CEMENT-LOCK™ TECHNOLOGY FOR DECONTAMINATING DREDGED ESTUARINE SEDIMENTS

Phase II: Pilot-Scale Studies

Final Report

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March 24, 1999

EXECUTIVE SUMMARY

This report presents the results of an experimental program conducted by the Institute of Gas Technology (IGT, Des Plaines, IL) under Contract No. 725043 with Brookhaven National Laboratory (BNL) for the program entitled "Cement-Lock™ Technology for Decontaminating Dredged Estuarine Sediments - Phase II: Pilot-Scale Studies." The overall sediment decontamination program is funded through the Water Resources Development Act (WRDA) of 1992 and 1996. Cofunding for the project was provided by Unitel Technologies, Inc. (Mt. Prospect, IL). The pilot-scale experimental program work was conducted during the period from October 1 through November 30, 1996.

The overall objectives of the program were to apply IGT's Cement-Lock™ Technology to decontaminate dredged sediment from the Newtown Creek estuary in New York, to produce a salable product from the sediment, and to determine some of the important physical and chemical properties of the product.

The accomplishments and results achieved during the experimental tasks of the pilot-scale program are described below. Overall, the results of both bench- and pilot-scale test programs for evaluating the Cement-Lock Technology for decontaminating dredged sediments have been very favorable.

The Cement-Lock pilot-scale campaign was conducted in existing facilities at Hazen Research, Inc. (Golden, CO). The facilities were modified from their original configuration to accommodate the specific requirements of the Cement-Lock Technology. The facilities include a sediment feeding system, a modifier feeding system, a 63.4-cm (2-foot) diameter by 1.98-m (6½-foot) long rotary kiln melter, an Ecomelt™ quencher, an Ecomelt dewatering screw conveyor, a secondary combustion chamber, a lime scrubber and flue gas cooler, a bag house, a fixed-bed activated carbon and Sorbalit™ adsorber, and an induced-draft fan.

A total of 2.3 cubic meters (3 cubic yards or 605 gallons) of as-received sediment were processed through the Cement-Lock pilot plant during the campaign. A total of 424.6 kg (936 pounds) of amorphous Ecomelt product was generated during the approximately 40 hours of continuous sediment and modifier feeding during the campaign. Samples of raw sediment, modifiers, Ecomelt, quench water, and bag house solids were taken during the campaign and submitted to BNL according to a sampling protocol developed by BNL, a number of collaborating universities, and IGT. The sampling protocol included both composite and discrete samples of the feeds and products generated. Triangle Laboratories, Inc. (Durham, NC) conducted analyses of samples generated during the pilot-scale testing. Flue gas samples were taken by AirNova (Pennsauken, NJ). Both of these companies were under subcontract to BNL. A continuous emission monitoring system (CEMS) monitored the flue gas for O_2, CO, CO_2, SO_2, NOx, and total hydrocarbons.

A 50-kg sample of Ecomelt™ was shipped to Construction Technology Laboratories (CTL, Skokie, IL – the research arm of the Portland Cement Association) for fine grinding. The ground Ecomelt was then converted into Cement-Lock construction-grade cement. CTL also

conducted compressive strength tests on the Cement-Lock cement according to ASTM (American Society for Testing and Materials) standard protocols. The results of the compressive strength tests conducted on the Cement-Lock cement exceeded ASTM requirements for conventional portland cement as well as blended cement. The compressive strengths of the cement samples after 3, 7, and 28 days of curing were 15.4, 19.9, and 36.3 MPa (2230, 2885, and 5270 psi), respectively. The corresponding requirements for portland cement (ASTM C-150) are 13.0, 19.9, and 28.0 MPa (1890, 2890, and 4060 psi), respectively. These results were achieved without the use of accelerators or performance enhancers, such as gypsum.

Chemical analysis conducted on the Cement-Lock cement product showed that essentially all of the organic contaminants originally present in the sediment had been destroyed.

The leachability of the finely ground Cement-Lock cement product was also determined according to the EPA TCLP (Toxicity Characteristic Leaching Procedure). The results showed that none of the priority metals leached above the TCLP regulatory limits. The leachability of hardened mortar (a set mixture of cement, sand, and water) produced from the Cement-Lock cement was even lower than the cement powder alone.

The flue gas downstream of the lime injection, bag house, and fixed-bed activated carbon adsorber was analyzed for CO, SO_2, NOx, total hydrocarbons (THC), hydrogen chloride (HCl), O_2, CO_2, and particulates. The average concentrations of CO, SO_2, NOx, THC, and HCl were 25, 44.1, 67.5, 10.6, and 14.2 ppm, respectively (corrected to 7 mol % O_2). The O_2 and CO_2 concentrations averaged 2.5 and 8.1 percent, respectively. The flow rate of particulates was below the analytical detection limit of 0.09 g/hour. Analyses of the flue gas for hydrocarbons, polychlorinated biphenyls (PCBs), chlorophenols, chlorobenzenes, and pesticides were below detection limits. Chlorinated dioxins and furans were also below detection limits on a TEF (Toxicity Equivalency Factor) basis of $< 4.0 \times 10^{-12}$ and $< 8.1 \times 10^{-12}$ lb/hr, respectively.

Overall, the Cement-Lock pilot-scale test campaign confirmed the results achieved during the bench-scale tests and showed further that:

- Essentially all of the organic contaminants originally present in the sediment were completely destroyed during Cement-Lock processing.
- The Cement-Lock cement product readily passes the TCLP test for priority metals.
- The Cement-Lock cement product has compressive strength that exceeds the ASTM requirements for portland cement.
- The flue gas from the pilot-scale test was devoid of PCBs, chlorophenols, chlorobenzenes, and pesticides.
- The chlorinated dioxins and furans in the flue gas from the pilot-scale test were below the detection limits of 4×10^{-12} and 8.1×10^{-12} lb/hr, respectively, on a TEF basis.

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INTRODUCTION

Sediments must be routinely dredged from the New York/New Jersey harbor to maintain water depths for shipping channels, berthing areas for commercial vessels, and to insure safe navigation. In the past, dredged sediments were typically barged out into the open ocean and dumped. However, these dredged materials often contain a variety of contaminants including polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), insecticides, chlorinated dioxins and furans as well as heavy metals. The concentrations of some of the contaminants in the sediment are high enough to preclude their being dumped into the open ocean. Further, the ocean dumping area commonly known as the "Mud Dump Site" was closed to further dumping of contaminated material as of September 1, 1997. These contaminated dredged sediments must be rendered innocuous to the environment before being disposed of, or, as in the case of the Cement-Lock™ process, converted into a salable product for beneficial use.

The Cement-Lock Technology being developed by the Institute of Gas Technology (IGT) offers a one-step solution for remediating these contaminated materials in which the organic contaminants are completely destroyed, inorganic contaminants are immobilized, and the resultant solid product from the treatment can be put to beneficial use. The technology is flexible enough to accommodate the complex and varying nature and levels of contaminants and their widespread spatial distribution within the estuarine environment. The Cement-Lock Technology simultaneously immobilizes the heavy metals and destroys the organic contaminants such as PCBs, PAHs, dioxins, furans, chlorinated pesticides, and herbicides.

This report presents the results of a pilot-scale program conducted by IGT for Brookhaven National Laboratory (BNL, under Contract No. 725043) entitled "Cement-Lock™ Technology for Decontaminating Dredged Estuarine Sediments - Phase II: Pilot-Scale Studies." Funding from BNL was provided through the Water Resources Development Acts (WRDA) of 1992 and 1996. Unitel Technologies, Inc. (Mt. Prospect, IL) provided cofunding for the project. The overall objectives of the program were to apply IGT's Cement-Lock Technology to decontaminate dredged sediment from the Newtown Creek estuary in New York, to produce a salable product from the sediment, and to determine some of the important physical and chemical properties of the product. The specific objective of Phase II (Pilot-Scale Studies) was to process a bulk sample of dredged estuarine sediment in continuous pilot-scale operations.

Construction Technology Laboratories, Inc. (CTL, Skokie, IL – the research arm of the Portland Cement Association) and Hazen Research, Inc. (Golden, CO) were subcontractors to IGT on the project. CTL analyzed several samples of the as-received sediment and finely ground a bulk sample of the Ecomelt™ from which the Cement-Lock cement was produced. CTL also conducted the compressive strength testing on the cement product per ASTM standard procedures. The existing rotary kiln melter system at Hazen Research was modified for the Cement-Lock pilot-scale campaign.

The pilot-scale program was conducted during the period from October 1 through November 30, 1996.

CEMENT-LOCK™ TECHNOLOGY DESCRIPTION

The Cement-Lock™ Technology is an advanced management system for remediating contaminated dredged sediments from estuarine and river environments, hazardous and non-hazardous wastes, and municipal solid wastes (MSW). In addition to decontamination, Cement-Lock converts the wastes into construction-grade cement, which can be sold on the open market. Depending upon the waste stream and its composition, other beneficial products could be produced, for example, steam for power generation. Further, there are no secondary hazardous waste streams produced during Cement-Lock processing as in some other treatment processes.

The beneficial use of sediments and wastes through the application of Cement-Lock Technology has many advantages over conventional waste processing. These include: a) additional revenues generated from the sale of construction-grade cement product, b) the ability to accept materials with fairly low tipping fees because of the secondary revenue streams, and c) environmental superiority when compared to conventional incineration technologies.

The Cement-Lock Technology should not to be confused with either cement manufacturing plants or with MSW incineration technologies. The Cement-Lock Technology is considerably simpler than a portland cement manufacturing plant and bears little or no resemblance to the actual complex cement plant. Unlike a cement plant, the Cement-Lock Technology does not have the extensive sizing requirements for the materials being processed; it does not have the extreme temperature requirements of a cement plant; it does not produce waste streams (such as cement kiln dust); it does not require complex energy management to save energy; it does not produce high NOx; it does not have stringent requirements for materials of construction; and finally, the starting raw materials are entirely different.

Nor is the Cement-Lock Technology an incineration process either. Rather it is a thermo-chemical manufacturing process that utilizes the inherent properties of sediments and wastes as feedstocks for producing economically attractive products (Figure 1). Conventional MSW incinerators do not produce a salable product. Rather, they generate ash that may contain leachable heavy metals, which must be disposed of as hazardous waste. Further, MSW incinerators have been shown to generate dioxins and dioxin precursors.

The Process

Contaminated materials are reacted in a melter with suitable modifiers in proportions required for producing materials with latent cementitious properties. The proprietary modifiers are inexpensive materials that are used in conventional cement manufacturing. The melter for carrying out this process is operated at temperatures in the range of 1200° to 1400°C (2192°-2552°F or temperatures sufficient to completely melt the sediment-modifier mixture). At these temperatures in the presence of oxygen, organic contaminants originally present in the sediment are completely destroyed and converted to innocuous carbon dioxide (CO_2) and water (H_2O). Chlorine present in some of the organic compounds (dioxins, furans, PCBs) is converted to hydrogen chloride (HCl), which can be readily scrubbed from the flue gas by direct injection

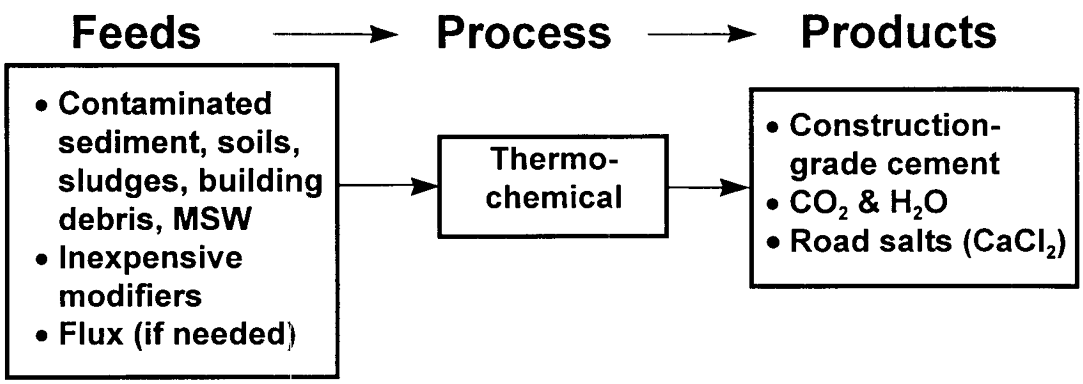

Figure 1. CEMENT-LOCK TECHNOLOGY IS A THERMO-CHEMICAL MANUFACTURING PROCESS

of powdered lime. The flue gas could also be passed through a solid media filter containing calcium oxide (operating at 540° to 595°C; 1004° to 1100°F). Some of the chlorine will be sequestered within the stable matrix of the melt. Sodium and potassium chlorides (NaCl and KCl) from seawater will be volatilized and captured in the downstream flue gas processing stages.

The melt, which contains the heavy metals present in the contaminated sediment, is quickly quenched. The metals are locked into the matrix of the melt that completely immobilizes them. The solidified melt can be crushed and pulverized by conventional methods or it can be drawn into micrometer-size fibers by fiberization techniques. The fibers can then be easily pulverized and mixed with another appropriate additive to yield construction-grade cement as a product for beneficial use. Highly volatile metals, such as mercury, are removed from the off-gas by adsorption onto activated carbon or by amalgamating them with an affinity metal distributed over a filter element.

Flue gas from the melter enters a secondary combustion chamber (SCC), where it is subjected to an additional two-(2) seconds residence time at temperature to ensure complete combustion of any organic compounds. The flue gas exiting the SCC is cooled by direct water injection to a temperature of about 204°C (400°F) to prevent the formation of dioxin and furan precursors. Powdered lime (CaO) is injected into the flue gas to capture hydrogen chloride (HCl), SO_2 and other acid gases. The flue gas then passes through a bag house to capture the spent lime, fine particulates, and NaCl and KCl volatilized from the estuarine sediments. From the bag house, the flue gas passes through a fixed bed of activated carbon to capture volatile metal species (e.g., mercury). In an alternative process configuration, powdered activated carbon can be injected into the flue gas stream to capture mercury and be removed by a second bag house. The clean flue gas is vented to the atmosphere. A simple schematic diagram of the Cement-Lock Technology is shown in Figure 2.

All of the components required for applying the Cement-Lock Technology to the remediation and beneficial use of dredged sediments can be adapted from commercially available equipment. The following sections describes the major process equipment, the feed system, the reactive melter, and the melt fiberizer or granulator.

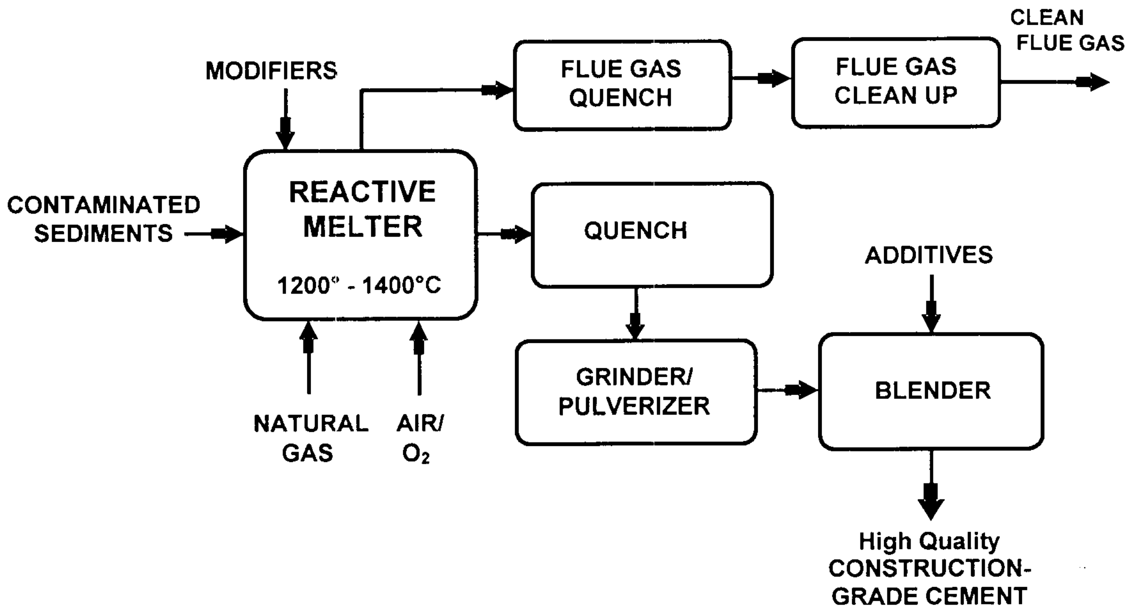

Figure 2. SCHEMATIC DIAGRAM OF THE CEMENT-LOCK PROCESS FOR TREATING DREDGED ESTUARINE SEDIMENTS

Feed System

The system for feeding dredged estuarine sediments into the reactive melter is a simple screw conveyor. Dredged sediments containing 60-weight percent water are scooped from the barge and dumped into the screw conveyor feed hopper. The rate of sediment feeding into the reactive melter can be controlled by regulating the screw rotation rate. Depending upon the pumpability of the sediments (from different geographical locations), it may be possible to use a sludge pump (reciprocating piston) to transport sediments from the barge to the reactive melter. Since sediments are essentially sandy, silty, or clayey in nature, the only feed pretreatment required is to remove large objects from the feed using a scalper.

Reactive Melter

Any suitable natural gas-fired melter can be adapted to the Cement-Lock Technology. IGT has considered three vendors for providing melters, which are described below. The current pilot-scale testing was conducted in a rotary kiln melter.

1). A rotary kiln-type melter as manufactured by ABB or Svedala Industries is suitable for the Cement-Lock Technology. The rotary kiln-type melter is more forgiving of variations in the size of feed materials that it can process.

The rotary kiln melter employed for the pilot-scale testing was designed and built by ABB. During pilot-scale operation, sediment containing 60-weight percent water was readily processed without predrying. ABB has subsequently quoted and is willing to provide the required guarantees for a rotary kiln melter with a processing capacity of 100,000 cubic yards per year of harbor sediment. Through the years, rotary kilns have been installed in hundreds of locations worldwide.

2). The reactive melter developed by Ausmelt Technology Corporation, is a vertically oriented, refractory-lined cylinder. The melter is constructed with water-wall cooling to minimize refractory thickness. A layer of frozen slag coats the internal walls of the melter to extend refractory life. Feed material and modifiers are fed into the melter through a port at the top of the melter. The energy required to melt the sediment-modifier mixture is supplied through a submerged lance, which is comprised of concentric tubes for feeding air or oxygen and natural gas into the melt. The lance can be moved up or down depending upon the depth of the melt. Typically, air (or enriched air) is fed through the outer shell of the lance thereby cooling the lance somewhat. Natural gas is fed through the inner tube.

Combustion products bubble vigorously throughout the melt. The flow of gas from the lance instills a circulating pattern through the melt ensuring complete mixing. During initial melter operation, the lance becomes coated with a layer of frozen slag, which extends its life. When the lance must be replaced, a spare can be installed within about 30 minutes.

Melt Fiberizer or Granulator

The melt (Ecomelt™) from the reactive melter flows from the reactor into a flowing stream of quench water or high-velocity air which quickly freezes the melt and effectively disperses it into fibers or granules. In IGT's pilot-scale tests, the water-quencher effectively produced fibers from the melt. The fibers were readily crushed to the particle size required for blending with the final additive to produce the construction-grade cement product.

Fiberization techniques are well known in industry, however it appears that specific industries have developed their own proprietary processes. Fiberglass and mineral wool are produced utilizing existing fiberization techniques. A similar, but more mundane example is the fibers of sugar produced during cotton candy production.

CEMENT-LOCK PILOT PLANT DESCRIPTION

5.5.1. Pilot-Scale Work

Pilot-scale Cement-Lock processing of dredged estuarine sediment was performed in the existing rotary-kiln pilot plant system at Hazen Research, Inc. (Golden, CO). This pilot plant consists of four sections: a Denver Holoflite conveyor heated with a hot oil system for predrying the material, a 63.4-cm (2.08-foot) diameter by 1.98-m (6½-foot) long refractory-lined rotary kiln, a 53.3-cm (21-inch) diameter by 7.31-m (24-foot) long refractory-lined secondary combustion chamber (SCC), and a gas-emission treatment system consisting of a quench tower for cooling the gas with a lime-water solution, a fabric-filter bag house for dust control, and a two-bed adsorption column for final emission control. The SCC is divided into two separate 3.66-m (12-foot) long sections on a horizontal plane. An induced-draft fan provides vacuum control throughout the system.

During a process upset early in the campaign, the Holoflite dryer became plugged with dried, caked sediment and could not be cleared. It was subsequently removed from the system. This simplified the pilot-scale operation and demonstrated the capability of the Cement-Lock Technology to process "as received" dredged sediment. A drawing of this system as it was successfully operated (without the Holoflite dryer) is given in Figure 3. A photograph of the rotary kiln melter is shown in Figure 4.

The pilot plant is fully instrumented to facilitate control and to generate design data. System instrumentation includes:

- Six thermocouples that measure temperatures in the kiln, SCC, quench tower, bag house, and absorption column.
- Temperature controllers that regulate air and natural gas flow to the burner systems.
- Magnehelic gauges that measure pressure throughout the system and indicate differentials across orifice meters to measure air and natural gas flow.
- A continuous emission monitor (CEM) that measures O_2, CO_2, CO, SO_2, NOx, and total hydrocarbons (THC) in the SCC exhaust gas.

The kiln was lined with monolithic casting of Ultra Green 57 A, manufactured by A. P. Green. This refractory is an ultra-low cement, 57 percent alumina castable with an andalusite base for thermal shock resistance, and is suitable for temperatures up to 1650°C (3000°F). The casting was poured over a 2.54-cm thick (1 inch) layer of 1038°C (1900°F) insulating board to reduce heat flow to the steel shell and was secured to the kiln shell with stainless steel anchors. The casting included a dam 15.2 cm wide by 5.1 cm (6 inch by 2 inch) high on the feed end and a dam 10.2 cm wide by 2.5 cm (4 inch by 1 inch) high on the discharge end.

