DECONTAMINATION OF DREDGED MATERIAL FROM PORT OF NY/NJ

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ABSTRACT

The Port of New York and New Jersey ranks first in the United States in volume of petroleum products handled each year. In addition, many refineries are in operation on the New Jersey side of the Port. These activities have led to the discharge of significant amounts of petroleum hydrocarbons into the waters of the New York/New Jersey region. Intense industrial and commercial activities have also brought about major inputs of other organic and inorganic contaminants as would be expected in an industrialized, heavily populated urban port. Sediments that then are contaminated are a major problem for the region since they can no longer be disposed of by the traditional method of ocean disposal following the dredging operations required for the efficient operation of the Port. Decontamination and beneficial reuse of the dredged materials is one component of a comprehensive dredged material management plan being developed by the US Army Corps of Engineers. A demonstration decontamination project extending from bench- to field-scale operations is now in progress in the Port, and its current status and relevance for other regions is summarized.

INTRODUCTION

Environmental effects resulting from petroleum consumption are diverse and must be considered for all steps in the chain starting with drilling and recovery from a reservoir and ending with use as fuel or chemical product. Minimizing environmental impacts is clearly an important goal, but it should also be recognized that minimizing the environmental impact of petroleum use will also have related benefits by improving the overall energy efficiency of the United States and thereby reducing overall energy consumption. The purpose of this paper is to describe a project to show that it is possible to clean dredged material from the Port of New York/New Jersey at an acceptable cost and to dispose of the end material in an environmentally responsible way. Funding for the demonstration has been provided through the Water Resources Development Acts (WRDA) of 1990, 1992, 1996, and 1998.

The need for the demonstration was brought about by the introduction of more stringent regulations governing the disposal of dredged material from the Port of NY / NJ. These regulations ultimately led to a ban on ocean disposal of sediments that did not pass certain testing for sediment toxicity and bioaccumulation tests in selected marine organisms. Since approximately 2.3- to 3,100,000 m^3 of material are dredged each year to maintain channel depths and approximately 75% of this total does not pass the more stringent criteria, a major operational problem has resulted. Further, the shipping industry is introducing a new generation of container ships that require much deeper channels. Channel deepening projects must be carried out to meet regional demands, and new alternatives are needed for disposing of the dredged material generated. Decontamination of the sediments and conversion to a beneficial reuse can offer at least a partial solution to the problem. The WRDA dredged material decontamination project is validating and bringing suitable technologies into commercial use (Amiran et al. 1999; Crawford et al. 1995; Gasbarro et al. 1997; Goswami et al. 1995; Hall et al. 1998; Jones et al. 1997; Jones et al. 1998; Krishna et al. 1995; Ma et al. 1998; Massa et al. 1996; McLaughlin et al. 1999;

McManus et al. 1995; Rehmat et al. 1999; Stern et al. 1994; Stern et al. 1998a; Stern et al. 1998b; Stern 1998; Stern et al. 1998c; Stern et al. 1999; Waisel 1996).

The demonstration, while being carried out in the Port of NY/NJ has national significance through the entire country. If viewed narrowly in terms of the specific project mission the goal is only to provide part of a solution to management of dredged material in the Port. A broader statement is that it is one part of a search for ways to optimize the efficiency/minimization of energy consumption for much of the eastern seaboard of the United States. Thus, it is an important building block for operation of the urban centers in the region. The Department of Energy is rightly concerned with the environmental problems directly related to the production of petroleum. It is clear that environmental problems of concern to the Department should also include the problems related to transport and use as well. Our decontamination demonstration brings together a collaboration of the US Environmental Protection Agency - Region 2 (EPA), the US Army Corps of Engineers - New York District (ACE), and the US Department of Energy - Brookhaven National Laboratory (DOE-BNL) all of whom have specific strengths and interests at stake.

The impact of petroleum-related activities on the Port can be established quantitatively. The volumes of petroleum passing through the top ten oil ports in the United States are listed in Table 1. New York is the leading port in the country and carries more than three times the volume than does the number two port, Houston. New York is responsible for 38.6% of the total for all ports. Changes in the shipping patterns to New York could affect the distribution of petroleum products in the region and have unforeseen effects on energy efficiency and the environment which could have either positive or negative impact.

