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Maintaining Access to America's Intermodal Ports/Technologies for Decontamination of Dredged Sediment: New York/ New Jersey Harbor

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Maintaining Access to America's Intermodal Ports/Technologies for Decontamination of Dredged Sediment

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

BROOKHAVEN NATIONAL LABORATORY

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MAINTAINING ACCESS TO AMERICA'S INTERMODAL PORTS/TECHNOLOGIES FOR DECONTAMINATION OF DREDGED SEDIMENT: NEW YORK/NEW JERSEY HARBOR

by

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1. INTRODUCTION

One of the greatest drivers for maintaining access to America's Intermodal ports and related infrastructure redevelopment efforts over the next several years will be the control and treatment of contaminated sediments dredged from our nation's waterways. More than 306 million cubic meters (m^3) (400 million cubic yards [cy]) of sediments are dredged annually from U.S. waterways, and each year close to 46 million m^3 (60 million cy) of this material is disposed of in the ocean (EPA 842-F-96-003). The need to protect our environment against undesirable effects from sediment dredging and disposal practices is gaining increased attention from the public and governmental agencies.

Meeting this need is a challenging task not only from the standpoint of solving formidable scientific and engineering problems, but also, and more importantly, from the need to implement complex collaborations among the many different parties concerned with the problem. Some 40 years ago, C.P. Snow pointed out the problems involved in communicating between the two cultures of the sciences and the humanities (Snow, 1993). Today, it is necessary to extend Snow's concept to a multicultural realm with groups that include governmental, industrial, environmental, academic, and the general public communicating in different languages based on widely different fundamental assumptions.

The handling of contaminated sediments in the Port of New York/New Jersey (Port) exemplifies this problem. This paper describes a multicultural team that has formed as the result of a Congressional mandate for the development of procedures suitable for the decontamination of sediments in the Port under the Water Resources Development Act (WRDA) of 1992 (Section 405C) and 1996 (Section 226).

The WRDA Program is the responsibility of the U.S. Environmental Protection Agency (EPA) - Region 2 and the U.S. Army Corps of Engineers (USACE) - New York District, with the U.S. Department of Energy (DOE) - Brookhaven National Laboratory acting as the Technical Project Manager.

Both EPA and USACE have stepped up their efforts to manage contaminated sediments and dredged materials. With the recent release of EPA's Contaminated Sediment Management Strategy, and the ongoing efforts of the USACE Waterways Experiment Station Dredging Operations and Environmental Research Program, as well as individual USACE District initiatives, the development of economically and technologically feasible sediment treatment and disposal alternatives is being aggressively pursued.

The WRDA Program has progressed through demonstrations of varying technologies at bench and pilot scales and is now being moved to construction of commercial-scale facilities. The step-wise procedure has resulted in a reduction of the number of participants through specific selection criteria, including technical performance, demonstration costs, public-private cost sharing, beneficial reuse of treated material, and corporate evaluations of the business potential for sediment decontamination.

One of several multicultural teams growing from the WRDA Program includes the federal groups previously mentioned and three commercial sector entities. BioGenesis Enterprises, Inc. (BioGenesis) and ENDESCO Services, Inc., a wholly owned subsidiary of the Institute of Gas Technology (ENDESCO/IGT), provide technologies suitable for decontamination of sediments with varying contamination levels. Roy F. Weston, Inc. (WESTON®) provides the engineering, construction, and operational skills needed to move the technologies to the commercial marketplace. Federal funding from the WRDA legislation provides assistance to the commercialization process, but the private sector will provide the capital needed for facility construction and operation. It is believed that this type of cooperative approach will be useful in the New York and New Jersey Region and may have features of interest to other Port communities throughout the country that are faced with problems caused by the need to dispose of contaminated sediments.

2. CONTAMINATED SEDIMENTS IN THE NEW YORK/NEW JERSEY HARBOR

New York/New Jersey (NY/NJ) Harbor contaminated sediments constitute a major crisis to the economic well being of the region. NY/NJ Harbor has a natural, undredged depth of 5.8 meters (19 ft). Ships need a depth of 12 to 14 meters (40 to 45 ft) for safe navigation. The difference between natural and required depths requires that 3 to 5 million m^3 (4 to 7 million cy) of sediment be dredged and disposed of every year for safe navigation and commerce. Exhibit 1 shows the NY/NJ Harbor Federal Navigation Channels that require dredging. According to the New York and New Jersey Port Authority, the Port generates more than $20 billion in revenue and is responsible for more than 180,000 jobs. Thus, any prolonged interruption in dredging would adversely affect the regional economy. The Port is currently faced with an operational crisis brought about by stricter regulations that reduce the amount of dredged material that is considered suitable for ocean disposal in the coastal Atlantic Ocean.

In a final rule that became effective on September 29, 1997, EPA de-designated and terminated the dredged material ocean disposal site (Mud Dump Site) and simultaneously designated the Historic Area Remediation Site (HARS). Exhibit 2 shows the location of the former Mud Dump Site. The HARS is restricted to receive only dredged material suitable for use as Material for Remediation. This material is defined as "uncontaminated dredged material (i.e., dredged material that meets current Category I standards and will not cause significant undesirable effects, including those effects caused through bioaccumulation)."

Sediments and soils found in and around the Port have been contaminated with a large variety of toxic materials produced by human and industrial activities in the region from colonial times to the present. Sediment contaminant concentrations in the NY/NJ Harbor rank among the highest in the nation (NOAA, 1995). Squibb et al. (1991) concluded that concentrations of a variety of toxic contaminants in these sediments are sufficiently elevated in many locations to cause adverse effects on the biological community. Heavy metals (Hg, Cd, Pb, Ni, Cu, Zn, As), chlorinated pesticides (including DDT metabolites, chlordane, dieldrin, and endrin), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dioxins/furans are major contaminants of concern in the Port region. Toxicological assessment studies, such as the U.S. EPA Regional Environmental Monitoring and Assessment Program and the NOAA/U.S. EPA Multi-Agency Sediment Toxicity Survey of the Newark Bay Complex, have all shown significant mortality to the marine amphipod *Ampelisca abdita* when exposed to sediment from the Harbor (NOAA, 1995). Furthermore, several contaminants detected in the Harbor sediments, as well as in the tissue of fish and shellfish, have resulted in fishing advisories in the NY/NJ Harbor. Bioaccumulation testing of dredged material has identified many of these same contaminants. Generally, the material is chemically stable and is found to pass the toxicity characteristic leaching procedure (TCLP) for testing the leachability of contaminants.

The physical characteristics of the sediments found in the Port are generally very fine-grained silts and clays (80 to 95%) with a small fraction of larger grain sizes and large-size debris. The bulk material has a gel-like consistency. The total organic content of Harbor sediments ranges from 3 to 10%. The solids content of the as-dredged material is 30 to 40% when obtained using a conventional clamshell bucket dredge.

Scientific visualization and scatter data modeling techniques have been applied in analyzing sediment sampling data from the NY/NJ Harbor (Hong et al., 1998). High-resolution data sets were visualized to determine the spatial patterns from surface sediments down to core depth where data were available. Specific "hot spots" have been visualized for a range of contaminants such as dioxins, PAHs, and metals. Exhibit 3 is an illustration of a 3-dimensional contaminated sediment visualization image from the Passaic River, New Jersey, characterizing dioxin concentrations from the sediment surface to a depth of 6 ft.

Current proposals for solutions to the dredged material disposal problem include continued unrestricted ocean disposal of uncontaminated material to the HARS, the use of confined disposal facilities (both upland facilities and containment islands), subaqueous borrow pits, and processing/treatment of contaminated materials. A complete solution to the dredging problem will no doubt include a combination of many or all of these alternatives. Decontamination of dredged material is one component of an overall dredged material management strategy. It can reduce the magnitude of the contamination and may provide a treated product with a beneficial reuse, thus simplifying disposal and, if salable, reduce the overall cost of treatment.