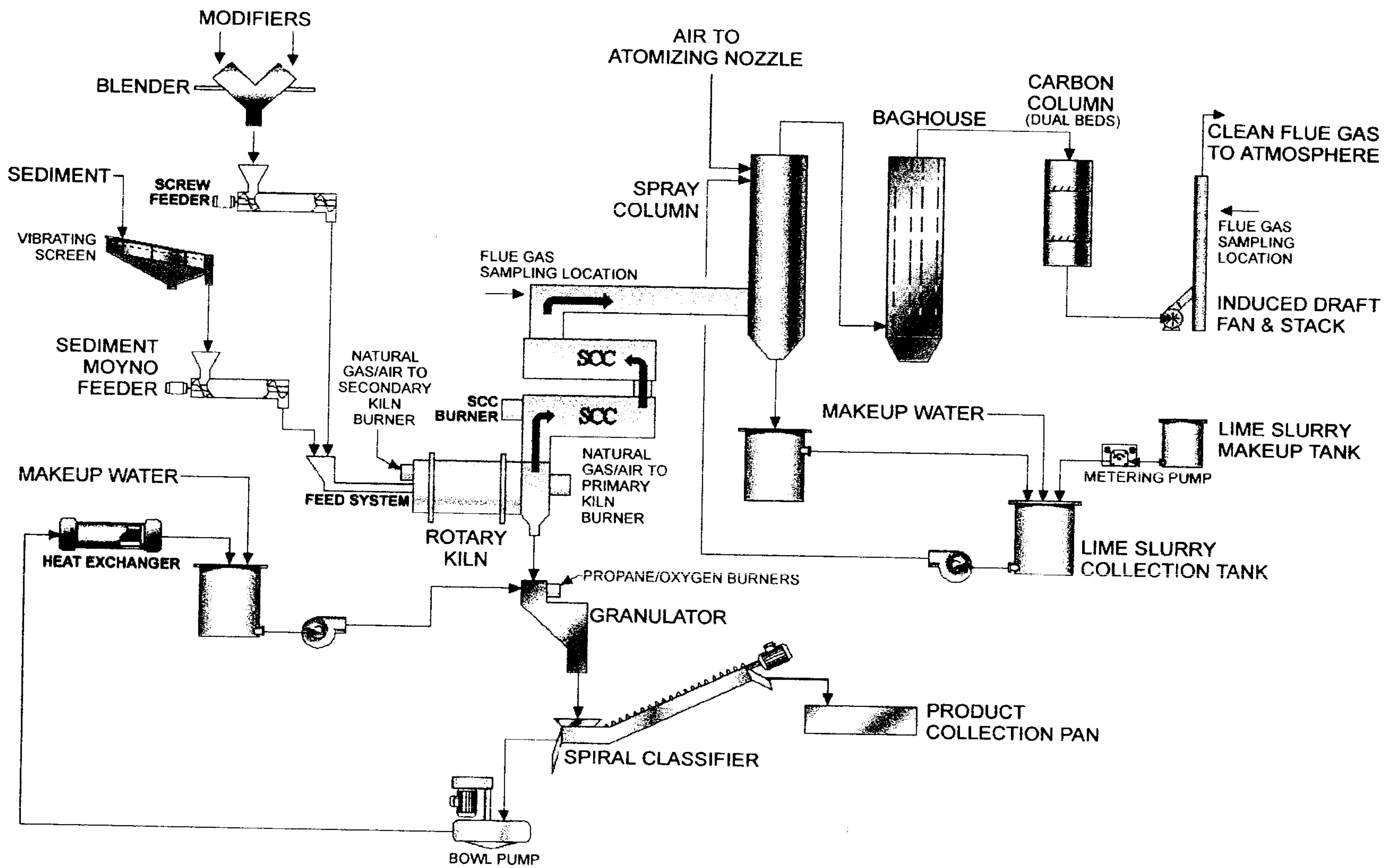

Figure 3. CEMENT-LOCK TECHNOLOGY PILOT PLANT PROCESS FLOW DIAGRAM

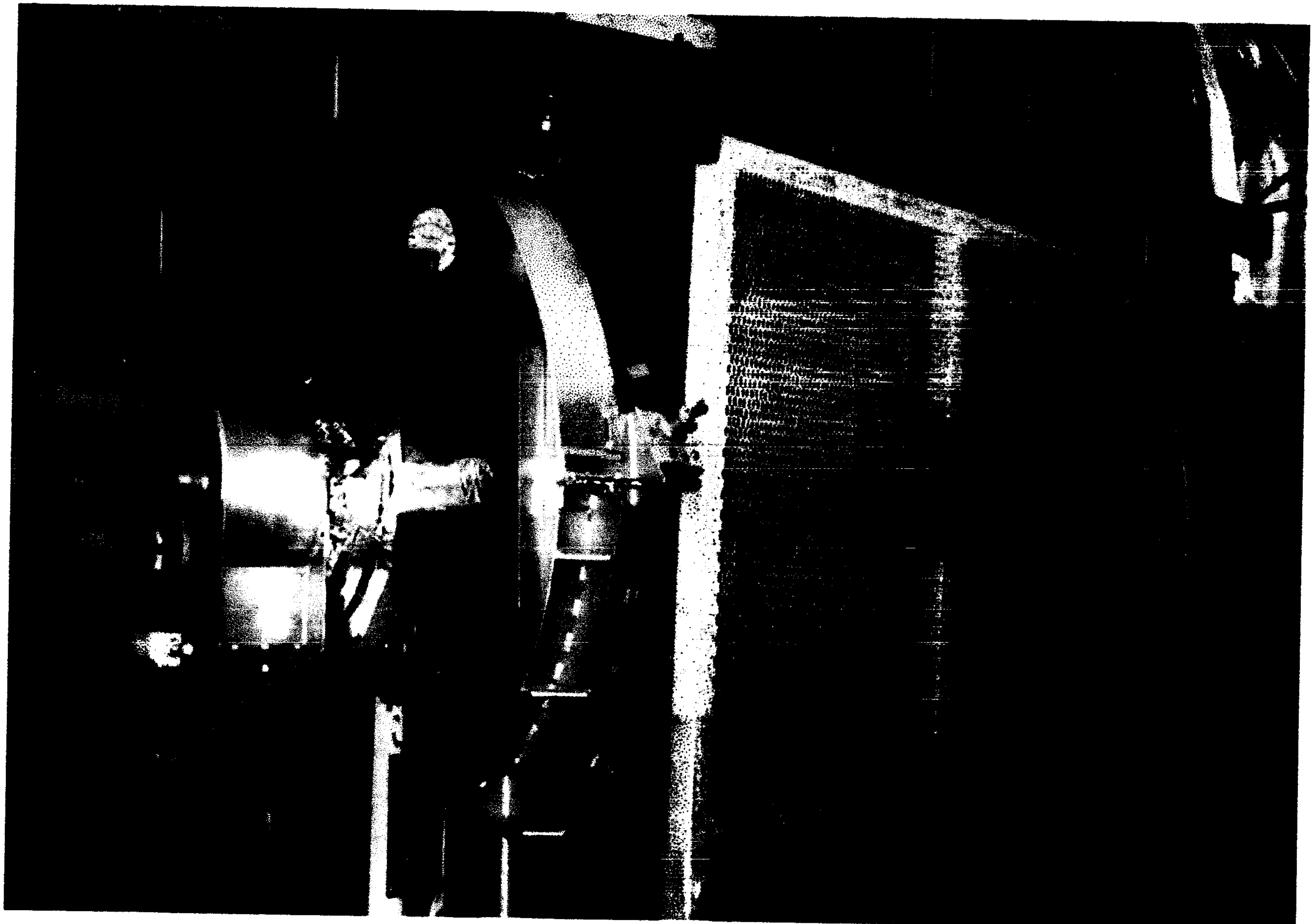

Figure 4. PHOTOGRAPH OF THE ROTARY KILN MELTER USED FOR CEMENT-LOCK PILOT-SCALE TESTS WITH ESTUARINE SEDIMENT

The kiln was heated using the primary natural-gas-fired burner located opposite the feed end. A secondary natural-gas-fired burner located above the kiln feeder was used to reach the temperatures needed to melt the sediment and modifiers in the kiln. The hot combustion gases generated by the burners were used to heat the dense refractory lining and the burden in the kiln. Combustion gases and volatile matter released from the material in the kiln entered the SCC. The SCC was heated with a natural-gas-fired burner located directly past the kiln exhaust.

Hot gases and entrained solids were quenched/cooled in a tower 53.3 cm (21 inches) in diameter by 2.29 m (7½ feet) in height. A recirculating lime solution was used to cool the gases in the quench tower. The pH of the solution was controlled by the addition of a lime slurry to the recirculating lime solution tank. The cooled gases at about 177°C (350°F) were filtered in a fabric-filter bag house with a total surface area of 17.1 m^2 (184 ft^2).

The clean gas was conveyed to a two-bed adsorption column, which is shown schematically in Figure 5. Gas flow through the adsorption column was downward. The beds were each 91.4 cm (3 feet) in diameter and 30.5 cm (1 foot) deep. The beds were supported with a 14-mesh stainless steel screen on top of 2.54-cm (1-inch) bar grating. The first bed contained pelletized Sorbalit® and the second bed contained American Norit R-1540 extruded activated-carbon pellets. The Sorbalit®, which was quite dusty, was placed upon a 2.5-cm (1-inch) layer of $^3/_8$-inch ceramic balls placed on top of the screen, to minimize dust penetration into the carbon bed. The gases were vented to the atmosphere with an induced-draft fan. A manually controlled damper was used to maintain the required pressures in the system.

Process gases generated during the Cement-Lock campaign were sampled at the SCC exhaust duct and analyzed continuously for O_2, CO_2, CO, SO_2, NOx, and total hydrocarbons (THC). The gas sample was filtered and cooled to remove entrained particulate matter and water vapor before the gas entered the analyzer. The THC analyzer received a filtered hot sample. The specific gas analyzers used in the continuous emission monitoring system (CEMS) for this program are given in Table 1. AirNova, Inc. (Pennsauken, NJ) performed flue gas sampling downstream from the SCC (designated as "afterburner" by AirNova) and at the flue gas vent downstream of the activated carbon adsorption column (designated as "outlet" by AirNova). See Figure 3 for the flue gas sampling locations. AirNova analyzed the samples for particulates, metals, dioxins, furans, semivolatile organic compounds (SVOCs), HCl, O_2, CO_2, SO_2, and NOx (discussed in a later section).

The sediment and modifiers were introduced into the kiln using a standard-pitch, variable-speed screw auger 15.2 cm (6 inches) in diameter and 1.52 m (5 feet) long. The screw flights were kept full of material during operation to prevent air infiltration into the kiln through the flights. The sediment was metered into the screw feeder hopper with a Robbins and Myers open-throat 2JS3 Moyno progressive cavity pump. In order to protect the pump, the sediment was screened to -6 mm (¼ inch) using a 45.7-cm (18-inch) vibrating Sweco screen that discharged directly into the throat of the Moyno progressive cavity pump. Tramp materials like wood, stone, and plastic were picked off the screen. The modifiers were pre-blended before metering into the screw feeder hopper, using a (10.2-cm 4-inch) standard-pitch screw feeder.

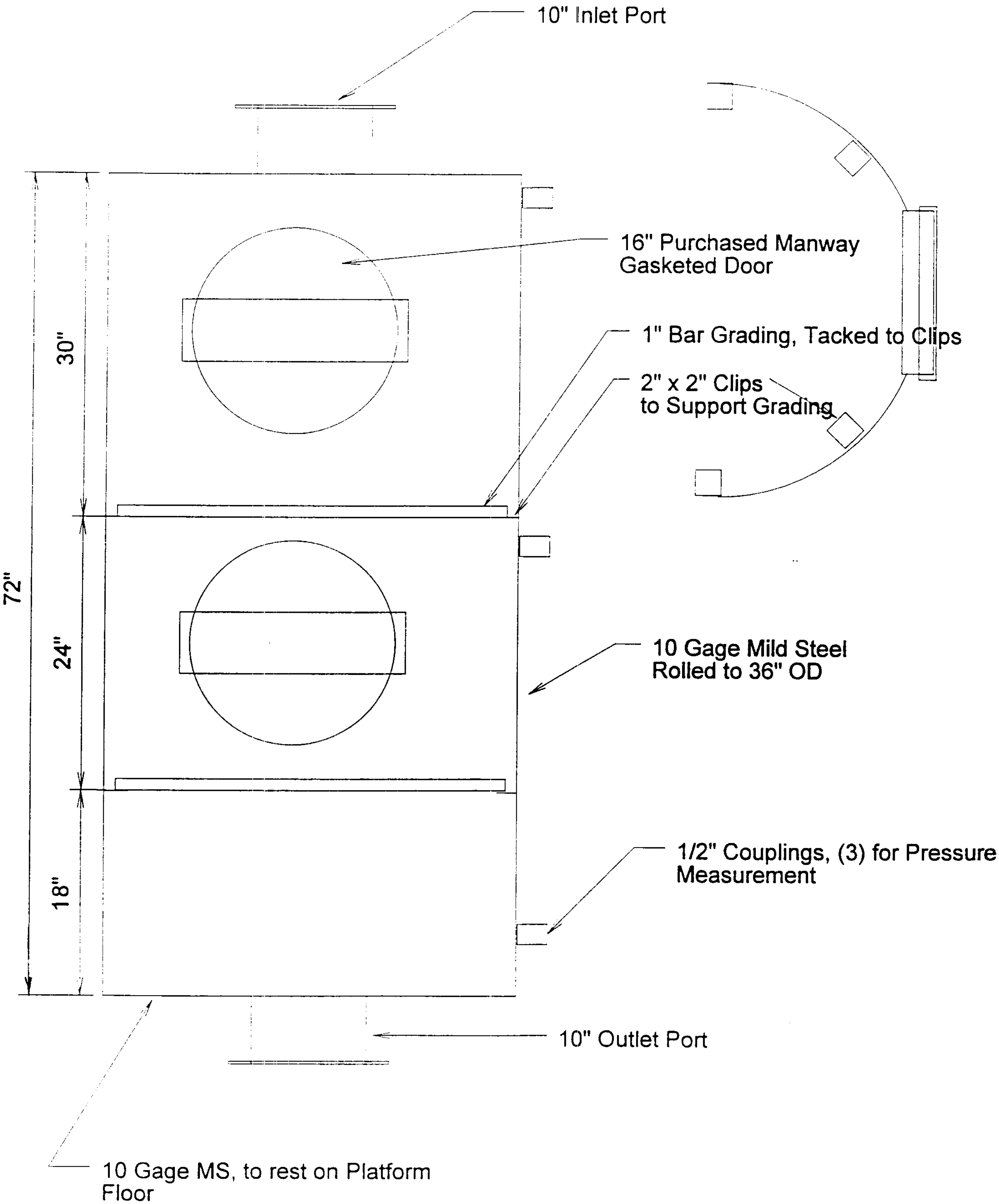

Figure 5. FIXED-BED CARBON ADSORPTION COLUMN FOR CEMENT-LOCK PILOT-SCALE TESTING

Table 1. CONTINUOUS EMISSION MONITORS USED DURING THE PILOT-SCALE CEMENT-LOCK CAMPAIGN

Component	Equipment	Range
Oxygen	Beckman Model 755	0 to 25%
Carbon Dioxide	Beckman Model 864	0 to 5% 0 to 25%
Carbon Monoxide	Beckman Model 864	0 to 500 ppm 0 to 5,000 ppm
Sulfur Dioxide	Beckman Model 865	0 to 1,000 ppm 0 to 2,500 ppm 0 to 5,000 ppm
Nitrogen Oxides	Beckman Model 951A	0 to 10 ppm 0 to 25 ppm 0 to 100 ppm 0 to 250 ppm 0 to 1,000 ppm 0 to 2,500 ppm 0 to 10,000 ppm
Total Hydrocarbons:	Thermo Environmental	0 to 100 ppm 0 to 1,000 ppm 0 to 10,000 ppm

A refractory-lined box, 45.7-cm (18 inches) long and with a 30.5-cm (12-inch) square inside opening, was placed between the kiln discharge and the quencher/granulator (Figure 6). Propane-oxygen burners were positioned inside the box to provide a heat shield between the kiln discharge and the water-quench granulator. These burners were used to prevent the molten Ecomelt from freezing before the slag reached the water sprays inside the granulator. The granulated product was collected in an open-trough inclined screw and conveyed onto a pan on the operation deck. The product discharge of the granulator was submerged in water to provide a seal that prevented ambient air from entering the kiln discharge. Two high-velocity water spray nozzles inside the granulator were used to quench and granulate the molten Ecomelt as it flowed from the kiln discharge. A ½-inch pipe with seven $^{3}/_{16}$-inch holes along one side was used to flood the sloped bottom of the granulator with additional water. The quench water overflowed the screw trough into a bowl pump. The water was cooled in a heat exchanger and recirculated continuously during the test. Makeup water was added as necessary.

Gas composition, kiln temperature, and two SCC temperatures were logged using a MOLYTEK data acquisition system. All other data were manually recorded hourly on data log sheets, and notes on operations and problems were recorded in an operations logbook. The log sheets are presented in Appendix A.

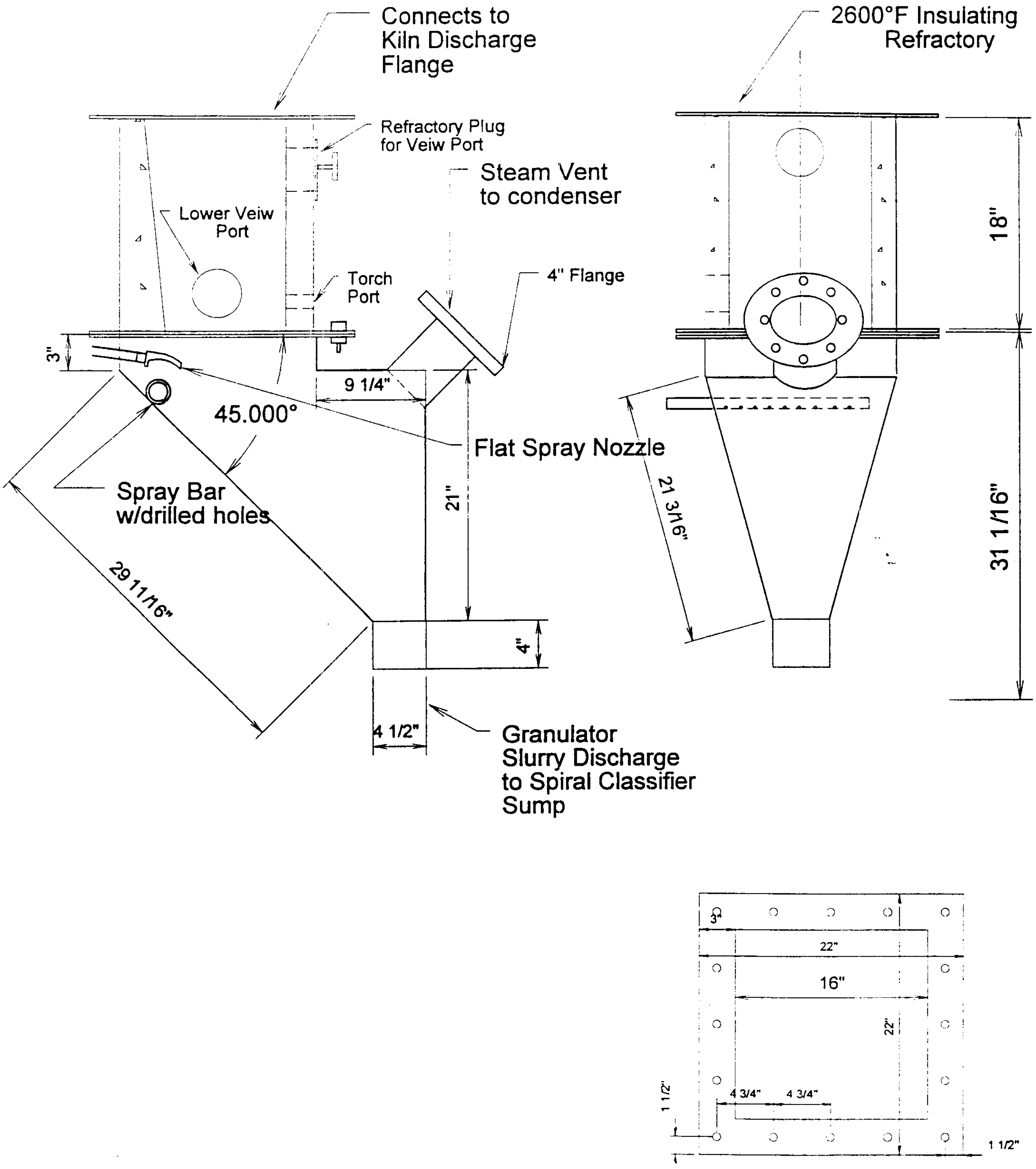

Figure 6. DESIGN OF THE TWO-FOOT RECTANGULAR
PILOT-PLANT KILN GRANULATOR

Initial Pilot Plant Modifications

Modifications to the existing pilot plant included installation of a fabric-filter bag house and an adsorption column downstream of the existing quench tower. Design drawings for the bag house and adsorption column were prepared by Hazen and sent to IGT for approval on October 8, 1996. Fabrication was started soon after approval was received.

The bag house design included a standard 16-bag pulse-jet, clean air plenum attached to a housing fabricated at Hazen. The housing included an access door (45.7 cm wide by 91.4 cm tall) for installing 2.44-m (8-feet) long by 14.3-cm ($5^5/_8$-inch) diameter bags and cages. Ten-inch-diameter inlet and outlet ports were provided to connect to the quench chamber outlet and absorption column inlet. The bag material was 29-ounce Huyglas™ fabric filter. The bags and cages were available on site; they have a maximum continuous operating temperature of 260°C (500°F) and excellent chemical resistance to acid gases. The bag house is shown schematically in Figure 7.

The absorption column vessel was 91.4 cm (3 feet) in diameter and 1.83 m (6 feet) tall. Two support gratings were welded on the inside of the vessel. Two 40.6-cm (16-inch) doors were provided for loading and unloading the adsorbent material. Gas flow was downward through the beds. 25-cm (10-inch) diameter inlet and outlet ports were provided to connect to the bag house outlet and draft fan inlet.

The design for the granulator was completed by Hazen on November 1, 1996 and approved by IGT. Fabrication of the granulator began soon after approval was received. Since additional vertical space would be required under the kiln discharge, a three-foot-deep pit was made by cutting the existing concrete pad, digging a hole, and pouring a new concrete floor and walls to support the kiln column loads. The original granulator design (not shown) proved to be inadequate and was replaced by the one presented previously in Figure 6.

The hot flue gas quench chamber had an existing air-atomizing spray nozzle. An additional spray bar that was added to the tower used two fine-mist hydraulic atomizing spray nozzles. These spray nozzles plugged quickly with lime particles early in the program and their use was discontinued. The original water spray system was used throughout the program.

Process Material Description

The as-dredged sediment was received at the Hazen Research facilities on September 23, 1996, in two 22-cubic-yard sealed roll-off containers. The sediment had been dredged from Newtown Creek estuary on September 17, 1996, and transported to Hazen by Nappi Trucking Corporation.

Very little freestanding liquid was observed on the surface of the sediment upon its arrival at Hazen in September. However, when the sample was uncovered again in November for the pilot-scale test campaign, some liquid was present on the surface. A backhoe shovel was used to first stir and homogenize the sample before the sediment was scooped into a one-cubic-yard hopper

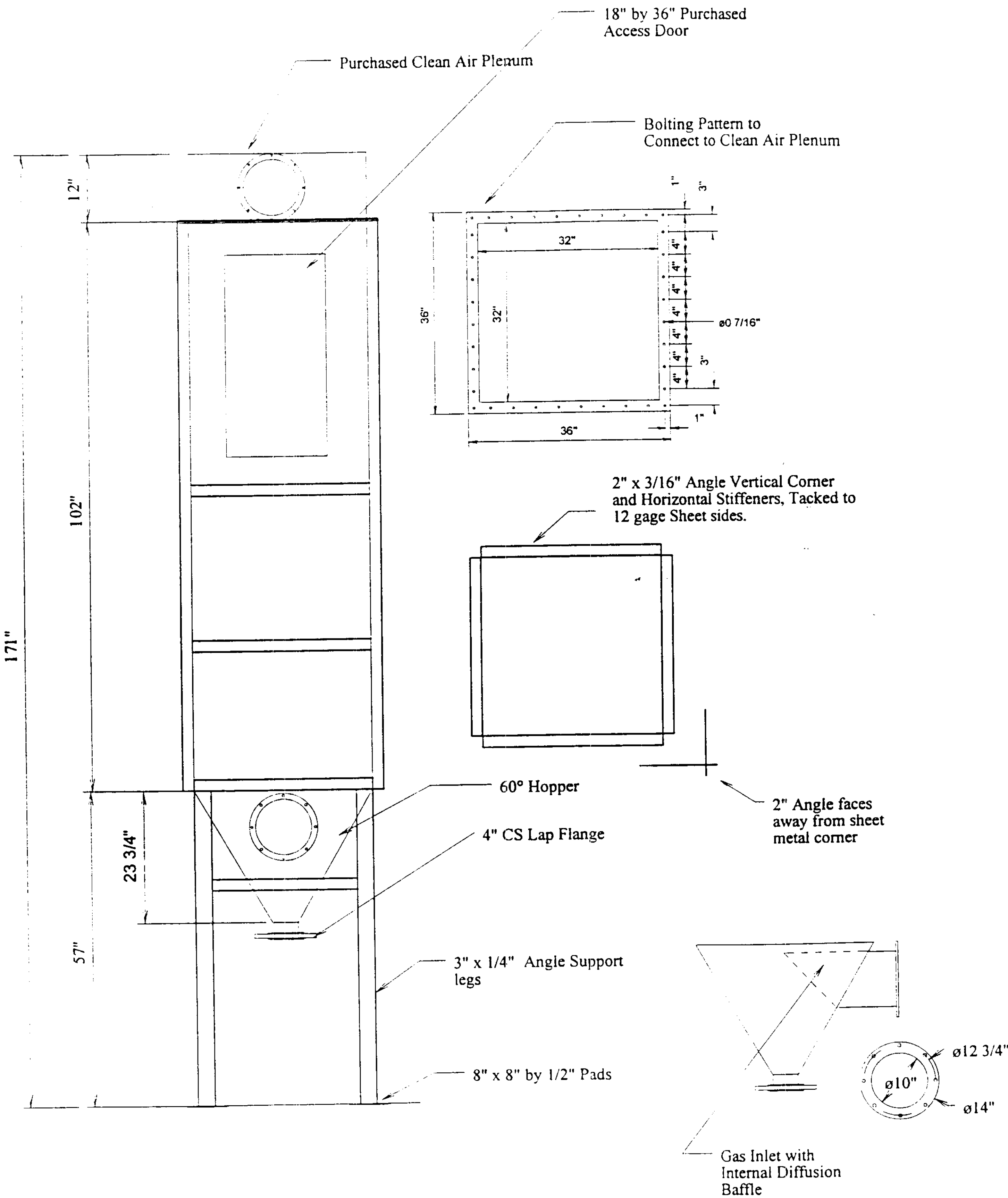

Figure 7. DESIGN OF THE BAG HOUSE FOR THE CEMENT-LOCK PILOT PLANT

for transport to the pilot plant site. The sample was a black mud with some lumps of grayish clay. Of approximately 2.3 cubic meters (3 cubic yards or 605 gallons) processed during the pilot plant operation, less than about one half (½) of a 55-gallon drum was collected as oversize material. Six representative samples were taken by Hazen from three areas in both of the two containers on September 24, 1996, and delivered to IGT for analysis prior to the start of the pilot plant work.

Modifier 1 was sized at 40 by 140 mesh and was received in 50-pound paper bags from Colorado Lien Company. Modifier 2 was sized at 28 by 200 mesh and was also received in 50-pound bags. All-purpose type N hydrated lime (95% minus 325 mesh) was also received in 50-pound bags. Six 55.1-pound bags of Norit R1540 extruded activated-carbon pellets 4 millimeters (mm) in diameter and 8 to 12 mm long, were received from Norit Americas, Inc. The Sorbalit®, nominally 4 mm pellets, was received in two 55-gallon plastic barrels. The Sorbalit® pellets, however, ranged in size from about 8 mm to dust. Flux was received during the shakedown period from Seaforth Mineral and Ore, Inc. as a fine powder (minus 50 mesh) in 50-pound bags.

The types and quantities of modifiers are proprietary to the Cement-Lock™ Technology. However, the modifiers are inexpensive materials that are used in conventional cement manufacturing.

