H_2S smell Dark laminations at 27 cm Sandy laminations at 35 cm
52 - 67	Sorted sand

CHEMICAL AND PHYSICAL DATA

	Interval (cm)		
Measurement	0-30.5	30.5-61	EPA Standards
% Water	55.0	42.2	-
Volatile Solid (%)	7.9	5.1	6
Oil-Grease (mg/kg) *	2380	880	1500
Total Kjeldahl Nitrogen (mg/kg)	2300	1400	1000
Total Phosphorus (mg/kg)	1000	660	1000
Mercury (mg/kg)	0.21	0.18	1.0
Zinc (mg/kg)	200	120	50
Lead (mg/kg)	43	26	50
% Clay	48	40	
% Silt	42	50	
% Sand	10	10	

* All data in mg/kg dry weight

Table 2. Sediment core data from the flats adjacent to Interstate Island (latitude: 4644.70, longitude 9307.60). The 104 cm long core was collelcted on July 6, 1983, at a water depth of 10 feet.

VISUAL CORE DESCRIPTION

Interval (cm)	Remarks
0 - 104	Uniform sandy clay Gas bubbles, H_2S smell Occasional features (1) sandy lenses (1mm thick) (2) organic rich lenses (1mm thick) (3) organic woody pieces (4) reddish/organic clay blobs

CHEMICAL AND PHYSICAL DATA

	Interval (cm)		
Measurements	0-30.5	30.5-61.0	EPA Standards
% water	54.2	46.0	-
Volatile Solids (%)	7.9	7.1	6
Oil-Grease (mg/kg) *	2550	1050	1500
Total Kjeldahl Nitrogen (mg/kg)	2300	1900	1000
Total Phosphorus (mg/kg)	920	740	1000
Mercury (mg/kg)	0.36	0.16	1.0
Zinc (mg/kg)	220	170	50
Lead (mg/kg)	51	46	50
% Clay	48	40	
% Silt	46	52	
% Sand	6	8	

* All data in mg/kg dry weight

Table 3. Sediment core data from the deep hole adjacent to the East Gate Basin (latitude: 4644.51, longitude: 9205.34). The 56 cm long core was collected on July 6, 1983, at a water depth of 28 feet.

VISUAL CORE DESCRIPTION

Interval(cm)	Remarks
0-18	Clay, with plant debris, gas bubbles, H_2S smell
18-21	Sand lens, uniform grain size
21-29	Clay grading to organic rich at 29 cm
29-36	Peaty layer - organic rich
36-56	Uniform sorted sand

CHEMICAL AND PHYSICAL DATA

	Interval (cm)		
Measurement	0-30.5	30.5-56	EPA Standards
% water	54.2	26.2	-
Volatile Solids (%)	7.0	1.7	6
Oil-Grease (mg/kg)*	2050	500	1500
Total Kjeldahl Nitrogen (mg/kg)	1500	390	1000
Total Phosphorus (mg/kg)	710	210	1000
Mercury (mg/kg)	0.52	0.12	1.0
Zinc (mg/kg)	156	20.3	50
Lead (mg/kg)	42	4.4	50
% Clay	46	16	
% Silt	24	16	
% Sand	30	68	

* All data in mg/kg dry weight

Table 4. Sediment core data from the flats adjacent to the East Gate Basin deep hole (latitude: 4644.59, longitude: 9205.17). The 58 cm long core was collected July 6, 1983, at a water depth of 9 feet.

VISUAL CORE DESCRIPTION

Interval (cm)	Remarks
0 - 11	Clay grading to poorly sorted sand
11 - 25	Cohesive clay blobs and lenses throughout clay matrix
25 - 58	Sandy clay Broken bits of clam shell at 33 cm Charcoal at 43 cm

CHEMICAL AND PHYSICAL DATA

	Interval (cm)		
Measurement	0-30.5	30.5-58	EPA Standards
% Water	37.7	28.4	-
Volatile Solids (%)	2.9	3.1	6
Oil-Grease (mg/kg)*	1040	610	1500
Total Kjeldahl Nitrogen (mg/kg)	780	640	1000
Total Phosphorus (mg/kg)	420	410	1000
Mercury (mg/kg)	0.18	0.20	1.0
Zinc (mg/kg)	66.6	41.5	50
Lead (mg/kg)	16	10	50
% Clay	38	34	
% Silt	24	40	
% Sand	38	26	

* All data in mg/kg dry weight

Table 5. Oxygen and temperature profiles for the deep holes adjacent to Interstate Island and East Gate Basin.

	Interstate			East Gate Basin		
Depth (m)	D O (ppm)	Temp (°C)	% Saturation	D O (ppm)	Temp (°C)	% Saturation
1	6.4	23.8	75	8.5	22.8	97
2	6.1	23.0	70	7.9	21.8	89
3	6.0	22.8	69	7.3	21.2	82
4	5.9	22.5	67	7.3	20.2	80
5	5.8	22.5	66	7.3	19.2	78
6	5.8	22.2	66	7.6	18.5	82
7	5.5	22.0	63			
8	5.6	22.0	64			
9	5.4	22.0	61			
10	5.0	21.9	57			

Table 6. Species and number of fish captured in experimental gill nets on June 8-10 and July 26-28, 1983, in and adjacent to the deep holes by Interstate Island and East Gate Basin. Also included is one Minnesota DNR gill net lift from the deep hole adjacent to Hearding Island.