2.1 WRDA Program Background

Currently there are limited alternative disposal options for contaminated sediment, and as a result, the continued economic operation of the Port is threatened. The WRDA Program is intended to demonstrate decontamination technologies for sediment treatment and to create a viable treatment train capable of processing sediment volumes on the order of 382,300 m^3 (500,000 cy) per year. The work is divided into several phases; treatability studies of commercial and nonproprietary technologies at volumes of 19 to 38 liters (5 to 10 gallons) for bench-scale, and up to 19 m^3 (25 cy) for pilot-scale. Exhibit 4 shows the locations in the NY/NJ Harbor where sediment samples were taken for the bench- and pilot-scale tests. Both bench- and pilot-scale phases of the project were completed in December 1996. The technologies investigated included several types of thermal destruction and desorption processes, stabilization/solidification, sediment washing, advanced chemical treatments, solvent extraction methods, and manufactured soil production.

Results obtained in the treatment tests have been presented previously (Stern et al. 1996 and 1997; Jones et al. 1997 and 1998). Because of the complexities of mixed contaminants (metals, organics, etc.), different end-uses of the post-treated materials, and the importance of developing a sediment delivery system (materials handling) to move the dredged material into the physical plant, WRDA's objective from the onset was to develop a "treatment train" approach to processing and decontaminating dredged material. This approach puts together several key components that entail dredging, processing of the sediment, beneficial use of the post-treated material, and environmental/human health assessments. Under WRDA, the specification of a treatment train and potential implementation of a large-scale facility capable of processing up to 382,300 m^3 (500,000 cy) of dredged material per year is already underway. The development of an overall conceptual plan for implementing a large-scale treatment facility is now in progress.

WRDA has categorized the technologies that have been tested in the bench- and pilot-scale phases of the Program. They fall into the following categories: 1) those that are carried out at ambient or at least low temperatures; 2) those that are carried out at intermediate temperatures that do not destroy the organic constituents; and 3) those that are carried out at high temperatures above the decomposition point of the organic compounds. The wide variety of contaminants and differing concentration levels make it plausible to search for technologies that can be applied to specific concentration levels. In addition, the low-temperature technologies may be more acceptable to the local and regulatory communities, making obtaining building and other environmental permits easier. The higher temperature technologies may be more applicable to the most contaminated sediments that are found outside of navigational channel and depositional areas. These areas may lend themselves to "hot spot" remediation. High-temperature technologies may also produce beneficial use products that have higher resale values than solidification/stabilization.

3. TECHNOLOGIES FOR THE DECONTAMINATION OF DREDGED MATERIALS

The variety of contaminants and the wide range of contamination levels found in dredged material in the NY/NJ Harbor emphasize the need for developing several types of decontamination technologies for a comprehensive treatment process. This is exemplified by two approaches supported under the WRDA Program (see Exhibit 5) for large-scale decontamination facilities. One technology is a sediment washing method developed by BioGenesis. The other process developed by the Institute of Gas Technology uses high temperatures to completely destroy organic materials, while binding metals into a cementitious matrix (Cement-Lock™ process). In both cases the processed materials have beneficial uses that produce a revenue stream, which can be used to offset the decontamination processing costs.

The essential properties of the dredged material are the grain size distribution and the major element composition. A typical grain size distribution is shown in Exhibit 6 for dredged material taken from Newtown Creek, NY. Material from other locations with respect to grain size distribution in the Harbor is similar. Examination of the data shows that most of the sediment is less than 2 millimeters in size. The small particles are easily handled during the washing or cement-making procedures. Oversized material can be sorted into material that should be sent to a landfill or reduced to the smaller sizes needed in the two processes. The major element composition is silica and overall is suitable as input material for the production of cement or as the basis of a soil.

A schematic diagram and photograph of the equipment used by BioGenesis in a recent demonstration are shown in Exhibits 7 and 8. The contaminants found in the sediments were reduced by approximately 90% for silts, clays, and sands. The results are shown in Exhibit 9 (BioGenesis℠ Two-Cycle Treatment Process). The dredged material suitable for processing depends on the criteria for its end use. If an artificial soil is chosen, then the initial contaminant levels must be less than a factor of 30 greater than the appropriate soil criteria for the disposal site. This factor includes both the contaminant's reduction efficiency and the reduction resulting from the addition (dilution) of the original materials required for soil formulation.

A schematic diagram and photographs of the IGT Cement-Lock™ equipment used for a pilot-scale test of cement production are shown in Exhibits 10 and 11. The input material was similar in grain size, composition, and contamination to that used in the BioGenesis ℠ test. The operating temperature range of the thermal processing for the test was between 1200° and 1500°C (2200° and 2700°F). These conditions are sufficient for achieving complete destruction of all organic contaminants. The reduction efficiency is shown in Exhibit 12.

In summary, essentially all of the organic contaminants originally present in the dredged sediment were destroyed to below the analytical detection limit as a result of the high-temperature Cement-Lock™ Technology processing. DREs in excess of 99.99% have been achieved in both the bench-scale and pilot-scale testing. It is expected that organic compound DREs in excess of 99.99% will be consistently achieved in the production-scale Cement-Lock™ plant that will be built in Phase III of the WRDA program. In addition to the extreme thermal conditions that exist in the melter (Ecomelt Generator), organic compounds will be subjected to 2 seconds residence time at 1200° C (2200° F) in the secondary combustion chamber. This is the process requirement for 99.9999% destruction of PCBs.

The product from Cement-Lock processing of dredged sediment is blended cement. As part of the WRDA program, the Cement-Lock blended cement was tested according to American Society for Testing and Materials (ASTM) protocol to evaluate its compressive strength. The compressive strength exceeds the ASTM requirements for portland cement. The cement can be used in concrete for general construction applications.

4. COMMERCIAL OPERATIONS

Detailed design plans for large-scale treatment facilities have now been completed that will meet the WRDA goal of achieving operation at 382,300 m^3 (500,000 cy) per year in the next 12 to 30 months. One of the major hurdles in placing any facility into an operational condition will be the issuance of permits from state and local authorities. The sediment washing permitting process should be relatively straightforward, since there are no gaseous side streams and the contaminants found in a liquid side stream can be removed by standard water processing techniques.

The use of a high-temperature process will require comprehensive air permits. Initial discussions in public groups have indicated that this type of process may be acceptable, if it is completely environmentally responsible from the public standpoint. From a purely technical standpoint, both technologies can be engineered to be completely environmentally responsible.

Technologies that are environmentally safe and that effectively decontaminate dredged material are not enough. They must also be economically viable and in this regard dredged material is now being stabilized with cement and fly ash and used for construction material and cover at several locations in New Jersey. Currently, the total cost for dredging, treatment (stabilization), and disposal ranges from $40 to $50/cy. Current total disposal costs in the Newark Bay confined disposal facility are approximately $35/cy. We anticipate that the costs for sediment washing and cement production will be competitive when full-scale operation is achieved and when the economic benefits of beneficial uses are considered. Preliminary estimates for the demonstration-scale level for processing costs range from $50 to $70. Larger scale demonstrations planned in 1998 (minimum of 7,600 m^3/10,000 cy each) will provide economic information for scale-up volumes as well as information on potential return for beneficial reuse. The target range of costs for full-scale/commercial-scale operations is to be at or below $35/cy.

There is good reason to believe that lower costs can be achieved for the Port to remain competitive. Competition from other East Coast ports also needs to be considered. Environmental regulations for handling of dredged material are not uniform and can be much lower than the NY/NJ Harbor benchmark. If other ports attract deep water shipping away from the NY/NJ Harbor, then the whole transportation pattern in the region could change and completely change the current needs for dredged material management in the Port. From an examination of the two technologies, it is believed that costs that are low enough to meet the market cost as it is currently projected can be achieved.