Pilot Plant Testing

The Cement-Lock pilot-scale test program was conducted from October 1 through November 30, 1996. During that time, the existing pilot-scale equipment was modified to the Cement-Lock configuration. The modified system was tested to confirm its operability. During subsequent pilot-plant operations, raw dredged sediment was fed to the rotary kiln melter at a nominal rate of 45.4 kg/hr (100 lb/hr) with the required rate of modifiers. As mentioned above, about 2.3 cubic meters (3 cubic yards or 605 gallons) of dredged sediment from the Newtown Creek estuary in New York were processed through the unit during the campaign. Also during the testing, samples of raw sediment, modifiers, Ecomelt, quench water, bag house solids, etc. were collected for subsequent analysis by BNL.

The operating conditions and some of the results of the pilot-scale campaign are presented in Table 2. The data in the table includes the average, high, and low values of sediment and modifier feed rates, Ecomelt production rate, kiln temperatures, air and natural gas flow rates, and system pressures. The flow rate of raw sediment to the kiln was held constant at 45.4 kg (100 lb/h) per hour. The temperature in the kiln averaged 1327°C (2420°F) during the test.

The major component analyses (O_2, CO_2, CO, NOx, THC) of the flue gas at the exhaust of the secondary combustion chamber (SCC) are also presented. These data were from the existing CEMS at Hazen. As indicated in Table 2, some of the flue gas data were from the analyses performed by AirNova during the test. However, the AirNova data are from the exit of the pilot-plant system after the quencher, bag house, and activated carbon beds.

Major oxide analysis of some of the products and materials from the rotary kiln showed that some variations in sediment composition occurred during the test that may have affected the melting temperature of the material. Closer control of the flow rate of modifiers and flux to the melter should facilitate subsequent production-scale Cement-Lock testing and insure consistent product quality.

After the test was terminated, the kiln was operated to remove the molten material that remained in the system. This material was collected and shipped to IGT for ultimate disposition. All of the samples collected during the test campaign were shipped to IGT for distribution to BNL and CTL as specified in the sampling protocol.

Table 2. SUMMARY OF OPERATING CONDITIONS DURING THE CEMENT-LOCK PILOT-SCALE CAMPAIGN

Kiln Parameter	Average	High	Low
Sediment Feed Rate, lb/hr	100	100	95
Modifier Feed Rate, lb/hr	28	41.5	20.5
Ecomelt Product, lb/hr	28.6	80	3
Kiln Rotation, rpm	0.54	0.6	0.4
Slope, ft/ft	0.0234	0.0234	0.0234
Retention Time, min	49	66	44
Temperature, °F			
Kiln Bed (Optical)	2420	2440	2385
Kiln Outlet	2390	2425	2350
SCC, First Section	2340	2440	2190
SCC, Outlet	2005	2090	1860
Precooler Outlet	210	260	190
Bag House Inlet	355	370	340
Adsorption Column	310	330	290
Gas Flows, scfm			
Air to Primary Kiln	86	157	67
Secondary Kiln	77	87	75
SCC	51	72	46
Natural Gas to Primary Kiln	12	17	8.3
Secondary Kiln	4.5	4.5	4.3
SCC	6.2	6.6	4.4
Pressures, inches w.c.			
Kiln	-0.03	-0.08	-0.01
Precooler Inlet	-0.37	-0.45	-0.28
Precooler Outlet	-0.58	-0.80	-0.40
Bag House Inlet	-0.88	-1.00	-0.50
Bag House Differential	10.2	14.9	5.0
Sorbalit™ Bed	7.1	8.1	5.9
Activated Carbon Bed	1.4	2.9	0.5
SCC Exhaust Gas Composition (Hazen)			
O_2, %	2.5	4.3	2.0
CO_2, % (corrected to 7% O_2)	8.8	10.9	7.9
CO, ppm (corrected to 7% O_2)	24	71	8
NOx, ppm (corrected to 7% O_2)	71	94	51
THC, ppm (corrected to 7% O_2)	10.6	16	7
Outlet Flue Gas Composition (AirNova)			
SO_2, ppm (corrected to 7% O_2)	44.1	--	--
NOx, ppm (corrected to 7% O_2)	67.5	--	--
HCl, ppm (corrected to 7% O_2)	14.2	--	--

DISCUSSION OF PILOT-SCALE TEST RESULTS

The Cement-Lock pilot-scale test campaign extended through nearly 40 hours of integrated operation during which time as-received dredged sediment containing about 60 weight percent water (screened to -6 mm) was fed directly to the rotary kiln melter at 45.4 kg per hour (100 lb/h) with appropriate modifiers. The melt produced was effectively quenched/cooled with water that was recirculated within a closed loop. The Ecomelt™ product was subsequently finely ground by Construction Technology Laboratories, Inc. The ground Ecomelt was then converted to construction-grade cement. Overall, the Cement-Lock pilot-scale studies confirmed the results of bench-scale tests and demonstrated the flexibility and robustness of the technology for decontaminating dredged sediments at the next stage of development.

One of the significant achievements of the campaign was the successful operation of the system without predrying the sediment as was originally planned in the Holoflite dryer. As described in one of the previous sections, the Holoflite dryer was removed from the system when it became inoperative due to plugging by dried sediments.

Sampling Protocol

A detailed sampling protocol was established by BNL and a number of collaborating universities and carried out by IGT personnel during the pilot-scale studies. Samples collected were logged in as required by the protocol and sent to BNL for chemical analysis. For EPA-certified analysis, BNL subcontracted Triangle Laboratories, Inc. (Durham, NC) to analyze the samples taken for specific elements and compounds. BNL also subcontracted AirNova, Inc. (Pennsauken, NJ) to conduct flue gas sampling and analysis during pilot plant operations. The overall objective of the sampling protocol was to ensure that the solid, liquid, and gaseous samples taken during the pilot-scale studies were of high quality and would be useful for process evaluation.

The following categories of samples were collected during the Phase II - Cement-Lock Pilot-Scale Studies -

- Modifiers: discrete samples
- Activated carbon: (raw, unused) sample
- Activated carbon (used): riffled sample
- Sorbalit™ (raw, unused): riffled sample
- Sorbalit (used): riffled sample
- Raw sediment from the bulk container: discrete and composite samples
- Ecomelt (intermediate) product: discrete and composite samples
- Construction-grade cement product: discrete and composite samples
- Bag house collection: chronological samples

A complete list of samples collected with relevant information is presented in Appendix B. Flue gas samples were taken by AirNova, Inc. at the exit of the secondary combustion chamber (SCC, designated as "afterburner" by AirNova) and at the exit of the pilot-scale system in the vent (downstream of the I.D. fan, designated as "outlet" by AirNova).

A total of 34 samples were shipped to BNL for analysis. Chain-of-custody protocols were followed to ensure that the samples sent were properly labeled and identified. Three bulk samples of Ecomelt were shipped to CTL. The remaining samples were stored at IGT facilities.

Chemical Analysis

Some of the samples shipped to BNL were ultimately shipped to Triangle Laboratories, Inc. for specific chemical analysis. BNL specified which analytes and which samples would be analyzed in detail. BNL budget limitations precluded all of the samples from being analyzed in detail. The following discussion includes the summary of chemical analysis of the raw dredged sediment, the Ecomelt product, and the construction-grade cement product.

Some of the physical and chemical properties of the raw dredged sediment are included in Table 3. The sample designations refer to the samples taken during the pilot-scale testing as summarized in Appendix B. They include two 5-gallon samples of as-dredged sediment (No. 37 and 38) taken from the 22-cubic yard roll-off container, one 5-gallon sample (No. 9) composited over a several-hour period during testing, and two discreet one-gallon samples (No. 10 and 11) taken during the compositing interval. These analyses were conducted by Triangle Laboratories, Inc. for BNL and are included here for completeness.

The data in the table indicate that the sediment is very fine with 70 or more percent of the sediment in the silt and clay categories. The pH was in the narrow range of 7.25 to 7.84. The solids content of the sediment ranged from 36.9 to 53.6 weight percent (conversely, the water content ranged from 63.1 to 46.4 wt %). The sulfide content ranged from 3,300 to 6,500 mg/kg (dry basis). The total organic carbon in the sediment ranged from 3.16 to 8.67 weight percent. The TPH (Total Petroleum Hydrocarbons) ranged from 3,960 to 16,100 mg/kg (dry basis). Overall, the data show that there is considerable variability in the sediment composition.

Samples of the raw dredged sediment were also analyzed for semi-volatile aromatic hydrocarbons (SVOCs), polychlorinated biphenyls (PCBs), and chlorinated dioxins and furans. A summary of the organic contaminants present in the Newtown Creek estuary sediment is included in Table 4. Table 4 also includes organic contamination present in the bench-scale sediment sample, the organic contaminants present in the construction-grade cement product, and the Destruction and Removal Efficiency (DRE) achieved as a result of Cement-Lock processing.

The SVOCs present in the bench-scale and pilot-scale sediment samples were 116 and 370 mg/kg (dry basis), respectively. Three samples of sediment were analyzed from the pilot-scale tests for organic as well as inorganic contaminants. The results showed that the types and concentrations of organic compounds and metals present vary considerably. For example, benzoic acid was detected in raw sediment Sample No. 9 at 489 μg/kg, while the other two raw sediment samples (No. 37 and 38) were below detection limit for this compound. Acenaphthene was present in Samples No. 37 and 38 at 9,923 and 10,628 μg/kg, respectively, but only 591 μg/kg in Sample No. 9.

Table 3. SUMMARY OF PHYSICO-CHEMICAL PROPERTIES OF RAW DREDGED ESTUARINE SEDIMENT FROM NEWTOWN CREEK

Sample Designation		IGT-37 As Dredged Sediment	IGT-38 As Dredged Sediment	IGT-9 Raw Feed Composite	IGT-10 Raw Feed #1	IGT-11 Raw Feed #2
Particle size, wt % (dry basis)						
Medium gravel	(> 4.75 mm)	11.03	2.77	0.00	0.00	0.00
Fine gravel	(2 - 4.75 mm)	2.54	0.24	0.90	2.37	0.44
Very coarse sand	(0.85 - 2 mm)	1.78	1.51	0.79	1.61	1.50
Coarse sand	(0.425 - 0.85 mm)	3.21	3.50	1.66	3.72	4.08
Medium sand	(0.24 - 0.425 mm)	5.03	5.82	3.48	5.76	6.83
Fine sand	(106 - 240 μm)	9.38	10.55	5.59	10.18	11.31
Very fine sand	(75 - 106 μm)	2.84	2.86	2.25	2.74	2.74
Clay		28.23	30.75	38.68	33.27	33.82
Silt		35.96	42.00	46.65	40.35	39.28
		100.00	100.00	100.00	100.00	100.00
pH		7.25	7.84	7.43	7.45	7.34
Total Solids, wt % (dry basis)		44.6	36.9	53.6	46.6	47.7
Total Sulfides, mg/kg (dry basis)		5,900	6,170	3,300	4,900	6,500
Total Organic Carbon, wt % (dry basis)		7.50	8.67	3.16	4.80	5.83
TPH (Total Petroleum Hydrocarbons), mg/kg (dry basis)		16,100	15,200	3,960	7,000	6,430

Table 4. SUMMARY OF ORGANIC CONTAMINANTS IN DREDGED NEWTOWN CREEK SEDIMENT, CEMENT-LOCK CEMENT PRODUCTS, AND DESTRUCTION AND REMOVAL EFFICIENCIES FOR LAB- AND PILOT-SCALE TESTS

	Untreated Sediment		Cement-Lock Cement		DRE*	
Contaminant	Lab-Scale	Pilot-Scale	Lab-Scale	Pilot-Scale	Lab-Scale	Pilot-Scale
	mg/kg (dry)				%	
SVOCs	116	370	0.3	0.22	99.24	99.93
	μg/kg (dry)					
PCBs	5,270	8,585	0.75	< D.L.**	> 99.96	> 99.99
	ng/kg (dry)					
2,3,7,8-TCDD/TCDF	381	262	< D.L.	< D.L.	> 99.99	> 99.99
TEF Basis	--	*46.5*	--	*< 0.396*	--	*> 99.14*
Total TCDD/F	2,620	2,871	< D.L.	< D.L.	> 99.99	> 99.99
TEF Basis	--	*5.0*	--	*< 0.00397*	--	*> 99.92*
Total PeCDD/F	3,231	4,363	< D.L.	< D.L.	> 99.99	> 99.99
TEF Basis	--	*5.6*	--	*< 0.0034*	--	*> 99.94*
Total Hx/Hp/OCDD/F	38,945	34,252	18	< 29	99.88	> 99.90
TEF Basis	--	*4.8*	--	*< 0.0036*	--	*> 99.93*

* Destruction and removal efficiency.

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

The levels of PCBs were 5,270 and 8,585 μg/kg, respectively, in the bench-scale and pilot-scale program samples. Of the three sediment samples analyzed for PCBs, two (No. 37 and 38) had PCB concentrations that were fairly close. The PCB concentrations in Sample No. 9 were about one half those of Sample No. 37 and 38.

For the three samples of Ecomelt tested for PCBs, all were below detection limits for all PCB congeners. The detection limits for the mono, di, tri, and tetra congeners were 0.1 to 0.3 μg/kg. The detection limits for the penta, hexa, hepta, and octa congeners were 0.3 to 0.6 μg/kg. The detection limits for the nona and deca congeners were 0.8 or 1.0 μg/kg.

The total of the most toxic congeners of dioxin [2,3,7,8-dibenzo(p)dioxin] and furan [2,3,7,8-dibenzo(p)furan] were present in the bench-scale and pilot-scale sediment samples at 381 and 262 ng/kg, respectively. The totals of pentachloro dioxins and furans (PeCDD/F) were 3,231 and 4,363 ng/kg, respectively. The totals of hexa, hepta, and octachloro dioxin and furans (Hx, Hp, and OCDD/F) were 38,945 and 34,252 ng/kg, respectively. The relative concentrations of dioxins and furans in sediment Sample No. 37 and 38 were fairly close. The concentrations of dioxins and furans in sediment Sample No. 9 were about one-half to one-third those of Sample No. 37 and 38.

The Destruction and Removal Efficiencies (DRE) for the organic contaminants are based on the quantity of organic compounds present in the sediment before Cement-Lock processing compared to the quantity of organic compounds present in the construction-grade cement or Ecomelt after Cement-Lock processing. The component analyses conducted by Triangle Laboratories and provided by BNL do not always allow for straightforward calculations of DRE.

For example, in the three samples of Ecomelt (No. 13, 14, and 15) analyzed for octachloro dibenzo(p)dioxin, one sample showed 45.6 ng/kg, while the other two samples were non-detect at detection limits of 4.8 and 2.6 ng/kg, respectively. If the average of the three analyses is used, employing the detection limit as the conservative value for the two non-detect samples, the DRE calculation for Hx,Hp,OCDD/F yields >99.90 percent (see Table 4). If the single value is used, the DRE calculation yields 99.78 percent.

On a TEF basis, the destruction and removal efficiencies for the polychlorinated dibenzo dioxins and furans consistently exceed 99 percent, with some DREs exceeding 99.9 percent.

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 percent have been achieved for compounds in both the lab-scale and pilot-scale testing. It is expected that organic compound DREs in excess of 99.99 percent will be consistently achieved in the demonstration-scale Cement-Lock plant that will be built and operated in Phase III. Organic compounds will be subjected to the extreme thermal conditions that exist in the melter (Ecomelt Generator). Further, any organic compounds that somehow elude the Ecomelt Generator will be subjected to 2 seconds residence time at elevated temperature (>1204°C [2200°F]) in the secondary combustion chamber (SCC). This is a process requirement for 99.9999 percent (6-9s) destruction of PCBs.

The chemical analyses of process samples performed by Triangle Laboratories are included in Appendix C.

Flue Gas/Stack Sampling

During the pilot plant campaign, AirNova, Inc., under subcontract to BNL, sampled the flue gas from the kiln to characterize the effluent. Samples were taken from two locations:

- **First Sample** - downstream of the Secondary Combustion Chamber (SCC), but upstream of the lime slurry quench (hot sample, designated by AirNova as "afterburner")
- **Second Sample** - downstream of the activated carbon/Sorbalit™ bed in the flue gas vent (cold sample, designated by AirNova as "outlet")

Refer to Figure 3 for the flue gas sampling locations in the Cement-Lock pilot plant. After the sampling was completed, AirNova also conducted the detailed analyses of the samples collected. AirNova noted several limitations to the quality of the samples taken in their report to BNL:

"A single test run was conducted in determination of each emission parameter with the exception of particle size, sulfur dioxide and nitrogen oxides. Two (2) test runs were conducted in determination of particle size at the system outlet in lieu of conducting one test run at each location as the exhaust gas temperature at the afterburner outlet precluded sampling at this point. Sampling was not performed simultaneously in determination of each parameter at the two test locations.

Any individual measurement, or sample, made to determine a true value will incorporate both random and systematic error. Systematic error is addressed by careful and documented calibration and operation of the measurement equipment. Random errors are normally distributed around a mean or true value and are addressed statistically in terms of probability. For this reason, the collection and analysis of stack gas samples is usually performed in triplicate. Triplicate determinations provide a minimum statistical basis for evaluating the representativeness of a result. As noted, in the determination of nearly all emission parameters conducted as part of this program, only one test run was performed. The validity of this data cannot be rejected as a result however, but must be evaluated in terms of statistical validity."

The emission data collected by AirNova during the pilot-scale Cement-Lock campaign with dredged sediment are summarized in Table 5. The data are not the average value over the entire pilot plant campaign, but rather the value measured during specific sampling periods. Further, the data have been adjusted by IGT to an oxygen concentration in the flue gas of 7 volume percent, which is the appropriate value for high-temperature thermal treatment systems.

Table 5. AIR EMISSION DATA FROM THE CEMENT-LOCK PILOT PLANT CAMPAIGN

Flue Gas Composition	Afterburner (SCC)	Outlet (Vent)
O_2, mol %	3.2 – 3.5	3.0 – 3.8
CO_2, mol %	10.1 – 10.8	10.1 – 10.8
HCl, ppm* (lb/hour)	149.6 – (0.33)	14.2 – (0.04)
NOx, ppm* (lb/hour)	63.0 – (0.20)	67.5 – (0.23)
SO_2, ppm* (lb/hour)	92.8 – (0.41)	44.1 – (0.21)
	------------ lb/hour	------------
PCBs	$< 9.2 \times 10^{-7}$	$< 1.1 \times 10^{-6}$
Pesticides	$< 1.9 \times 10^{-7}$	$< 2.1 \times 10^{-7}$
Chlorobenzenes/Chlorophenols	$< 5.8 \times 10^{-5}$	$< 6.8 \times 10^{-5}$
SVOCs	BDL**	BDL**
Total 2,3,7,8-CDDs (TEF)***	$< 8.6 \times 10^{-12}$	$< 4.0 \times 10^{-12}$
Total 2,3,7,8-CDFs (TEF)	1.0×10^{-11}	$< 8.1 \times 10^{-12}$
Particulates, grains/dscf	5.3×10^{-2}	$< 4.9 \times 10^{-5}$
grams/hour	63.5	< 0.09
Particulate Phase Composition		
PCBs	$< 4.6 \times 10^{-7}$	$< 5.3 \times 10^{-7}$
Total 2,3,7,8-CDDs (TEF)	$< 7.0 \times 10^{-12}$	$< 8.0 \times 10^{-12}$
Total 2,3,7,8-CDFs (TEF)	$< 7.8 \times 10^{-13}$	$< 7.3 \times 10^{-13}$
Particulate Size, µm	NA+	0 - 1.5

* Dry basis, adjusted to 7 volume percent oxygen in flue gas

** Below the detection limit of the analytical procedure used. Minute quantities of phenol and diethylphthalates were detected in samples.

*** Toxicity Equivalency Factor.

\+ Not analyzed.

The concentrations of HCl, NOx, and SO_2 in the flue gas from the SCC (afterburner) were 149.6, 63.0, and 92.8 ppm, respectively (adjusted to 7 mol % O_2). These concentrations represent mass flow rates of the individual species of 0.33, 0.20, and 0.41 pounds per hour, respectively. The O_2 and CO_2 concentrations ranged from 3.2 to 3.5 and 10.1 to 10.8 mol %, respectively. Particulates in the SCC flue gas were 63.5 grams per hour (0.14 lb/hr).

The concentrations of HCl, NOx, and SO_2 in the flue gas outlet were 14.2, 67.5, and 44.1 ppm, respectively (adjusted to 7 mol % O_2). These concentrations represent mass flow rates of the individual species of 0.04, 0.23, and 0.21 pounds per hour, respectively. The O_2 and CO_2 concentrations ranged from 3.0 to 3.8 and 10.1 to 10.8 mol %, respectively. Particulates in the flue gas were below the analytical detection limit of < 0.09 g/hour (< 2.0×10^{-4} lb/hr). Of the minute quantity of particulates captured during sampling, all were less than 1.5 μm in size.

Analyses of the flue gas at the outlet for polychlorinated biphenyls (PCBs), chlorophenols, chlorobenzenes, and pesticides were below detection limits. The values presented in the table are based on the summation of the detection limits for the individual species.

Regarding SVOC air emissions, minute quantities of phenol and diethylphthalate were detected in the flue gas samples from the afterburner (SCC) and the outlet.

On a Toxicity Equivalency Factor (TEF) basis, the quantities of dioxins and furans in the afterburner flue gas samples were < 8.6×10^{-12} and 1.0×10^{-11} lb/hr, respectively. In the afterburner particulate phase samples, the quantities of dioxins and furans were < 7.0×10^{-12} and < 7.8×10^{-13} lb/hr, respectively. In the outlet gas phase samples, the quantities of dioxins and furans were < 4.0×10^{-12} and < 8.1×10^{-11} lb/hr, respectively. In the outlet particulate phase samples, the quantities of dioxins and furans were < 8.0×10^{-12} and < 7.3×10^{-13} lb/hr, respectively.

Some metals were detected at very low levels in both the particulate phase and the gas phase from the outlet sampling location. In the particulate phase, Sb, As, Cr, Cu, Pb, Ni, and Zn were detected at 0.28, 0.76, 1.99, 5.97, 1.63, 1.59, and 29.4 μg/dscm, respectively. In the gas phase, As, Cu, Hg, and Se were detected at 0.24, 1.19, 7.12, and 1.19 μg/dscm, respectively. In the particulate phase, sodium was detected at 374 μg/dscm. Sodium is volatilized from the seawater as NaCl present in the estuarine sediment. In terms of enhancing the mitigation of metallic emissions from the process, the performance of both the scrubber and bag house will be improved for the next scale of operation.

The results of chemical analyses performed on flue gas samples by AirNova are included in Appendix D.

A preliminary sulfur balance was performed around the Cement-Lock pilot plant to estimate the fate of the sulfur present in the raw sediment. The sulfur contents of several samples of raw sediment were determined by Triangle Laboratories (see Table 3 and Appendix C). The average sulfur content was about 0.57 weight percent. Based on this sulfur analysis, the sulfur appearing in the flue gas at the stack represents about 50 percent of the sulfur fed. About 1 percent appeared in the particulates. The balance of the sulfur, about 49 percent, is assumed to be in the form of $CaSO_3$ which was collected by the bag house.

This sulfur capture efficiency of 50 percent is considered to be low for typical lime injection processes. For the next scale of operation, the sulfur collection efficiency will to be significantly higher. A vendor of sulfur capture equipment has quoted 85 percent sulfur capture efficiency for a lime injection system that will be employed in the next scale of operation.

Leachability Tests

Samples of the construction-grade cement powder from both the bench-scale and pilot-scale test programs were subjected to the EPA Toxicity Characteristic Leaching Procedure (TCLP) test to determine metals leachability.

In the TCLP test, 100 grams of subject material is crushed to -¼ inch and leached for 18 (+2/-0) hours in 2 liters of buffered acidic solution. The sample is filtered through 0.45-µm filter paper and the leachate is analyzed for specific metals and organic compounds. If the concentration of any metal or organic compound exceeds the regulatory limit, the material is classified as a characteristic waste according to the Resource Conservation and Recovery Act (RCRA). It must be disposed of as a hazardous waste.

The results of the TCLP tests on samples of construction-grade cement are presented in Table 6. The results are considered to be fairly conservative, since the cement is in finely divided powder form, whereas the TCLP size requirement is a nominal -¼ inch. The results show that none of the priority metals leach above the regulatory limits. Further, only chromium was present in the leachate above the analytical detection limit. In the cement sample from the pilot-scale test, the chromium leached at 0.15 mg/L (the TCLP regulatory limit for Cr is 5.0 mg/L). In the cement sample from the lab-scale test, chromium leached at 0.2 mg/L. This difference is an artifact of the analytical procedure and is not considered significant. The analytical detection limits for the pilot-scale TCLP samples were significantly lower than those for the lab-scale samples.

It should be noted that when the Cement-Lock cement is combined with water, sand, and aggregate to make concrete, the metals leachability would be even lower. The metals are then doubly "locked" within the concrete matrix.

Compressive Strength Tests

Construction-grade cement from the pilot-scale tests was produced according to the ASTM (American Society for Testing and Materials) specifications. A bulk sample of Ecomelt from the melter is first dried and then finely ground. The ground Ecomelt is then combined with another ingredient (hydrated lime, for example) in the ratio of 40 percent Ecomelt and 60 percent additive to yield Cement-Lock cement. According to the ASTM specification, the ratio of Ecomelt to other ingredient can range from 15 to 40 weight percent.