A direct impact on the local environment results from discharges into the harbor waters that come from sources that include storage tank and pipeline leakage, fuel transfer spills , combined sewer overflows, and other point and non-point sources. Crawford, Bonnevie, and Wenning (1995) listed the discharges into Newark Bay where a major port of the shipping to the Port docks in Port Newark and Port Elizabeth. Table 2 shows volumes of petroleum products and hazardous chemicals released from October 1986 to 1991 and the volume for 1991 alone. Table 3 gives a breakdown of the production and release of industrial chemicals through publicly owned treatment works (POTWS) and to surface water. Table 4 shows the percentage contributions from different types of sources. It can be seen from the work of Crawford et al. that petroleum products and petrochemicals are of major importance in contamination of the Harbor sediments. It is also obvious that the contamination is of major magnitude and that sediments in the harbor in general can be expected to contain heavy metals, polynuclear hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), insecticides, etc. The concentrations are high enough, as mentioned above, to make approximately 75% of the dredged material in the Harbor unacceptable for unrestricted disposal in the coastal Atlantic Ocean.

The status of the WRDA decontamination project is summarized in the following sections. The experience gained in the Harbor is transferable to other areas with significant petrochemical industries such as the Mississippi River around New Orleans and the Houston/Galveston region. A similar decontamination demonstration in the State of New Jersey is in progress under the auspices of the New Jersey Commerce and Economic Growth Commission, and in Michigan by the Michigan Department of Environmental Quality and the US

Environmental Protection Agency - Region 5 with a program intended to clean sediments in waterways around Detroit. Many of the technologies considered have already gone through testing in NY/NJ.

PROJECT DESCRIPTION

The ultimate goal of the WRDA project is to create decontamination facilities that can process dredged material at a rate of 382,000 m^3/y. This goal must be reached in a timely way so that decontamination procedures are a meaningful part of the overall comprehensive dredged material management plan for the Harbor. The stipulation that it is necessary to perform the work as rapidly as possible made it necessary to focus on technologies which could be put into operation without carrying out an extensive research program. On the other hand, turn-key facilities do not exist so that some research and development activity is an ineluctable part of the effort.

In order to meet these requirements a conservative path was chosen. The initial steps were to carry out testing at the bench scale (5 gallons), pilot scale (1.5-15 m^3), operational scale (7,650-76,500 m^3/y), and full scale (382,000 m^3/y) levels. This ramp-up sequence is advantageous since it demonstrated the efficacy of the decontamination procedure and also identified problems to be solved in putting together a large treatment facility prior to making commitments to a specific design that had not been adequately tested. The sequential testing procedure made it possible to evaluate results from each step and then make a selection of the technologies to be given further consideration based on the results and the level of WRDA funding.

Selection of vendors was made through a full-scale request for proposals (RFP). It was desired to make funding selections from as wide a base of technologies as possible. An important consideration was that the chosen technologies could be moved to productive operations easily. Approximately 150 bid packages were sent to companies responding to the RFP. A total of 25 formal proposals were ultimately received and evaluated by a review panel of scientists and engineers from Brookhaven, EPA, ACE, and universities. Seven technologies were selected for the bench-scale testing. Other tests were performed by the Army Corps of Engineers Waterways Experiment Station (WES).

BENCH- AND PILOT-SCALE TESTING

The technologies tested in the bench-scale work (5 gallons) are as follows:

US Army Corps of Engineers, Waterways Experiment Station (WES). Manufactured soil: created by addition of compost (yard waste), and other materials such as cellulose and biosolids (cow manure) to the as-dredged sediment. Contaminant concentrations are reduced through dilution by the additives.

WES, International Technology Corporation, Marcor, and Metcalf & Eddy. Solidification/stabilization (S/S) by addition of Portland cement, fly ash, lime and/or proprietary chemicals to create solid aggregates.

BioGenesis. Sediment washing using a proprietary blend of surfactants, chelating and oxidizing agents, and high pressure water jets to remove both organic and inorganic contaminants. The decontaminated product can be used to produce a manufactured soil with the WES approach or with proprietary mixtures.

Metcalf & Eddy. Solvent extraction using organic chemicals at an elevated temperature.

Battelle Memorial Institute. Base-catalyzed decomposition. This is a two-stage process combining thermal desorption with a catalyst to dehalogenate chlorinated compounds.

