Navigation Improvement Study
Dredge Material Disposal Plan
Supplement to Feasibility Report

Boston Harbor, Massachusetts

Mystic River, Chelsea River and Reserved Channel

August 1990

US Army Corps
of Engineers
New England Division

BOSTON HARBOR
MASSACHUSETTS

DREDGE MATERIAL DISPOSAL PLAN

SUPPLEMENT TO
FEASIBILITY REPORT
AND ENVIRONMENTAL ASSESSMENT
FOR
DEEP-DRAFT NAVIGATION IMPROVEMENTS
TO
BOSTON HARBOR INCLUDING
MYSTIC RIVER, CHELSEA RIVER, AND RESERVED CHANNEL

PREPARED BY:

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

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Executive Summary

This report summarizes the environmental testing that was performed in accordance with Section 103 of the Marine Protection, Research and Sanctuaries Act to evaluate the suitability of dredged material from Boston Harbor for disposal at the Massachusetts Bay Disposal Site. Testing was performed using the procedures described in the draft national protocol (Draft Ecological Evaluation of Proposed Discharge of Dredged material into Ocean Waters, January 1990) and the draft regional protocol for New England (Guidance for Performing Tests on Dredged Material to be Disposed of in Ocean Waters, May 1990).

Physical, chemical and biological tests were performed on sediments from six locations in the Mystic River, Chelsea River and Reserved Channel. Sediments were chemically analyzed for fourteen metals and numerous organics constituents including polychlorinated hydrocarbons, pesticides and sixteen different polycyclic aromatic hydrocarbons. The results indicate generally moderate concentrations of metals with moderate to high concentrations of PAHs in the Mystic and Chelsea River.

Biological testing (28-day bioassays) using deposit-feeding clams (Macoma nasuta) and sand worms (Nereis virens) and a 10-day toxicity test using the amphipod, Ampelisca abdita. No significant worm mortality was observed in any of the tests. Significant mortality was observed in clams exposed to sediments from one location in the Mystic River. Significant amphipod mortality was observed for all locations but was attributed to testing procedures. Bioaccumulation testing indicated moderate uptake of certain metals (lead and chromium). No uptake in the worms was noted.

Based on the results of the biological testing, it was determined that sediments form the Chelsea River and Reserved channel meet the Ocean Dumping Act criteria and are suitable for unconfined ocean disposal. The surface sediments from the Mystic River may pose a potential environmental risk to benthic organisms. The capping of Mystic River sediments with cleaner material from the project during disposal operations will significantly reduce the impact of these sediments on the marine environment. A computer model was used to determine the feasibility of capping at the MBDS. It was determined that capping is a feasible alternative for isolating contaminated material from the Mystic River. This is the recommended plan for the disposal of dredged material from Boston Harbor.

BOSTON HARBOR
MASSACHUSETTS
SUPPLEMENT TO FEASIBILITY REPORT
DREDGE MATERIAL DISPOSAL PLAN

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I. Introduction.

The Boston Harbor Navigation Improvement Project consists of deepening the existing 35-foot deep Federal Channel in the Mystic River, Chelsea River, Reserve Channel and vicinity to 38 to 40 feet. Additionally, a nonstructural realignment of the Federal Channel through President Roads Anchorage is recommended. Approximately 2.25 million cubic yards of dredge material is proposed to be disposed at the Massachusetts Bay Disposal Site (MBDS).

This report summarizes the environmental testing that has been performed on the Boston Harbor project subsequent to the publication of the Feasibility Report and Environmental Assessment (EA) in August 1988. The environmental testing has been focussed on evaluating the suitability of dredged material from Boston Harbor for disposal at the Massachusetts Bay Disposal Site.

The EA identified the following items as potential impacts: interference with anadromous fisheries migration, removal of benthic infauna, resuspension of sediments, release of contaminants and burial during disposal. The proposed mitigation for these impacts included seasonal restrictions for dredging, use of rock excavated for habitat creation and sequential dredging/disposal to layer or cap contaminants at the point of disposal.

The testing of material to be dredged for ocean disposal suitability was deferred in recognition of the development of a new national protocol for the evaluation of dredged material. It was also felt that deferring the testing would insure that test results more accurately reflect the conditions at the time of dredging.

The physical, chemical, and biological testing was performed using the procedures described in the draft National protocol (Draft Ecological Evaluation of Proposed Discharge of Dredged material into Ocean Waters, January 1990) and the draft regional protocol for New England (Guidance for Performing Tests on Dredged Material to be Disposed of in Ocean Waters, May 1990).

These protocols utilize a tiered approach to testing. Tier I is a review of existing literature and the physical characteristics of the area to determine the potential for contamination and the need for chemical testing. In Tier II testing, bulk chemical analysis of the material is performed to determine whether contaminants are present at concentrations that have the potential for environmental impacts. Tier III uses biological testing (bioassay and bioaccumulation) to determine the potential impacts of dredged material disposal to the marine organisms. The results of these analysis are used to determine if the material is suitable for unconfined ocean disposal. The feasibility of capping material not meeting the requirements for unconfined disposal is also evaluated.

Tier I Evaluation.

The goal of Tier I testing is to determine the need for physical and chemical testing and identify contaminants of concern (Figure 1). This usually entails a compilation of all relevant existing information.