Table 6. COMPARISON OF TCLP RESULTS ON SAMPLES OF CEMENT-LOCK CEMENT PRODUCED FROM LAB- AND PILOT-SCALE TESTS WITH ESTUARINE SEDIMENT

	Untreated Sediment		TCLP*		
			Cement-Lock Cement		Regulatory
Metal	Lab-Scale	Pilot-Scale	Lab-Scale	Pilot-Scale	Limit
	------ mg/kg (dry) ------		------------------ mg/L ------------------		
Arsenic	33	39	< 0.1**	< 0.005	5
Barium	--	--	< 0.5	--	100
Cadmium	37	27	< 0.01	< 0.001	1
Chromium	377	298	0.2	0.15	5
Lead	617	542	< 0.05	< 0.002	5
Mercury	1.3	2.9	< 0.001	< 0.0004	0.2
Selenium	<3.2	6.2	< 0.1	< 0.003	1
Silver	18	13	< 0.01	< 0.001	5

* Toxicity Characteristic Leaching Procedure.
** Less than the detection limit of the analytical procedure used.
*** TCLP on raw dredged sediment seldom exceed the regulatory limits

The compressive strength of the samples of cements produced from both the lab-scale and pilot-scale test programs were also determined according to ASTM standard methods. The tests were conducted by CTL under a subcontract to IGT.

In the ASTM compressive strength test, several 2-inch cubes of mortar are made from the cement being evaluated. The ASTM recipe calls for the following relative quantities of cement, water, and Ottawa sand to be blended together:

- Cement 1
- Water 0.484
- Ottawa sand 2.75

by weight, respectively. The cement/water/sand mixture is blended in a specific blender for specific times at specific rates. The mortar is then packed into 2-inch cube forms and cured for 3, 7, and 28 days. After each curing period, at least 3 mortar cubes are sacrificed to determine their compressive strength. The average of the 3 compressive strength tests is reported.

The results of the compressive strength tests with construction-grade cement made from the bench-scale and pilot-scale tests are presented in Table 7. The compressive strengths of the cement samples after 3, 7, and 28 days of curing were 15.4, 19.9, and 36.3 MPa (2230, 2885, and 5270 psi), respectively. The corresponding requirements for portland cement (ASTM C 150) are 13.0, 19.9, and 28.0 MPa (1890, 2890, and 4060 psi), respectively. These results were achieved without the use of accelerators or performance enhancers, such as gypsum.

Table 7. COMPARISON OF COMPRESSIVE STRENGTHS OF CEMENT-LOCK CEMENT FROM LAB- AND PILOT-SCALE TESTS WITH ESTUARINE SEDIMENT

	Cement-Lock Cement		ASTM Cement Requirements	
			C-595	C-150
Test Period, days	Lab-Scale	Pilot-Scale	Blended	Portland
	MPa (psi)			
3	13.4 (1950)	15.4 (2230)	13.0 (1890)	12.0 (1740)
7	18.8 (2730)	19.9 (2885)	20.0 (2900)	19.0 (2760)
28	31.9 (4620)	36.3 (5270)	24.0 (3480)	28.0 (4060)

There are numerous other tests that can be conducted on cement samples to determine their suitability for different construction-related activities. Compressive strength is the primary requirement. Other tests include autoclave expansion/contraction, freeze-thaw resistance, sulfate resistance, setting time, slump, etc.

Sediments Suitable for the Cement-Lock Technology

Based on the results achieved to date with sediment dredged from the Newtown Creek estuary, almost any sediment could be suitable for decontamination via Cement-Lock Technology. The reasons are

1) The elemental composition of typical sediments can be adjusted to the desired Ecomelt composition by blending inexpensive modifiers,
2) The mixing and intense combustion in the rotary kiln melter ensures complete destruction of organic contaminants,
3) Inorganic contaminants are locked within the melt matrix regardless of their original source, and
4) Volatilized metals are captured using scrubbers and activated carbon or affinity metal filters, also regardless of sediment source.

The moisture content of the dredged sediment directly affects the energy required to dry the sediment before it can be fed to the melter. Lower moisture content sediment will require less energy and higher moisture content sediment will require more energy. However, none of the other aspects of sediment source impact the effectiveness of the Cement-Lock process for decontaminating sediments.

5.5.2. Potential for Cement-Lock Production-Scale Operations

Based on the results of the pilot-scale Cement-Lock campaign including the high organic contaminant destruction achieved, the low leachability of the cement product, and the high compressive strength of the cement product, the Cement-Lock Technology has a very high potential for successfully scaling up to production-scale operations (100,000 cubic yards per year treatment capacity) as specified by the Phase III requirements. It should be noted that rotary kilns are used in hundreds of installations worldwide for a variety of thermal processing steps including slagging operations. The rotary kiln technology is readily adaptable for implementing the Cement-Lock Technology for production-scale operations.

5.5.2.1. Production-Scale and Full-Scale Processing Rates

The Cement-Lock Technology is presented as a modular system for treating dredged sediment. The design throughput capacity for one Cement-Lock module is 100,000 cubic yards of sediment per year. The corresponding processing rate for the production-scale facility is also 100,000 cubic yards (or 76,455.5 m^3) per year of dredged sediment. For a stream factor of 90 percent (about 330 days of operation per year), this relates to 303 cubic yards (231.7 m^3) of sediment per day, or 12.6 cubic yards (9.7 m^3) per hour.

The construction-grade cement output from the production-scale plant (operating a full capacity) will be 317.5 metric tons (350 tons) per day.

Because the Cement-Lock Technology is modular, the processing rate for the full-scale facility is five times that of the production-scale facility or 500,000 cubic yards (382,277.4 m^3) per year of dredged sediment. For a stream factor of 90 percent (about 330 days of operation per year), this relates to 1,515.1 cubic yards (1,158.4 m^3) of sediment per day, or 63.1 cubic yards (48.3 m^3) per hour.

The construction-grade cement output from the full-scale facility (operating a full capacity) will be 1587.6 metric tons (1750 tons) per day.

The effectiveness of the Cement-Lock Technology for destroying organic contaminants present in dredged sediment is expected to improve by scaling up from pilot- to the production scale of operation. This is because in the production-scale system, each of the Cement-Lock processing steps will be integrated and optimized for achieving destruction and removal efficiencies (DREs) required for treating the expected range of contaminants. Although the pilot-scale Cement-Lock campaign demonstrated success in destroying organic contaminants, the unit was not integrated nor optimized.

The effectiveness of the Cement-Lock Technology for immobilizing heavy metals present in the dredged sediment, is not expected to be significantly different from that achieved in the pilot-scale unit or bench-scale unit.

5.5.2.2. Reagents, Space, Utilities, and Personnel Required

Reagents required for Cement-Lock production-scale operations (100,000 cubic yards per year) will be based directly upon the quantities required in the pilot-scale campaign as well as engineering estimates for some materials. These quantities have been determined as part of ongoing Phase III activities and are included in this report for completeness. The nominal quantities of Modifier 1 and Modifier 2 that will be required are 46.3 and 2.7 metric tons (51 and 3 tons) per day, respectively. Standard industrial-grade modifiers available in bulk will be employed for the production-scale facility.

The quantities of lime for flue gas injection (for sulfur and salt collection) and powdered activated carbon for volatile metal collection are 10.0 and 0.115 metric tons (11 and 0.127 tons) per day, respectively. Other utilities required include

- Electricity 21,620 kW-hr/day
- Natural Gas 1.63 TJ/day (1,545,600,000 Btu/day)
- City Water 98,220 L/day (25,950 gallon/day)
- De-mineralized Water 20,820 L/day (5,500 gallon/day)

The production-scale Cement-Lock module for processing 100,000 cubic yards of sediment per year will occupy approximately 4,050 m^2 (1 acre) of land, which includes the various storage hoppers for modifiers, additives, and construction-grade cement product. The area required for storing sediment prior to Cement-Lock treatment will depend upon the eventual site selected and the allowance required to accommodate the dredging season. The storage area could range up to 5 acres or more. This sediment storage requirement would be similar for any large-scale sediment decontamination technology.

The production-scale Cement-Lock plant will require a complement of 26 full-time employees to accomplish round-the-clock operations of the plant.

5.5.2.3. Environmental, Health, and Safety Impacts

This section discusses some of the anticipated environmental, health, and safety concerns that could arise during Cement-Lock production-scale plant operations with dredged sediments.

Based on the pilot-scale test results, the cement produced from Cement-Lock processing of contaminated sediments is fully expected to meet all applicable regulatory requirements of the U.S. EPA as well as those of the American Society for Testing and Materials (ASTM). The cement readily passed the EPA Toxicity Characteristic Leaching Procedure (TCLP) and the compressive strength requirements of ASTM for portland as well as blended cements. Further, the residual organic material present in the cement product have been shown to be very low, indicating DREs exceeding 99.99 percent for most organic compounds originally present in the sediment.

Concerns that may arise over the potential emissions of NOx and SO_2 from the flue gas during operation of the production-scale facility can be addressed during the design and permitting phase. The analysis of the flue gases downstream of the activated carbon adsorption bed (by Air Nova and Hazen) showed 67.5 ppm of NOx, 44.1 ppm of SO_2, and 14.2 ppm of HCl (adjusted to 7 volume percent O_2 in the flue gas). The data from the pilot plant tests can be scaled up directly to obtain an estimate of the emissions from a production-scale (100,000 cubic yards per year capacity) plant. However, as the operating conditions for the Cement-Lock pilot plant and pollution control equipment were not optimized, this direct scale up exercise is premature. The emissions of these potential pollutants can be effectively controlled using currently existing technology. The Cement-Lock production-scale plant will have the following air pollution control equipment installed.

Flue Gas Quench – The flue gas quench utilizes direct water injection to cool the flue gas from the elevated temperature of the secondary combustion chamber (SCC) to about 204°C (400°F). This protects the fabric of the bag house and prevents the formation of dioxin and furan precursors in the flue gas.

Lime Injection – powdered lime is injected into the flue gas to capture hydrogen chloride (HCl) and other acid gases, such as sulfur dioxide (SO_2). The powdered lime also serves facilitate collection of condensed salts of sodium and potassium.

Bag House – the bag house collects the spent lime, salts, and any other entrained particulate material.

Activated Carbon Injection (or Activated Carbon Fixed Bed) – the activated carbon collects volatilized heavy metals, such as mercury. The spent activated carbon containing metals can be shipped back to a processor to regenerate the carbon and collect the metals.

The level of particulate matter in the flue gas from the outlet was below the detection limit. Further, no chlorobenzenes, chlorophenols, PCBs, or pesticides were detected in the flue gas. The levels of dioxins and furans in the flue gas were below the detection limit from the Toxicity Equivalency Factor (TEF).

The U.S. Army Corps of Engineers policy has been that dredged material is not regulated under RCRA as hazardous material and typically dredged materials do not exhibit toxic characteristics (per the TCLP). No hazardous material permits will be required to operate the production-scale Cement-Lock plant with dredged estuarine sediment. The types of permits required for constructing and operating the production-scale facility will be determined during the Phase III effort. The types of permits required will also depend upon the state in which the production-scale plant is sited. New York and New Jersey each have their own different types of permits for manufacturing plants such as Cement-Lock.

Permits required will be construction and operating permits for the plant and air permits for any emissions. Other permits, such as CZM (coastal zone management) may be required depending upon the site.

It is IGT's corporate policy to ensure the environmental and occupational safety and health of its employees through mandated informational and training programs. Programs are in place to ensure the appropriate and lawful storage, treatment, and disposal of oversize materials as well as any other type of residual. The cement produced during the day-to-day operations of the production-scale facility will be sold on the open market.

The Cement-Lock process itself is free of nuisance odors, noise, and occupational exposure hazards. However, due to the potentially hazardous nature of the as-received dredged sediments, there is some concern for employee health through accidental contact with the sediment (exposure to skin as well as inhalation and ingestion). IGT has several employees who have taken courses and are certified for hazardous material handling. Mr. John R. Conrad, Manager of IGT biotechnology laboratories, has completed the 40-hour course entitled "Hazardous Waste Worker Training" from the University of Illinois at Urbana. He is a certified supervisor under this program. Other IGT employees have been certified under the same or similar programs including Dr. J. Robert Paterek and Mr. Salil Pradhan.

The other solid wastes generated by the process, namely chloride and sulfate salts collected by the bag house and the volatile heavy metals collected by activated carbon, will be handled by conventional means. As mentioned above, the used activated carbon can be shipped to a reprocessor. One such company is US Ecology Beatty Company (Nevada), which has facilities for handling and processing of mercury laden spent carbon adsorbent.

5.5.2.4. Licensing, Royalty, or Proprietary Fees

Cement-Lock Group, L.L.C. owns the intellectual property of the Cement-Lock Technology. Cement-Lock Group will grant a royalty-free license to the first 100,000 cubic yard capacity Cement-Lock plant that becomes operational. Therefore, no licensing, royalty, or proprietary fees are associated with the operations of the production-scale Cement-Lock plant.

5.5.2.5. End Product Management

The production-scale Cement-Lock plant will be operated as a prototype commercial-scale module. Therefore, the cement produced from plant operations will not be disposed of, but will be sold as a fungible product on the open market. The cement will ultimately find beneficial use in general construction projects within the New York/New Jersey harbor area. Other residual materials from plant operations will be disposed of through conventional means. Where possible, waste materials will be reintroduced into the Cement-Lock Technology for ultimate assimilation in the cement product.

The final forms that contaminants originally present in the dredged sediments will ultimately exit the production-scale Cement-Lock plant are summarized in Table 8.

5.5.2.6. Pretreatment Requirements

Pretreatment requirements for the production-scale Cement-Lock plant operations with raw sediment are minimal. The raw sediment may contain some relatively large pieces of debris, such as automobile parts, white goods, etc., which may interfere with the efficient operation of the production-scale plant. Those items that are not readily reduced in size via the crushing operation will be removed from the sediment via a scalper and discarded in a conventional landfill.

To ensure efficient plant operation, the moisture content of the sediment will be reduced from its as-received level (60 weight percent water or more) to about 10 weight percent. This will be accomplished by utilizing the sensible heat recuperated from the water quench/cooler step to dry the raw sediment. The sediments will be indirectly dried and the sediment temperature will not exceed 110°C (230°F). The evaporated water from the dryer will be incorporated into the flue gas quenching/cooling step. This reduces the energy required for processing sediments.

Table 8. FINAL FORMS OF MATERIALS FROM CEMENT-LOCK PRODUCTION-SCALE PLANT OPERATIONS

Waste Component	Final Form
Priority Metals (if present):	
Ba, Cd, Cr, Cu, Pb, Ni, Ag, Se, Zn	Construction-grade cement, stable
As, Hg	Adsorbed onto activated carbon, solidified, and immobilized[1]
Polynuclear Aromatic Hydrocarbons, Organochlorine Pesticides, PCBs 2,3,7,8-Chlorine Substituted PCDD/PCDF Isomers:	
Organic Hydrogen	Demineralized water[2]
Chlorine, SO_2	Salts, solidified, stable, some SO_2 in off gas[3]
Organic Nitrogen	Oxides of nitrogen, N_2[3] (off-gas)
Organic Carbon	CO_2 (off-gas)

1. Elements could be recovered.
2. De-mineralized water is free released.
3. SO_2 and NOx will be within regulatory limits.

To facilitate the sediment drying procedure described above, some of the dried sediment may be recycled to the raw sediment. This will reduce the net moisture content of the feed material being dried.

It is not necessary to remove the salt from the sediment prior to Cement-Lock processing as it is with some other decontamination technologies.

5.5.2.7. Capital, Operating, Unit Sediment Treatment, Maintenance, and Disposal Costs

Details of the capital, operating, unit sediment treatment, maintenance, and disposal costs for the production-scale plant based on the pilot-scale demonstration are being prepared as part of the ongoing effort in Phase III (Preconstruction Activities). The complete details of the costs associated with building the Cement-Lock plant will be presented as a result of that effort.

5.5.2.8. Production- and Full-Scale Implementation Plans

The overall plan for implementing the Cement-Lock Technology in the New York/New Jersey harbor area targets the treatment of 3,000,000 cubic yards of dredged sediment annually. The successful implementation will bring the following benefits to the area:

- The contaminated sediment will be completely treated so that it will no longer pose any danger for long-term exposure or hazard to human as well as to ecological health.
- The contaminated sediment will not require any long-term disposal or long-term monitoring.
- The contaminated sediment will be completely converted into high quality construction-grade cement, which will be used for general construction purposes in applications where portland cement is currently being used.
- The Cement-Lock Technology will create a brand new infrastructure industry with all the attendant benefits to the community where it is located.
- In addition, the targeted Cement-Lock plants will be planned such that they are located on waterfront sites so that land transportation of the contaminated sediment is minimized; thereby minimizing exposure of these sediments to humans, animals, and vegetation.

In order to process 3,000,000 cubic yards of sediment per year, the plans are to construct 5 plants each having a capacity of 100,000 cubic yards and 5 plants each having a capacity of 500,000 cubic yards. The processing capacity will be divided between New York and New Jersey according to the sediment dredging plans. The plants will be cited in various locations based on the following criteria:

Sediment Availability

It is crucial to the economic viability of each plant that a steady supply of sediment is provided during most of the year. The interruption in the sediment supply due to fish windows, weather, etc., can be tolerated to the extent to which storage facilities are available at the site. 100,000-cubic-yard capacity plants will be located at facilities where only small supply of sediment is available and where storage facilities are restricted due to the size of the site. 500,000-cubic-yard capacity plants will be cited where larger sites are available and where the delivery of larger quantities of the sediment is assured.

Cement Marketability

To ensure the successful operation of the plants, they will be located in regions where either the demand for cement exists locally or where there is a prospect of exporting the cement to other states. For 100,000-cubic-yard capacity plants, the market alignment with small ready-mix dealers will be sought so that the product can be utilized at the site. In this way the expenses associated with cement distribution are also eliminated for a small business in order to assure profitability. For 500,000-cubic-yard capacity plants, market alignment with cement manufacturers as well as with bulk cement distributors will be sought so that the product can be distributed either for local consumption or for export to other states and countries.

Possibilities will also be explored to align with manufacturers of prefabricated concrete slabs and with the producers of low density aggregates to consume cement on site and to export manufactured products for use locally and in neighboring states.

Public Acceptance

The Cement-Lock Technology has received favorable reviews by the public attending outreach meetings held in New York and New Jersey communities as part of the WRDA project. The objectives of the meetings were to inform the public about the sediment decontamination technologies being developed and to provide a venue for the public to voice their concerns about sediments and their treatment. There are several apparent reasons for the favorable public support of the Cement-Lock Technology, including

- It provides a viable disposal option for dredged sediment
- The technology is effective in decontaminating the dredged sediment
- It eliminates health and safety hazards associated with the sediment
- It manufactures a salable product for beneficial reuse in the community
- It is an infrastructure industry sustainable over 20 years or longer, and
- It can provide jobs in the local community.

Even though the public has shown acceptance of the Cement-Lock Technology at these public outreach meetings, we will continue to actively seek public support and input during the production-scale program. The public's input will affect the selection of plant sites as well as capacities for each plant. This is, after all, an important demonstration of a public-private partnership working together for the public benefit.

Support of Local Government

Support of the local government will also influence the size of the plant. In locations where local and state level support exist for utilization of the cement produced from the sediment in local construction projects, incentives will be proffered for building larger plants in those localities.

Permits

The size of a plant in a particular locality will also be limited by existing regulations with respect to permitted air discharges for CO_2, NOx, and SOx. Other permits required may include construction, operation, local community permits, coastal zone management, Beneficial Use Determination (BUD), water quality, among others, etc.

Availability of Alternate Feedstocks

The Cement-Lock Technology can operate with alternate feedstocks such as contaminated soils, municipal sludges, fly ash and bottom ash from MSW incinerators and coal-fired power plants. These material can be processed together in the reactive melter. The only requirement is to adjust the types and quantities of modifiers to achieve the proper melt composition. The selection of alternative feedstocks will have some economic ramifications;

therefore, site selection will be favored at locations that have the prospect of bringing alternate feedstocks that command tipping fees at least in the same price range as that of dredged sediment.

Natural Gas Availability

At this stage of development, the Cement-Lock Technology depends upon natural gas as its fuel of choice, because it is a clean burning fuel and does not add complexity to the environmental aspects of the technology. Therefore, citing of the plant will also be dependent upon the guaranteed availability of natural gas throughout the year. Alternate fuels such as fuel oil and propane will also be considered if an uninterruptible supply of natural gas cannot be guaranteed for either logistical or economical reasons.

Economic Enterprise Zone

Citing the plant in an Economic Enterprise Zone will assure favorable economic treatment required by this new industry.

5.5.3. Permitting and Regulatory Requirements

The permitting and regulatory requirements for the 100,000 cubic yard per year Cement-Lock plant will be determined during the preconstruction activities of Phase III.

5.5.4. Post Treatment Management Requirements

The requirements for post Cement-Lock treatment are minimal. The sediment will be converted completely into a salable construction-grade cement product. Other than ensuring that the Cement-Lock cement continues to meet ASTM and EPA requirements, there will be no other post treatment management requirements.

5.5.5. Quality Assurance/Quality Control Procedures

The quality assurance/quality control procedures for the Cement-Lock production-scale plant will be developed during the engineering design phase of the program. At a minimum, the QA/QC procedures will include the frequent analysis of the sediment being received at the plant site for water content, organic and inorganic contaminant content, and elemental content of the mineral fraction. These analyses are required to assure that the composition of the Ecomelt being generated is within specifications. The analyses are also required to assure that the dredging has indeed been done in the appropriate harbor area.

Other QA/QC procedures will be developed for assuring that the cement product from the plant meets ASTM requirements.

5.5.6. Time Schedule for Production- and Full-Scale Facilities

A parallel effort is underway to build the first production plant as well as to exploit the technology commercially by building several plants to meet the target of 3,000,000 cubic yards annually for dredged sediment. All the engineering and permitting efforts are directed equally towards the production plant as well as for the subsequent commercial plants. Similarly, the sites are being evaluated for production as well as commercial plants. This parallel effort will greatly facilitate the overall commercialization process and at the same time reduce the time required to attain the ultimate target of processing 3,000,000 cubic yards of sediment annually. The following schedule for the construction of the production plant and the subsequent commercial plants is based upon time estimates received from our meetings with the permitting agencies, the engineering contractors, and the equipment manufacturers.

The following assumptions have been made in arriving at the schedule for completing plant construction and for starting the plant operation:

- The permit application, consideration and final issuance will require 9 months to complete. The permit process will proceed in parallel with detailed engineering and equipment procurement.
- The detailed engineering will require 6 months to complete and will proceed in parallel with placing orders for the critical delivery items. The selection of the engineering company is presumed to be completed during the preconstruction phase.
- The time required for the fabrication of the longest delivery item will not exceed 9 months. At least 3 vendors have been identified who can supply all the equipment required for the Cement-Lock plant. The Ecomelt generator has been identified as the longest delivery item requiring 9 months for the delivery.
- All the finances required for the production plant are in place at the start of the construction phase.
- Negotiations are underway with the investors for the subsequent plants; and that the finances will be in place by the end of 1999.

With these assumptions, the construction schedule is as follows:

1	100,000 cubic yards/year production plant	End of 1999
2	100,000 cubic yards/year each commercial plant	End of 2000
1	500,000 cubic yards/year commercial plant	End of 2001
2	100,000 cubic yards/year each commercial plant	End of 2002
4	500,000 cubic yards/year each commercial plant	End of 2005

Sites in both New York and New Jersey are being considered for the first Cement-Lock demonstration plant.

CONCLUSIONS AND RECOMMENDATIONS

Pilot-scale studies were conducted with sediment from the Newtown Creek estuary in New York to evaluate the applicability of the Cement-Lock Technology for remediating this material as well as converting it to a salable product for beneficial reuse.

The following conclusions can be made based on the results of the pilot-scale campaign reported above:

Overall, the Cement-Lock pilot-scale test campaign confirmed the results achieved during the bench-scale tests and showed further that:

- Essentially all of the organic contaminants originally present in the sediment were completely destroyed during Cement-Lock processing.
- The construction-grade cement product readily passes the TCLP test for priority metals.
- The construction-grade cement product has compressive strength that exceeds the ASTM requirements for portland cement.
- The flue gas from the pilot-scale test was devoid of PCBs, chlorophenols, chlorobenzenes, and pesticides.
- The quantity of chlorinated dioxins and furans in the flue gas from the pilot-scale test were $< 4.0 \times 10^{-12}$ and $< 8.1 \times 10^{-12}$ lb/hr, respectively, below detection limits on a TEF (Toxicity Equivalency Factor).

The Cement-Lock Technology is ready for deployment at the 100,000-cubic yard per year production-scale of operation.

ACKNOWLEDGMENTS

The authors acknowledge the sponsorship of the pilot-scale work during Phase II by Brookhaven National Laboratory under Contract No. 725043 with funding provided, in part, through the Water Resources Development Act of 1996 (Section 226) through Interagency Agreement No. DW89941761-01-1 between the U.S. EPA-Region 2 and the U.S. Department of Energy. Cost sharing for the pilot-scale program by Unitel Technologies, Inc. (Mount Prospect, IL) is also acknowledged.

The authors would also like to acknowledge the contributions to the project by Dr. Keith W. Jones, BNL project manager, Mr. Eric A. Stern, U.S. EPA Region 2 project manager, and Mr. Kerwin Donato, U.S. Army Corps of Engineers project manager.