The actual costs for decontamination in the future will be determined by effective responses to requests for proposals from USACE, the Port Authority of NY/NJ, and private dredging clients.

5. BENEFICIAL REUSE

In order to evaluate the potential beneficial reuses for treated sediment, one must understand the characteristics of the material following treatment. First, dredged material from the NY/NJ Harbor consists mainly of fine-grained materials (silts and clays). The treated material, therefore, cannot be used directly as structural fill. The organic material contained in the treated dredged materials is removed or destroyed. This includes contaminants as well as other naturally occurring organic material. The treated material, therefore, is typically not good as a growth substrate.

Given these characteristics, potential direct beneficial reuse pathways for the treated sediment are limited. The treated material, however, can be mixed with other materials to obtain a useful end product. The amendment of the treated materials will require additional processing; therefore, the revenue from the end-use product will offset costs of processing and provide an additional source of revenue. Some potential end uses for amended treated dredged material include:

- Manufactured soil - High-end growth use (i.e., potting soil).
- Manufactured soil - Low-end growth use (i.e., top soil).
- Nonstructural fill material (daily landfill cover).
- Shoreline stabilization.
- Restoration/fill for underwater areas.
- Wetlands/habitat restoration.
- Blended cement.

In order to offset dredged material treatment costs and provide a cost-competitive overall treatment approach for management of NY/NJ Harbor sediments, beneficial reuse pathways need to be utilized. In addition, beneficial reuse of dredged materials is "environmentally sustainable and responsible" in that contamination contained in the materials is reduced to a level acceptable for use instead of disposal.

As stated previously, the total cost for dredging, stabilization with cement fly ash, and use as construction material currently ranges from $40 to $50/cy. Current predictions of full-scale/commercial-scale operations of the BioGenesis℠ Sediment Washing process and the IGT Cement-Lock™ Process put the processing costs in this same range; however, in order to be cost competitive and offer a more cost-effective operation for full-scale commercialized use, the operation costs must be reduced or offset.

Presented in Exhibit 13 is a summary of potential beneficial reuse products for the BioGenesis[SM] soils washing and ENDESCO/IGT Cement-Lock™ treated dredged materials. Included in this listing is an evaluation of the treatment requirements (i.e., regulatory standards applicable for the treated sediment) as well as estimates of the value of the end product. The end-use products that can be produced from each individual source of dredged materials will be dictated by the initial contaminant levels, the treatment costs needed to meet the applicable standards for the particular end use, and the costs associated with amending the treated dredged material to be marketable.

Beneficial reuse of treated dredged materials is a "sustainable and environmentally responsible" approach to handling dredged materials. Depending of the full-scale treatment costs, beneficial reuse of treated dredged materials will provide a revenue source to make treatment technologies more economically competitive. As full-scale treatment costs are refined, treatment becomes less costly, and beneficial reuse products are utilized, the net cost of treatment of contaminated sediments will be reduced.

6. CONCLUSIONS

There has been significant progress to date in the WRDA Program to evaluate and demonstrate decontamination technologies for contaminated sediments. The progress is based on a collaborative effort between federal, state, and local governments, academia, private industry, and the community. Many technologies have been evaluated from technical and economic perspectives. Both non-thermal and thermal technologies (i.e., BioGenesis [SM] and ENDESCO/IGT Cement-Lock™) are components of an overall treatment train approach to handling sediments with different levels of contamination and physical characteristics. Emphasis has been placed on treated sediments with established beneficial reuse markets. The WRDA Program has conceptualized the treatment facilities required for commercial-scale operations. The future goal of the WRDA Program is to finalize large-scale treatment economics based on currently planned demonstration projects in 1998. The ultimate objective of the Program is the commercial use of one or more of these technologies up to 382,300 m^3 (500,000 cy)/year capacity.

7. ACKNOWLEDGMENTS

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8. REFERENCES

Jones, K.E., Stern, E.A., Donato, K.R., and N.L. Clesceri. 1997. Processing of NY/NJ Harbor Estuarine Dredged Material in "Dredging and Management of Dredged Materials," proceedings of 3 sessions held in conjunction with GeoLogan 97, Utah, July 16-17, 1997. Jay N. Meegoda, Thomas H. Wakeman III, Arul K. Arulmoli, and William J. Librizzi, eds. Geotechnical Special Publication No. 65, American Society of Civil Engineers, New York, NY, pp.49-66.

Jones, K.W., Guadagni, A.J., Stern, E.A., Donato, K.R. and N.L. Clesceri. 1998. Commercialization of Dredged Material Decontamination Technologies. Remediation. Volume 8, Number.

Hong, Ma, Jones, K.W., and Stern, E.A. 1998. Scientific Visualization and Scattered Data Modeling of Sediment Contaminant Concentrations in the Lower Passaic River, Newark, NJ. Presented at the American Geophysical Union National Conference May 26-29, 1998. Boston, MA.

Long, E.R., Wolfe, D.A., Scott, J.K., Thursby, G.B., Stern, E.A., Peven, C. and Schwartz, T. 1995. Magnitude and Extent of Sediment Toxicity in the Hudson-Raritan Estuary. NOAA Technical Memorandum NOS ORCA 88. National Oceanic and Atmospheric Administration, Silver Spring, MD.

Squibb, K.S., O'Connor, J.M., and T.J. Kneip. 1991. NY/NJ Harbor Estuary Program. Module 3.1: Toxics Characterization Report. Prepared by the Institute of Environmental Medicine, New York University Medical Center for U.S. EPA Region 2, New York City, NY. 188 pp.

Stern, E.A., Donato, K.R., Jones, K.W., and N.L. Clesceri. 1996. Processing Contaminated Dredged Material from the Port of NY/NJ. Presented at the Estuarine and Coastal Sciences Association (ESCA) Estuarine Research Federation (ERF) 1996 Symposium, Middleburg, The Netherlands, 16-20 September 1996. Manuscript accepted for publication in Estuaries (December 1998).

Stern, E.A., Donato, K.R., Clesceri, N.L., and Jones, K.W. 1997. Integrated Sediment Decontamination for the NY/NJ Harbor. Presented at the National Conference on Management and Treatment of Contaminated Sediments. U.S. Environmental Protection Agency, Cincinnati, Ohio, May 13-14, 1997. To be published in conference proceedings.

Snow, C.P., Collini, S. The Two Cultures, Cambridge University Press, reissue edition, New York, 1993.

U.S Environmental Protection Agency (4504F). Ocean Dumping Program Update, Overview of Dredged Material Testing Framework. http://www.epa.gov/OWOW/OCPD/oceans/update3.html. EPA842-F-96-003.

AUTHOR BIOGRAPHIES

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Keith W. Jones, Ph.D. – Dr. Jones is a Senior Scientist at Brookhaven National Laboratory (BNL) in Upton, New York, with research experience in nuclear and atomic physics and the development of materials characterization methods based on the use of x-ray and ion beams. He is BNL's Technical Project Manager for the U.S. EPA and USACE Programs for demonstration of sediment decontamination technologies for the Port of NY/NJ.

Kerwin R. Donato – Mr. Donato is the U.S. Army Corps of Engineers' Program Manager for the sediment decontamination project, and he is also working on the Dredged Material Management Program. He is a chemical engineer with experience on both industrial and government projects.

John D. Pauling, P.E. – Mr. Pauling is Program Manager of WESTON's Dredged Materials Management Program and is currently coordinating two projects that are designed to demonstrate the use of innovative technologies on sediments from the NY/NJ Harbor. He is a civil engineer with broad-based environmental design and construction project experience and specific dredge sediment technology review, process study, and siting study experience.