Boston is an industrialized urban harbor and major port area. Data on the sediment quality within Boston Harbor can be found in several sources (Cortell, 1980; USDOT/MADPW, 1982, 1985; Metcalf and Eddy, 1984; Boehm et al. 1984; NOAA, 1987; and Shiaris, 1986). These reports along with Corps data (COE, 1980, 1983, and 1986) indicate the potential for contaminants in concentrations with potential for biological impact.

During preparation of the EA, eighteen sediment samples were collected for bulk analysis in 1986 from the three reaches. Overall the project material is described as organic clay with some patches of clayey sand. The Mystic River had elevated levels of arsenic, lead, and zinc and moderate levels of copper, chromium, nickel, and mercury. The Chelsea River and Reserved Channel had elevated concentrations of lead and moderate levels of chromium, mercury, nickel and zinc. PCB analysis revealed elevated concentration in one sample from the Mystic River and moderate concentration from one sample in the Reserved Channel.

It was determined that these results adequately characterize the chemical nature of the sediments to be dredged during the project, but that further chemical and biological testing would be required to determine the suitability of the material for unconfined ocean disposal.

Tier II Evaluation.

At Tier II, the chemical and physical characteristics of the dredged material and the general environmental conditions at the disposal site are evaluated.

Using the 1986 test results as a basis, two sites from each of the three reaches were resampled for additional chemical and biological testing (Chelsea River, Sites A and E; Mystic River, Sites A and B; Reserved Channel, Sites B and D). Sediment samples from these locations and the Reference Station near the MBDS were collected January 17 and 18, 1990.

Chemical analysis was performed on these sediments assure that sediments were comparable to 1986 sampling and to allow better interpretation of the bioassay/bioaccumulation results. Because of the industrial nature of Boston Harbor, a much broader range of chemicals were analyzed. Chemical analyses were performed for all chemical listed in draft regional protocol Table I and III (See Appendix IB). In addition to metals and PCBs, sediments were analyzed for pesticides, volatile and semi-volatile organics (including 16 polycyclic aromatic hydrocarbons).

Tiered Testing & Decision Protocol For Open Water Disposal of Dredged Material

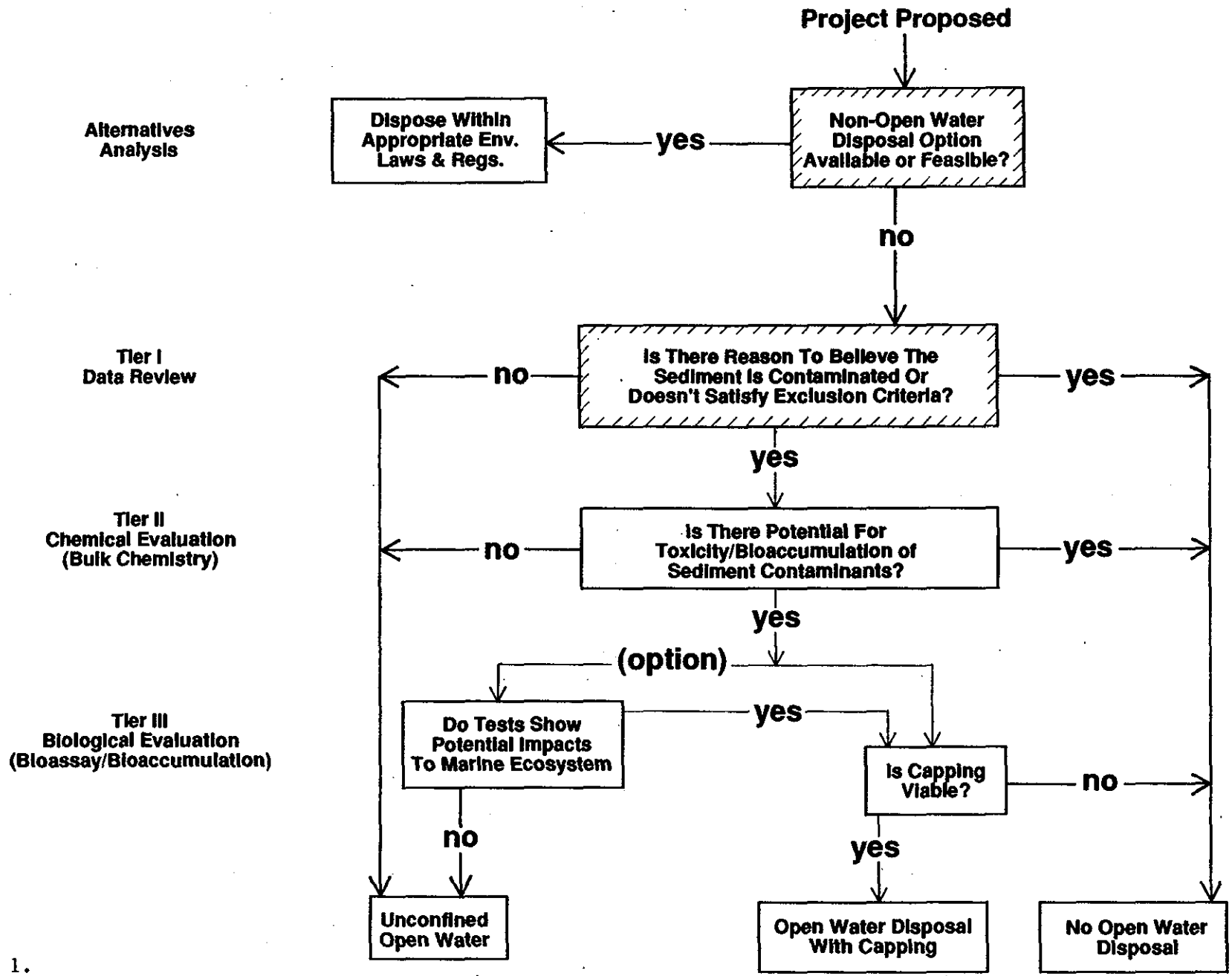

Figure 1.