The authors further acknowledge the invaluable assistance of Dr. Javed I. Bhatty, Senior Scientist of CTL, for independently verifying the quality of the cement produced by the technology. Dr. Bhatty's knowledge and technical experience in the field of cement and cement chemistry is also acknowledged.

Appendix A.

DATA LOG SHEETS FROM CEMENT-LOCK PILOT-SCALE CAMPAIGN

TEMPERATURE DATA - ROTARY KILN

Project # 8981-03
Date 11/22/96

Time	Kiln System Temperatures										
	Kiln Control °F	Kiln Exit Gas °F	Mid. SCC Gas °F	SCC Control °F	SCC Gas Exit °F	Precooler Outlet Gas °F	Baghouse Inlet Gas °F	Carbon Column °F	Optical Kiln Bed °F		
1500	2289	2281	2193	1830	1833	180	340	285	2420		
1600	2351	2345	2251	1877	1859	180	345	300	2440		
1700	2373	2365	2281	1936	1920	193	360	304	2430		
1800	2379	2375	2329	1875	1955	185	340	305	2430		
1900	2390	2385	2359	2003	1986	185	355	300	2430		
2000	2406	2402	2389	2039	2021	190	375	325	2430		
2100	2402	2395	2395	2039	2039	190	360	320	2430		
2200	2418	2411	2406	2086	2076	220	370	325	2430		
2300	2403	2409	2406	2070	2058	195	355	320	2425		

REGULATED GAS FLOW RATES - ROTARY KILN

Project # 8981-03
Date 11/22/96

Barometric Pressure 24.45 in Hg

Sheet

Time	Primary Burner Air			Primary Burner Gas			SCC Burner Air			SCC Burner Gas			Sec. Kiln Burner Air			Sec. Kiln Burner Gas			Total
	Delta P in H2O	Pressure in H2O	SCFM	Delta P in H2O	Pressure in H2O	SCFM	Delta P in. H20	Pressure in. H2O	SCFM	Delta P in. H20	Pressure in. H2O	SCFM	Delta P in. H20	Pressure in H2O	SCFM	Delta P in H20	Pressure in H2O	SCFM	Gas Input SCFM
1500	7.4	43	136.8	3.3	1.7	16.69	0.9	50	48.6	0.5	1.7	6.55	2.25	27	75.20	1.1	25		
1600	10	37	157.2	3.4	1.7	16.95	0.9	49	48.5	0.5	1.7	6.55	2.22	27	74.69	1.09	25		
1700	4.1	46	102.2	2.5	1.7	14.57	0.9	50	48.6	0.5	1.7	6.55	2.5	27	79.23	1.1	25		
1800	3.9	46	99.7	2.4	1.7	14.28	0.9	50	48.6	0.5	1.7	6.55	2.5	27	79.23	1.1	25		
1900	2.9	46	86.5	2	1.7	13.05	0.9	50	48.6	0.5	1.7	6.55	2.5	27	79.23	1.1	25		
2000	2.8	46	85.1	1.7	1.7	12.04	0.9	50	48.6	0.5	1.7	6.55	2.3	27	76.02	1.1	25		
2100	2.6	47	82.1	1.6	1.7	11.69	0.9	51	48.7	0.5	1.7	6.55	2.3	27	76.02	1.1	25		
2200	2.2	47	75.6	1.4	1.7	10.94	0.9	51	48.7	0.5	1.7	6.55	2.3	27	76.02	1.1	25		
2300	2.2	47	75.6	1.6	1.7	11.69	0.9	51	48.7	0.5	1.7	6.55	2.3	27	76.02	1.1	25		

Project # 8981-03
Date 11/22/96

PRODUCT DATA - ROTARY KILN

Time	BGH Product lb	Water Flow Rates Quench GPM	Quench Psig	Solution pH	Gas Analyzer Zero Time	Span Time	SCC Exhaust Gas Analysis Dry Volume Basis O2, %	CO2, %	CO,ppm	SO2,ppm	THC,ppm	NOx,ppm
1500		3	34	10.55	0930	0930	2.2	11.7	28.5	-	12.6	96.3
1600		3	34	10.53			2.2	11.5	24.1	-	12.4	89.8
1700		3.4	42	10.43			2.5	11.7	21.8	-	13.7	112.0
1800		3.5	42	10.00			2.4	10.8	33.8	-	15.0	105.8
1900		3.1	36	10.64			2.1	12.5	35.4	-	15.2	88.8
2000	0.2	3.3	40	10.78			2.3	11.7	31.9	-	19.3	91.8
2100	0.2	3.3	39	10.68			2.3	12.2	31.9	-	15.2	90.3
2200	0.1	3.3	40	10.69			2.3	11.5	85.0	-	13.8	99.2
2300	0.1	3.1	37	10.68			2.4	11.5	23.0	-	9.7	96.2

Gas analysis values were corrected for air dilution caused by a leak in the gas delivery line to the CEM found on 11/23/96.

OPERATING DATA - ROTARY KILN

Project # 8400
Date 11/22/96

Time	Kiln Draft (-) or Pressure (+), in WC									Kiln Parameters		
	Tumble Burner	Precooler Inlet	Precooler Outlet	BGH Inlet	BGH Differential	Carbon #1 Differential	Carbon #2 Differential	Pitot Delta Pressure	Stack Flow, SCFM	RPM	Slope ft/ft	Retention min.
1500	-0.06	-0.40	-0.60	-1.0	5.0	5.9	2.3	0.8	634	0.4	0.0234	66
1600	-0.08	-0.38	-0.50	-0.9	5.0	5.9	1.5	0.8	620	0.4	0.0234	66
1700	-0.05	-0.52	-0.80	-1.0	7.5	7.5	1.0	0.7	578	0.6	0.0234	44
1800	-0.04	-0.41	-0.70	-1.0	9.0	7.3	0.5	0.3	378	0.6	0.0234	44
1900	-0.05	-0.40	-0.60	-1.0	10.0	7.3	0.4	0.5	465	0.6	0.0234	44
2000	-0.04	-0.45	-0.70	-1.0	7.0	7.0	1.0	0.9	629	0.6	0.0234	44
2100	-0.03	-0.38	-0.55	-0.9	9.0	6.5	0.5	0.6	507	0.6	0.0234	44
2200	-0.03	-0.39	-0.60	-0.9	9.0	7.0	2.0	1.0	682	0.6	0.0234	44
2300	-0.03	-0.39	-0.60	-0.9	10.0	7.0	1.7	1.2	749	0.6	0.0234	44

FEED DATA - ROTARY KILN

Project # 8981-03
Date 11/22/96

Sheet 5 of 5

	Sediment Feed				Limestone Blend Feed								Kiln Product					Notes
Time	Setting %	Weight lb	Time Minutes	Rate lb/hr.	Setting %	Weight lb	Time Minutes	Rate lb/hr.	Setting %	Weight lb	Time Minutes	Rate lb/hr.	Time	Weight lb	Time Minutes	Rate lb/hr.	Time	About Feed Operations
1600	10				10	10												
1637	10	Calibrated rate		100.0	10	25	37	40.5										Turning feed off occationally to
1733	10	both feeds		100.0	10	25	56	26.8										allow kiln screw to catch up.
1827	10	off to allow		100.0	10	25	54	27.8										Feed off 1833
		kiln screw																Feed on 1856 off 23 min.
1942	10	to catch up		100.0	10	25	52	28.8										Feed off 2014
2057	10			100.0	10	25	64	23.4										Feed on 2025 off 11 min.
2255	10			100.0	10	25	57	26.3					2034	Product discharge				Feed off 2108
														collection started				Feed on 2134 off 26 min.
Summation		533	320	99.9		160.0	320.0	30.0						180				Feed off 2220
																		Feed on 2255 off 35 min.

TEMPERATURE DATA - ROTARY KILN

Sheet 1 of 5

Project # 8981-03
Date 11/23/96

Time	Kiln System Temperatures										
	Kiln Control °F	Kiln Exit Gas °F	Mid. SCC Gas °F	SCC Control °F	SCC Gas Exit °F	Precooler Outlet Gas °F	Baghouse Inlet Gas °F	Carbon Column °F	Optical Kiln Bed °F		
0000	2400	2400	2407	2072	2066	200	370	330	2425		
0100	2400	2397	2408	2075	2070	200	360	330	2430		
0200	2403	2400	2412	2020	2075	200	350	315	2430		
0300	2402	2385	2416	2076	2072	210	355	315	2440		
0400	2399	2399	2414	2086	2080	200	355	315	2450		
0500	2401	2395	2408	2082	2074	210	350	310	2460		
0600	2400	2397	2415	2081	2076	210	360	310	2430		
0700	2399	2392	2416	2080	2076	210	365	315	2430		
0800	2421	2415	2425	2083	2076	215	355	310	2430		
0900	2443	2431	2438	2090	2080	225	340	300	2420		
1000	2407	2394	2380	2083	2072	228	345	298	2420		
1100	2406	2397	2323	2066	2056	243	370	325	2420		
1200	2394	2387	2313	2049	2045	235	370	309	2420		
1300	2398	2390	2305	2044	2029	235	370	310	2420		
1400	2400	2397	2302	2026	2020	225	345	307	2420		
1500	2399	2394	2285	2007	2004	218	323	295	2420		
1600	2403	2389	2284	1997	1986	230	350	292	2410		
1700	2409	2397	2286	2007	1996	227	330	313	2390		
1800	2404	2392	2285	1996	1980	225	340	290	2390		
1900	2405	2405	2298	2006	2001	235	360	300	2395		
2000	2405	2395	2295	1996	1990	240	345	310	2395		
2100	2402	2397	2300	1994	1985	245	355	310	2385		
2200	2390	2365	2276	1989	1984	260	370	325	2390		
2300	2429	2426	2348	2023	2015	255	360	315	2400		
2400	2400	2397	2295	1999	1994	250	355	310	2400		
0100	2425	2412	2323	2008	2001	260	345	305	2405		

Hazen Research, Inc.

REGULATED GAS FLOW RATES - ROTARY KILN

Project # 8981-03
Date 11/23/96

Barometric Pressure 24.45 in Hg

Sheet

Sheet 2 of 5

Time	Primary Burner Air			Primary Burner Gas			SCC Burner Air			SCC Burner Gas			Sec. Kiln Burner Air			Sec. Kiln Burner Gas			Total
	Delta P in H20	Pressure in H2O	SCFM	Delta P in H2O	Pressure in H2O	SCFM	Delta P in. H20	Pressure in. H2O	SCFM	Delta P in. H20	Pressure in H2O	SCFM	Delta P in. H20	Pressure in. H2O	SCFM	Delta P in H20	Pressure in. H2O	SCFM	Gas Input SCFM
0000	2.2	47	75.6	1.6	1.7	11.69	0.9	50	48.6	0.5	1.7	6.55	2.3	27	76.03	1.1	25	4.54	223.0
0100	2.2	47	75.6	1.4	1.7	10.94	0.9	50	48.6	0.5	1.7	6.55	2.2	27	74.36	1.1	25	4.54	220.6
0200	2.0	47	72.1	1.4	1.7	10.94	0.9	50	48.6	0.5	1.7	6.55	2.2	27	74.33	1.1	25	4.54	217.0
0300	1.9	48	70.4	1.1	1.8	9.71	0.9	51	48.7	0.5	1.8	6.56	2.2	27	74.33	1.1	25	4.54	214.1
0400	2.0	49	72.3	1.3	1.8	10.54	0.9	51	48.7	0.5	1.8	6.56	2.3	28	76.10	1.1	25	4.54	218.7
0500	1.8	50	68.7	1.1	1.9	9.71	0.9	51	48.7	0.5	1.9	6.56	2.3	28	76.12	1.1	25	4.54	214.3
0600	1.9	50	70.5	1.2	2.0	10.14	0.9	52	48.7	0.5	2.0	6.56	2.3	28	76.12	1.1	25	4.54	216.6
0700	1.6	50	64.8	0.9	1.9	8.79	0.9	52	48.7	0.5	1.9	6.56	2.3	28	76.12	1.1	25	4.54	209.5
0800	1.7	50	66.7	1.0	1.7	9.25	0.8	52	45.9	0.5	1.7	6.55	2.3	28	76.12	1.1	25	4.54	209.2
0900	1.7	50	66.7	1.0	2.0	9.26	0.8	52	45.9	0.5	2.0	6.56	2.3	28	76.12	1.1	25	4.54	209.2
1000	1.7	50	66.7	0.8	2.0	8.29	0.8	52	45.9	0.23	2.0	4.45	2.3	28	76.12	1.1	25	4.54	206.1
1100	2.2	50	75.9	1.2	1.7	10.13	0.8	52	45.9	0.23	1.7	4.45	2.3	28	76.12	1.1	25	4.54	217.0
1200	3.1	50	89.9	1.7	1.7	12.04	0.8	52	45.9	0.23	1.7	4.45	2.3	28	76.12	1.1	25	4.54	233.0
1300	3.4	49	94.0	1.9	1.9	12.73	0.9	53	48.8	0.23	1.9	4.45	2.3	28	76.12	1.1	25	4.54	240.7
1400	2.7	49	83.9	1.5	2.0	11.32	0.8	53	46.0	0.25	2.0	4.64	2.3	28	76.12	1.05	25	4.43	226.4
1500	2.1	50	74.1	1.2	2.0	10.14	0.8	53	46.0	0.25	2.0	4.64	2.3	28	76.12	1.1	25	4.54	215.6
1600	1.8	51	68.8	1.0	2.5	9.27	1.3	53	58.6	0.38	2.5	5.72	2.6	28	80.93	1.05	25	4.43	227.7
1700	2.8	50	85.5	1.1	1.8	9.71	0.8	53	46.0	0.25	1.8	4.64	2.3	28	76.12	1.1	25	4.54	226.5
1800	2.0	51	72.4	1.1	2.5	9.72	1.3	53	58.6	0.35	2.5	5.49	2.6	28	80.93	1.1	25	4.54	231.8
1900	2.0	51	72.4	1.1	2.0	9.71	0.9	53	48.8	0.25	2.0	4.64	2.6	28	80.93	1.1	25	4.54	221.1
2000	1.8	51	68.8	1.0	2.5	9.27	1.0	54	51.5	0.3	2.5	5.09	2.6	28	80.93	1.1	25	4.54	220.1
2100	1.8	51	68.8	0.9	4.0	8.81	2.0	52	72.5	0.5	4.0	6.58	2.6	28	80.93	1.1	25	4.54	242.2
2200	1.8	51	68.8	0.9	4.0	8.81	2.0	52	72.5	0.5	4.0	6.58	3.0	30	87.09	1.1	25	4.54	248.3
2300	1.6	51	64.8	0.8	2.5	8.29	1.5	53	62.9	0.35	2.5	5.49	2.6	28	80.93	1.1	26	4.54	227.0
2400	1.6	51	64.8	0.8	3.5	8.30	1.7	52	66.9	0.9	3.5	8.81	2.6	29	81.04	1.1	25	4.54	234.4
0100	1.7	51	66.8	0.9	3.0	8.80	1.7	52	66.9	0.4	3.0	5.88	2.4	27	77.65	1.0	24	4.32	230.4

Hazen Research, Inc.

Project # 8981-03

Date 11/23/96

PRODUCT DATA - ROTARY KILN

Time	BGH Product lb	Water Flow Rates: Quench GPM	Quench Psig	Solution pH	Gas Analyzer: Zero Time	Span Time	SCC Exhaust Gas Analysis, Dry Volume Basis: O2, %	CO2, %	CO,ppm	SO2,ppm	THC,ppm	NOx,ppm
0000	wet, in oven	3.1	37	10.63			2.4	11.4	28.5	-	12.6	96.3
0100	0.02	3.3	38	10.72			2.5	11.1	24.1	-	12.4	89.8
0200	0.0	3.3	40	10.68			2.4	11.7	21.8	-	13.7	112.0
0300	0.0	3.3	39	10.89			2.4	11.6	33.8	-	15.0	105.8
0400	0.02	3.0	35	10.94			2.6	10.7	35.4	-	15.2	88.8
0500	0.0	3.0	36	10.86			2.6	10.5	31.9	-	19.3	91.8
0600	0.0	2.8	31	10.92			2.4	11.7	31.9	-	15.2	90.3
0700	-	3	35	11.00			2.4	11.6	85.0	-	13.8	99.2
0800	-	2.4	26	11.02			CEM off for repair of leak in gas delivery line					
0900	-	2.9	32	10.76	0950							
1000	-	2.7	28	10.75			2.4	11.5	31.8	-	13.8	99.7
1100	-	2.8	28	10.45			-	-	-	-	-	-
1200	1.0	3.3	40	10.35			4.3	10.7	15.2	-	10.9	101.8
1300	0.3	3.25	36	9.81			3.5	11.5	19.9	-	9.9	103.7
1400	-	2.9	34	9.64	1400	1400	3.3	11.2	11.1	-	9.9	96.2
1500	-	2.9	32	10.17			3.9	10.8	12.7	-	13.8	97.1
1600	0.5	2.5	28	10.93			1.5	13.0	18.9	-	14.8	116.2
1700	-	3.1	34	10.64			2.7	11.5	12.6	-	11.9	101.7
1800	-	3.0	32	10.72			2.4	11.6	17.5	-	13.8	83.1
1900	1.1	3.0	32	10.73			3.2	11.6	19.0	-	11.0	81.0
2000	0.2	3.0	32	10.77			2.2	12.6	48.0	-	10.0	68.0
2100	0.5	3.0	34	10.71			2.5	11.9	19.0	-	13.0	77.0
2200	0.3	3.3	38	10.72			2.6	11.8	18.0	-	12.0	69.0
2300	0.2	3.0	32	9.8			2.2	10.9	50.0	-	12.0	70.0
2400	0.2	3.1	36	11.12			3.6	12.6	16.0	-	11.0	75.0
0100	0.22	3.0	34	10.97			2.0	12.0	42.0	-	11.0	73.0

Hazen Research, Inc.

OPERATING DATA - ROTARY KILN

Sheet 4 of 5

Project # 8400
Date 11/23/96

Time	Kiln Draft (-) or Pressure (+), in WC									Kiln Parameters		
	Tumble Burner	Precooler Inlet	Precooler Outlet	BGH Inlet	BGH Differential	Carbon #1 Differential	Carbon #2 Differential	Pitot Delta Pressure	Stack Flow, SCFM	RPM	Slope ft/ft	Retention min.
0000	-0.03	-0.36	-0.60	-1.0	10.0	7.0	1.6	1.1	713	0.6	0.0234	44
0100	-0.03	-0.38	-0.60	-1.0	10.5	7.0	1.5	1.1	697	0.6	0.0234	44
0200	-0.02	-0.36	-0.50	-0.9	11.0	7.0	1.5	1.1	720	0.6	0.0234	44
0300	-0.02	-0.31	-0.50	-0.8	11.5	6.8	1.4	0.9	651	0.6	0.0234	44
0400	-0.03	-0.39	-0.60	-0.9	13.0	7.5	1.4	1.0	686	0.6	0.0234	44
0500	-0.03	-0.38	-0.55	-0.9	13.0	7.5	1.4	1.5	843	0.6	0.0234	44
0600	-0.02	-0.34	-0.50	-0.9	13.5	7.5	1.1	0.3	344	0.6	0.0234	44
0700	-0.02	-0.30	-0.49	-0.7	14.0	7.3	1.0	0.1	217	0.6	0.0234	44
0800	-0.02	-0.30	-0.45	-0.9	14.0	7.3	0.7	0.6	511	0.6	0.0234	44
0900	-0.02	-0.30	-0.45	-0.7	14.5	7.3	0.7	0.6	537	0.6	0.0234	44
1000	-0.02	-0.26	-0.40	-0.7	14.9	7.3	0.7	0.5	486	0.60	0.0234	44
1100	-0.08	-0.42	-0.70	-1.0	9.0	8.1	2.7	0.6	528	0.50	0.0234	53
1200	-0.04	-0.46	-0.70	-1.0	8.2	7.6	2.9	0.8	616	0.50	0.0234	53
1300	-0.03	-0.42	-0.70	-1.0	9.5	7.4	2.7	0.9	646	0.50	0.0234	53
1400	-0.04	-0.33	-0.50	-0.9	11.0	7.2	2.2	0.9	647	0.50	0.0234	53
1500	-0.04	-0.32	-0.50	-0.9	12.0	7.1	2.0	0.5	482	0.50	0.0234	53
1600	-0.01	-0.26	-0.40	-0.7	13.0	7.0	1.7	0.5	467	0.50	0.0234	53
1700	-0.02	-0.32	-0.50	-0.8	13.0	7.8	2.0	0.9	652	0.50	0.0234	53
1800	-0.01	-0.28	-0.45	-0.7	14.0	7.5	1.3	0.7	584	0.50	0.0234	53
1900	-0.02	-0.34	-0.55	-0.8	13.0	7.8	1.6	0.6	537	0.50	0.0234	53
2000	-0.01	-0.26	-0.40	-0.5	14.5	7.5	1.2	0.5	487	0.50	0.0234	53
2100	-0.01	-0.30	-0.50	-0.7	13.5	7.5	1.5	0.6	511	0.50	0.0234	53
2200	-0.01	-0.28	-0.40	-0.5	14.0	7.5	1.5	0.5	482	0.50	0.0234	53
2300	-0.02	-0.32	-0.50	-0.8	13.5	7.5	1.5	0.6	532	0.50	0.0234	53
2400	-0.01	-0.31	-0.50	-0.7	14.0	7.5	1.5	0.7	576	0.50	0.0234	53
0100	-0.01	-0.30	-0.50	-0.7	14.0	7.5	1.5	0.6	512	0.5	0.0234	53

Hazen Research, Inc.

FEED DATA - ROTARY KILN

Project # 8981-03
Date 11/23/96

	Sediment Feed				Limestone Blend Feed								Kiln Product					Notes
Time	Setting %	Weight lb	Time Minutes	Rate lb/hr.	Setting %	Weight lb	Time Minutes	Rate lb/hr.	Setting %	Weight lb	Time Minutes	Rate lb/hr.	Time	Weight lb	Time Minutes	Rate lb/hr.	Time	About Feed Operations
0024	10	Calibrated rate		100.0	10	25	65.0	23.1					22-Nov	180				Turning feed off occationally to
0155	10			100.0	11	25	39	38.5					0030	Start BBI #1 Comp.				allow kiln screw to catch up.
	9	= calibrated rate		95.0	Re-calibrated again								0100	33	30	66.0		Feed off 2340
	9.2	= calibrated rate		100.0	10	=	27 lb/hr						0200	22	60	22.0		Feed on 0024 off 44 min
0515	9				10	25							0300	25	60	25.0		Feed off 0044 on 20
0645	9.2			100.0	10	25	30	25.8					0400	20	60	20.0		Feed on 0155 off 71 min.
1024	9.2			100.0	10	27	39	41.5					0500	14	60	14.0		Feed off 0234 39
1122	9.2			100.0	10	27	58	27.9					0600	10	60	10.0		Feed on 0515 off 161 min
1240	9.2				10	27	78.0	20.8					0700	44	60	44.0		Feed off 0548 33
1328	9.2				10	27	48.0	33.8					0800	21	60	21.0		Feed on 0617 off 29 min.
1428	9.2				10	27	58.0	27.9					0900	3	60	3.0		Feed off 0702 45
1625	9.2				10	27	80.0	20.3					1000	0	60	0.0		Feed on 0945 off 163 min.
1723	9.2				10	27	58.0	27.9					1100	40	60	40.0		Feed off 1347 242
1824	9.2				10	27	61.0	26.6					1200	49	60	49.0		Feed on 1349 off 2 min.
1926	9.2				10	25.0	62.0	24.2					1300	37	60	37.0		Feed off 1518 89
2027	9.2				10	25.0	61.0	24.6					1400	34	60	34.0		Feed on 1555 off 37 min.
2127	9.2				10.1	25.0	60.0	25.0					1500	80	60	80.0		Feed off 0130 575
2240	9.2				10.2	25.0	73.0	20.5					1600	27	60	27.0		off for good
2333	9.2				10.5	25.0	53.0	28.3					1700	42	60	42.0		kiln discharge plugged
													1800	37	60	37.0		
													1900	32	60	32.0		
													2000	34	60	34.0		
													2100	39	60	39.0		
													2200	14	60	14.0		
													2300	32	60	32.0		
													2400	18	60	18.0		
													0100	33	60	33.0		Feed hours
		lbs	hr	lb/hr		lbs	hr	lb/hr						lbs	hr	lb/hr		off on
Summation		1738	17.38	100		441.00	17.38	25.4						740	25.83	28.6		8.45 17.38

Hazen Research, Inc.

Appendix B.