International Technology Corporation. Thermal desorption: uses heat to remove surface contaminants. The temperatures used are not high enough to destroy the organic compounds. Metals are not treated *per se*.

BioSafe. High temperature thermal destruction of organic compounds in a fluidized bed reactor.

Institute of Gas Technology/ENDESCO. High temperature thermal destruction of organic compounds using a natural gas fired melter. Metals are reduced in the end product by reason of loss to gaseous side streams and by dilution with cement-forming additives. The remaining metals are incorporated in the cementitious matrix.

Westinghouse Science and Technology Center. High temperature thermal destruction of organic compounds in a plasma torch. Metals are reduced by dilution with glass- forming additives. The remaining metals are incorporated in the glassy matrix.

The evaluation of the bench-scale test results lead to the selection of four projects for evaluation at the pilot-scale level of 1.5-15 m^3. Each of the choices represent a treatment train for processing of the dredged material through a series of steps from the initial dredging to a final beneficial reuse. The demonstrations were:

WES. Manufactured soil

BioGenesis.

Institute of Gas Technology/ENDESCO.

Westinghouse Science and Research Center.

The pilot-scale work included the successful treatment of the larger volume of sediments, the conceptual design for treatment facilities that could process 76,500 to 382,000 m^3/y of dredged material, and indicated a beneficial use for the material following treatment. Results obtained for decontamination removal are shown in Table 5 for BioGenesis, Institute of Gas Technology/ENDESCO, and Westinghouse. The reductions for the WES manufactured soil test are about 70%. All of these technologies were found to merit consideration for development at the field-scale level. The status of the field-scale projects is presented in the next section.

FIELD-SCALE DEMONSTRATIONS

Several field-scale demonstrations are now in progress. Each one will comprise a complete treatment train for the contaminated dredged material. That is, the project team will dredge the material, carry out pre-treatment steps to remove large debris and possibly dewater the material, remove contaminants, prepare a final product for beneficial reuse, and then sell the product in the open market place. The technologies chosen include the low temperature BioGenesis sediment washing procedure and the high temperature treatments by the Institute of Gas Technology and Westinghouse.

BioGenesis is now in the field at a temporary site in Kearny, NJ. This site is presently undergoing brownfield remediation. They are setting up a complete sediment-washing facility that can process 6.1 m^3/hr that will be used to treat approximately 229 to 382 m^3 of sediment taken from a dredging site in Newark Bay. This test is scheduled for completion by the end of February 1999. Following the successful completion of this work, the equipment will be moved to another site with water access and used to treat 7,650 cy or more of dredged material. Present schedules call for an equipment upgrade which will bring processing capacity to 31 m^3/hr by the latter part of 1999. Work on market development for the manufactured soil beneficial use product is now in progress so that a complete treatment train can be in operation at that time.

The Institute of Gas Technology and its subsidiary, ENDESCO, are now negotiating for a demonstration site in New Jersey. At the same time the fabrication of a rotary kiln facility designed specifically for this project is in progress. The kiln will be able to process approximately 22,900 m^3/y of dredged material in its original configuration. Additional equipment can be added to reduce the moisture content of the material going into the kiln that should yield even higher through puts. The beneficial use of the product as cement has already been established with several cement distributors and end users. This facility will be ready for initial testing by the summer of 1999.

Westinghouse is presently completing a demonstration of the feasibility of converting the vitrified material product that results from their process into glass tile. This is not merely to show that tile can be produced from the material. That has already been done. Rather, several tons of the vitrified harbor dredged material will be used in a production run at an actual tile manufacturing facility. The results of the test will be used to show that it is truly feasible to use the material in an operational facility devoted to tile manufacture. The next step in this part of the project is to develop a team that incorporates the Westinghouse vitrification technology with a partner who will be concerned with the end use as a glass product. The time scale for this is not now clear.

CONCLUSIONS

The work carried out under during the WRDA demonstration project has been successful in showing that decontamination technologies can perform successfully and at estimated costs which are far below those estimated from previous test projects.