Tiered Testing & Decision Protocol For Open Water Disposal of Dredged Material

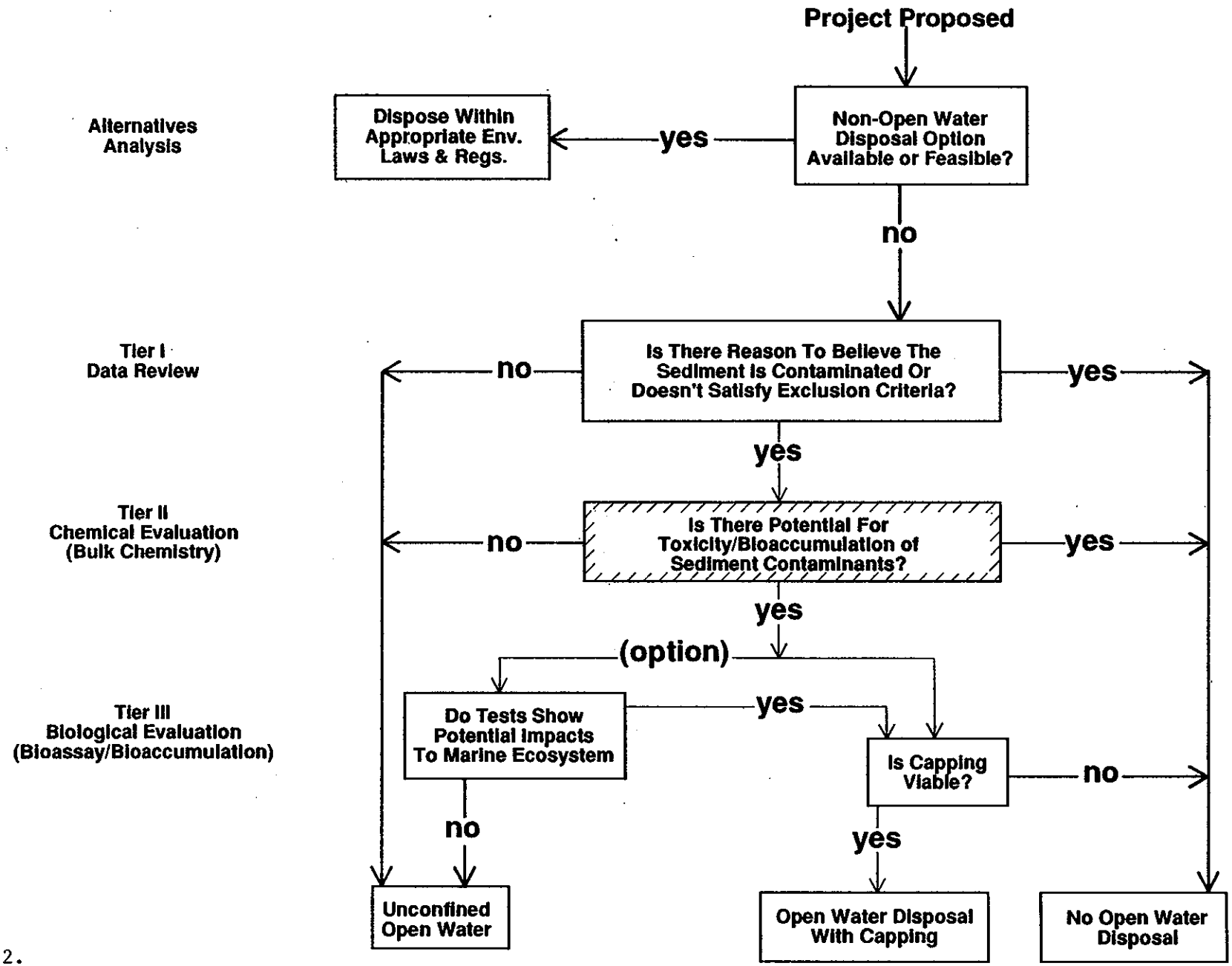

Figure 2.

TABLE 1. SEDIMENT METAL CONCENTRATIONS (ppm)
RESERVE CHANNEL

	1986 Samples (Environmental Assessment)				1990 Samples (Bioassay/Bioaccumulation)			MASS REGS
	A	B	C	D	B	D	REF	I - III
An					93	97	120	
As	8.8	5.4	6.9	7.2	12[2]	13[2]	12[2]	10-20
Ba	810	1200	680	720	91	99	74	
Cd	<3	<4	<3	<3	1.9	1.9	0.17	5-10
Cr	186[2]	93	82	109[2]	150[2]	180	95	100-300
Cu	161	73	100	67	130	130	20	200-400
Pb	221[3]	84	105	109[2]	95	100	45	100-200
Hg	1.48[2]	0.55	1.54	0.41	0.59[2]	1.0[2]	<0.06	0.5-1.5
Ni	58[2]	56[2]	37	37	34	33	29	50-100
Se					0.64	0.70	0.64	
Ag	<7	8	<7	<8	<10	<10	<10	
Th					<0.5	<0.5	<0.5	
Zn	264[2]	178	137	136	220[2]	250[2]	120	200-400
Cy					<0.005	<0.005	<0.005	
V	<700	<700	<620	<670				