SAMPLES, DESCRIPTIONS, SAMPLER, SAMPLE QUANTITY, AND DISPOSITION

Table B-1. SAMPLES COLLECTED DURING THE CEMENT-LOCK PILOT-SCALE CAMPAIGN WITH DREDGED ESTUARINE SEDIMENTS

Sample No.	Description	Sampler	Quantity	Disposition
1. Modifier 1	Bulk Modifier	MCM	1 gallon	BNL
2. Modifier 2	Bulk Modifier	MCM	1 gallon	BNL
3. Flux	Bulk Modifier	MCM	1 quart	BNL
4. Hydrated Lime	Flue Gas Quench	MCM	1 gallon	BNL
5. Makeup Water	Ecomelt Quench	MCM	1 quart	BNL
6. Makeup Water	Ecomelt Quench	MCM	1 quart	BNL
7. Makeup Water	Ecomelt Quench	MCM	1 quart	BNL
8. Makeup Water	Ecomelt Quench	MCM	1 quart	BNL
9. Feed Composite	Raw Sediment	MCM	5 gallons	BNL
10. Feed Discrete	Raw Sediment	MCM	1 gallon	BNL
11. Feed Discrete	Raw Sediment	MCM	1 gallon	BNL
12. Feed Discrete	Raw Sediment	MCM	1 gallon	BNL
13. Quenched Composite	Ecomelt	MCM	20 kg	BNL
14. Quenched Discrete	Ecomelt	MCM	5 kg	BNL
15. Quenched Discrete	Ecomelt	MCM	4 kg	BNL
16. Quenched Discrete	Ecomelt	MCM	4 kg	BNL
17. Ecomelt for CTL	Ecomelt	MCM	24 kg	CTL
18. Quenched Composite to CTL	Ecomelt	TIM	23.8 kg	CTL
19. Granulator Water	Decanted Water	SDW	1 quart	BNL
20. Granulator Water	Decanted Water	SDW	1 quart	BNL
21. Granulator Water	Decanted Water	SDW	1 quart	BNL
22. Granulator Water	Decanted Water	SDW	1 quart	BNL
23. Whole Activated Carbon	From Adsorber	SDW	126.1 kg	IGT
24. Whole Sorbalit	From Adsorber	SDW	226.3 kg	IGT
25. Kiln Product #1	Ecomelt	SDW	55-gal drum	IGT
26. Kiln Product #2	Ecomelt	SDW	55-gal drum	IGT

Table B-1 (Continued). LIST OF SAMPLES COLLECTED DURING THE CEMENT-LOCK PILOT-SCALE CAMPAIGN WITH DREDGED ESTUARINE SEDIMENTS

Sample No.	Description	Sampler	Quantity	Disposition
27. Kiln Product #3	Ecomelt	SDW	55-gal drum	IGT
28. Kiln Clean Out	Ecomelt	SDW	55-gal drum	IGT
29. Granulated Slag	Early Sample	SDW	55-gal drum	IGT
30. -4 Mesh Product	Ecomelt	MCM	55-gal drum	IGT
31. Bag House Products	Spent Lime	TIM	5-gallons	IGT
32. CTL Composite	From #1 and #2	MCM	16.3 kg	CTL
33. Composite to BNL	From #1 and #2	MCM	--	BNL
34. Activated Carbon	Norit (unused)	MCM	1 gallon	BNL
35. Sorbalit	Unused	MCM	1 gallon	BNL
36. Raw Sediment	BNL Request	SDW	5 gallons	BNL
37. Raw Sediment	BNL Request	SDW	5 gallons	BNL
38. Raw Sediment	BNL Request	SDW	5 gallons	BNL
39. Raw Sediment	BNL Request	SDW	5 gallons	BNL
40. Cement	From CTL (to BNL)	MCM	5 gallons	BNL
41. Cement	From CTL (to BNL)	MCM	1 gallon	BNL
42. Sand	Ottawa	MCM	Bag	BNL
43. Cement	Portland	MCM	Bag	BNL
44. 2" Mortar Cubes	From cement	MCM/CTL	9	BNL
45. Sorbalit	Used	IGT	1 kg	BNL
46. Activated Carbon	Used	IGT	1 kg	BNL

Appendix C

Compilation of Analyses From BNL (Triangle Laboratories, Inc.)

Data Legend:
Normal Type = Below Detection Limit
Bold Type = Valid Data
Italics = Estimated Maximum Possible Concentration

IGT		As of 30May97			
Report#	**Entered ?**	**Analysis**	**Samples**		
40664A	Y	SVOC's	IGT-8	IGT-19	Makeup and Granulator Water
40664B	Y	PCB's	IGT-6	IGT-20	Makeup and Granulator Water
40664C	Y	Dioxin's and Furans	IGT-7	IGT-21	Makeup and Granulator Water
40664D	Y	Metals	IGT-22		Granulator Water
40664E	Y	SVOC's (TCLP)	IGT-40	IGT-41	Blended Cement
40664F	Y	PCB's (TCLP)	IGT-40	IGT-41	Blended Cement
40664G	Y	Dioxin's and Furans (TCLP)	IGT-41		Blended Cement
40664Gr1	Y	Dioxin's and Furans (TCLP)	IGT-40		Blended Cement
40664H	Y	Metals(TCLP)	IGT-40	IGT-41	Blended Cement
40664I	Y	Subcontract Data	IGT-37, -38, -9, -10,-11,-13,-14,-15		As Dredged, Feed Stocks and Products
40664J	Y	SVOC's	IGT-37, -38, -9, -10,-11,-13,-14,-15		As Dredged, Feed Stocks and Products
40664K	Y	Dioxin's and Furans	IGT-37, -38, -9, -10,-11,-13,-14,-15		As Dredged, Feed Stocks and Products
40664L	Y	PCB's	IGT-37, -38, -9, -10,-11,-13,-14,-15		As Dredged, Feed Stocks and Products
40664M	Y	Metals	IGT-37, -38, -9, -10,-11,-13,-14,-15		As Dredged, Feed Stocks and Products
40664N	Y	Metals (Extra TCLP)	IGT-40, -41		Blended Cement

		IGT-37	IGT-38	IGT-9	IGT-10	IGT-11
		As Dredged Sediment	As Dredged Sediment	Raw Feed Composite	Raw Feed #1	Raw Feed #2
Gross Physico-Chemical Properties						
Particle size						
(% Dry Weight)						
ASTM D422 (Mod)						
Medium gravel	> 4.75 mm	12.00	2.78	0.00	0.00	0.00
Fine gravel	2-4.75	2.76	0.24	0.91	2.44	0.43
V. coarse sand	0.85-2	1.94	1.52	0.80	1.66	1.46
Coarse sand	0.425-0.85	3.49	3.52	1.69	3.84	3.97
Medium sand	0.24-0.425	5.47	5.85	3.54	5.94	6.64
Fine sand	0.106-0.24	10.20	10.60	5.68	10.50	11.00
V. fine sand	0.075-0.106	3.09	2.87	2.29	2.83	2.67
Clay		30.70	30.90	39.30	34.30	32.90
Silt		39.10	42.20	47.40	41.60	38.20
pH						
EPA 9045A	pH Units	7.25	7.84	7.43	7.45	7.34
Solids (total)						
EPA 160.3	% dry wt.	44.6	36.9	53.6	46.6	47.7
Sulfides (total)						
EPA 9030M	mg/Kg dry wt.	5900	6170	3300	4900	6500
Organic carbon (total)						
ASTM D4129-82M	% dry wt.	7.50	8.67	3.16	4.80	5.83
TPH						
EPA 3550A/8015 Mod	mg/Kg Dry Wt.	16100	15200	3960	7000	6430

	IGT-37	IGT-38	IGT-9	IGT-10	IGT-11
	As Dredged Sediment	As Dredged Sediment	Raw Feed Composite	Raw Feed #1	Raw Feed #2
Report 40664J					
SVOC's - Page 1 of 2		**Missing Data are below the detection limit**			
EPA 8270A (ug/kg dry weight)					
Phenol					
bis(2-Chloroethyl)ether					
2-Chlorophenol					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
1,2-Dichlorobenzene					
Benzyl alcohol					
2,2'-oxybis(1-Chloropropane)					
2-Methylphenol					
3/4-Methylphenol					
N-Nitroso-di-n-propylamine					
Hexachloroethane					
Nitrobenzene					
Isophorone					
2-Nitrophenol					
2,4-Dimethylphenol					
bis(2-Chloroethoxy)methane					
Benzoic acid			489.33	612.71	
2,4-Dichlorophenol					
1,2,4-Trichlorobenzene					
Naphthalene	7110.92	8572.72	541.99	1786.32	1641.47
4-Chloroaniline	1598.12	2555.9	434.22	1287.83	1960.75
Hexachlorobutadiene					
4-Chloro-3-methylphenol					
2-Methylnaphthalene	7927.7	8594.71	238.97	599.42	827.9
Hexachlorocyclopentadiene					
2,4,6-Trichlorophenol					
2,4,5-Trichlorophenol					
2-Chloronaphthalene					
2-Nitroaniline		1399.38			
Dimethylphthalate					
2,6-Dinitrotoluene					
2,4-Dinitrotoluene					

	IGT-37	IGT-38	IGT-9	IGT-10	IGT-11
	As Dredged Sediment	As Dredged Sediment	Raw Feed Composite	Raw Feed #1	Raw Feed #2
Report 40664J					
SVOC's - Page 2 of 2					
EPA 8270A (ug/kg dry weight)					
Acenapthylene	4003.49	3917.32	512.78	1146.71	1486.53
3-Nitroaniline					
Acenaphthene	9922.82	10627.67	590.67	1205.02	1295.32
2,4-Dinitrophenol					
4-Nitrophenol					
Dibenzofuran	7239.86	6764.71	237.81	609.35	811.52
Diethylphthalate					
4-Chlorophenyl-phenylether					
Fluorene	12197.78	11983.21	561.56	1319.27	1639.31
4-Nitroaniline					
4,6-Dinitro-2-methylphenol					
N-Nitrosodiphenylamine					
4-Bromophenyl-phenylether					
Hexachlorobenzene					
Pentachlorophenol					
Phenanthrene	59342.74	55476.23	1038.56	4555	5607.17
Anthracene	19513.21	17957.69	1344.91	3335.71	4306.74
Di-n-butyl phthalate					636.38
Fluoranthene	66890.26	56068.01	5306.68	12459.5	16345.17
Pyrene	36927.34	33515.75	3439.34	7102.96	9480.26
Butylbenzylphthalate	1187.23	1584.11	1263.71	1638.03	2422.79
3,3'-Dichlorobenzidine					
bis-2-ethylhexylphthalate	57405.23	78312.28	22243.78	43827.66	77162.43
Benzo(a)anthracene	17997.69	16312.1	2028.29	3950.56	5171.94
Chrysene	17550.01	16205.01	2259.33	4251.43	5359.63
Di-n-octylphthalate					
Benzo(b)fluoranthene	12419.8	11094.78	1761.41	3395.93	4130.42
Benzo(k)fluoranthene	5415.62	4599.64	767.84	1051.65	2047.13
Benzo(e)pyrene	8480.54	7597.59	1269.08	2384.32	3002.49
Benzo(a)pyrene	10595.96	10179.05	1481.96	2864.35	3670.87
Perylene	3081.19	2863.96	574.92	941.47	1238.9
Indeno(1,2,3-cd)pyrene	2958.13		525.54	1000.58	1096.24
Dibenz(a,h)anthracene			263.93	489.93	
Benzo(g,h,i)perylene	3425.59		649.68		1244.89

	IGT-37	IGT-38	IGT-9	IGT-10	IGT-11
	As Dredged Sediment	As Dredged Sediment	Raw Feed Composite	Raw Feed #1	Raw Feed #2
Report 40664K					
Dioxins and Furans					
(ng/kg dry weight)					
EPA 8290					
2378-TCDD	**20.8**	**24.3**	**8.2**	**12.3**	**13.8**
12378-PeCDD	**35.0**	**37.5**	**14.3**	**25.0**	**24.5**
123478-HxCDD	**51.5**	**58.3**	**20.1**	**36.7**	**34.1**
123678-HxCDD	**89.3**	**101**	**36.9**	**86.2**	**67.8**
123789-HxCDD	**94.4**	**130**	**43.8**	**76.7**	**77.2**
1234678-HpCDD	**1327**	**1460**	**555**	**1894**	**975**
OCDD	**9913**	**13845**	**4794**	**24161**	**7935**
2378-TCDF	**225**	**254**	**77.2**	**114**	**140**
12378-PeCDF	**394**	**320**	**61.0**	**111**	**104**
23478-PeCDF	**149**	**139**	**43.5**	*69*	**80.9**
123478-HxCDF	*1860*	*1410*	*341*	*680*	*625*
123678-HxCDF	**594**	**466**	**98.4**	**197**	**166**
234678-HxCDF	**169**	**167**	**51.9**	**80.3**	**80.6**
123789-HxCDF	**8.6**	**7.5**	**2.0**	**6.6**	**5.3**
1234678-HpCDF	**6881**	**5803**	**1191**	**2319**	**2000**
1234789-HpCDF	**152**	**107**	**27.4**	**67.5**	*56.9*
OCDF	**11980**	**3654**	**779**	**3620**	**2137**
Totals: Dioxins					
-TCDD	**225**	**257**	**86**	**155**	**181**
-PeCDD	**277**	**343**	**122**	**159**	**206**
-HxCDD	**871**	**1263**	**455**	**750**	**727**
-HpCDD	**1809**	**3203**	**1228**	**3072**	**1712**
Totals: Furans					
-TCDF	**2707**	**2552**	**682**	**1020**	**1220**
-PeCDF	**4180**	**3926**	**904**	**1574**	**1612**
-HxCDF	**4648**	**3898**	**881**	**1777**	**1623**
-HpCDF	**7303**	**6116**	**1271**	**2488**	**2101**

		IGT-37	IGT-38	IGT-9	IGT-10	IGT-11
		As Dredged Sediment	As Dredged Sediment	Raw Feed Composite	Raw Feed #1	Raw Feed #2
Report 40664L						
Polychlorinated Biphenyls						
(ug/Kg dry weight)			Low resolution analysis only			
EPA MM680/HRGC/MS						
2-Mono	Congener # 1					
44'-Di	# 15					
244'-Tri	# 28					
22'55'-Tetra	# 52					
33'44'-Tetra	# 77					
2344'5-Penta	# 118					
233'44'-Penta	# 105					
33'44'5-Penta	# 126					
233'44'5-Hexa	# 156					
33'44'55'-Hexa	# 169					
22'344'55'-Hepta	# 180					
22'33'44'55'-Octa	# 194					
22'33'44'55'6-Nona	# 206					
Deca	# 209					
PCB Totals:						
-Mono		*833*	**292**	*148*	*210*	**85**
-Di		*714*	**345**	**80.8**	**152**	**158**
-Tri		**1930**	**1940**	**494**	**905**	**1090**
-Tetra		**2050**	**2720**	**1150**	**1550**	**1720**
-Penta		**2130**	**2040**	**918**	**1160**	**1430**
-Hexa		**568**	**847**	**410**	**391**	**430**
-Hepta		**252**	**300**	**94.8**	**115**	**132**
-Octa		**69.9**	**45**	**15.0**	**18.7**	**21**
-Nona		**30.6**	**27.7**	**6.5**	14.4	*6.0*
-Deca		**31.2**	4.4	**5.7**	8.7	**9.9**

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	IGT-37	IGT-38	IGT-9	IGT-10	IGT-11	
	As Dredged Sediment	As Dredged Sediment	Raw Feed Composite	Raw Feed #1	Raw Feed #2	
Report 40664M						
Metals						
(mg/kg dry weight)						
EPA 6010A & EPA 7471						**IGT-37 dup**
						As Dredged Sediment
Ag	**11.3**	**15.5**	**6.0**	**8.1**	**11.9**	**13.6**
As	**38.8**	**38.9**	**12.1**	**16.9**	**20.5**	**48.1**
Be	**0.584**	**0.747**	**0.936**	**0.690**	**0.702**	**0.671**
Cd	**21.2**	**32.1**	**10.0**	**14.0**	**15.9**	**26.9**
Cr	**260**	**335**	**140**	**175**	**223**	**300**
Cu	**853**	**1170**	**423**	**562**	**709**	**968**
Ni	**226**	**296**	**94**	**109**	**262**	**222**
Pb	**473**	**610**	**268**	**368**	**502**	**574**
Sb	**6.55**	**3.75**	**1.59**	**1.70**	**3.20**	**1.97**
Se	**6.76**	**5.68**	**3.82**	**3.61**	**5.90**	**7.58**
Tl	2.24	2.49	1.95	2.03	2.19	2.24
Zn	**1430**	**1640**	**761**	**1000**	**1420**	**1410**
Hg (total)	**3.03**	**2.66**	**0.977**	**1.67**	**1.90**	

Data Legend:
Normal Type = Below Detection Limit
Bold Type = Valid Data
Italics = Estimated Maximum Possible Concentration

			IGT-13	IGT-14	IGT-15
			Quenched Grab Compos	Quenched Grab #1	Quenched Grab #2
Gross Physico-Chemical Properties					
Particle size					
(% Dry Weight)					
ASTM D422 (Mod)					
Medium gravel	> 4.75 mm				
Fine gravel	2-4.75				
V. coarse sand	0.85-2				
Coarse sand	0.425-0.85				
Medium sand	0.24-0.425				
Fine sand	0.106-0.24				
V. fine sand	0.075-0.106				
Clay					
Silt					
pH					
EPA 9045A	pH Units				
Solids (total)					
EPA 160.3	% dry wt.				
Sulfides (total)					
EPA 9030M	mg/Kg dry wt.		ND	ND	1
Organic carbon (total)					
ASTM D4129-82M	% dry wt.		ND	ND	ND
TPH					
EPA 3550A/8015 Modified	mg/Kg		ND	ND	ND

		IGT-13	IGT-14	IGT-15
		Quenched Grab Compos	Quenched Grab #1	Quenched Grab #2
Report 40664J				
SVOC's - Page 1 of 2		**Missing data means sample below detection limit**		
EPA 8270A (ug/Kg dry weight)				
Phenol				
bis(2-Chloroethyl)ether				
2-Chlorophenol				
1,3-Dichlorobenzene				
1,4-Dichlorobenzene				
1,2-Dichlorobenzene				
Benzyl alcohol				
2,2'-oxybis(1-Chloropropane)				
2-Methylphenol				
3/4-Methylphenol				
N-Nitroso-di-n-propylamine				
Hexachloroethane				
Nitrobenzene				
Isophorone				
2-Nitrophenol				
2,4-Dimethylphenol				
bis(2-Chloroethoxy)methane				
Benzoic acid				
2,4-Dichlorophenol				
1,2,4-Trichlorobenzene				
Naphthalene				
4-Chloroaniline				
Hexachlorobutadiene				
4-Chloro-3-methylphenol				
2-Methylnaphthalene				
Hexachlorocyclopentadiene				
2,4,6-Trichlorophenol				
2,4,5-Trichlorophenol				
2-Chloronaphthalene				
2-Nitroaniline				
Dimethylphthalate				
2,6-Dinitrotoluene				
2,4-Dinitrotoluene				

		IGT-13	IGT-14	IGT-15
		Quenched Grab Compos	Quenched Grab #1	Quenched Grab #2
SVOC's - Page 2 of 2				
EPA 8270A (ug/Kg dry weight)				
Acenapthylene				
3-Nitroaniline				
Acenaphthene				
2,4-Dinitrophenol				
4-Nitrophenol				
Dibenzofuran				
Diethylphthalate			20.99	
4-Chlorophenyl-phenylether				
Fluorene				
4-Nitroaniline				
4,6-Dinitro-2-methylphenol				
N-Nitrosodiphenylamine				
4-Bromophenyl-phenylether				
Hexachlorobenzene				
Pentachlorophenol				
Phenanthrene				
Anthracene				
Di-n-butyl phthalate		39.07	37.41	41.81
Fluoranthene		18.44	26.51	18.93
Pyrene		27.88	40.17	27.42
Butylbenzylphthalate				
3,3'-Dichlorobenzidine				
bis-2-ethylhexylphthalate		26.88	21.80	17.14
Benzo(a)anthracene				
Chrysene				
Di-n-octylphthalate				
Benzo(b)fluoranthene		12.60	15.03	
Benzo(k)fluoranthene				
Benzo(e)pyrene		17.59	17.62	17.29
Benzo(a)pyrene		19.59	23.05	20.46
Perylene				
Indeno(1,2,3-cd)pyrene		14.86	9.31	
Dibenz(a,h)anthracene				
Benzo(g,h,i)perylene		48.90	49.58	44.63

		IGT-13	IGT-14	IGT-15
		Quenched Grab Compos	Quenched Grab #1	Quenched Grab #2
Report 40664K				
Dioxins and Furans				
(ng/kg dry weight)				
EPA 8290				
2378-TCDD		0.4	0.3	0.4
12378-PeCDD		0.6	0.6	0.6
123478-HxCDD		0.9	1.0	1.1
123678-HxCDD		0.7	0.7	0.8
123789-HxCDD		0.8	0.8	0.9
1234678-HpCDD		**7.6**	1.5	1.5
OCDD		**45.6**	*4.8*	*2.6*
No justification in case narrative for high composite				
2378-TCDF		0.3	0.3	0.3
12378-PeCDF		0.4	0.4	0.4
23478-PeCDF		0.4	0.4	0.4
123478-HxCDF		0.7	0.7	0.7
123678-HxCDF		0.5	0.5	0.5
234678-HxCDF		0.7	0.7	0.7
123789-HxCDF		0.8	0.8	0.8
1234678-HpCDF		**1.0**	*1.0*	1.0
1234789-HpCDF		1.3	1.2	1.3
OCDF		3.0	2.3	2.2
Totals: Dioxins				
-TCDD		0.4	0.3	0.4
-PeCDD		0.6	0.6	0.6
-HxCDD		0.8	0.8	0.9
-HpCDD		**10.6**	1.5	1.5
Totals: Furans				
-TCDF		0.3	0.3	0.3
-PeCDF		0.4	0.4	0.4
-HxCDF		**2.4**	0.7	0.7
-HpCDF		**3.0**	*2.5*	1.1

			IGT-13	IGT-14	IGT-15
			Quenched Grab Compos	Quenched Grab #1	Quenched Grab #2
Report 40664L					
Polychlorinated Biphenyls					
(ug/Kg dry weight)					
EPA MM680/HRGC/MS					
				Low Resolution Data Only	
2-Mono	Congener # 1				
44'-Di	# 15				
244'-Tri	# 28				
22'55'-Tetra	# 52				
33'44'-Tetra	# 77				
2344'5-Penta	# 118				
233'44'-Penta	# 105				
33'44'5-Penta	# 126				
233'44'5-Hexa	# 156				
33'44'55'-Hexa	# 169				
22'344'55'-Hepta	# 180				
22'33'44'55'-Octa	# 194				
22'33'44'55'6-Nona	# 206				
Deca	# 209				
PCB Totals:					
-Mono			0.1	0.1	0.1
-Di			0.1	0.1	0.1
-Tri			0.2	0.1	0.1
-Tetra			0.3	0.2	0.2
-Penta			0.4	0.3	0.3
-Hexa			0.4	0.3	0.3
-Hepta			0.3	0.3	0.3
-Octa			0.5	0.4	0.4
-Nona			0.6	0.5	0.5
-Deca			1.0	0.8	0.8

		IGT-13	IGT-14	IGT-15
		Quenched Grab Compos	Quenched Grab #1	Quenched Grab #2
Report 40664M				
Metals				
(mg/kg dry weight)				
EPA 6010A & EPA 7471				
Ag		**0.800**	**0.851**	**0.813**
As		**2.25**	**1.23**	**1.81**
Be		**1.55**	**1.42**	**2.04**
Cd		**0.730**	**0.612**	**0.703**
Cr		**591**	**646**	**619**
Cu		**315**	**307**	**305**
Ni		**569**	**330**	**331**
Pb		**30.0**	**27.6**	**31.2**
Sb		0.795	0.790	0.785
Se		**1.40**	**1.05**	**1.46**
Tl		**4.57**	**2.59**	**3.50**
Zn		**303**	**270**	**289**
Hg (total)		0.087	0.097	0.087

		Data Legend:		
		Normal Type = Below Detection Limit		
		Bold Type = Valid Data		
		Italics = Estimated Maximum Possible Concentration		
		IGT-40	**IGT-41**	
		Blended Cement	Blended Cement	
Gross Physico-Chemical Properties				
Particle size				
(% Dry Weight)				
ASTM D422 (Mod)				
Medium gravel	> 4.75 mm			
Fine gravel	2-4.75			
V. coarse sand	0.85-2			
Coarse sand	0.425-0.85			
Medium sand	0.24-0.425			
Fine sand	0.106-0.24			
V. fine sand	0.075-0.106			
Clay				
Silt				
pH				
EPA 9045A	pH Units			
Solids (total)				
EPA 160.3	% dry wt.			
Sulfides (total)				
EPA 9030M	mg/Kg dry wt.			
Organic carbon (total)				
ASTM D4129-82M	% dry wt.			
TRPH				
EPA 3550A/8015 Modified	ug/L			

		IGT-40	IGT-41	
		Blended Cement	Blended Cement	
Report 40664E				
SVOC's - Page 1 of 2		**These are TCLP Data**		
EPA 8270A (ug/L extract)				
Phenol		1.35	1.39	
bis(2-Chloroethyl)ether		1.72	1.76	
2-Chlorophenol		1.5	1.54	
1,3-Dichlorobenzene		1.22	1.25	
1,4-Dichlorobenzene		1.26	1.29	
1,2-Dichlorobenzene		1.32	1.35	
2,2'-oxybis(1-Chloropropane)		1.81	1.86	
Benzyl alcohol		2.56	2.63	
2-Methylphenol		1.89	1.94	
3/4-Methylphenol		1.76	1.8	
N-Nitroso-di-n-propylamine		2.06	2.12	
Hexachloroethane		2.24	2.3	
Nitrobenzene		1.22	1.25	
Isophorone		0.68	0.69	
2-Nitrophenol		2.4	2.45	
2,4-Dimethylphenol		1.47	1.5	
bis(2-Chloroethoxy)methane		1.38	1.41	
Benzoic acid		3.75	3.83	
2,4-Dichlorophenol		1.81	1.85	
1,2,4-Trichlorobenzene		1.6	1.63	
Naphthalene		0.59	0.61	
4-Chloroaniline		1.38	1.41	
Hexachlorobutadiene		1.86	1.9	
4-Chloro-3-methylphenol		1.59	1.62	
2-Methylnaphthalene		0.8	0.82	
Hexachlorocyclopentadiene		2.58	2.67	
2,4,6-Trichlorophenol		2.47	2.56	
2,4,5-Trichlorophenol		2.52	2.61	
2-Chloronaphthalene		0.91	0.94	
2-Nitroaniline		2.58	2.68	
Dimethylphthalate		0.69	0.72	
2,6-Dinitrotoluene		3.29	3.42	
2,4-Dinitrotoluene		2.31	2.4	