John G. Sontag, Jr., P.E. – Mr. Sontag is a Project Manager at WESTON and is currently managing WESTON's efforts on the WRDA Sediment Washing Demonstration Program. He is a mechanical/civil engineer with 10 years of experience with environmental remediation technologies.

Nicholas L. Clesceri – Professor Clesceri is the Director of the Environmental Engineering Program at Rensselaer Polytechnic Institute in Troy, NY. He has served as a consultant to numerous governmental agencies and private industry. His research interests have been in the area of water quality responses to man's activities. He is the Deputy Project Manager for the WRDA Sediment Decontamination Program.

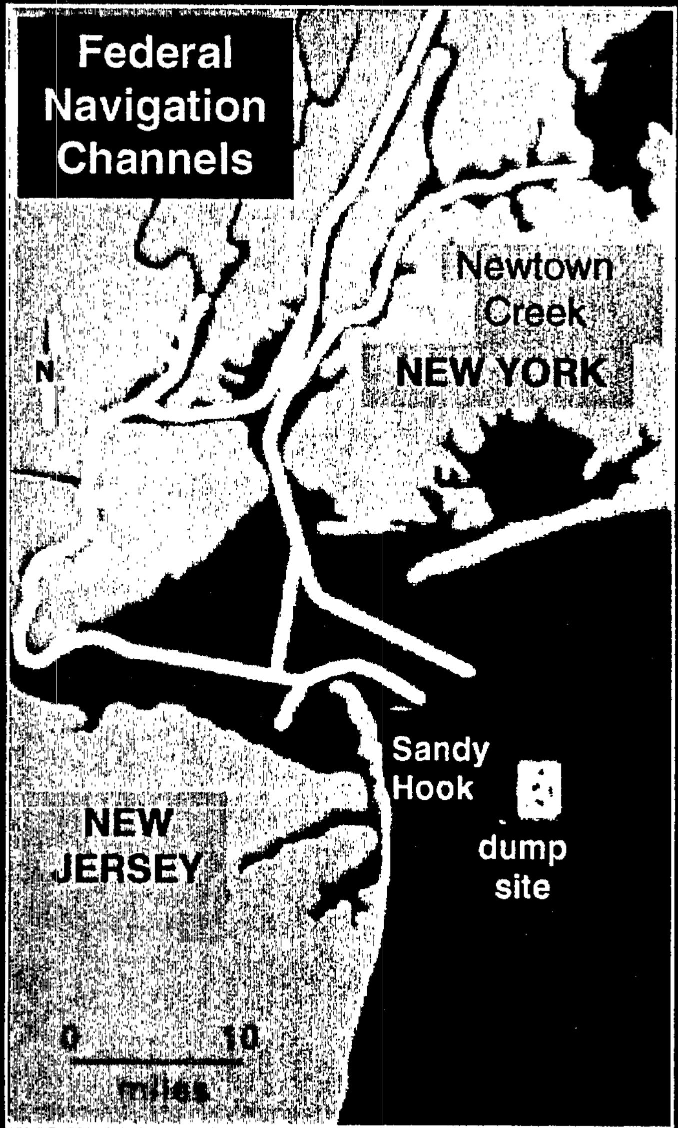
Michael C. Mensinger – Mr. Mensinger is a Chemical Engineer and Director of Technology Development for ENDESCO Services, Inc., a wholly owned subsidiary of the Institute of Gas Technology. He currently directs technical activities and manages the experimental development of IGT's Cement-Lock™

Technology for converting contaminated sediments, sludges, and soils into salable products, such as blended cements. He has been instrumental in the development of the Cement-Lock™ Technology from inception through pilot-scale testing and beyond, and is co-inventor of the technology.

Charles L. Wilde – Mr. Wilde is Executive Vice President and Chief Operating Officer of BioGenesis Enterprises, Inc., an environmental firm specializing in production of oil cleaning chemicals and soil remediation and the inventor of the BioGenesis SM Sediment Washing process. He is an expert in petroleum matters, with focus on storage, distribution, testing, and pollution control, and has extensive experience in government regulation and contracting, planning, budgeting, and systems analysis.

Exhibit 1

NY/NJ Harbor Estuary



- 4 to 7 million cubic yards of sediment are dredged from the channels annually
- Much of this sediment contains pollutants
- Various options are being pursued for management of this sediment

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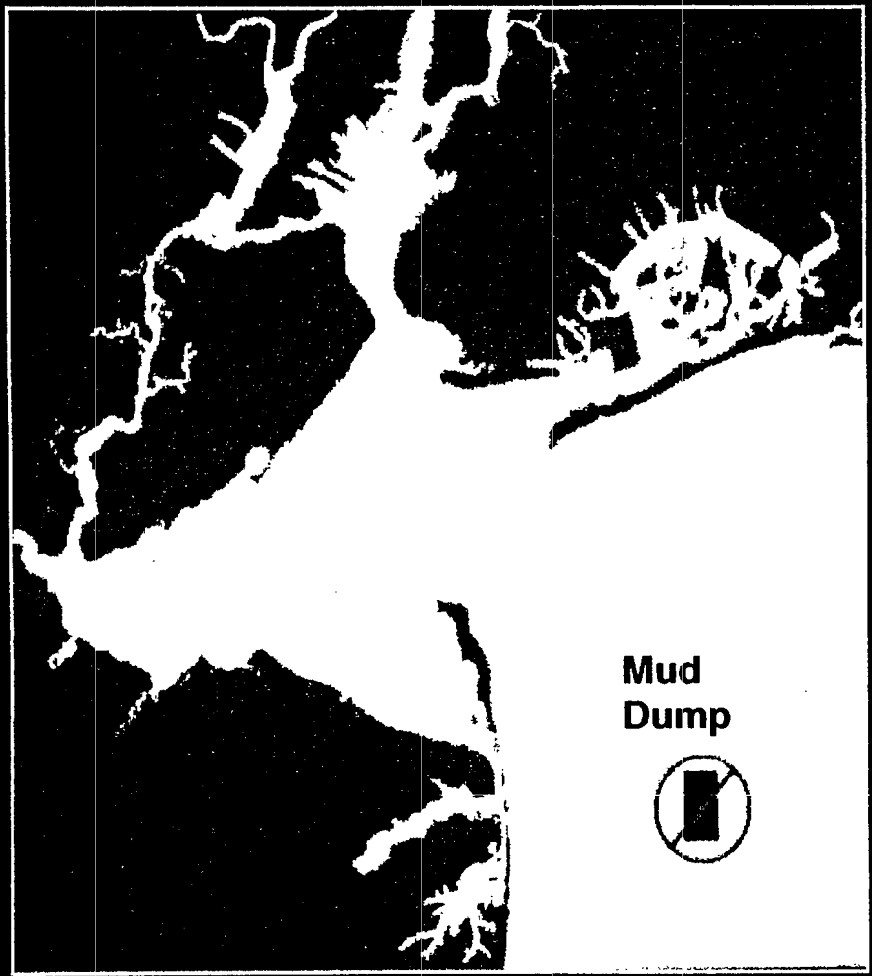
Exhibit 2

What is Done with the Dredged Material?