TABLE 2. SEDIMENT METAL CONCENTRATIONS (ppm)
MYSTIC RIVER

	1986 Samples (Environmental Assessment)					1990 Samples (Bioassay/Bioaccumulation)			MASS REGS
	A	B	B	C	D	A	B	REF	I - III
An						120	110	120	
As	21.7[3]	11.7[2]	28.4[3]	4.8	-	24[3]	27[3]	12[2]	10-20
Ba	840	1200	1200	940	500	110	110	74	
Cd	<3	4	<4	<3	<3	2.6	2.9	0.17	5-10
Cr	77	180[2]	102[2]	42	37	140[2]	170[2]	95	100-300
Cu	112	218[2]	124	35	39	140	180	20	200-400
Pb	213[3]	342[3]	289[3]	23	94	210[3]	190[2]	45	100-200
Hg	0.69[2]	1.35[2]	1.17[2]	0.14	0.53[2]	1.1[2]	1.0[2]	<0.06	0.5-1.5
Ni	29	75[2]	52[2]	37	<2	39	38	29	50-100
Se						0.69	0.88	0.64	
Ag	<7	<8	<8	<7	<7	<10	<10	<10	
Th						0.50	<0.5	<0.5	
Zn	242[2]	435[3]	381[2]	102	81	420[3]	380[2]	120	200-400
Cy						0.025	<0.005	<0.005	
V	<660	<710	<700	<610	<580				75-125

TABLE 4.
POLYCYCLIC AROMATIC HYDROCARBONS
Boston Harbor, MA

PAH, ppb, by GC/MS	Reserve "B"	Reserve "D"	Chelsea "A"	Chelsea "E"	Mystic "A"	Mystic "B"	MBDS Reference
Napthalene				790	J380	J430	
Acenaphthylene				J280	J170	J370	
Acenapthene				J120			
Fluorene				J180	J210		
Phenanthrene	J130	J130		800	J260	J330	
Anthracene				J470	J210	J280	
Fluoranthene	J360	J270	J300	1700	J580	1100	
Pyrene	J270	J250	J290	2000	770	1200	
Benzo(a)anthracene	J140	J160	J150	1200		J630	
Chrysene	J180	J220	J220	1700	J340	690	
Benzo(b)fluoranthene				1500			
Benzo(k)fluoranthene	J310	J310	J360		J260	1400	
Benzo(a)pyrene		J100	J140	1100	J260	670	
Indeno(1,2,3-cd)pyrene				J570			
Dibenz(a,h)anthracene				J120			
Benzo(g,h,i)perylene				J560			
Total PAHs	1390	1440	1460	13090	3440	7100	

*Estimate value less than detection limit but a definite peak.

TABLE 3. SEDIMENT METAL CONCENTRATIONS (ppm)
CHELSEA RIVER

	1986 Samples (Environmental Assessment)							1990 Samples (Bioassay/accumulation)			MASS REGS
	A	B	C	D	E	F	G	A	E	REF	I -III
An								86	55	120	
As	5.1	5.9	5.9	7.3	7.2	6.0	7.1	12[2]	10[2]	12[2]	10-20
Ba	900	1500	1000	1800	1400	850	1400	80	50	74	
Cd	<4	<3	<4	<4	<4	<4	<3	1.6	1.1	0.17	5-10
Cr	160[2]	138[2]	146[2]	142[2]	134[2]	88	185[2]	210[2]	160[2]	95	100-300
Cu	71	41	64	89	67	52	139	110	64	20	200-400
Pb	158[2]	80	124[2]	262[3]	179[2]	125[2]	283[3]	120[2]	140[2]	45	100-200
Hg	0.61[2]	0.40	0.45	0.53[2]	1.16[2]	0.61	1.14[2]	0.71[2]	0.31	<0.06	0.5-1.5
Ni	<64[2]	45	66[2]	<26	<28	56[2]	37	24	17	29	50-100
Se								0.65	<0.5	0.04	
Ag	<8	<8	<8	<8	<8	<8	<7	<10	<10	<10	
Th								<0.5	<0.5	<0.5	
Zn	197	153	152	215[2]	164	145	276	260[2]	180	120	200-400
Cy								<0.005	<0.005	<0.005	
V	<720	<120	<720	<700	<710	<710	<710				75-125

In general, there is good agreement for grain size and metal concentrations for samples collected in 1990 for biological testing and the previously collected samples (See Tables 1 - 3). Therefore, we believe that the 1990 samples are similar to the 1986 samples. The metal results for the reference site also are in good agreement with the results from recent DAMOS monitoring (DAMOS, 1988).

PCBs were not detected in any of the 1990 samples. The elevated and moderate PCB concentrations observed at in the Mystic River (Station B) and Reserve Channel (Station B) were not observed in the 1990 samples. It should be noted that the location for Mystic B in the 1990 sampling is sligntly different than that in 1986 as the original location of Mystic B is outside the project limits. Differences in grain size may also explain the discrepancy as the 1990 samples from these locations had a slightly higher sand component.