	Number of fish per lift								
	Interstate Deep Hole		Interstate Flats		East Gate Basin Deep Hole		East Gate Basin Flats		Hearding Island Deep Hole
Species	Jun	Jul	Jun	Jul	Jun	Jul	Jun	Jul	Jul
Yellow Perch	1.5	14.0	13.0	31.5	0.7	3.5	17.5	69.5	10.0
Walleye	-	1.0	2.0	2.5	2.7	0.5	4.5	2.5	1.0
Northern Pike	-	-	2.0	-	1.3	-	-	0.5	
Black Bullhead	3.5	1.5	3.5	0.5	1.7	0.5	0.5	2.0	
White Sucker	3.0	5.0	11.5	4.5	-	8.0	9.0	6.0	8.0
Longnose Sucker	0.5	-	1.0	-	6.3	0.5	2.5	-	1.0
Shorthead Redhorse	-	-	-	1.0	-	-	-	-	
Silver Redhorse	-	-	-	0.5	-	-	-	-	
Alewife	-	-	-	1.0	-	-	-	0.5	
Lake Chub	-	-	-	-	0.7	-	-	-	
Spottail Shiner	-	-	-	-	-	-	-	1.0	
Tadpole Medtom	0.5	-	-	-	-	-	-	-	
Burbot	-	-	-	-	0.7	-	-	-	
Trout-perch	3.5	-	0.5	-	3.0	2.0	0.5	-	
TOTAL NUMBER	12.5	21.5	33.5	41.5	17.1	15.0	34.5	82.0	20.0
NUMBER of LIFTS	2	2	2	2	3	2	2	2	1

Table 7. Type and number of benthic organisms from samples collected with an Ekman grab sampler on June 9, 1983, in and adjacent to the deep holes by Interstate Island and East Gate Basin. Each number is the average of three samples.

	Number of Organisms			
	Interstate Deep Hole	Interstate Flats	East Gate Basin Deep Hole	East Gate Basin Flats
Amnelida				
Oligochaeta	200.3	7.0	57.3	13.7
Nematoda	0.3	0.3	2.0	0.3
Insecta				
Trichoptera	-	-	1.7	-
Diptera				
Chironomidae	48.3	3.3	18.3	5.0
Chaoboridae	0.7	-	0.3	-
Ephemeroptera	-	-	-	0.3
Mollusca				
Pelecypoda	1.7	0.7	0.7	3.0
TOTAL NUMBER	260.3	11.3	80.3	22.3