- Evaluated a wide range of technologies for potential use.
- Developed innovative procurement procedure to enable multi-step demonstration.
- Completed bench-scale testing of 9 technologies.
- Completed pilot-scale testing of 4 technologies.
- Completed planning for field-scale demonstrations of 4 technologies.
- Began field-scale demonstrations of two technologies.
- Worked on several projects in support of the demonstrations:

- Developed an active public outreach program that included public meetings, an internet list serve to enable posting notices and comments on the topic of contaminated sediments, and a project web page at http://www.wrdadcon.bnl.gov.
- Tested decontaminated materials for sediment toxicity.
- Carried out preliminary environmental and human risk assessment studies.
- Supported decontamination projects launched by the States of New Jersey and Michigan and the Port Authority of New York & New Jersey.
- Began a New York / New Jersey Harbor Atlas mapping the distribution of contaminants.
- Assisted several technology companies in developing project plans for commercialization of their technologies.

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Table 1. Top 10 U.S. Oil Ports - Average Annual Number of Liters Transported

(Source: New Jersey Petroleum Council)

Rank	Port	Liters
1	New York Harbor, NY/NJ	106,949,000,000
2	Houston, TX	32,497,000,000
3	New Orleans, LA	24,261,500,000
4	Corpus Christi, TX	21,813,100,000
5	Port Arthur, TX	19,475,900,000
6	San Francisco, CA	17,695,300,000
7	Boston, MA	17,027,500,000
8	Delaware Bay/River	15,580,800,000
9	Port Everglades, FL	12,019,400,000
10	Tampa, FL	9,682,300,000

Table 2. Volume of Petroleum Products and Hazardous Chemicals Released into Newark Bay and Its Major Tributaries from October 1986 to August 1991[a] (From Crawford, Bonnevie, and Wenning 1995.)

Material	Total volume released (liters) 1986-1991	1991
Petroleum products		
No. 1 Fuel oil	11,829	NR[b]
No. 2 Fuel oil	17,551,100	2,260
No. 4 Fuel oil	761	NQ[c]
No. 6 fuel oil	47,698,800	1,006
Creosote	284	284
Crude oil	3.8	NQ
Diesel fuel	190,323	24,151
Gasoline	161,482	29,042
Hydraulic oil	265	NQ
Kerosene	1,158	NQ
Liquid asphalt	200,630	NR
Motor oil	3,524	NR

Table 2 (continued)

Material	Total volume released (liters) 1986-1991	1991
Transmission fluid	114	NR
Waste oil	304,249	NR
Other oil products[d]	974,600	6,662
Total	67,099,100	63,406

Hazardous chemicals		
Alcohol	568	189
Aldehyde	15,142	15,142
Ammonia	379	NR
Antifreeze	21	21
Benzene	11,360	11,360
Chlorine	5,680	NQ
HCL	4,090	NR
Hexane	568	568
Hydrocarbons	38	NR
Isobropenyl	189	189
D-Liminone	38	38
Milk	284	284

Table 2 (continued)

	Total volume released (liters)	
Material	1986-1991	1991
Naptha	795	795
PCBs	492	114
Pesticides	NQ	NQ
Phenol	NQ	NQ
Solvents	4,773	NQ
Unidentified chemicals[e]	263,520	10,560
Total	307,930	39,018
Other materials		
Ink	NQ	NR

Paint	1,944	91
Waste water	60,850	60,850
Unidentified materials[f]	1,872,120	2,593
Total	1,934,920	63,534

Table 2 (continued)

[a]Data were compiled from computer database maintained by the NJDEPE Bureau of Communication and Support.

[b]An accidental spill incident involving this material was not recorded (NR) on the database.

[c]One or more spill incidents were reported to NJDEPE but the volume of the spill was not quantified in the database.

[d]Oil products in this category included infrequently released or unidentified petroleum products.

[e]Hazardous chemicals in this category included chemical compounds not specifically identified.

[f]Other material in this category included materials which were reported as unknown in the database.

Table 3. Summary of Production and Discharges of Industrial Chemicals[a] (From Crawford, Bonnevie, and Wenning 1995.)