Concentrations of polycyclic aromatic hydrocarbons (PAHs) in sediments are listed on Table 4. The total PAH concentrations in the Reserve Channel (Stations B and D) and the upper Chelsea River (Station A) were estimated to be 1.4 ppm. This concentration is considered low to moderate when compared with other coastal sediments (Tomey, unpublished). The estimated total PAH concentration in the lower Chelsea (Station E) is considered high (13 ppm). Estimated PAH concentrations from the Mystic ranged from 3.4 to 7.1 ppm These concentrations are in agreement with values found by the Status and Trends Program and are typical of other urban harbors in the Northeast (NOAA, 1990). PAHs were not detected in the samples from the Reference area near MBDS.

Another semi-volatile compound Bis(2-ethtylhexyl)phthalate was detected in all of the samples. Phthalates are used in the manufacture of plastics. Elevated sediment phthalate concentrations are commonly the result of sample contamination. The plastics operation in the upper Mystic River could also explain the more elevated levels found in this reach (Mystic A).

Four volatile organic compounds were detected in several of the samples. Most of these were at low concentrations. Acetone was found in all samples at a relatively high level. The source of acetone to these samples is unknown. Acetone is a natural by-product of microbial respiration in sediments. It is aslo a commonly used laboratory solvent and therefore laboratory contamination cannot be ruled out as a source. Volatiles would most likely be lost during the dredging process and are not a major concern.

The only pesticide which was detected in all of the samples was Endrin Aldehyde. This compound was also present in the blank, suggesting lab contamination as the source. The remaining pesticides were either non-detectable or low levels.

TABLE 5. SEDIMENT CHEMISTRY.
VOLATILES AND SEMIVOLATILE ORGANICS

	Reserve "B"	Reserve "D"	Chelsea "A"	Chelsea "E"	Mystic "A"	Mystic "B"	MBDS Reference
Volatile Organics, ppb							
Acetone	3181	4889	3223	8509	3774	5939	5441
2-butanone	371						
Trichloroethane	145		95		141		
Methylene Chloride					74		
Pesticides, ppb							
Alpha-BHC	6.5						41.7
Gamma BHC (Lindane)	29.4	4.0		9.0		3.9	39.7
Heptachlor		10.4				27.0	
4, 4'-DDT		31.1		28.1			
Endrin Aldehyde	151	369	168	188	837	864	84.4
Methoxychlor		111		25.3			
Other Detectable BNA, ppb							
2-Chlorophenol	J560			J280*	J430	J450	J370
4-Chloro-3-Methylphenol	J260						
Pentachlorophenol	J330					J210	
Bis(2ethylhexyl) phthalate	680	1800	1000	1600	12000	J380	1300
Dimethyl-phthalate				J180		J280	
Miscellaneous, ppb							
Total tetrachloro-dibenzo-p-dioxin (includes 2,3,7,8-TCDD)	<0.24	<0.21	<0.07	<0.12	<0.36	<0.08	<0.09
Total tetrachloro-furans (includes 2,3,7,8-TCDF)	<0.16	<0.14	<0.13	<0.23	<0.58	<0.11	<0.06
Total hepta-chloro-dibenzo-p-dioxin	0.52	0.55	0.62	1.4	<1.4	0.61	<0.25
Octachloro-dibenzo-p-dioxin	2.6	3.1	3.7	4.8	4.2	2.9	0.9

* Estimated value, below detection limit but definite peak.

Sediments were also analyzed for dioxin and furan homologs. There are approximately 75 possible congeners of polychlorodibenzodixins (PCDD) and 135 possible congeners of polychlorodibenzofurans (PCDF) which differ in the number and location of chlorine atoms on the molecules. The concentrations of all the congeners for each homolog were measured (Total Tetra-, Total Penta-, Total Hexa-, Total Hepta-, and Total Octa-chloro dibenzo dioxins and furans). Detectable concentrations were observed for HpCDD, and OCDD only.

Detectable levels for total HpCDD and OCDD ranged from 0.52 to 1.44 ng/g and 2.6 to 4.8 ng/g respectively Only OCDD was detected at MBDS (0.92 ng/g). HpCDD and OCDD tend to be ubiquitous (Rich Pruell, USEPA Lab - Narragansett, RI - Personal Communication). The EPA Narragansett Lab found HpCDD and OCDD levels of 0.38 and 1.2 ng/g at a reference site in Long Island Sound. Unfortunately there is little or no data on the toxicity of HpCDD or OCDD.

2,3,7,8 TCDD and 2,3,7,8 TCDF are considered to be the most toxic of the dioxin compounds and have defined FDA "Levels of Concern". The Center for Disease Control has stated that soils containing concentration of 2,3,7,8 TCDD above 1 ng/g could constitute a health risk. The concentration of Total TCDD and Total TCDF were below detection limits for all samples. Detection limits for total TCDD and TCDF ranged from 0.07 to 0.36 ng/g and 0.06 to 0.58 ng/g respectively.

EPA Narragansett Lab noted accumulation of 2,3,7,8 TCDD and TCDF in clams and worm tissue in sediments with concentrations of these isomers averaging 0.66 ng/g and 0.33 ng/g respectively. Mean concentration of 2,3,7,8 TCDD and TCDF for polychaetes from the New York Bight were 3.38 pg/g and 7.34 pg/g, respectively. For molluscs the 2,3,7,8 TCDD and TCDF averaged 0.95 pg/g and 1.94 pg/g respectively (Pruell, et al. 1990).

Dioxins are not thought to be a problem in the Boston Harbor samples. Even if detection limits reflected actual quantities, it is likely that the 2,3,7,8 isomers represent only a small fraction of the Total TCDD and TCDF component and are not likely to pose any significant risks.