APPENDIX B

BENTHOS DATA FROM CROSS-CHANNEL DEEP-HOLE

Provided by

U.S. ARMY CORPS of ENGINEERS
ENVIRONMENTAL ANALYSIS BRANCH
PLANNING DIVISION
DETROIT

COLLECTED FALL OF 1982 AND SPRING OF 1983

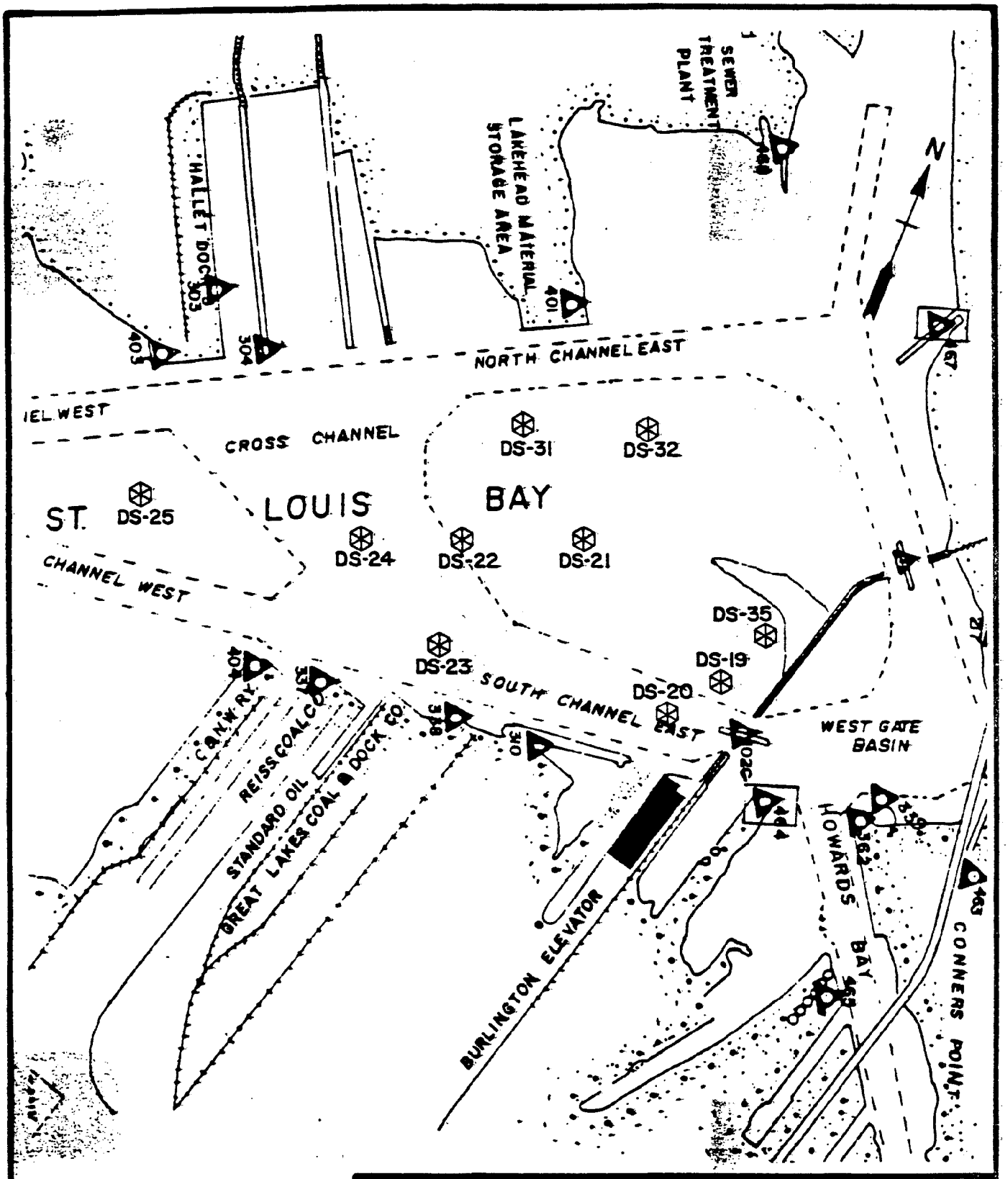

FIGURE 4

SAMPLING SITE LOCATIONS

BENTHOS ANALYSIS
DULUTH-SUPERIOR HARBOR
September 28 - October 1, 1982

Site: DS 19

Sample No: 1

Substrate Recovered:

Volume: 2240 ml
Description: 100% silt

ORGANISMS RECOVERED

Classification	Key*	Numbers Actual	Numbers Per Sq Meter	Volume (ml) Actual	Volume (ml) Per Liter
Diptera					
Chaoborus sp.	2	5	4.8	<0.1	--
Pentanuerini	4,5	1	9.6	<0.1	--
Oligochaeta		42	403.2	0.1	0.05
Tubificidae	2	38	364.8		
Other		4	38.4		
3 **taxa** **TOTALS:**		48	460.8	>0.1	>0.05

*See taxanomic key.

BENTHOS ANALYSIS
DULUTH-SUPERIOR HARBOR
September 28 - October 1, 1982

Site: DS 19

Sample No: 2

Substrate Recovered:

Volume: 2180 ml
Description: 100% silt

ORGANISMS RECOVERED

Classification	Key*	Numbers Actual	Numbers Per Sq Meter	Volume (ml) Actual	Volume (ml) Per Liter
Diptera					
Chironomidae		1	19.1	<0.1	--
Pentaneurini	4,5	1	19.1		
Oligochaeta		55	1050.5	0.1	0.05
Tubificidae	2	36	687.6		
Other		19	362.9		
2 **taxa** **TOTALS:**		56	1069.6	>0.1	>0.05

*See taxanomic key.

BENTHOS ANALYSIS

DULUTH - SUPERIOR HARBOR

MAY 10 - 12, 1983

SITE:	DS-19	EQUIPMENT:	Eckmann (1)
SAMPLE NO.:	1	DEPTH:	6.4'
DATE ENUMERATED:	June 14, 1983	VOLUME:	1000 mls
		DESCRIPTION:	95% dark brown silt 5% detritus
		VEGETATION:	None.

ORGANISMS RECOVERED

CLASSIFICATION	KEY*	NUMBERS ACTUAL	NUMBERS PER SQ. METER	VOLUME (ml) ACTUAL	VOLUME (ml) PER LITER
Oligochaeta					
Aeolosoma	1	63	2709	0.45	0.45
Naididae	1	3	129	<0.1	--
Diptera					
Chironomus	1,3	1	43	<0.1	--
Psychoda	1,3	3	129	<0.1	--
Chaobrus	1,3	1	43	<0.1	--
Pelecypoda	1	1	43	<0.1	--
6 taxa	TOTALS:	72	3096	>0.45	>0.45

*see listing in Appendix

BENTHOS ANALYSIS

DULUTH - SUPERIOR HARBOR

MAY 10 - 12, 1983

SITE: DS-19
SAMPLE NO.: 2
DATE ENUMERATED: June 14,1983

EQUIPMENT: Eckmann (2)
DEPTH: 6.4'
VOLUME: 3100 mls
DESCRIPTION: 95% dark brown silt
5% detritus
VEGETATION: None.