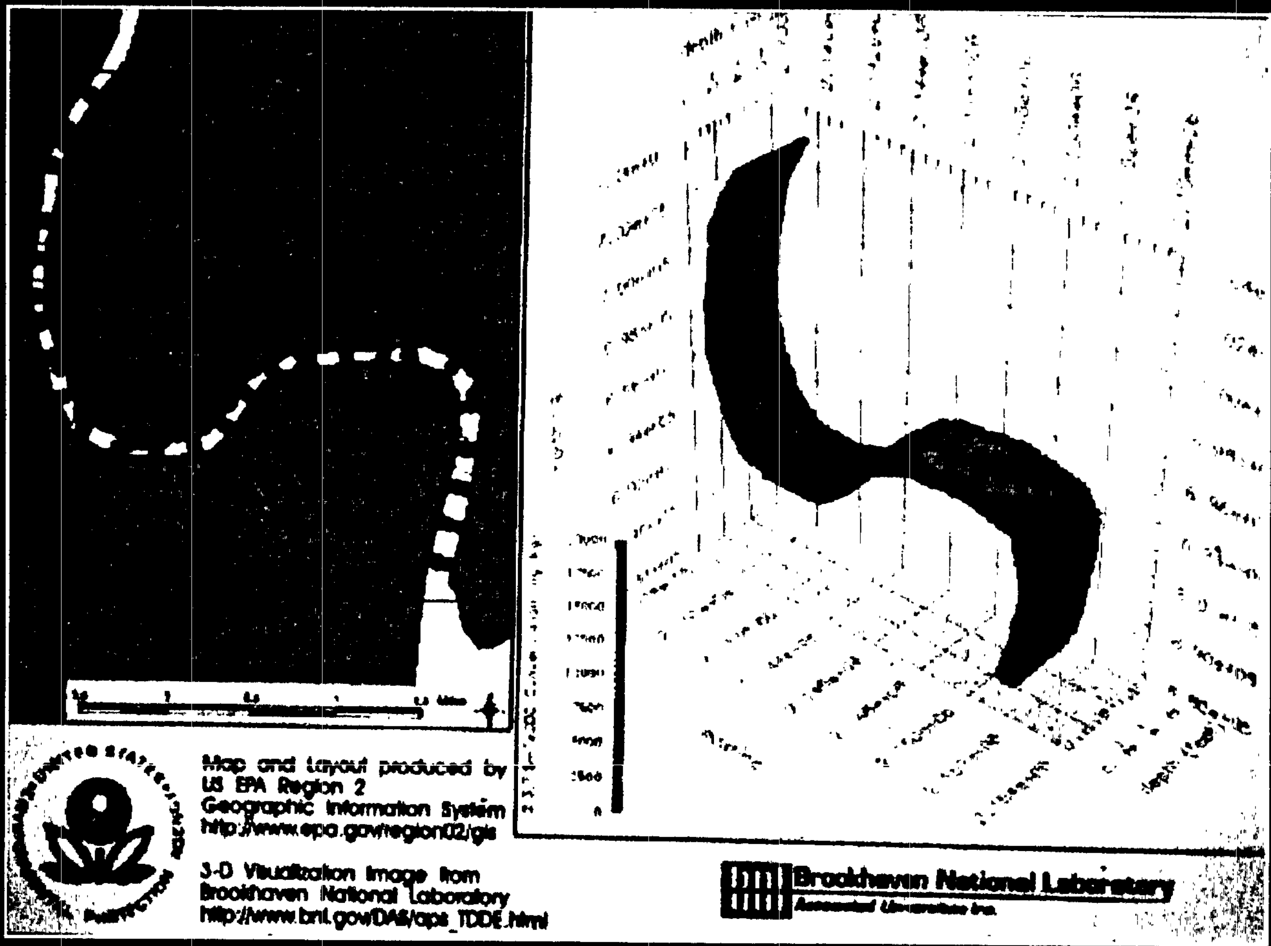


- > 90% to Mud Dump
  Prior to 1992
- 35% to Mud Dump
  1992 to 1997
- 25% to Mud Dump
  after 1997

Dredged Material Management Plan
U.S. Army Corps of Engineers - New York District

Exhibit 3.

Contaminated Sediments
3-D Visualization



Hong Ma et al. 1998

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Exhibit 4.

WRDA Sediment ...
Sampling Locations for ...