The Ocean Dumping Act also requires an assessment of the potential impact of disposal on water quality. The proposed EPA/COE manual provides a computer model, known as the DUMP model, which can be used to simulate ocean disposal of dredged material. By providing the bulk sediment concentration of a parameter of concern and its water quality criteria, the DUMP model can be used to develop a worst-case analysis for water quality impacts. For Boston Harbor sediments, endrin aldehyde was used in the simulation. This compound was chose because of its potentially high concentration in the sediment (ignoring the blank problem) and its low water quality criteria concentration. The output from the indicates that there will be no violations of water quality criteria (See Appendix IV. A for model run).

The results of the model agree with the results of previous field studies. In, 1982, NED carried out a study to compare the results of disposal by hydraulic/hopper versus clamshell/scow dredging (DAMOS Report #41) at the MBDS. This study used acoustic profiling and suspended sediment measurements to track the plume of dredged material from the hopper as it settled to the bottom. The maximum extent of the plume dispersal was approximately 750 meters. The maximum concentration of suspended solids in the water column was 750 mg/l immediately after disposal. The concentration dropped to 39 mg/l within 20 minutes. After 40 minutes, the concentration of fine grained material ranged from 5 - 12 mg/l (background concentrations were approximately 1 mg/l). An estimation of the amount of material remaining in the water column was approximately 3% of the total load of the hopper. This estimate is in good agreement with estimates an estimate of 5% made for scows in the NY mud dump (Tavolaro, 1984).

The results of the chemical analysis performed in Tier II, verify that there are contaminants in concentrations with the potential for impacts to biological organisms. Model runs indicate that there will be no violations of water quality criteria (Appendix IV. A). Since there are no expected water quality impacts, biological testing for this project focusses on impacts to benthic organisms and the potential for trophic uptake.

Tier III.

Tier III testing assesses the impacts of contaminants in the dredged material on appropriate organisms to determine if there is a potential for unacceptable adverse impact. Bioassay and bioaccumulation tests are used. Both have to considered fully to evaluate the potential for impacts.

Bioassay.

Solid phase bioassays were performed on sediments from the six sample locations in Boston Harbor using the guidelines in the implementation manual titled "The Ecological Evaluation of Proposed Discharge of Dredged material into Ocean Waters" EPA/COE, 1977) and the Draft National Protocol, published January 1990.

The tests used were a 10-day toxicity test using the amphipod, Ampelisca abdita and 28-day bioassays were performed using deposit-feeding bivalves (Macoma nasuta) and sandworms (Nereis virens).

The clam and worm bioassay were performed using flow-through systems following standard NED procedures. The amphipods toxicity test outlined in EPA/COE manual is a static test (Swartz et al. 1985). Because of limited availability of organisms at the time of analysis amphipods and clams were obtained from a west coast supplier. The west coast variety of Macoma (Macoma nasuta) was used in the analysis. This deviation from the regional protocol was coordinated with EPA prior to initiating the study (Tomey, personal communication). Although Macoma nasuta is a slightly larger species it is functionally similar to Macoma balthica. Thirty Macoma were used instead of the required twenty to increase the sample size for chemical analysis in the bioaccumulation phase. A detailed description of the methods and materials is provided in Appendix II-A (Sea Plantation Inc., 1990). The results of these analyses are summarized below (Table 6).

There was poor survival of amphipods in all of the test sediments. Average survival in the test samples ranged from 14% to 41%. The reference and control sediments did have acceptable survival averaging 85% and 92%, respectively. Following the report of high mortality we contacted Dr. Norman Rubenstein of the EPA Environmental Research Laboratory at Narragansett, RI. It appears that the Narragansett Lab does not follow the procedures given in the revised manual. They run the amphipod tests using a flow-through system or a static system with daily renewal of seawater.

It is possible that high mortality of amphipods could be related to the fact that the test sediments were much more anoxic than the control or reference sediments. The static nature of these tests combined with the clayey nature of the test sediments could result in anoxic conditions below the sediment-water interface. Ampelisca are extremely sensitive to ammonia and hydrogen sulfide. Elutriate tests performed in 1981 reported ammonia concentrations (2 - 20 mg/l) which were greater than the acute toxicity concentration for many marine invertebrates and fish (0.1 to 3 mg/l; EPA Criteria for Ammonia). The release of ammonia from sediments has been studied in the Marine Ecosystem Research Laboratory (MERL) mesocosms. These studies show significant zooplankton mortality when ammonia levels increased above 1.4 mg/l. Based on the above, there is reason to believe that the results of the amphipod bioassays may not be valid.

The only other test species to show poor survival were the Macoma. With the exception of Mystic A, the clams (Macoma) generally had good survival the average ranging from 84% to 95%. Survival in Mystic A averaged 44%, with survivorship in the replicates ranging widely from 0% to 90%. Reference and control sediment had 93% and 99% survival, respectively.

The sandworms (Nereis) had high survival in all treatments, the average survival ranging from 93% to 98%. Survival in the reference and control were 93% and 95%, respectively.

The criteria for significant difference in survival is a statistically difference in survival between the test and reference sample which is is greater that 10%. Statistical analysis of the results was performed using a one-way analysis of variance (ANOVA). Cochran's test was performed to test the assumption of homogeneity of variances. The results of the statistical analyses are presented below.