ORGANISMS RECOVERED

CLASSIFICATION	KEY*	NUMBERS ACTUAL	NUMBERS PER SQ. METER	VOLUME (ml) ACTUAL	VOLUME (ml) PER LITER
Oligochaeta					
Aeolosoma	1	76	1634	0.5	0.16
Naididae	1	6	129	<0.1	--
Diptera					
Chironomus	1,3	6	129	<0.1	--
Psychoda	1,3	13	280	<0.1	--
Chaobrus	1,3	1	22	<0.1	--
Hirvoinea					
Actinobdella ineq.	1,5	2	43	0.1	0.03
Pelecypoda	1	2	43	0.1	--
7 taxa	TOTALS:	106	2279	>0.7	>0.19

*see listing in Appendix

BENTHOS ANALYSIS

DULUTH - SUPERIOR HARBOR

MAY 10 - 12, 1983

SITE:	DS-35	EQUIPMENT:	Eckmann (1)
SAMPLE NO.:	1	DEPTH:	28.0'
DATE ENUMERATED:	July 6, 1983	VOLUME:	1600 mls
		DESCRIPTION:	100% dark brown silt

VEGETATION: None.

ORGANISMS RECOVERED

		NUMBERS		VOLUME (ml)	
CLASSIFICATION	KEY*	ACTUAL	PER SQ. METER	ACTUAL	PER LITER
Oligochaeta					
Aeolosoma	1	57	2451	0.50	0.31
Diptera					
Palpomyia	1,3	2	86	<0.1	--
Procladius	1,3	7	301	<0.1	--
Hirudinea					
Helobdella	1,5	1	43	<0.1	--
4 taxa	TOTALS:	67	2881	>0.51	>0.31

*see listing in Appendix

BENTHOS ANALYSIS

DULUTH - SUPERIOR HARBOR

MAY 10 - 12, 1983

SITE:	DS-35	EQUIPMENT:	Eckmann (1)
SAMPLE NO.:	2	DEPTH:	28.0'
DATE ENUMERATED:	July 6, 1983	VOLUME:	1800 mls
		DESCRIPTION:	100% dark brown silt

VEGETATION: None.

ORGANISMS RECOVERED

		NUMBERS		VOLUME (ml)	
CLASSIFICATION	KEY*	ACTUAL	PER SQ. METER	ACTUAL	PER LITER
Oligochaeta					
Aeolosoma	1	72	3096	0.65	0.36
Diptera					
Procladius	1,3	11	473	<0.1	--
Chaobrus	1,3	1	43	<0.1	--
unknown (damaged)	1,3	1	43	<0.1	--
Hirudinea					
Actinobdella ineq.	1,5	1	43	<0.1	--
Helobdella	1,5	1	43	<0.1	--
6 taxa	TOTALS:	87	3741	>0.65	>0.36

*see listing in Appendix

APPENDIX C

STATE AND FEDERAL AGENCY LETTERS
Regarding
ENVIRONMENTAL CONCERNS
With
DEEP-HOLE DISPOSAL of DREDGED MATERIAL

United States Department of the Interior

FISH AND WILDLIFE SERVICE

St. Paul Field Office, Ecological Services
570 Nalpak Building
333 Sibley Street
St. Paul, Minnesota 55101

IN REPLY REFER TO:

January 5, 1983

Mr. Tom Davis
Natural Resources Planner
Metropolitan Interstate Committee
200 Arrowhead Place
Duluth, Minnesota 55802

Dear Mr. Davis:

This responds to your December 6, 1982 letter requesting Fish and Wildlife Service comments on potential environmental issues related to the filling of several deep holes in the Duluth-Superior Harbor with dredged material. The holes in question, which result from the excavation of harbor bottom sediment for use as construction fill in prior years, appear to range from 25 to 35 feet in maximum depth and lie adjacent to, or are surrounded by, waters of 4 to 8 foot depth. Four such holes are identified in St. Louis and Superior Bays on recent harbor navigation maps.

The following comments related to water quality and aquatic life are based on the assumption that only maintenance dredged materials are proposed to be placed in the holes.

Aquatic Life

The deep holes appear to offer an aquatic environment not common elsewhere in the harbor-calm water at depths beyond the photic zone. The value of that combination of environmental factors is unknown and may, in fact, be negligible. However, because the deep holes do represent a distinct, uncommon aquatic niche, their potential as aquatic habitats should be explored. Since data from the M.L. Hibbard Plant's 316(b) Report suggests that young-of-year walleyes may move from deeper to shallower harbor waters at night, an investigation of the use of the deep holes by walleye and other fish species may be warranted.

Water Quality

Situated as they are in shallow areas adjacent to active navigation channels, the deep holes would appear to provide ideal conditions for

the settling of finer water-borne sediments. In view of the above, several questions come to mind:

1. What are the chemical and physical properties of the upper sediment layers at the bottoms of the deep holes?

2. To what extent would disposal by the various alternative methods (e.g., bottom dump scow, hydraulic pipeline) lead to dispersal of those upper sediment layers?

3. To what extent would available disposal technology confine any adverse water quality impacts to the immediate area?

Regarding positive aspects of deep hole disposal, it is common knowledge that shallow waters can provide conditions for the establishment of aquatic vegetation beds which may provide food for aquatic invertebrates, water birds and some mammals as well as cover for invertebrates and fish. However, other factors such as turbidity and water turbulance have a negative effect on the establishment of such beds. Given existing harbor conditions, I see little chance that aquatic vegetation beds would become established over any of the deep holes should they be filled.

Before the Fish and Wildlife Service could arrive at a conclusion regarding the net biological worth of your proposal, information on the present biological values of the deep holes as well as impacts associated with the disposal process would have to be obtained. Such information would be crucial to our review of the required Department of the Army permit for such disposal.