Group number and name	Total amount produced, annually[b] (kg)	Total discharged, POTWS (kg)	Total discharged, surface water (kg)
Halogenated alkanes and alkenes	9.1-46.3 M	441,758	14,480
Phenols	272-907 T	485,600	7,580
Halogenated aromatics	454 T-2.27 M	109,860	11,930
Phthalates	70-277 M	9,421	1,980
Ethers, epoxides, aldehydes, and anhydrides	50-249 M	485,571	22,770
Imines, nitriles, and hydrazines	45	158,780	4.5
Nitroso compounds	23-45 T	0	136
Amides and amino compounds	1.4-6.8 M	3,270	453
Pesticides	2.3-4.5 M	5.90	0
Aromatic hydrocarbons	4.5 M-.91 B	411,363	8,460
Inorganics	.91-3.2 M	1,005,510	49,628
Nitro compounds	27-72.6 M	13.6	16,515
Dyes	286-454 T	894	4.5
Miscellaneous	4.5-22.7 M	181	272
Total	.45-1.58 B	3,112,200	134,608

Table 3 (continued)

Totals in kg/d[C]	8,525	368
Amount directly discharged to Newark Bay	512	121
Amount indirectly discharged to Newark Bay[d]4,689	---	

[a]Data from NJDEPE (1986b; New Jersey Industrial Survey for selected substances).

[b]T, 10^3 kg; M, 10^6 kg; B, 10^9 kg.

[c]kg/d, kilograms/days.

[d]Indirect discharges include the Passaic Valley Sewage Commission (PVSC) and Middlesex County Sewer Authority (MCSA) discharges.

Table 4. Percentage Contributions of Pollutant Mass Loadings to the Newark Bay Estuary by Sources

(From Crawford, Bonnevie, and Wenning 1995.)

	Municipal treatment systems	Industry direct discharge	Combined sewer overflows	Storm-water runoff	Tributary flow	Total direct discharges	Total indirect discharges	Percentage contribution Direct	Percentage contribution Indirect
Flow (Mℓ/d)	1,075	173	207	1,132	3,445	6,034	1,298	82	18
Percentage	17.8	2.9	3.4	18.8	57.1	100			
Total conventional (mt/d)	116	9.4	93.9	47.8	129	396	146	73	17
Percentage	29	2.0	24	12	33	100			
Total metals (kg/d)	637	36.8	365	336	398	1,773	1,549	53	47
Percentage	36	2.0	20.5	19.0	22.5	100			

Accidental spills[a]

Petroleum products (kg/d)	33,880
Hazardous chemical (kg/d)	168
Other materials (kg/d)	1,059

[a]total volume for the period 1986-1991 averaged on a daily basis, Table 2.

Table 5. Summary of Results

Contaminant	BioGenesis			Institute of Gas Technology			Westinghouse		
	As-dredged	Treated	Percent Reduction	As-dredged	Treated	Percent Reduction	As-dredged	Treated	Percent Reduction
2,3,7,8 TCDD (ppt[1])	66	ND[2,3]	>98.9	23	0.35	98.47	19.0	---	100
O CDD (ppt)	5560	41[3]	99.3	11879	3.7	99.97	9655	8.0	100
TCDD/TCDF TEQ (ppt)	7442	127.1[3]	98.1	513.2	1.406	99.72	335	0.07	100
Total PCBs (ppm[4])	0.415	0.0195	95.3	8.6	0.31	96.39	0.900	0	100
Anthracene (ppb[5])	771	177	77.0	18735	0	100	7.72	0	100
Benzo(a)anthracene (ppb)	1793	234	86.9	17155	0	100	7.19	0	100
Chrysene (ppb)	1994	286	85.7	16878	0	100	8.76	0	100
Total PAHs (ppb)	19,502	3207	83.6	293,854	0.16	100	109	0	100
Arsenic (ppm)	22.2	12.8	42.3	39	1.52	96.10	15.8	4.94	68.7
Cadmium (ppm)	18.2	1.4	92.3	27	0.66	97.55	33.3	0.948	97.1
Chromium (ppm)	226	63	72.1	298	632.5	212	344	1001	---
Copper (ppm)	676	404	40.2	1012	306	69.76	1145	1077	5.9

Table 5 (continued)

Lead (ppm)	454	60	86.8	542	29.4	94.57	594	105	82.3

Mercury (ppm) total	2.11	1.09	48.3	2.8	0.092	96.71	2.08	0.087	95.8
Zinc (ppm)	1100	479	56.4	1535	280	81.76	1695	1240	26.8

[1]ppt, parts per thousand.

[2]Not detected.

[3]For grain size not passing through a 400-mesh screen.

[4]ppm, parts per million.

[5]ppb, parts per billion.

Decontamination of Dredged Material from

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