Ampelisca

	Chelsea A	Chelsea E	Mystic A	Mystic B	Reserve B	Reserve D
Cochran's	NS	NS	NS	NS	NS	NS
Anova	*	*	*	*	*	*

Macoma

	Chelsea A	Chelsea E	Mystic A	Mystic B	Reserve B	Reserve D
Cochran's	NS	NS	*	NS	NS	NS
Anova	NS	NS	*	NS	NS	NS

Nereis

	Chelsea A	Chelsea E	Mystic A	Mystic B	Reserve B	Reserve D
Cochran's	NS	NS	NS	NS	NS	NS
Anova	NS	NS	NS	NS	NS	NS

Tiered Testing & Decision Protocol For Open Water Disposal of Dredged Material

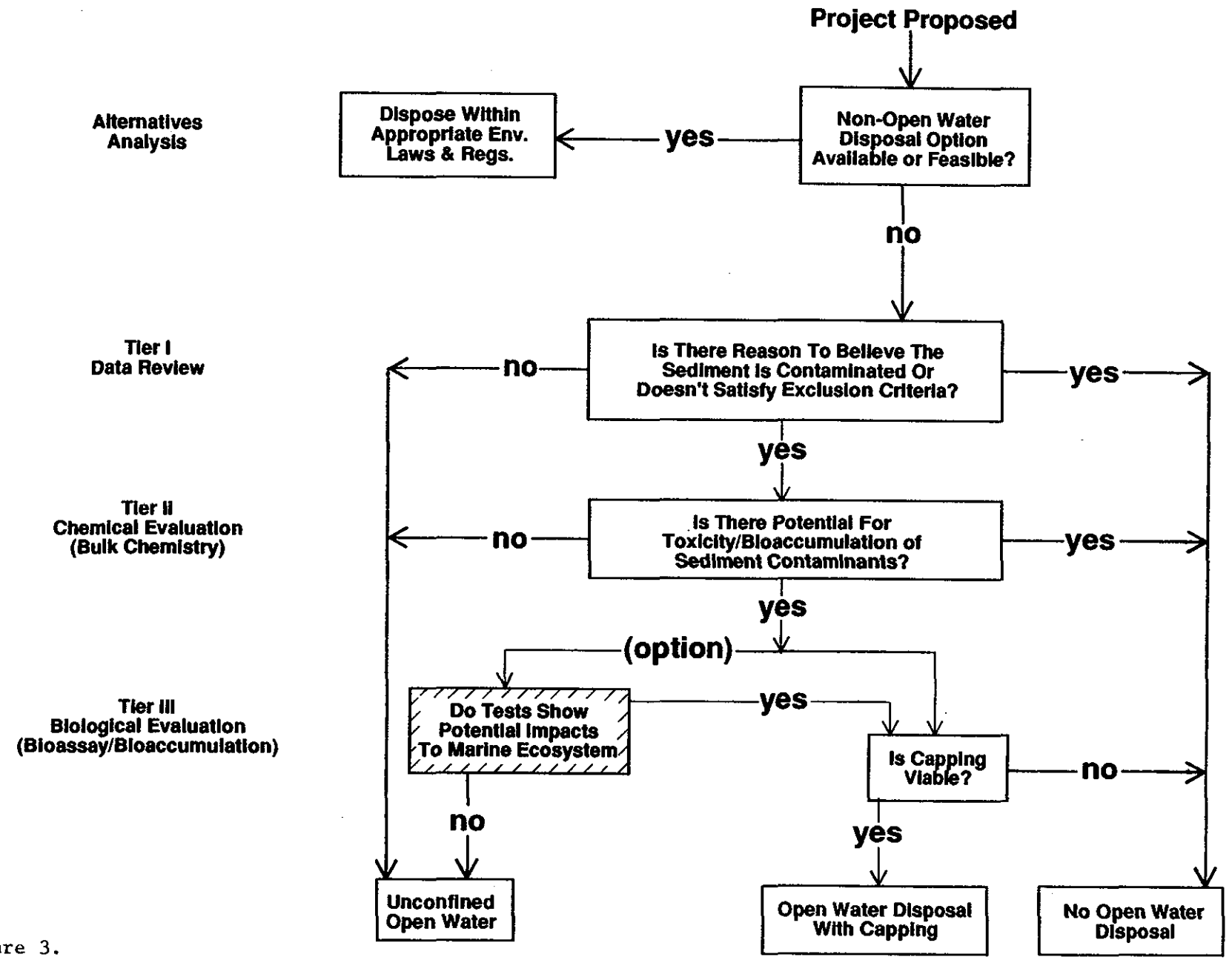

Figure 3.

These results indicate significant mortality of amphipods at all stations and significant mortality of Macoma at Mystic A. Only Mystic A exceeded the criteria. While the mortality of Macoma exposed to sediments from the lower Mystic River (Station B) was not statistically significant it was 9% higher than the reference. Given this level of mortality at Station B and the need for additional testing to delineate between these two areas, it was decided that the surface sediments from Mystic River would be treated as a unit for the purpose of analyzing disposal alternatives.

In summary the bioassay results indicate that the surface sediments from the Mystic River have the potential to impact benthic organisms. The surface sediments from the Chelsea River and the Reserved Channel are not considered toxic.