Thank you for this opportunity to express our views on your ongoing study.

Sincerely,

Kenneth C. Carr

Kenneth C. Carr
Acting Field Office Supervisor

cc: MN DNR, Grand Rapids
WI DNR, Madison

DEPARTMENT OF THE ARMY

DETROIT DISTRICT, CORPS OF ENGINEERS
BOX 1027
DETROIT, MICHIGAN 48231

22 April 1983

REPLY TO
ATTENTION OF

Planning Division-EA

Mr. Tom Davis
Metropolitan Interstate Committee
200 Arrowhead Place
Duluth, Minnesota 55802

Dear Mr. Davis:

This letter is in response to your December 6, 1982, correspondence and your subsequent telephone conversations with Jim Galloway and myself during February and March of 1983 concerning your study of the posssible use of deep holes in Duluth-Superior harbor as dredge material disposal sites. The use of such areas for dredge material disposal would appear to be beneficial in that disposal costs would likely be reduced and new shallow water areas of presumably higher productivity could be created.

Several potential environmental impacts which could result from this type of disposal activity merit investigation. The loss of deep areas would reduce the diversity of habitat available in a relatively shallow harbor such as Duluth-Superior. Deep areas may be used as a seasonal refuge by some species of fish and invertebrates, especially during the winter months. Deep holes may also act as settling basins collecting suspended solids which often have pollutants associated with them. Because of this, filling such areas may have adverse impacts on water quality. In addition, adverse short term water quality impacts could result from disposal activities and, from the creation of holes if they do not already exist.

As disposal sites will be needed in the future in the Duluth-Superior area if harbor improvements and maintenance are to continue, your efforts should prove valuable. If you have any questions concerning this matter, please contact me at (313) 226-6752.

Sincerely,

Les Weigum
Chief, Environmental Analysis Branch
Planning Division

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

REPLY TO ATTENTION OF: 5WQD

APR 18 1983

Mr. Thomas Davis
Metropolitan Interstate Committee
200 Arrowhead Place
Duluth, Minnesota 55802

Dear Mr. Davis:

The purpose of this letter is to respond to your request for comments concerning the use of Deep Hole disposal of dredge material from Duluth Superior Harbor.

It is our understanding that this matter has been the subject of discussion by the Interstate Committee for some time and that a number of alternatives to the use of the existing Erie Pier disposal site have been evaluated. Further possibilities exist that the Corps of Engineers could be convinced to accept maintenance dredge materials at an expanded site in the Superior National Forest now under consideration for use in the channel deepening project.

It is the desire of this Agency to see contaminated wastes disposed of in consolidated upland containment areas. The present proposal to disperse such wastes over a number of in Harbor locations, through the filling of previously excavated deep holes, is viewed with some concern for a number of reasons. The submerged disposal sites would require a Section 10/404 permit for filling in navigable waters of the United States. A permit application of this sort would be subject to an evaluation based on the following considerations:

1. As a non-water dependent activity alternative upland sites would have to be evaluated.

2. It would have to be determined whether the bottom in the area of the deep holes is an area of active scour or deposition.

3. If deposition of organic fines is occuring, what contaminents are present in the bottom sediments? Will contaminated sediments or leachate be displaced from the deep holes by the placement of heavy clay and sands, or the compaction of the sediments?

In providing these questions, we do not wish to leave the impression that these are the only pertinent water quality considerations. Nor do we wish to prejudice the future deliberations of the Interstate Committee against similar proposals that have been subjected to a more thorough environmental analysis than we can provide at this time. Please feel free to contact Mr. Wayne Gorski at 312/886-6683 if you have any questions regarding these comments.

Sincerely yours,

Elmer D. Shannon

Elmer D. Shannon, Chief
Dredge and Fill Section
Water Quality Branch

cc: Wisconsin DNR, Madison, WI
Minnesota DNR, St. Paul, MN

Minnesota Pollution Control Agency

APR 05 1983

Mr. Tom Davis
Natural Resources Planner
Metropolitan Interstate Committee
200 Arrowhead Place
Duluth, Minnesota 55802

Dear Mr. Davis:

RE: The Environmental Impacts of Deep Water Disposal of Dredged Material

This is in response to your letter of December 5, 1982 which transmitted a synopsis of a proposed project through which you intended to assess the potential use of manmade deep holes in the Duluth Superior harbor as temporary or permanent dredged material disposal sites. In your letter, you indicated your interest in discussing the environmental impacts as opposed to the legal questions involved in a proposal of this nature. You also indicate that although the project is primarily aimed at Wisconsin waters, you are seeking responses from the Minnesota agencies because of the interstate nature of the harbor and your interest in assessing inwater disposal options for disposal of dredged material in Minnesota.

Your letter indicates that your assessment of impacts will involve only limited onsite research and thus will rely heavily on previous work with deep holes and related data. With regard to previous work conducted on the impacts of deep water dredge material disposal, you are of course aware that the U.S. Army Corps of Engineers (Corps) have conducted extensive work both in the Duluth Superior Harbor and at other sites throughout the United States. The Waterways Experiment Station (WES) have conducted extensive studies on the effects and the impacts of dredged material disposal. We suggest a thorough review of this information be conducted. It is important to note, however, that we feel it is imperative that someone familiar with studies of dredged material be utilized to review the study information and to evaluate the applicability of the study to the Duluth Superior Harbor.