		IGT-40	IGT-41	
		Blended Cement	Blended Cement	
SVOC's - Page 2 of 2				
EPA 8270A (ug/L extract)				
Acenapthylene		0.54	0.56	
3-Nitroaniline		2.66	2.76	
Acenaphthene		0.95	0.99	
2,4-Dinitrophenol		8.09	8.39	
4-Nitrophenol		3.03	3.14	
Dibenzofuran		0.65	0.67	
Diethylphthalate		0.55	0.57	
4-Chlorophenyl-phenylether		1.51	1.57	
Fluorene		0.87	0.9	
4-Nitroaniline		2.5	2.59	
4,6-Dinitro-2-methylphenol		5.16	5.27	
N-Nitrosodiphenylamine		1.61	1.65	
4-Bromophenyl-phenylether		2.72	2.78	
Hexachlorobenzene		2.16	2.2	
Pentachlorophenol		3.75	3.83	
Phenanthrene		0.73	0.74	
Anthracene		0.8	0.82	
Di-n-butyl phthalate		**1.09**	0.35	
Fluoranthene		0.47	0.48	
Pyrene		0.55	0.52	
Butylbenzylphthalate		0.7	0.66	
3,3'-Dichlorobenzidine		1.42	1.35	
bis-2-ethylhexylphthalate		**0.62**	**0.32**	
Benzo(a)anthracene		0.49	0.46	
Chrysene		0.53	0.5	
Di-n-octylphthalate		0.4	0.39	
Benzo(b)fluoranthene		0.62	0.61	
Benzo(k)fluoranthene		0.71	0.7	
Benzo(e)pyrene		0.73	0.71	
Benzo(a)pyrene		0.75	0.73	
Perylene		0.8	0.78	
Indeno(1,2,3-cd)pyrene		0.68	0.66	
Dibenz(a,h)anthracene		0.86	0.84	
Benzo(g,h,i)perylene		0.76	0.74	

			IGT-40	IGT-41	
			Blended Cement	Blended Cement	
Report 40664F					
Polychlorinated Biphenyls			**These are TCLP Data**		
(ng/L Extract)					
EPA MM680/HRGC/MS					
2-Mono	Congener # 1		**0.25**	**0.28**	
44'-Di	# 15		**0.41**	*0.38*	
244'-Tri	# 28		**0.93**	**1.14**	
22'55'-Tetra	# 52		**0.46**	**0.95**	
33'44'-Tetra	# 77		0.04	0.09	
2344'5-Penta	# 118		**0.21**	0.12	
233'44'-Penta	# 105		*0.04*	0.12	
33'44'5-Penta	# 126		0.06	0.14	
233'44'5-Hexa	# 156		**0.07**	0.13	
33'44'55'-Hexa	# 169		0.09	0.17	
22'344'55'-Hepta	# 180		**0.80**	**0.14**	
22'33'44'55'-Octa	# 194		*0.12*	0.19	
22'33'44'55'6-Nona	# 206		0.14	0.26	
Deca	# 209		0.11	0.20	
PCB Totals:					
-Mono			**0.31**	**0.28**	
-Di			**2.45**	**2.13**	
-Tri			**5.67**	**6.81**	
-Tetra			**2.40**	**4.30**	
-Penta			**2.03**	**0.72**	
-Hexa			**7.14**	**1.03**	
-Hepta			**2.68**	**0.24**	
-Octa			*0.22*	0.19	
-Nona			0.14	0.26	

		IGT-40	IGT-41	
		Blended Cement	Blended Cement	
Report 40664G and 40664Gr1				
Dioxins and Furans		**TCLP Data**		
(pg/L Extract)				
EPA 8290				
2378-TCDD		4.5	5.2	
12378-PeCDD		6.3	6.7	
123478-HxCDD		8.8	6.4	
123678-HxCDD		6.6	5.9	
123789-HxCDD		7.5	5.7	
1234678-HpCDD		**13.7**	6.2	
OCDD	?	*115.0*	*8.1*	
2378-TCDF		3.9	4.3	
12378-PeCDF		4.7	4.7	
23478-PeCDF		4.7	4.5	
123478-HxCDF		6.6	4.3	
123678-HxCDF		*4.8*	3.4	
234678-HxCDF		6.6	*4.1*	
123789-HxCDF		7.6	4.7	
1234678-HpCDF		6.2	3.6	
1234789-HpCDF		7.9	5.6	
OCDF		*10.5*	6.8	
Totals: Dioxins				
-TCDD		4.5	5.2	
-PeCDD		6.3	6.7	
-HxCDD		7.5	6.0	
-HpCDD	?	**24.3**	6.2	
Totals: Furans		3.9	4.3	
-TCDF		4.7	4.6	
-PeCDF		6.2	*4.1*	
-HxCDF		7.0	4.4	
-HpCDF				

		IGT-40	IGT-41	
		Blended Cement	Blended Cement	
Report 40664H				
Metals		**TCLP data**		
(mg/L Extract)				
EPA 6010A & EPA 7471				**IGT-40 Duplicate**
Ag		0.001	0.001	0.001
As		0.005	0.005	0.005
Be		0.001	0.001	0.001
Cd		0.001	0.001	0.001
Cr		**0.152**	**0.152**	**0.159**
Cu		**0.008**	**0.008**	**0.008**
Ni		0.003	0.003	0.003
Pb		0.002	0.002	0.002
Sb		0.004	0.004	0.004
Se		0.003	0.003	0.003
Tl		0.005	0.005	0.005
Zn		**0.017**	**0.012**	**0.016**
Hg (total)		0.0004	0.0004	

		IGT-6	IGT-20	
		Makeup (Tap) Water	Granulator Water	
Report 40664A				
SVOC's - Page 1 of 2				
EPA 8270A (ug/L)				
Phenol		1.363	1.191	
bis(2-Chloroethyl)ether		1.622	1.409	
2-Chlorophenol		1.584	1.377	
1,3-Dichlorobenzene		1.21	1.053	
1,4-Dichlorobenzene		1.238	1.077	
1,2-Dichlorobenzene		1.402	1.223	
2,2'-oxybis(1-Chloropropane)		1.853	1.612	
Benzyl alcohol		2.544	2.211	
2-Methylphenol		1.834	**11.23**	
3/4-Methylphenol		1.824	1.588	
N-Nitroso-di-n-propylamine		2.227	1.936	
Hexachloroethane		2.486	2.163	
Nitrobenzene		1.526	1.207	
Isophorone		0.816	0.648	
2-Nitrophenol		2.65	2.098	
2,4-Dimethylphenol		1.661	1.312	
bis(2-Chloroethoxy)methane		1.498	1.183	
2,4-Dichlorophenol		1.978	1.563	
1,2,4-Trichlorobenzene		1.766	1.401	
Naphthalene		0.624	**10.14**	
4-Chloroaniline		1.459	1.158	
Hexachlorobutadiene		2.4	1.904	
4-Chloro-3-methylphenol		1.757	1.385	
2-Methylnaphthalene		0.854	0.672	
Hexachlorocyclopentadiene		1.968	1.669	
2,4,6-Trichlorophenol		2.314	1.968	
2,4,5-Trichlorophenol		2.227	1.887	
2-Chloronaphthalene		0.835	0.713	
2-Nitroaniline		2.554	2.171	
Dimethylphthalate		0.672	0.567	
2,6-Dinitrotoluene		2.918	2.471	
2,4-Dinitrotoluene		2.102	1.782	

		IGT-6	IGT-20	
		Makeup (Tap) Water	Granulator Water	
Report 40664A				
SVOC's - Page 2 of 2				
EPA 8270A (ug/L)				
Acenapthylene		0.48	**10.92**	
3-Nitroaniline		2.602	2.203	
Acenaphthene		0.787	**0.3**	
2,4-Dinitrophenol		6.019	5.103	
4-Nitrophenol		4.33	3.669	
Dibenzofuran		0.576	0.486	
Diethylphthalate		0.586	**4.54**	
4-Chlorophenyl-phenylether		1.574	1.337	
Fluorene		0.826	**2.22**	
4-Nitroaniline		2.717	2.3	
4,6-Dinitro-2-methylphenol		4.742	3.532	
N-Nitrosodiphenylamine		1.402	1.045	
4-Bromophenyl-phenylether		2.678	2.001	
Hexachlorobenzene		2.294	1.709	
Pentachlorophenol		3.264	2.43	
Phenanthrene		0.682	**27.09**	
Anthracene		0.739	0.551	
Di-n-butyl phthalate		**1.68**	**3.69**	
Fluoranthene		0.586	**23.61**	
Pyrene		0.518	**29.88**	
Butylbenzylphthalate		0.73	**0.81**	
3,3'-Dichlorobenzidine		2.026	1.507	
bis-2-ethylhexylphthalate		0.586	**0.55**	
Benzo(a)anthracene		0.576	0.429	
Chrysene		0.643	0.478	
Di-n-octylphthalate		0.336	0.267	
Benzo(b)fluoranthene		0.624	0.502	
Benzo(k)fluoranthene		0.672	0.535	
Benzo(e)pyrene		0.71	0.567	
Benzo(a)pyrene		0.758	0.608	
Perylene		0.835	0.664	
Indeno(1,2,3-cd)pyrene		0.73	0.591	
Dibenz(a,h)anthracene		0.989	0.794	
Benzo(g,h,i)perylene		0.826	0.664	

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			IGT-6	IGT-20	
			Makeup (Tap) Water	Granulator Water	
Report 40664B					
Polychlorinated Biphenyls					
(ng/L)					
EPA MM680/HRGC/MS					
2-Mono	Congener # 1		0.05	*0.04*	
44'-Di	# 15		0.03	0.02	
244'-Tri	# 28		**0.13**	**0.37**	
22'55'-Tetra	# 52		**0.16**	**0.37**	
33'44'-Tetra	# 77		0.04	**0.04**	
2344'5-Penta	# 118		**0.19**	**0.21**	
233'44'-Penta	# 105		**0.07**	*0.10*	
33'44'5-Penta	# 126		0.06	0.04	
233'44'5-Hexa	# 156		0.07	0.04	
33'44'55'-Hexa	# 169		0.09	0.06	
22'344'55'-Hepta	# 180		**0.16**	**0.18**	
22'33'44'55'-Octa	# 194		0.10	0.08	
22'33'44'55'6-Nona	# 206		0.13	0.10	
Deca	# 209		0.12	0.10	
PCB Totals:					
-Mono			0.05	0.11	
-Di			0.03	**0.02**	
-Tri			**0.31**	1.82	
-Tetra			**0.62**	3.34	
-Penta			**1.03**	1.33	
-Hexa			**0.88**	0.82	
-Hepta			**0.16**	0.50	
-Octa			0.10	**0.08**	
-Nona			0.13	**0.10**	

		IGT-6	IGT-20	
		Makeup (Tap) Water	Granulator Water	
Report 40664C				
Dioxins and Furans				
(pg/L)				
EPA 8290				
2378-TCDD		1.9	5.4	
12378-PeCDD		2.4	7.3	
123478-HxCDD		2.4	10.4	
123678-HxCDD		2.0	8.4	
123789-HxCDD		2.0	9.0	
1234678-HpCDD		2.3	*7.1*	
OCDD		**11.0 ?**	*12.7*	
2378-TCDF		1.4	**31.2**	
12378-PeCDF		1.7	*6.3*	
23478-PeCDF		1.7	**11.6**	
123478-HxCDF		1.5	**21.1**	
123678-HxCDF		1.2	**10.0**	
234678-HxCDF		*4.3*	**21.6**	
123789-HxCDF		1.7	8.4	
1234678-HpCDF		**1.9**	**21.6**	
1234789-HpCDF		2.0	12.8	
OCDF			14.7	
Totals: Dioxins				
-TCDD		1.9	5.4	
-PeCDD		2.4	7.3	
-HxCDD		2.1	**9.3**	**ND in Result Summ**
-HpCDD		2.3	**14.5**	
Totals: Furans				
-TCDF		1.4	**145.1**	**68.4 in Result Summ**
-PeCDF		1.7	**11.6**	**30.7 in Result Summ**
-HxCDF		***4.3***	**93.3**	
-HpCDF		**1.9**	**48.7**	

		IGT-7	IGT-21	
		Makeup (Tap) Water	Granulator Water	
Report 40664D				
Metals				
(mg/L)				**IGT-8**
EPA 6010A & EPA 7471				Duplicate
Ag		0.00		0.00
As		0.01		0.01
Be		0.00		0.00
Cd		**0.02**	**10.53**	**0.02**
Cr		0.00		0.00
Cu		**0.04**	**2.44**	**0.04**
Ni		**0.50**	**4.57**	**0.48**
Pb		0.00		0.00
Sb		0.01		0.01
Se		0.01		0.01
Tl		0.01		0.01
Zn		**1.68**	**4.76**	**1.60**
Hg (total)		0.0004		0.0004

Appendix D

Compilation of Analyses From BNL
(AirNova, Inc.)

Table 3 - 1
Hazen Research, Inc.
Cement-Lock Pilot Plant
Emission Summary - Particulate Matter

Location	Outlet	Afterburner
Run	1	1
Date	11/23/96	11/23/96
Time Period	0020-0120	1012-1112
Exhaust Gas Characteristics		
Oxygen (%dry)	3.38	3.50
Carbon Dioxide (%dry)	10.20	10.10
Moisture Content (%)	43.7	14.4
Stack Gas Temperature (°F)	286	1,575
Stack Gas Velocity (ft/sec)	44.2	43.7
Volumetric Flow Rate (acfm)	925	1,429
Volumetric Flow Rate (dscfm)	356	307
Particulate Matter		
Concentration (grains/dscf)	<4.9E-5	5.3E-2
Emission Rate (lb/hr)	<2.0E-4	0.14

Standard Conditions: 68°F, 29.92 in. Hg

Table 3 - 2
Hazen Research, Inc.
Cement-Lock Pilot Plant
Emission Summary - Hydrogen Chloride

Location	Outlet	Afterburner
Run	1	1
Date	11/23/96	11/23/96
Time Period	0020-0120	1020-1112
Exhaust Gas Characteristics		
Oxygen (% dry)	3.38	3.50
Carbon Dioxide (% dry)	10.20	10.10
Moisture Content (%)	43.7	14.4
Stack Gas Temperature (°F)	286	1,575
Stack Gas Velocity (ft/sec)	44.2	43.7
Volumetric Flow Rate (acfm)	925	1,429
Volumetric Flow Rate (dscfm)	356	307
Hydrogen Chloride - Particulate Phase		
Concentration (ppmV)	<0.2	14.2
Emission Rate (lb/hr)	<4.0E-5	0.02
Hydrogen Chloride - Gas Phase		
Concentration (ppmV)	17.9	187
Emission Rate (lb/hr)	0.04	0.33

Standard Conditions: 68°F, 29.92 in. Hg

Table 3 - 3
Hazen Research, Inc.
Cement-Lock Pilot Plant
Emission Summary - Sulfur Dioxide/Nitrogen Oxides

Location	Outlet	Outlet	Afterburner	Afterburner
Run	1	2	1	2
Date	11/22/96	11/22/96	11/23/96	11/23/96
Time Period	1652-1852	1930-0008	1012-1112	1226-1426
Exhaust Gas Characteristics				
Oxygen (% dry)	3.73	3.00	3.50	3.18
Carbon Dioxide (%-dry)	10.75	10.35	10.10	10.75
Moisture Content (%)	39.5	40.8	14.4	15.5
Stack Gas Temperature (°F)	275	286	1,575	1,579
Stack Gas Velocity (ft/sec)	41.7	43.8	43.7	56.1
Volumetric Flow Rate (acfm)	874	918	1,429	1,835
Volumetric Flow Rate (dscfm)	367	373	307	388
Sulfur Dioxide				
Concentration (ppmV-dry)	54	57	101	133
Emission Rate (lb/hr)	0.20	0.21	0.31	0.51
Nitrogen Oxides (as NO_2)				
Concentration (ppmV-dry)	95	75	80	79
Emission Rate (lb/hr)	0.25	0.20	0.18	0.22

Standard Conditions: 68°F, 29.92 in. Hg

Table 3-4
Hazen Research, Inc.
Cement-Lock Pilot Plant
Emission Summary - Trace Metals

Location	Outlet	Outlet	Afterburner	Afterburner
Run	1	1	1	1
Date	11/22/96	11/22/96	11/23/96	11/23/96
Time Period	1652-1852	1652-1852	1226-1426	1226-1426
Exhaust Gas Characteristics				
Oxygen (%-dry)	3.73	3.73	3.18	3.18
Carbon Dioxide (%-dry)	10.75	10.75	10.75	10.75
Moisture Content (%)	39.5	39.5	15.5	15.5
Stack Gas Temperature (F)	275	275	1579	1579
Stack Gas Velocity (fps)	41.7	41.7	56.1	56.1
Volumetric Flow Rate (acfm)	874	874	1,835	1,835
Volumetric Flow Rate (scfm)	367	367	388	388
Trace Metals	**Particulate Phase**	**Gas Phase**	**Particulate Phase**	**Gas Phase**
Antimony Concentration (ug/dscm) Emission Rate (lb/hr)	0.28 3.8E-07	<0.12 <1.6E-07	5.55 8.1E-05	4.67 6.8E-06
Arsenic Concentration (ug/dscm) Emission Rate (lb/hr)	0.76 1.0E-06	0.24 3.3E-07	335.00 4.8E-04	6.53 9.5E-06
Beryllium Concentration (ug/dscm) Emission Rate (lb/hr)	<0.04 <5.5E-08	<0.04 <5.5E-08	0.47 6.8E-07	<4.7 E-02 <6.8 E-08
Cadmium Concentration (ug/dscm) Emission Rate (lb/hr)	<0.80 <1.1E-06	<0.80 <1.1E-06	320.00 4.7E-04	<1.40 <2.0E-06

Table 3-4 (continued)
Hazen Research, Inc.
Cement-Lock Pilot Plant
Emission Summary - Trace Metals

Trace Metals	Particulate Phase	Gas Phase	Particulate Phase	Gas Phase
Location	Outlet	Outlet	Afterburner	Afterburner
Chromium Concentration (ug/dscm) Emission Rate (lb/hr)	 1.99 2.7E-06	 <0.80 < 1.1E-06	 551 8.0E-04	 5.60 8.2E-06
Copper Concentration (ug/dscm) Emission Rate (lb/hr)	 5.97 8.2E-06	 1.19 1.6E-06	 1870 2.7E-03	 4.67 6.8E-06
Lead Concentration (ug/dscm) Emission Rate (lb/hr)	 1.63 2.2E-05	 <7.95 < 1.1E-05	 6580 9.6E-03	 13.10 1.9E-05
Mercury Concentration (ug/dscm) Emission Rate (lb/hr)	 <0.16 <2.2E-07	 7.12 9.8E-06	 <0.47 6.7E-07	 56.60 8.2E-05
Nickel Concentration (ug/dscm) Emission Rate (lb/hr)	 1.59 2.2E-06	 <0.80 < 1.1E-06	 14.00 2.0E-05	 < 1.40 <2.0E-06
Selenium Concentration (ug/dscm) Emission Rate (lb/hr)	 <0.12 < 1.6E-07	 1.19 1.6E-06	 6.21 9.0E-06	 33.20 4.8E-05
Silver Concentration (ug/dscm) Emission Rate (lb/hr)	 <0.08 < 1.1E+07	 <0.08 < 1.1E-07	 4.95 7.2E-06	 <0.61 < 8.8E-07
Sodium Concentration (ug/dscm) Emission Rate (lb/hr)	 374.00 5.2E-04	 – –	 19800 2.9E-02	 – –
Titanium Concentration (ug/dscm) Emission Rate (lb/hr)	 21.90 3.0E-05	 < 2.39 < 3.3E-06	 789.00 1.2E-03	 39.20 5.7E-05
Zinc Concentration (ug/dscm) Emission Rate (lb/hr)	 29.40 4.1E-05	 < 3.98 < 5.5E-06	 395 5.8E-03	 < 5.60 < 8.2E-06

Table 3-4 (continued)
Hazen Research, Inc.
Cement-Lock Pilot Plant
Emission Summary - Trace Metals

Trace Metals	Particulate Phase	Gas Phase	Particulate Phase	Gas Phase
Location	Outlet	Outlet	Afterburner	Afterburner
Sulfur				
Concentration (ug/dscm)	163.00	—	1930	—
Emission Rate (lb/hr)	1.9E-03	—	2.8E-02	—

Standard Conditions: 68 deg. F, 29.92 in. Hg.

Table 3 - 5
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Dioxin and Furan Compounds
Outlet - Particulate Phase

Location	Outlet				
Run	1				
Date	11/22/96				
Time Period	1930-0008				
Exhaust Gas Characteristics					
Oxygen (%Odry)	3.00				
Carbon Dioxide (%-dry)	10.35				
Moisture Content (%)	40.8				
Stack Gas Temperature (F)	286				
Stack Gas Velocity (fps)	43.8				
Volumetric Flow Rate (acfm)	918				
Volumetric Flow Rate (scfm)	373				
Dioxin/Furan Compounds (Particulate Phase)					
Homologue/ Cogener	TEF *	Mass (ng)	Actual Concentration (ng/DSCM)	TEF Concentration (ng/DSCM)	TEF Emission Rate (lb/hr)
2,3,7,8 TCDD other TCDD	1.0 0.01	<0.01 <0.01	<2.7E-3 <2.7E-3	<2.7E-3 <2.7E-5	<3.8E-12 <3.8E-14
2,3,7,8 PeCDD other PeCDD	0.5 0.005	<0.02 <0.05	<5.4E-3 <5.4E-3	<2.7E-3 <2.7E-5	<3.8E-12 <3.8E-14
2,3,7,8 H_xCDD other H_xCDD	0.4 0.004	<0.03 <0.02	<8.1E-3 <5.4E-3	<3.3E-4 <2.2E-6	<4.6E-13 <3.0E-15
2,3,7,8 HpCDD other HpCDD	0.001 0.00001	<0.03 <0.03	<8.1E-3 <8.1E-3	<8.1E-6 <8.1E-8	<1.1E-14 <1.1E-16
OCDD	0.0	<0.07	<1.9E-2	0.0	0.0
2,3,7,8-CDD (Total)					<8.0E-12

Table 3 - 5 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Dioxin and Furan Compounds
Outlet - Particulate Phase

Dioxin/Furan Compounds (Particulate Phase)					
Location		Outlet			
Homologue/ Cogener	TEF *	Mass (ng)	Actual Concentration (ng/DSCM)	TEF Concentration (ng/DSCM)	TEF Emission Rate (lb/hr)
2,3,7,8 TCDF other TCDF	0.1 0.001	<0.01 <0.01	<2.2E-3 <2.2E-3	<2.2E-4 <2.2E-6	<3.0E-13 <3.0E-15
2,3,7,8 PeCDF other PeCDF	0.1 0.001	<0.01 <0.01	<2.7E-3 <2.7E-3	<2.7E-4 <2.7E-6	<3.8E-13 <3.8E-15
2,3,7,8 H_xCDF other H_xCDF	0.01 0.0001	<0.01 <0.01	<2.7E-3 <2.7E-3	<2.7E-5 <2.7E-7	<3.8E-14 <3.8E-16
2,3,7,8 HpCDF other HpCDF	0.001 0.00001	<0.02 <0.02	<5.4E-3 <5.4E-3	<5.4E-6 <5.4E-8	<7.6E-15 <7.6E-17
OCDF	0.0	<0.04	<1.1E-2	0.0	0.0
2,3,7,8-CDF (Total)					<7.3E-13

Standard Conditions: 68 deg. F, 29.92 in. Hg.