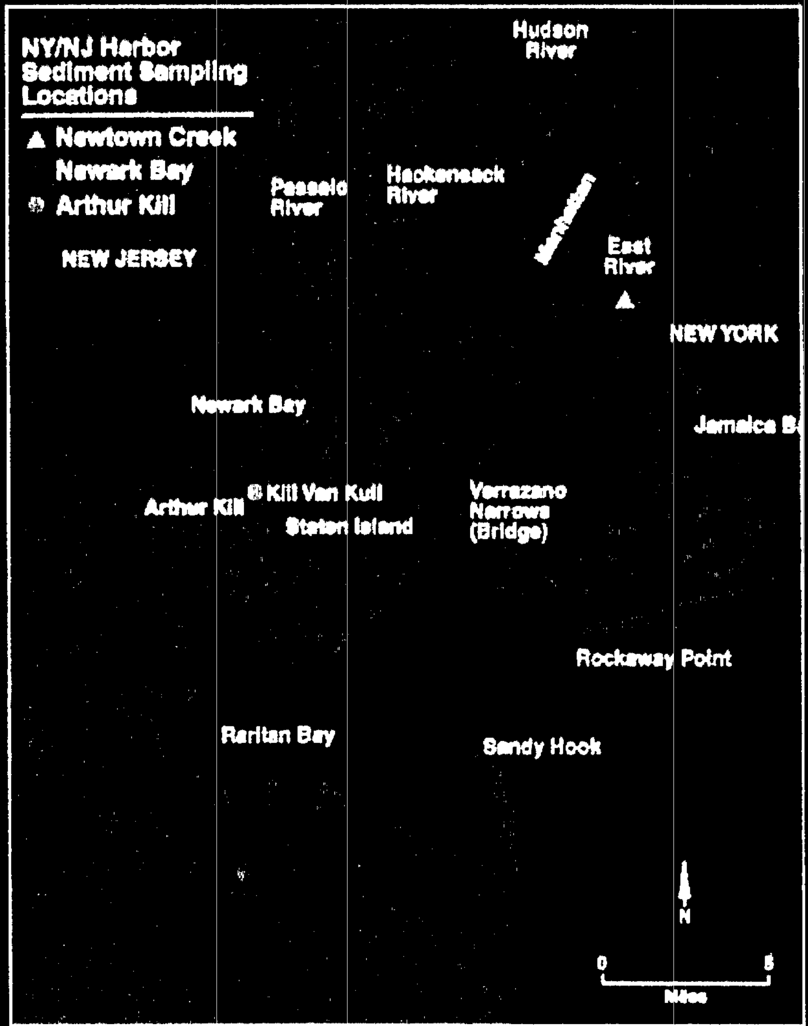

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Exhibit 5

WRDA Plans for Large-Scale Decontamination Facilities

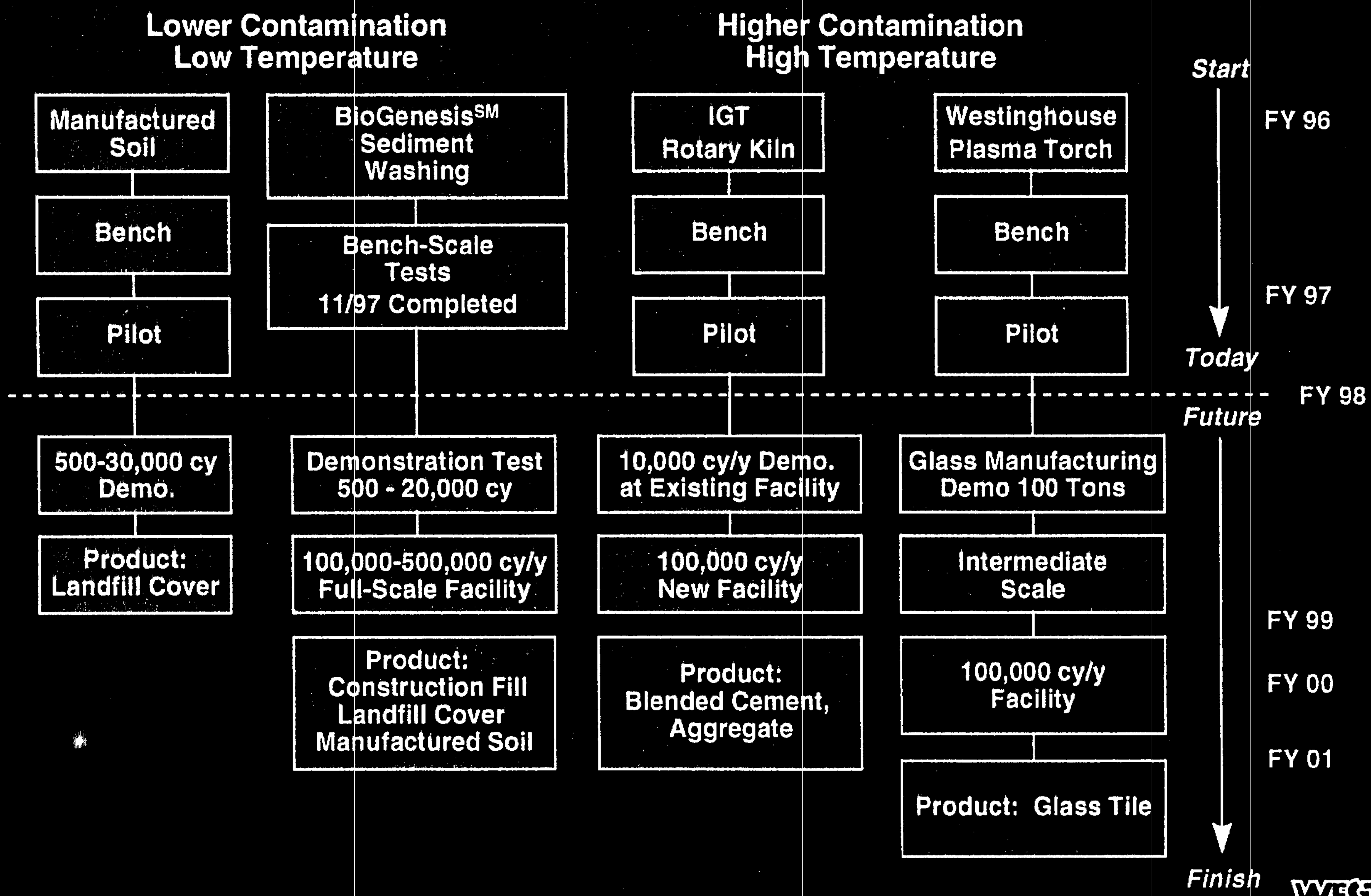

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Exhibit 6

Summary of Physical-Chemical Properties of Raw Sediment from [illegible]

Sample Designation		IGT-37 As Dredged Sediment
Particle size, wt % (dry basis)		
Medium gravel	(> 4.75 mm)	11.03
Fine gravel	(2 - 4.75 mm)	2.54
Very coarse sand	(0.85 - 2 mm)	1.78
Coarse sand	(0.425 - 0.85 mm)	3.21
Medium sand	(0.24 - 0.425 mm)	5.03
Fine sand	(106 - 240 mm)	9.38
Very fine sand	(75 - 106 µm)	2.84
Clay		28.23
Silt		35.96
		100.00
pH		7.25
Total Solids, wt % (dry basis)		44.6
Total Sulfides, mg/kg (dry basis)		5,900
Total Organic Carbon, wt % (dry basis)		7.50
TPH, mg/kg (dry basis)		16,100