The MPCA relies more heavily on information developed for fresh water than studies conducted in salt water habitats. Examples of the available information include technical report B-77-42 "Aquatic Disposal Field Investigations Ashtabula River disposal site, Ohio". We further rely on

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review documents such as technical report DS-78-1 "Aquatic Dredge Material Disposal Impacts" which presents summaries of the information developed through WES field investigations. The MPCA does not feel it is appropriate to depend on these conclusions without evaluating the studies and investigations upon which these conclusions are based. In particular, judgemental conclusions such as the "significance" of increase from background or "significance" of release of materials cannot be accepted on a general basis unless it can be shown that these conclusions would be applicable to the Duluth Superior Harbor.

The following is a list of concerns and general statements about the nature of dredged material and disposal impacts supported by the MPCA.

1. Dredged material which is released as a coherent unit that entrains ambient water, will affect the water column to some extent, but the primary impact will be the physical impacts to the bottom. The MPCA is also concerned that there are also impacts from secondary movement and bioaccumulation that may occur in the deposited strata.

2. Material which does not fall as a coherent unit may entrain the ambient water creating a neutrally buoyant plume with maximum water column interactions and little bottom impact. The exact water quality impacts from such a disposal occurrence will depend on the nature of the dredged material and the interaction with the water column.

3. The bottom dwelling organisms could be effected by reductions in dissolved oxygen, physical smothering, or toxicity in the dredged material. The effect will depend on the nature of the dredged material and on the nature of the organisms covered. Bioaccumulation may also effect the bottom dwelling organisms through accumulation or concentration of toxic substances from lower to higher concentrations via the food web or via direct contacts through respiratory or body surfaces.

4. The potential impact of nutrients such as phosphorus can be of concern in the discharge of dredged material. Excess of nutrients which removes a limiting factor (usually phosphorus) can bring about a bloom or shift in species dominance.

5. Habitat changes can occur which can affect the nature of the swimming organisms or bottom dwelling organisms. This will be most severe when the dredged material is quite different from the existing bottom as for example when fine material is placed on coarse sand and vice versa. The alteration of a deep water

habitat to a shallow water habitat can also create drastic habitat changes which can have a range of significance of effect depending on site specific situations.

6. If toxic substances are present such substances may be biologically active or available to the bottom dwelling community. Instances of concern include metals, pesticides, oil and grease, PCBs, ammonia, sulfide, and other elements and compounds.

7. Oxygen depleting constituents of dredged materials such as organics may reduce oxygen conditions within the sediments or in localized water areas. Anoxic conditions may increase the damage from other potentially toxic substances such as metals.

8. Bioaccumulation is of considerable importance since organisms may undergo lifetime or multigenerational exposure to this material. Organisms which burrow in, or live upon, the surface of the disposed material or deposit feeding organisms which may ingest large quantities of sediment can be severely effected.

9. The great natural variability in field testing and in the limitations of laboratory confirmation of field results indicate that laboratory or onsite test results cannot be universally applied or sited as being crucial to any other situation. Further, dredged material disposal does have measurable water quality and physical impacts but the ecological significance of the effect may not be clear. The short term impacts seem to be well understood, whereas the long term or chronic effects of dredge spoil disposal is not well documented and not well understood.

10. It is clear that the water quality impacts associated with dredge disposal are usually dramatic but short term. The physical changes are also dramatic and may be long lasting with a great deal of variation and impact on the biological community. Chemical changes in sediment can occur depending upon the nature of the sediment dredged and the nature of the disposal sites. The observed chemical changes in sediment have varied from none to changes lasting several weeks in duration. It should be noted that the WES has observed increased PCB in the water, long after other contaminents have disappeared.

We would also like to note that the MPCA considers the Minnesota Department of Natural Resources (MDNR) to be the primary agency responsible for the review of physical and habitat impacts in the State of Minnesota. It is our

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understanding that the review and study of any project will be coordinated with the MDNR. If you have any questions, please feel free to call me at 296-7225.

Sincerely,

Louis Flynn

Louis Flynn
Staff Engineer
Permits Section
Division of Water Quality

LLF:rbj

cc: Larry Seymour, Minnesota Department of Natural Resources
Dennis Cin, U.S. Army Corps of Engineers

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Box 125
Brule, WI 54820
Carroll D. Besadny
Secretary

May 19, 1983 1430

Mr. Tom Davis
MIC
200 Arrowhead Place
Duluth, MN 55802

Dear Tom:

I have solicited comments from district and area staff on the deep hole filling proposal for the Duluth-Superior Harbor. Let me simply relay you some of the comments I received from various staff:

Duane Lahti, Water Reg'ns. - "I see problems of where the material will go, will it remain, and effects on water quality and fish life."

Steve Schram, Fish Mgt. - "Granted we didn't give this project a high review in the past but this may be a good time to gather data which may end this concept all together or provide us with data necessary to reconsider it. I have always felt we should look at each project based on the merits of that project. The more information we can gather, the easier it will be to make management decisions."