Bioaccumulation

The purpose of bioaccumulation studies is to determine the potential for trophic uptake. Bioaccumulation tests were performed on Macoma and Nereis surviving the bioassay to determine the potential uptake of contaminants by organisms. The parameters measured for bioaccumulation were based on the results of the bulk chemical analysis of sediments. Metals, PAHs, PCBs and pesticides were measured. Testing procedures and target detection limits utilized for bioaccumulation analysis followed the testing guidance in the New England Division Draft Regional Protocol (May, 1990) as well as protocol developed for EPA (Batelle, 1985; Tetra Tech, 1986a, 1986b).

The test results are presented in detail in the contractor report (Normandeau, 1990) which is attached (Appendix II-B). Data was statistically analyzed using the Corps SAL program (Statistical Analysis of Dredged Material Program). The results of the analysis are summarized below.

Sample Site	Parameter	Mean Test Concentration	Mean Reference Concentration
Mystic A	Cadmium	0.49 ppm	0.31 ppm
Chelsea A	Chromium	2.26 ppm	0.85 ppm
	Lead	4.57 ppm	1.64 ppm
Chelsea E	Chromium	2.59 ppm	0.85 ppm
	Lead	4.07	1.64 ppm
Reserve B	Chromium	1.92 ppm	0.85 ppm
Reserve D	Chromium	2.22 ppm	0.85 ppm
	Lead	3.99 ppm	1.64 ppm

No statistically significant differences were noted in uptake of heavy metals by the sandworm (Nereis virens). Only three metals (cadmium, chromium and lead) showed any potential for significant accumulation in the clam (Macoma nasuta).

The results of the bioaccumulation testing showed significant uptake by Macoma for cadmium from the Mystic A sediment and chromium and lead from the Chelsea and the Reserved sediments. The toxicities of lead and chromium are generally less than other metals and they are not known to biomagnify (WES, Tech. Report D-84-7). The concentrations in the tissues are in the ranges reported for bivalves from the east coast (NOAA, 1990). Therefore we have no reason to believe that the uptake of the two metals at these levels will lead to long-term chronic impacts.

No statistically significant uptake of PCBs, pesticides or PAHs was observed for any of the clam or worm test treatments exposed to Boston Harbor sediment from any of the six stations over the reference station.

The results of the chemical and biological testing indicate that the sediments from the surface sediments from the upper Mystic River have the potential for adverse impact to the benthos at the disposal site. The surface sediments from the lower Mystic River should also be treated with caution since it is impossible to delineate between the two areas without additional testing.

The surface sediments in the Chelsea River and the Reserved Channel are not toxic nor is there any significant risk of bioaccumulation from these sediments. Therefore it has been determined that these sediments meet the Ocean Dumping Act criteria for unconfined ocean disposal.

Management Considerations

The potential toxicity of the Mystic River sediments can be minimized by proper management of the dredging and disposal operation. The most effective way of doing this is by dredging the surface sediments of the Mystic first and subsequent capping this material with clean Boston Blue Clay from subsurface sediments.

It is estimated that approximately 1.4 million cubic yards of the material to be generated by the Boston Harbor dredging project is Boston Blue Clay (See Below). The volume of surficial sediment in the Mystic River is estimated to be 103,000 cubic yards. There appears to be adequate clay in the subsurface sediments of the Mystic River to cap this material.

Estimated Volumes of Material from the Boston Harbor Project

	Blue Clay	Surface Sediment	Rock	Total
Mystic River	536,000	103,000	6,000	645,000
Inner Confluence	351,500	255,700	48,000	655,200
Reserve Channel	303,600	157,000	39,000	500,500
Chelsea River	252,000	202,700	---	455,200
Total	1,443,600	718,400	93,900	2,255,900

A capping model has been developed by our DAMOS program. Using information from Boston Harbor as input to the model, the model predicts a capping thickness 600 cm in the center with at least 50 cm thickness at the edges (See Appendix IV. B for computer output). By proper management of scow placement, a more uniform coverage can be produced. In fact, even using conservative estimates of the ratio of clay to overburden, all the overburden could be adequately capped using the clay in each reach. In reality, the project sequence is planned such that the Mystic would be dredged first, thus providing more than adequate capping coverage.

Capping of contaminated dredged material by cleaner sediments has been used by NED as a management tool in Long Island Sound and at the Portland Disposal Site. New York District also used this technique at the mud dump site. Laboratory studies by WES have shown that a 50 cm cap is sufficient to isolate the contaminated sediments.

One question that has been raised regarding the effectiveness of capping at MBDS is whether the material reaches the bottom to form a mound. A recent DAMOS survey at the MBDS did find significant mound formation around the disposal buoy (DAMOS Report #73). The radius of this mound was approximately 350 meters. The limited area of impact of dredged material on the bottom is supported by body burden measurements taken at the site in 1987.

The stability of the cap during storms has been questioned. The DAMOS program examined disposal mound stability after Hurricane Gloria passed over the Central Long Island Sound Disposal site (CLIS). The CLIS site is in much shallower location (20 m) than MBDS (80 m) and therefore more susceptible to storm wave effects. Following the Hurricane there was slight erosion (approximately 5 cm) on the newly deposited unconsolidated mound and no erosion on the older consolidated mounds. This was a worse case scenario, disposal mounds would be even more stable at the deeper, more protected MBDS.

In conclusion, surficial sediments from the Mystic River have the potential to pose a significant environmental risk to benthic organisms. All other sediments have been determined to be suitable for unconfined disposal at the MBDS. Sequential dredging and disposal operations can be used to cap material at the MBDS significantly reducing the environmental impacts of contaminated sediments. Capping at MBDS is recommended for the Mystic River sediments.

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