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Exhibit 7

BioGenesis℠ Sediment Washing Process

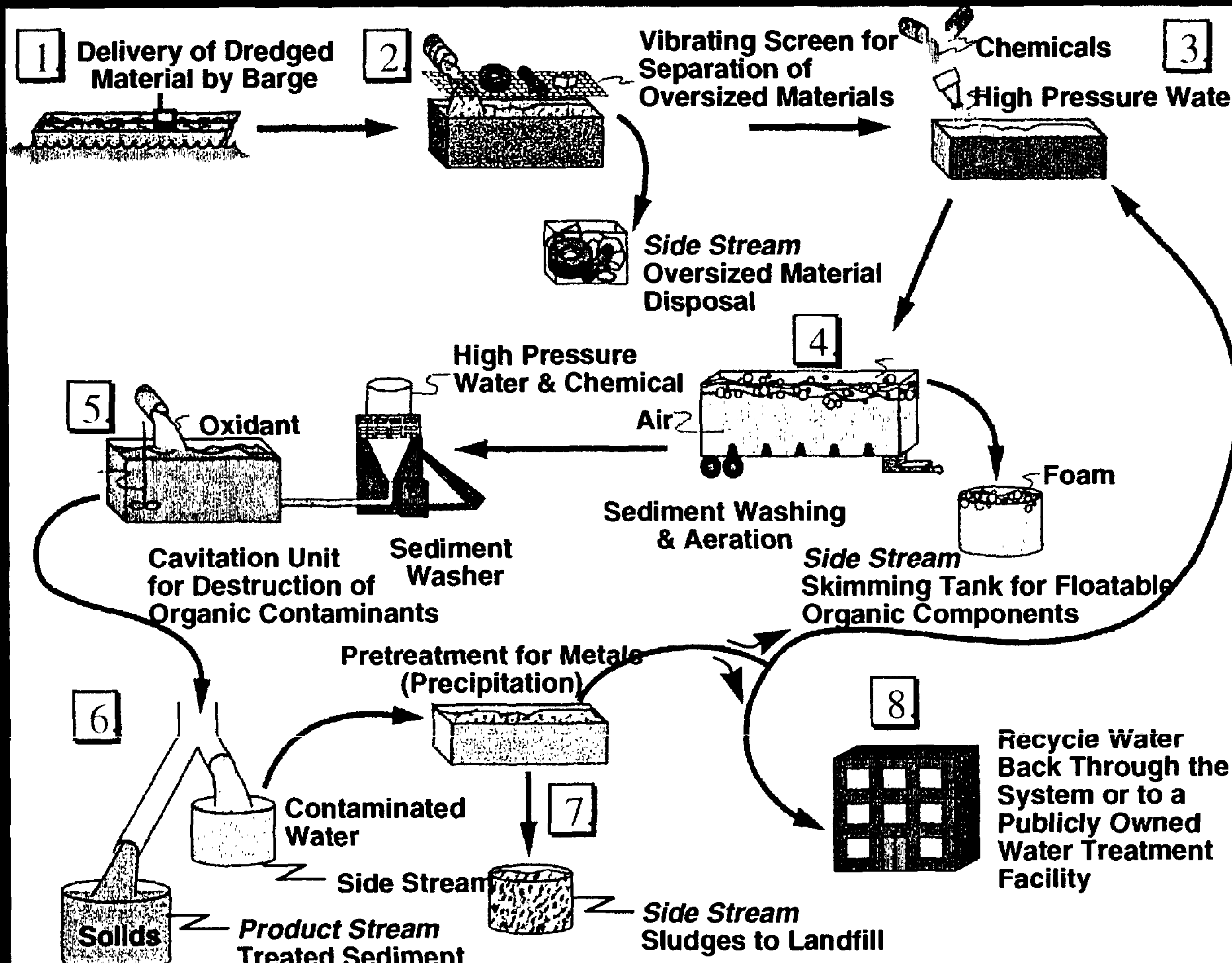

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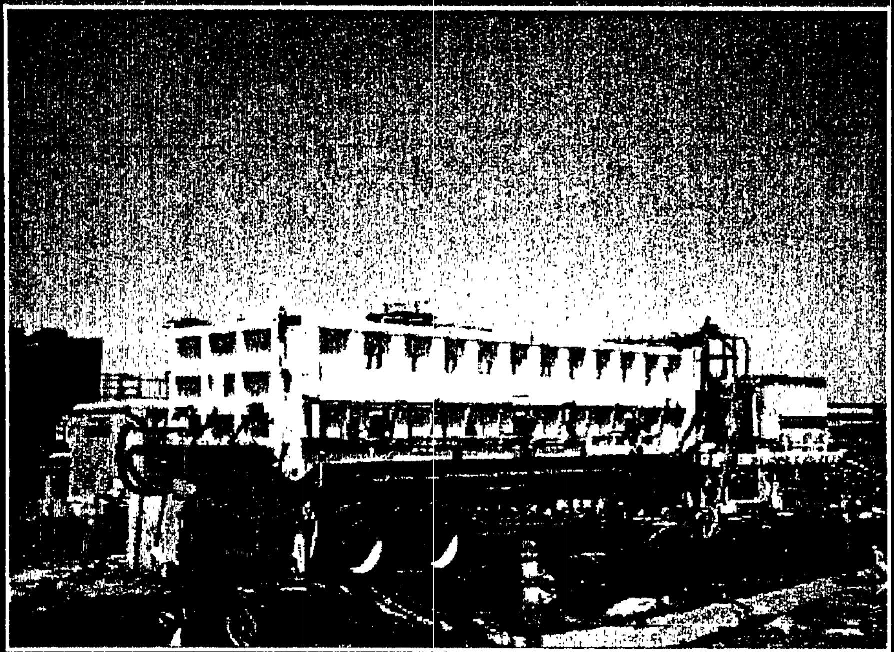
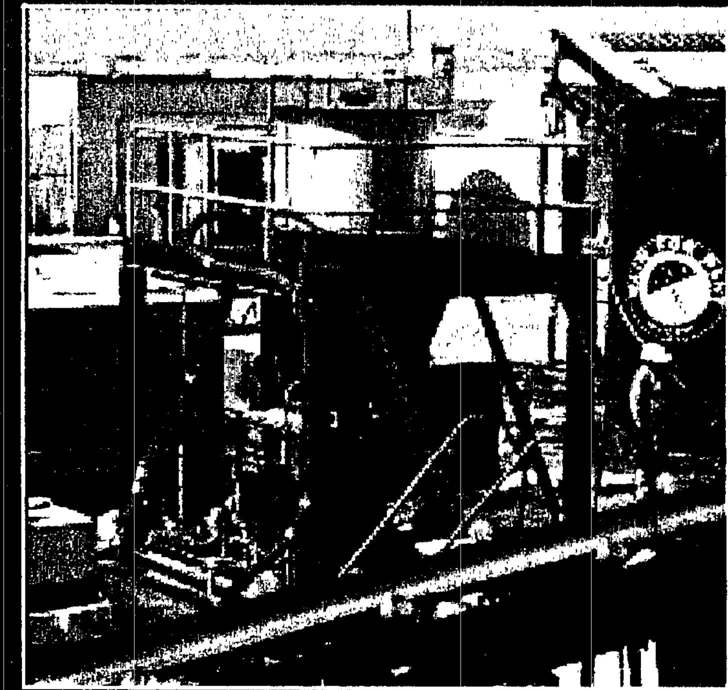
Exhibit 8

BioGenesis℠ Pilot Plant Washing Equipment



- Washing Gondola



Sediment Washer

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Exhibit 9

BioGenesis℠ Sediment Washing Two-Cycle Treatment Efficiency - Final Solids Analysis (11/97)

Contaminant	Untreated	Treated	Overall Removal Percent
TOC (%)			
Organic Content	9.2	2.0	78%
PAHs (ug/kg)			
napthalene	913	138	85%
acenaphthylene	326	34	90%
acenaphthene	434	34	92%
fluorene	533	51	90%
phenanthrene	2241	743	67%
anthracene	1612	177	89%
fluoranthene	7358	537	93%
pyrene	6767	177	97%
benzo(a)anthracene	3563	234	93%
chrysene	3781	286	92%
benzo(b)fluoranthene	3496	158	95%
benzo(k)fluoranthene	1155	204	82%
benzo(a)pyrene	2666	236	91%
indeno(1,2,3-cd)pyrene	1595	ND (MDL 26)	98%
benzo(ghi)perylene	1453	ND (MDL 27)	98%
Total PAHs	37895	3175	92%

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Exhibit 9 (Cont'd)

BioGenesis[SM] Sediment Washing Two-Cycle Treatment Efficiency - Final Solids Analysis (19[illegible]) (Cont'd)

Contaminant	Untreated	Treated	Overall Removal Percent
PCB (ug/kg)			
MonoCB	175 EMPC	ND (MDL 7.5)	96%
Total DiCB	191EMPC	ND (MDL 8.2)	96%
Total TriCB	429	ND (MDL 8.8)	98%
Total TetraCB	718	ND (MDL 6)	99%
Total PentaCB	487	ND (MDL 6.2)	99%
Total HexaCB	456	ND (MDL 8)	98%
Total HeptaCB	165	ND (MDL 10)	94%
Total OctaCB	39	ND (MDL 14)	Not Determined**
Total NonaCB	13	ND (MDL 25)	Not Determined**
Total PCB	2673	93.7	96%
METALS (mg/kg)			
As	22	12	42%
Cd	18.2	1.4	92%
Cr	226	63	72%
Pb	454	60	87%
Hg	13	0.3	86%