Fred Strand, Wildlife Mgt. - "Why or under what circumstances would anyone consider using deep hole fills as a temporary dredge disposal method?"

"I can't think of any detrimental direct effects on wildife if deep holes were filled. There is great potential for secondary effects on wildlife, i.e., fish resource (wildlife food), water quality, etc. - mostly of an environmental contamination concern."

Ted Smith, Water Quality - "I am not aware of existing sediment quality data nor am I aware of what benefits "deep holes" provide. If they are merely voids in the harbor, I don't see any harm in filling them provided the fill sediment is "clean." Pertinent data to be analyzed would be samples of the sediment to be dredged and samples of sediment from the disposal areas. Being vaguely aware of the harbor's history, I'm sure many pollutants reside in the sediment and disturbing them might re-release them into the water column. So much time, money and effort has gone into improving the water quality, I would hate to take a step backwards.

Obviously maintenance dreding is vital and necessary to the future of the harbor. Therefore, I think this project should be supported providing it answers questions regarding the quality of the sediment, what potential habitat impacts might occur and what if any beneficial uses for the sediment exist, i.e., road bed fill, landfill cover, soil conditioner, etc.."

My own personal concerns are expressed by those quoted above. I support the study to secure good basic data upon which to make intelligent management decisions.

Sincerely,

Jerry Rieckhoff

J. L. Rieckhoff
Area Director

JLR:da

APPENDIX D

PROPOSED MINNESOTA SEA GRANT STUDIES

Regarding

DREDGED MATERIAL DISPOSAL and SEDIMENTS
of
The DULUTH-SUPERIOR HARBOR
and
NEAR-SHORE AREAS of LAKE SUPERIOR

PRELIMINARY SEA GRANT RESEARCH PROPOSAL 738

MINNESOTA SEA GRANT INSTITUTE

Principal Investigator	Patrick L. Brezonik, Professor of Environmental Engineering
Campus Address	Department of Civil and Mineral Engineering, 103 Experimental Engineering Building, Minneapolis Campus
Project Title	Role of sediment resuspension as a source or sink for aquatic pollutants in harbor and near-shore areas of Lake Superior.

Amount requested from Sea Grant for first year $ 25,000 * Non-federal match $8,000 **

Research objectives during the first year:

The overall objective of the proposed research is to evaluate the role of resuspended sediments as sources or sinks of nutrients, heavy metals, and organic pollutants in shallow water environments of Lake Superior. Bottom sediments are large reservoirs for various substances, including phosphorus and nitrogen forms, heavy metals, and synthetic refractory organics. As such, sediments are commonly considered potential sources of pollutants to overlying water, but the fact that the materials are in the sediments implies an affinity of sediment solids for the substances and this implies that sediments also serve as sinks. Three mechanisms are involved in movement of pollutants between sediments and overlying water: diffusion fluxes, biological transport, and physical resuspension of bottom sediments. All three processes operate in both directions (as sources and sinks for the water column). Resuspension caused by wind-induced turbulence is especially important in shallow environments; turbulence caused by ship movements and by dredging activities are also important in areas like the Duluth-Superior harbor. Resuspension results in entrainment of pollutant-rich sediment pore water, thus acting as a pollutant source to overlying water. Contact of suspended sediments with the overlying water may result in either uptake or release of pollutants, depending on sediment and water concentrations and sediment/water partition coefficients.

Specific objectives during the first-year are to (1) characterize harbor sediments (including dredge spoils) physically (e.g. particle size, density) and chemically (pore water contents, total and exchangeable concentrations of N and P forms, and heavy metals); (2) refine, apply and calibrate an event-based sediment resuspension model my research group has developed for shallow lakes to the Duluth-Superior harbor; (3) develop partition functions for phosphorus, ammonium, and selected heavy metals between sediment and water; (4) apply the resuspension model and partition functions to the Duluth-Superior harbor to evaluate the role of resuspension as a source/sink for the above substances.)?

Research objectives for subsequent year; total years to complete project: 3

Objectives for future years will include expansion of the resuspension model to calculate annual fluxes of pollutants to (and from) the water column by sediment resuspension in the Duluth-Superior (and other) harbors. Objective (3) will be continued for other pollutants and for other near-shore sediments. In addition, work will be undertaken to evaluate partitioning of selected pollutants (e.g. heavy metals) with colloidal matter in the water column. (The idea that all substances released from sediments are in true solution and are directly available to aquatic organisms is simplistic. A second phase in partitioning studies will evaluate

the extent to which various substances are adsorbed or associated with dissolved macromolecular and colloidal material in the water column versus being present in true solution as independent "microsolutes.")

Briefly describe procedures to be used.

Sediment samples will be collected from various locations in the Duluth-Superior harbor by small boat. Dredge samples and short cores will be obtained. Standard laboratory procedures will be used for physical and chemical characterization of the sediments. Laboratory studies will parameterize uptake and release of various P and N forms and selected heavy metals from sediments as a function of aqueous conditions (temperature, pH, DOC, etc.). Results will be quantified by Langmuir and Freundlich models, and partition coefficients will be developed. Laboratory studies with small circular channels (wave-tanks) will determine critical shear velocities associated with scour (resuspension) of bed sediments. Field studies in the harbor will measure suspended sediment levels in the water column under defined conditions of turbulence (e.g. known wind stresses) to calibrate the resuspension model.

Note: Field sampling and laboratory characterization phases will be done in cooperation with related projects on sediment-water interactions in the Duluth-Superior harbor (e.g. S. Eisenreich, Dept. CME; R. Cook, Dept. Geol., UMD). Close contact will be maintained between the investigators to coordinate sampling and laboratory studies, to share information needed by all projects and to prevent duplication of effort.

Users

Potential users of the information obtained from this study include state and local pollution control agencies, the U.S. EPA, and the Corps of Engineers. The results have implications regarding the impacts of ship movement on sediment resuspension. The relative importance of sediment resuspension as a source or sink of pollutants in the harbor needs to be assessed and compared to other sources of the pollutants. For example, if resuspension of sediments is found to be an unimportant source of pollutants in the harbor, concern about disposal of dredge spoils in the harbor area will be lessened, and the need for more costly disposal methods can be averted.

PRELIMINARY SEA GRANT RESEARCH PROPOSAL

MINNESOTA SEA GRANT INSTIUTE

Fill out front and back. Return by November 15, 1982, to the Minnesota Sea Grant Institute, 116 Classroom-Office Building, University of Minnesota, 1994 Buford Avenue, St. Paul, MN 55108.

Principal Investigator(s) Steven J. Eisenreich, Associate Professor of Environmental Engineering

Campus address(es) Department of Civil and Mineral Engineering, 103 Experimental Engineering Building, Minneapolis Campus

Project title The Scientific Basis for Assessing Dredge Spoil Disposal

Amount requested from Sea Grant for first year $25,000* * Non-federal match $ 6,000 **
*Does not include 2 Graduate Trainees and 8 days of boat rental time.
Research objectives during the first year:

The overall objective of the proposed research is to establish the scientific basis for assessing alternatives for the safe and economic disposal of dredge spoil in the aquatic environment. Dredged sediment of the Duluth-Superior Harbor will provide the focus. Two scenarios will be examined for dredged sediment disposal: 1) within deep hole areas of the harbor not within the ship turning area; 2) deep water disposal (>200 m) in the trough along the Minnesota north shore of Lake Superior.

Research objectives during the first year are:

1. To characterize the chemical and physical characteristics of the potential dredged sediment.
2. To initiate a mass balance study on the inputs/outputs of selected trace elements and synthetic organics to the harbor constituent to the dredged sediment.
3. To study the partitioning of selected trace elements and organics between the sediment and pore water.
4. To quantify diagenesis and fluxes of selected trace elements and organics from sediments simulating disposal of dredged sediments.

Research objectives during subsequent years (if applicable); total years to complete the project 3

Research objectives in the subsequent years will include continuation of 2 through 4 above and
1. To quantify the partitioning of selected trace elements and organics between water and settling particles when discharged at >200 m depth.
2. To accumulate sufficient current data to model the field of particle flux.
3. To assess the environmental and economic impact of the proposed and existing dredged spoil disposal alternatives.

*Estimate of first-year dollar cost includes all direct costs, indirect costs, fringe benefits, student assistantships, etc. Fringe benefits for faculty and civil service staff are 23%. Indirect costs are calculated as 39% of the total amount less equipment and subcontracts. For calculation purposes, we ask you to estimate salary increases of 7%.

**Non-federal contribution by campus and others; the National Sea Grant Act requires one-third of all funds expended be from non-federal sources, generally composed of matching from University academic year salaries, but industrial contributions should be investigated with the help of the Sea Grant office.

Briefly describe the procedures to be used:

The inputs of chemical components (i.e., trace elements, organics) to the Duluth-Superior Harbor derive from the St. Louis and Namadji Rivers, treated wastewater effluent discharges, coal storage facilities, sediment resuspension and pore water fluxes and Lake Superior water. Outputs are sedimentation and Lake Superior water exchange. The relative contribution of dredge spoils deposited in deep, quiescent waters to the chemical budget of the St. Louis "estuary" will be dependent on resuspension and pore water fluxes. The major sources of selected trace metals and organics typical of specific sources and present in dredge sediment will be investigated in conjunction with related projects (e.g., R. Cook), UMD).

Recent studies conducted in my laboratory show that hydrophobic organics such as PCBs are elevated in concentration in sediment pore waters. Advective pore water fluxes of selected components thus will be studied to assess the importance of sediment recycling of once deposited species.

Users

Dredged sediment from the Duluth-Superior Harbor has been deposited in shallow, surface waters of Lake Superior or behind constructed, diked areas within the harbor. The former situation likely distributes sediment over large areas causing concern for environmental health, but is inexpensive. The latter is environmentally sound but expensive. The alternatives which may be both environmentally sound and inexpensive will be examined in this project. Economic comparisons will be a prominent feature of this research.

Are there identified users for this information? ✓ Yes _____ No
If yes, who are they and what documentation of their need or interest exists? Will they provide matching monies? What is the potential cost:benefit outlook for your findings?

This sheet will be reviewed by University researchers and staff of Minnesota Sea Grant. Full scale proposals will be sought from those whose projects are most promising and are for an amount appropriate to prospective funds. Your full proposal will be sent for review to several researchers in the appropriate field and to related agency persons.

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