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Exhibit 10

IGT Cement-Lock™ Process

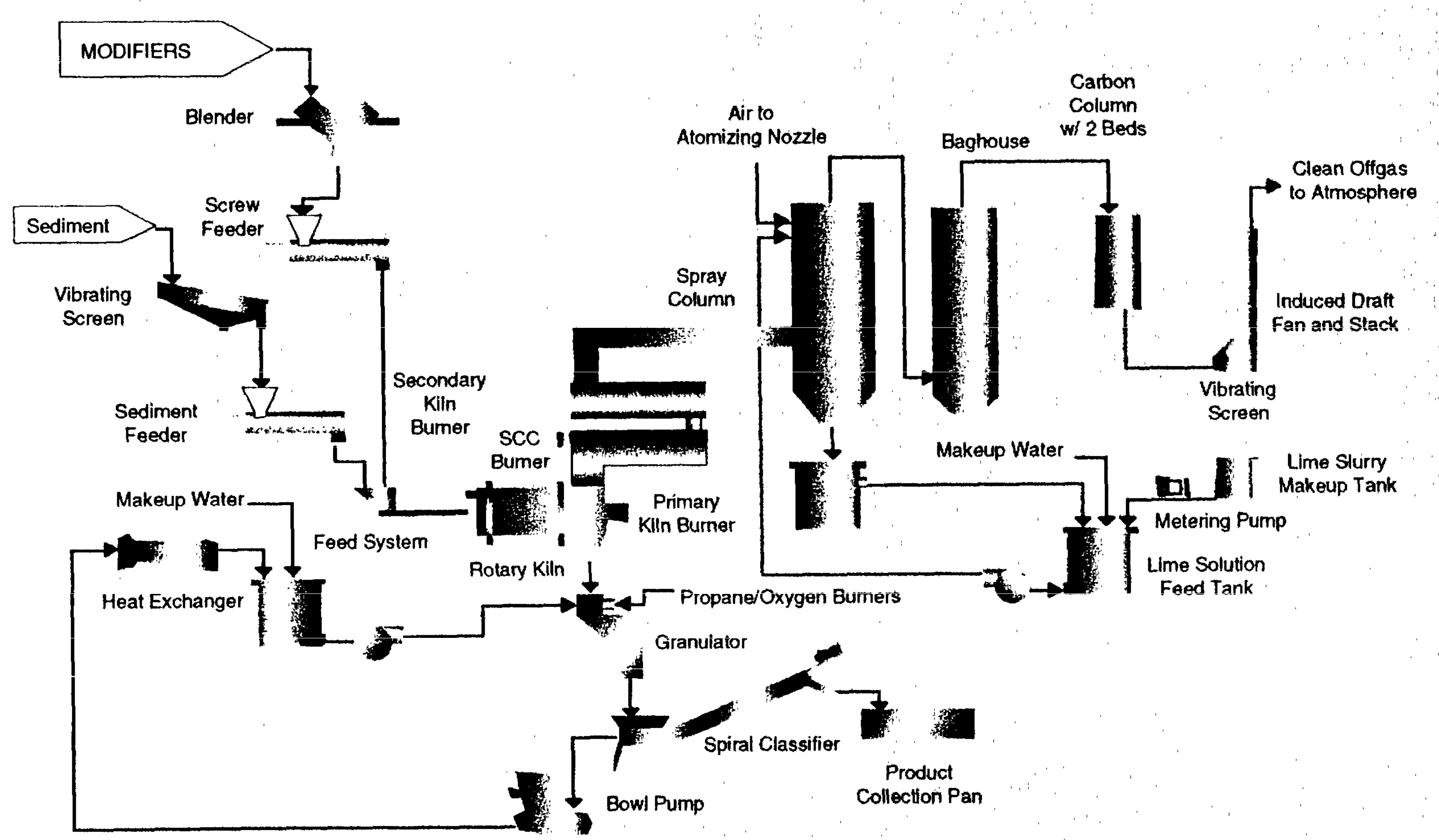

Exhibit 11

IGT Cement-Lock™ Pilot Plant Equipment

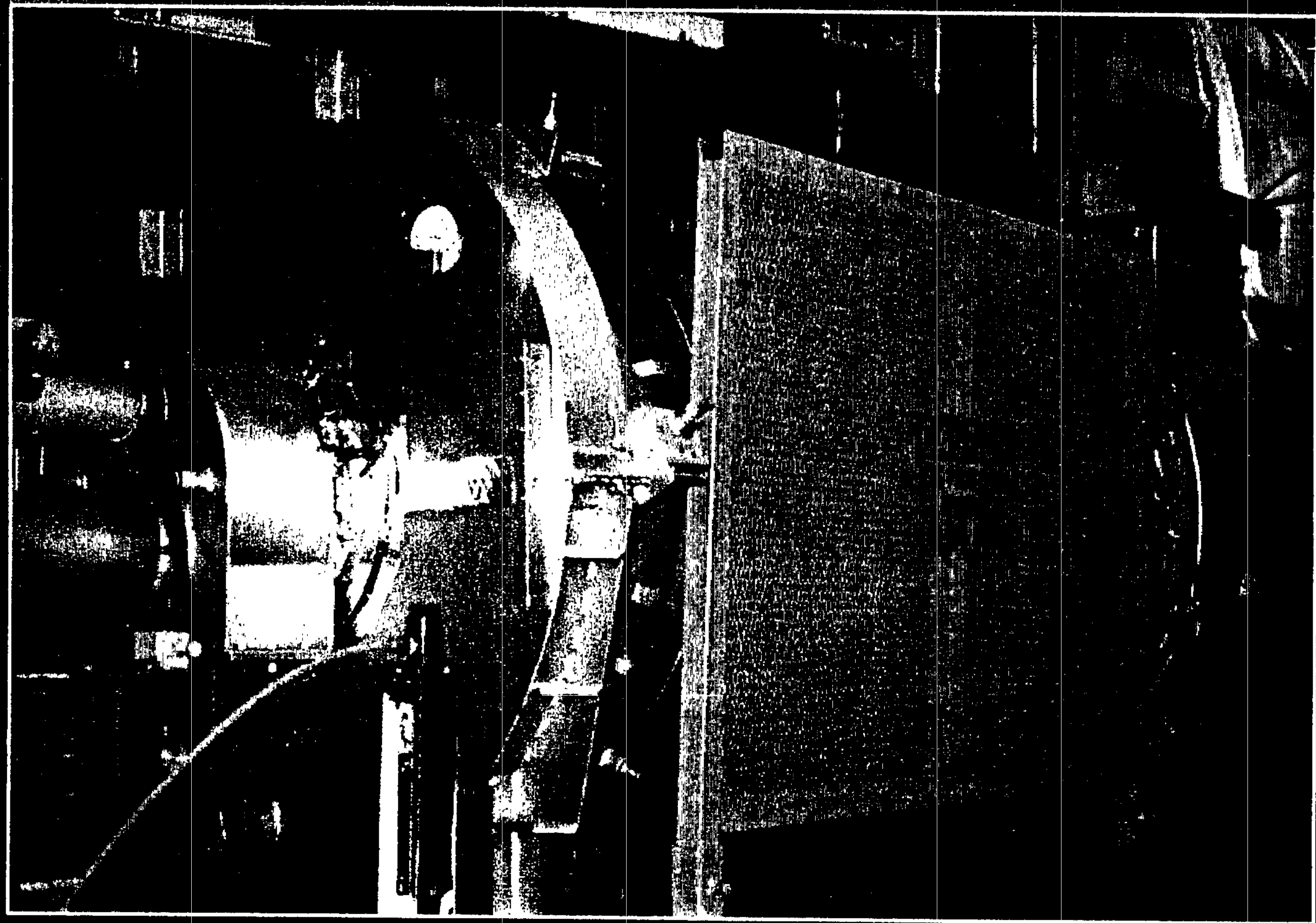

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Exhibit 12

Summary of Organic Contaminants in Dredged Newtown Creek Sediment, Blended Cement Products, and ECT Cement-Lock™ Destruction and Removal Efficiencies for Bench- and Pilot-Scale Tests

Contaminant	Units	Untreated Sediment Lab-Scale	Untreated Sediment Pilot-Scale	Blended Cement Lab-Scale	Blended Cement Pilot-Scale	DRE* Lab-Scale	DRE* Pilot-Scale
PAHs (SVOCs)	ug/kg	116	370	0.3	0.22	99.24	99.93
PCBs	ug/kg	5,270	8,585	0.75	<D.L.**	>99.96	>99.99
2,3,7,8-TCDD/TCDF	ng/kg	381	262	<D.L.	<D.L.	>99.99	>99.99
Total TCDD/F	ng/kg	2,260	2,871	<D.L.	<D.L.	>99.99	>99.99
Total PeCDD/F	ng/kg	3,231	4,363	<D.L.	<D.L.	>99.99	>99.99
Total Hx/Hp/OCDD/F	ng/kg	38,945	34,252	18	<29	99.88	>99.90

* Destruction and removal efficiency

** Less than the detection limit of the analytical procedure used

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Exhibit 13

Summary of Potential Beneficial Reuse Products

Treatment Technology	Treatment Abilities	Beneficial Reuse Product	Amendment Requirements	Regulatory Standards	Product Value
BioGenesis[SM] Sediment Washing	Reduction in Organic and Inorganic levels	Nonstructural Fill (Daily Landfill Cover, etc.)	Bulking materials	NY/NJ Non-residential Standards	\$3 to \$8/cy
		Low End Manufactured Soil (Top Soil, Wetlands restoration, Brownfields, etc.)	Bulking materials, organic additives	NY/NJ Residential and/or Nonresidential Standards	\$7 to \$17/cy
		High End Manufactured Soil (Potting Soil)	Bulking materials, organic additives	NY/NJ Residential Standards	\$100/cy
IGT Cement-Lock™	Reduction in Organic levels and stabilization of Inorganic levels	Blended Cement	Cement	NY/NJ Residential and/or Nonresidential Standards	\$50 to \$70/ton
		Construction	Cement	NY/NJ Residential and/or Nonresidential Standards	\$10 to \$20/ton

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