* Toxicity Equivalency Factor

Table 3 - 6
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Dioxin and Furan Compounds
Outlet - Gas Phase

Location	Outlet
Run	1
Date	11/22/96
Time Period	1930-0008
Exhaust Gas Characteristics	
Oxygen (%Odry)	3.00
Carbon Dioxide (%-dry)	10.35
Moisture Content (%)	40.8
Stack Gas Temperature (F)	286
Stack Gas Velocity (fps)	43.8
Volumetric Flow Rate (acfm)	918
Volumetric Flow Rate (scfm)	373

Dioxin/Furan Compounds (Gas Phase)

Homologue/ Cogener	TEF *	Mass (ng)	Actual Concentration (ng/DSCM)	TEF Concentration (ng/DSCM)	TEF Emission Rate (lb/hr)
2,3,7,8 TCDD other TCDD	1.0 0.01	<0.01 <0.01	< 1.4E-3 < 1.4E-3	< 1.4E-3 < 1.4E-5	< 1.9E-12 < 1.9E-14
2,3,7,8 PeCDD other PeCDD	0.5 0.005	<0.01 <0.01	< 2.7E-3 < 2.7E-3	< 1.4E-3 < 1.4E-5	< 1.9E-12 < 1.9E-14
2,3,7,8 H_xCDD other H_xCDD	0.4 0.004	<0.01 <0.01	< 2.7E-3 < 2.7E-3	< 1.1E-4 < 1.1E-6	< 1.5E-13 < 1.5E-15
2,3,7,8 HpCDD other HpCDD	0.001 0.00001	< 0.08 < 0.03	< 2.2E-2 < 8.1E-3	< 2.2E-5 < 8.1E-8	< 3.0E-14 < 1.1E-16
OCDD	0.0	< 0.32	< 8.7E-2	0.0	0.0
2,3,7,8-CDD (Total)					< 4.0E-12

Table 3 - 6 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Dioxin and Furan Compounds
Outlet - Gas Phase

Dioxin/Furan Compounds (Gas Phase)					
Location		Outlet			
Homologue/ Cogener	TEF *	Mass (ng)	Actual Concentration (ng/DSCM)	TEF Concentration (ng/DSCM)	TEF Emission Rate (lb/hr)
2,3,7,8 TCDF other TCDF	0.1 0.001	<0.17 <0.17	<4.6E-2 <4.6E-2	<4.6E-3 <4.6E-5	<6.4E-12 <6.4E-14
2,3,7,8 PeCDF other PeCDF	0.1 0.001	<0.03 <0.04	<8.1E-3 <1.1E-2	<8.1E-4 <1.1E-5	<1.1E-12 <1.5E-14
2,3,7,8 H_xCDF other H_xCDF	0.01 0.0001	0.12 0.13	3.3E-2 3.5E-2	3.3E-4 3.5E-6	4.6E-13 4.9E-15
2,3,7,8 HpCDF other HpCDF	0.001 0.00001	<0.18 0.07	<4.9E-2 1.9E-2	<4.9E-5 1.9E-7	<6.8E-14 2.7E-16
OCDF	0.0	0.79	2.1E-1	0.0	0.0
2,3,7,8-CDF (Total)					<8.1E-12

Standard Conditions: 68 deg. F, 29.92 in. Hg.

* Toxicity Equivalency Factor

Table 3 - 7
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Dioxin and Furan Compounds
Afterburner - Particulate Phase

Location	Afterburner				
Run	1				
Date	11/23/96				
Time Period	1525-1955				
Exhaust Gas Characteristics					
Oxygen (%Odry)	3.05				
Carbon Dioxide (%-dry)	10.80				
Moisture Content (%)	16.4				
Stack Gas Temperature (F)	1,496				
Stack Gas Velocity (fps)	43.5				
Volumetric Flow Rate (acfm)	1,424				
Volumetric Flow Rate (scfm)	311				
Dioxin/Furan Compounds (Particulate Phase)					
Homologue/ Cogener	TEF *	Mass (ng)	Actual Concentration (ng/DSCM)	TEF Concentration (ng/DSCM)	TEF Emission Rate (lb/hr)
2,3,7,8 TCDD other TCDD	1.0 0.01	<0.01 <0.01	<2.8E-3 <2.8E-3	<2.8E-3 <2.8E-5	<3.3E-12 <3.3E-14
2,3,7,8 PeCDD other PeCDD	0.5 0.005	<0.02 <0.02	<5.7E-3 <5.7E-3	<2.8E-3 <2.8E-5	<3.3E-12 <3.3E-14
2,3,7,8 H_xCDD other H_xCDD	0.4 0.004	<0.03 <0.03	<8.5E-3 <8.5E-3	<3.4E-4 <3.4E-6	<4.0E-13 <4.0E-15
2,3,7,8 HpCDD other HpCDD	0.001 0.00005	<0.04 <0.03	1.1E-2 <8.5E-3	1.1E-5 <8.5E-8	1.3E-14 <.9.9E-17
OCDD	0.0	<0.13	<3.7E-2	0.0	0.0
2,3,7,8-CDD (Total)					<7.0E-12

Table 3 - 7 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Dioxin and Furan Compounds
Afterburner - Particulate Phase

Dioxin/Furan Compounds (Particulate Phase)					
Location		Afterburner			
Homologue/ Cogener	TEF *	Mass (ng)	Actual Concentration (ng/DSCM)	TEF Concentration (ng/DSCM)	TEF Emission Rate (lb/hr)
2,3,7,8 TCDF other TCDF	0.1 0.001	<0.01 <0.01	<2.8E-4 <2.3E-6	<2.8E-4 <2.3E-6	<3.3E-13 <2.7E-15
2,3,7,8 PeCDF other PeCDF	0.1 0.001	<0.01 <0.01	<2.8E-4 <2.8E-6	<2.8E-4 <2.8E-6	<3.3E-13 <3.3E-15
2,3,7,8 H_xCDF other H_xCDF	0.01 0.0001	0.03 0.01	8.5E-5 2.8E-7	8.5E-5 2.8E-7	9.9E-14 3.3E-16
2,3,7,8 HpCDF other HpCDF	0.001 0.00001	0.06 <0.03	1.7E-5 <8.5E-8	1.7E-5 8.5E-8	2.0E-14 <9.9E-17
OCDF	0.0	<0.14	4.0E-2	0.0	0.0
2,3,7,8-CDF (Total)					<7.8E-13

Standard Conditions: 68 deg. F, 29.92 in. Hg.

* Toxicity Equivalency Factor

Table 3 - 8
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Dioxin and Furan Compounds
Afterburner - Gas Phase

Location	Afterburner
Run	1
Date	11/23/96
Time Period	1525-1955
Exhaust Gas Characteristics	
Oxygen (%Odry)	3.05
Carbon Dioxide (%-dry)	10.80
Moisture Content (%)	16.4
Stack Gas Temperature (F)	1,496
Stack Gas Velocity (fps)	43.5
Volumetric Flow Rate (acfm)	1,424
Volumetric Flow Rate (scfm)	311

Dioxin/Furan Compounds (Gas Phase)

Homologue/ Cogener	TEF *	Mass (ng)	Actual Concentration (ng/DSCM)	TEF Concentration (ng/DSCM)	TEF Emission Rate (lb/hr)
2,3,7,8 TCDD other TCDD	1.0 0.01	<0.01 <0.01	<2.8E-3 <2.6E-3	<2.8E-3 <2.6E-5	<3.3E-12 <3.0E-14
2,3,7,8 PeCDD other PeCDD	0.5 0.005	<0.03 <0.02	<8.5E-3 <5.7E-3	<4.3E-3 <2.8E-5	<5.0E-12 <3.3E-14
2,3,7,8 H_xCDD other H_xCDD	0.4 0.004	<0.02 <0.03	<5.7E-3 <8.5E-3	<2.3E-4 <3.4E-6	<3.7E-13 <5.0E-15
2,3,7,8 HpCDD other HpCDD	0.001 0.00005	0.06 <0.02	1.7E-2 <5.7E-3	1.7E-5 <5.7E-8	2.0E-14 <6.6E-17
OCDD	0.0	0.11	3.1E-2	0.0	0.0
2,3,7,8-CDD (Total)					<8.6E-12

Table 3 - 8 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Dioxin and Furan Compounds
Afterburner - Gas Phase

Dioxin/Furan Compounds (Gas Phase)					
Location		Afterburner			
Homologue/ Cogener	TEF *	Mass (ng)	Actual Concentration (ng/DSCM)	TEF Concentration (ng/DSCM)	TEF Emission Rate (lb/hr)
2,3,7,8 TCDF other TCDF	0.1 0.001	0.20 0.01	5.7E-2 2.0E-3	5.7E-3 2.0E-6	6.6E-12 2.3E-15
2,3,7,8 PeCDF other PeCDF	0.1 0.001	0.09 0.06	2.6E-2 1.7E-2	2.6E-3 1.7E-5	3.0E-12 2.0E-14
2,3,7,8 H_xCDF other H_xCDF	0.01 0.0001	0.20 0.21	5.7E-2 6.0E-2	5.7E-4 6.0E-6	6.6E-13 7.0E-15
2,3,7,8 HpCDF other HpCDF	0.001 0.00001	0.31 <0.04	8.8E-2 < 1.1E-2	8.8E-5 < 1.1E-7	1.0E-13 < 1.3E-16
OCDF	0.0	<0.56	1.6E-1	0.0	0.0
2,3,7,8-CDF (Total)					1.0E-11

Standard Conditions: 68 deg. F, 29.92 in. Hg.

* Toxicity Equivalency Factor

Table 3 - 9
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Polychlorinated Biphenyl Compounds
Outlet

Location	Outlet
Run	1
Date	11/22/96
Time Period	1930-0008
Exhaust Gas Characteristics	
Oxygen (%Odry)	3.00
Carbon Dioxide (%-dry)	10.35
Moisture Content (%)	40.8
Stack Gas Temperature (F)	286
Stack Gas Velocity (fps)	43.8
Volumetric Flow Rate (acfm)	918
Volumetric Flow Rate (scfm)	373

Polychlorinated Biphenyl Compounds

	Particulate Phase		Gas Phase	
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm)	Emission Rate (lb/hr)
Aroclor 1016	< 5.43E-02	< 7.58E-08	< 1.09E-01	< 1.52E-07
Aroclor 1221	< 5.43E-02	< 7.58E-08	< 1.09E-01	< 1.52E-07
Aroclor 1232	< 5.43E-02	< 7.58E-08	< 1.09E-01	< 1.52E-07
Aroclor 1242	< 5.43E-02	< 7.58E-08	< 1.09E-01	< 1.52E-07
Aroclor 1248	< 5.43E-02	< 7.58E-08	< 1.09E-01	< 1.52E-07
Aroclor 1254	< 5.43E-02	< 7.58E-08	< 1.09E-01	< 1.52E-07
Aroclor 1260	< 5.43E-02	< 7.58E-08	< 1.09E-01	< 1.52E-07

Standard Conditons: 68 deg. F, 29.92 in. Hg.

Table 3 - 10
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Polychlorinated Biphenyl Compounds
Afterburner

Location	Afterburner
Run	1
Date	11/23/96
Time Period	1525-1955
Exhaust Gas Characteristics	
Oxygen (%Odry)	3.05
Carbon Dioxide (%-dry)	10.8
Moisture Content (%)	16.4
Stack Gas Temperature (F)	1496
Stack Gas Velocity (fps)	50.7
Volumetric Flow Rate (acfm)	1,658
Volumetric Flow Rate (scfm)	362

Polychlorinated Biphenyl Compounds

	Particulate Phase		Gas Phase	
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm)	Emission Rate (lb/hr)
Aroclor 1016	< 5.68E-2	< 6.62E-8	< 1.14E-1	< 1.32E-7
Aroclor 1221	< 5.68E-2	< 6.62E-8	< 1.14E-1	< 1.32E-7
Aroclor 1232	< 5.68E-2	< 6.62E-8	< 1.14E-1	< 1.32E-7
Aroclor 1242	< 5.68E-2	< 6.62E-8	< 1.14E-1	< 1.32E-7
Aroclor 1248	< 5.68E-2	< 6.62E-8	< 1.14E-1	< 1.32E-7
Aroclor 1254	< 5.68E-2	< 6.62E-8	< 1.14E-1	< 1.32E-7
Aroclor 1260	< 5.68E-2	< 6.62E-8	< 1.14E-1	< 1.32E-7

Standard Conditions: 68 deg. F, 29.92 in. Hg.

Table 3-11
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Pesticide Compounds

Location	Outlet		Afterburner	
Run	1		1	
Date	11/22/96		11/23/96	
Time Period	1930-0008		1525-1955	
Exhaust Gas Characteristics				
Oxygen (%-dry)	3.00		3.05	
Carbon Dioxide (%-dry)	10.35		10.8	
Moisture Content (%)	40.8		16.4	
Stack Gas Temperature (F)	286		1,496	
Stack Gas Velocity (fps)	43.8		43.5	
Volumetric Flow Rate (acfm)	918		1,424	
Volumetric Flow Rate (scfm)	373		311	
Pesticide Compounds				
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm)	Emission Rate (lb/hr)
alpha-BHC	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6.62E-09
a-Chlordane	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6.62E-09
Aldrin	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6.62E-09
beta-BHC	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6.62E-09
delta-BHC	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6.62E-09
4,4'-DDD	< 1.09E-02	< 1.52E-08	< 1.14E-02	< 1.32E-08
4,4'-DDE	< 1.09E-02	< 1.52E-08	< 1.14E-02	< 1.32E-08
4,4'-DDT	< 1.09E-02	< 1.52E-08	< 1.14E-02	< 1.32E-08
Dieldrin	< 1.09E-02	< 1.52E-08	< 1.14E-02	< 1.32E-08
Endrin	< 1.09E-02	< 1.52E-08	< 1.14E-02	< 1.32E-08

Table 3-11 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Pesticide Compounds

Pesticide Compounds				
	Outlet		Afterburner	
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm)	Emission Rate (lb/hr)
Endrin aldehyde	< 1.09E-02	< 1.52E-08	< 1.14E-02	< 1.32E-08
Endosulfan I	< 1.09E-02	< 1.52E-08	< 5.68E-03	< 6.62E-09
Endosulfan II	< 5.43E-03	< 7.58E-09	< 1.14E-02	< 1.32-E-08
Endosulfan sulfate	< 1.09E-02	< 1.52E-08	< 1.14E-02	< 1.32E-08
gamma-BHC (Lindane)	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6:62E-09
g-Chlordane	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6.62-E-09
Heptachlor	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6.62-E-09
Heptachlor epoxide	< 5.43E-03	< 7.58E-09	< 5.68E-03	< 6.62-E-09
Methoxychlor	< 5.43E-03	< 7.58E-09	< 5.68E-02	< 6.62-E-08
Toxaphene	< 5.43E-02	< 7.58E-08	< 5.68E-01	< 6.62-E-07

Standard Conditions: 68 deg. F, 29.92 in. Hg.

Table 3-12
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Chlorobenzene/Chlorophenol Compounds

Location	Outlet		Afterburner	
Run	1		1	
Date	11/22/96		11/23/96	
Time Period	1930-0008		1525-1955	
Exhaust Gas Characteristics				
Oxygen (%-dry)	3.00		3.05	
Carbon Dioxide (%-dry)	10.35		10.8	
Moisture Content (%)	40.8		16.4	
Stack Gas Temperature (F)	286		1,496	
Stack Gas Velocity (fps)	43.8		43.5	
Volumetric Flow Rate (acfm)	918		1,424	
Volumetric Flow Rate (scfm)	373		311	
Chloropenzene/ Chlorophenol Compounds				
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm)	Emission Rate (lb/hr)
2-Chlorophenol	<0.92	< 1.29E-06	< 1.01	< 1.18E-06
1,3 Dichlorobenzene	<0.99	< 1.38E-06	< 1.08	< 1.26E-06
1,4-Dichlorobenzene	<0.99	< 1.38E-06	< 1.08	< 1.26E-06
1,2-Dichlorobenzene	< 1.01	< 1.42E-06	< 1.11	< 1.29E-06
3/4-Chlorophenol	< 1.83	< 2.56E-06	< 2.01	< 2.34E-06
1,3,5-Trichlorobenzene	< 1.52	< 2.13E-06	< 1.48	< 1.73E-06
2,4-Dichlorophenol	< 1.52	< 2.12E-06	< 1.48	< 1.72E-06
2,5-Dichlorophenol	< 1.47	< 2.05E-06	< 1.43	< 1.67E-06

Table 3-12 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Chlorobenzene/Chlorophenol Compounds

Chloropenzene/ Chlorophenol Compounds				
	Outlet		Afterburner	
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm	Emission Rate (lb/hr)
2,3-Dichlorophenol	< 2.00	< 1.29E-06	< 1.95	< 2.27E-06
1,2,4-Trichlorobenzene	< 1.55	< 2.16E-06	< 1.50	< 1.75E-06
2,6-Dichlorophenol	< 1.52	< 2.13E-06	< 1.48	< 2.01E-06
1,2,3-Trichlorobenzene	< 1551	< 2.16E-06	< 1.50	< 1.75E-06
1,2,3,5-Tetrachlorobenzene	< 2.98	< 4.16E-06	< 2.90	< 3.38E-06
1,2,4,5-Tetrachlorobenzene	< 1.88	< 2.62E-06	< 1.83	< 2.13E-06
2,3,5-Trichlorophenol	< 2.26	< 3.16E-06	< 2.19	< 2.55E-06
2,4,6-Trichlorophenol	< 2.15	< 3.00E-06	< 2.08	< 2.42E-06
2,4,5-Trichlorophenol	< 1.99	< 2.77E-06	< 1.92	< 2.24E-06
2,3,4-Trichlorophenol	< 2.20	< 3.07E-06	< 2.13	< 2.48E-06
3,5-Dichlorophenol	< 4.87	< 6.80E-06	< 4.71	< 5.48E-06
1,2,3,4-Tetrachlorobenzene	< 1.34	< 1.86E-06	< 1.29	< 1.50E-06
2,3,6-Trichlorophenol	< 2.13	< 2.97E-06	< 2.06	< 2.40E-06
3,4-Dichlorophenol	< 1.44	< 2.00E-06	< 1.39	< 1.62E-06
Pentachlorobenzene	< 1.48	< 2.06E-06	< 1.43	< 1.66E-06
2,3,5,6 Tetrachlorophenol	< 2.40	< 3.35E-06	< 2.32	< 2.70E-06
2,3,4,5-Tetrachlorophenol	< 2.77	< 3.87E-06	< 2.68	< 3.12E-06
Hexachlorobenzene	< 1.25	< 1.75E-06	< 1.43	< 1.66E-06
Pentachlorophenol	< 2.06	< 2.88E-06	< 2.36	< 2.74E-06

Standard Conditions: 68 deg. F, 29.92 in. Hg.

Table 3-13
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Semivolatile Organic Compounds

Location	Outlet		Afterburner	
Run	1		1	
Date	11/22/96		11/23/96	
Time Period	1930-0008		1525-1955	
Exhaust Gas Characteristics				
Oxygen (%-dry)	3.00		3.05	
Carbon Dioxide (%-dry)	10.35		10.8	
Moisture Content (%)	40.8		16.4	
Stack Gas Temperature (F)	286		1,496	
Stack Gas Velocity (fps)	43.8		43.5	
Volumetric Flow Rate (acfm)	918		1,424	
Volumetric Flow Rate (scfm)	373		311	
Semivolatile Organic Compounds				
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm)	Emission Rate (lb/hr)
Phenol	4.85	6.78E-06	0.40	4.7E-07
bis(2-chloroethyl) ether	< 1.36	< 1.91E-06	< 1.50	< 1.7E-06
2-Chlorophenol	< 1.04	< 1.45E-06	< 1.14	< 1.3E-06
1,3-Dichlorobenzene	< 1.07	< 1.50E-06	< 1.17	< 1.4E-06
1,4-Dichlorobenzene	< 1.01	< 1.42E-06	< 1.11	< 1.3E-06
1,2-Dichlorobenzene	< 1.11	< 1.55E-06	< 1.22	< 1.4E-06
Benzyalcohol	< 0.60	< 8.34E-07	< 1.58	< 1.8E-06
2,2'-oxybis(1-Chloropropane)	< 2.61	< 3.65E-06	< 2.9	< 3.3E-06
2-Methylphenol	< 1.02	< 1.42E-06	< 1.11	< 1.3E-06
3/4 Methylphenol	< 1.01	< 1.41E-06	< 1.11	< 1.3E-06
N-nitroso-di-n-propylamine	< 2.70	< 3.77E-06	< 2.96	< 3.5E-06

Table 3-13 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Semivolatile Organic Compounds

Semivolatile Organic Compounds				
	Outlet		Afterburner	
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm	Emission Rate (lb/hr)
Hexachloroethane	< 1.78	< 2 48E-06	< 1.95	< 2.3E-06
Nitrobenzene	< 1.55	< 2.17E-06	< 1.51	< 1.8E-06
Isophorone	< 0.71	< 9.93E-07	< 0.69	< 8.1E-07
2-Nitrophenol	< 1.85	< 2.58E-06	< 1.80	< 2.1E-06
2,4-Dimethylphenol	< 1.09	< 1.52E-06	< 1.06	< 1.2E-06
bis-(2-Chloroethoxy)methane	< 1.12	< 1.57E-06	< 1.09	< 1.3E-06
2,4-Dichlorophenol	< 1.52	< 2.12E-06	< 1.48	< 1.7E-06
1,2,4-Trichlorobenzene	< 1.39	< 1.95E-06	< 1.36	< 1.6E-06
Naphthalene	< 2.65	< 3.70E-06	< 0.37	< 4.3E-07
4-Chloroaniline	< 1.02	< 1.42E-06	< 1.00	< 1.2E-06
Hexachlorobutadiene	< 2.75	< 3.84E-06	< 2.68	< 3.1E-06
4-Chloro-3-methylphenol	< 1.35	< 1.88E-06	< 1.31	< 1.5E-06
2-Methylnaphthalene	< 0.40	< 5.61E-07	< 0.68	< 7.9E-07
Hexachloocyclopentadiene	< 2.10	< 2.93E-06	< 2.03	< 2.4E-06
2,4,6-Trichlorophenol	< 2.17	< 3.03E-06	< 2.09	< 2.4E-06
2,4,5-Trichlorophenol	< 1.93	< 2.69E-06	< 1.86	< 2.2E-06
2-Chloronaphthalene	< 0.62	< 8.72E-07	< 0.60	< 7.0E-07
2-Nitroaniline	< 3.01	< 4.21E-06	< 2.91	< 3.4E-06
Dimethylphthalate	< 0.59	< 8.22E-07	< 0.57	< 6.6E-07
2,6-Dinitrotoluene	< 2.43	< 3.39E-06	< 2.34	< 2.7E-06
2,4-Dinitrotoluene	< 1.89	< 2.64E-06	< 1.83	< 2.1E-06
Acenaphthylene	< 0.37	< 5.23E-07	< 0.36	< 4.2E-07

Table 3-13 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Semivolatile Organic Compounds

Semivolatile Organic Compounds				
	Outlet		Afterburner	
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm)	Emission Rate (lb/hr)
3-Nitoraniline	<2.00	<2.80E-06	<1.94	<2.3E-06
Acenaphthene	< 0.62	<8.68E-07	<0.60	<7.0E-07
2,4 Dinitrophenol	<4.02	<5.61E-06	<3.88	<4.5E-06
4-Nitrophenol	<3.48	<4.87E-06	<3.37	<3.9E-06
Dibenzofuran	<0.49	<6.82E-07	<0.47	<5.5E-07
Diethylphthalate	3.11	4.35E-06	1.61	1.9E-06
4-Chlorophenyl-phenylethene	<1.39	<1.94E-06	<1.34	<1.6E-06
Fluorene	<0.66	<9.25E-07	<0.64	<7.5E-07
4-Nitroaniline	<1.75	<2.44E-06	<1.69	<2.0E-06
4,6-Dinitro-2-methylphenol	<2.20	<3.07E-06	<2.51	<2.9E-06
N-Nitrosodiphenylamine	<0.79	<1.10E-06	<0.90	<1.1E-06
4-Bromophenyl-phenylethene	<1.74	<2.44E-06	<1.99	<2.3E-06
Hexachlorobenzene	< 1.24	< 1.73E-06	<1.41	<1.7E-06
Pentachlorophenol	<1.83	<2.55E-06	<2.09	<2.4E-06
Phenanthrene	<0.34	<4.70E-07	<0.13	<1.5E-07
Anthracene	<0.33	<4.66E-07	<0.38	<4.4E-07
Di-n-butyphthalate	<3.54	<4.94E-06	<2.14	<2.5E-06
Fluoranthene	<0.18	<2.54E-07	<0.33	<3.8E-07
Pyrene	<0.21	<2.99E-07	<0.30	<3.5E-07
3,3'-Dichlorobenzidine	<1.15	<1.61E-06	<1.15	<1.3E-06
bis(2-Ethylhexyl)phthalate	0.36	4.97E-05	< 1.88	<2.2E-06
Benzo(a)anthracene	<0.38	<5.34E-07	<0.38	<4.4E-07

Table 3-13 (continued)
Hazen Research, Inc.
Cement - Lock Pilot Plant
Emission Summary - Semivolatile Organic Compounds

Semivolatile Organic Compounds				
	Outlet		Afterburner	
Compound	Conc. (ug/dscm)	Emission Rate (lb/hr)	Conc. (ug/dscm	Emission Rate (lb/hr)
Chrysene	<0.42	<5.84E-07	<0.42	<4.8E-07
Di-n-octylphthalate	<0.36	<4.96E-07	<0.19	<2.2E-07
Benzo(b)fluoranthene	<0.45	<6.29E-07	<0.39	<4.5E-07
Benzo(k)fluoranthene	<0.43	<6.02E-07	<0.38	<4.4E-07
Benzo(a)pyrene	<0.50	<6.97E-07	<0.44	<5.1E-07
Indeno(1,2,3-cd)pyrene	<0.49	<6.78E-07	<0.42	<4.9E-07
Dibenz)a.h)anthracene	<0.66	<9.25E-07	<0.57	<6.7E-07
Benzo(g,h,i)perylenenylethe	<0.56	<7.84E-07	<0.33	<3.9E-07

Standard Conditions: 68 deg. F, 29.92 in. Hg.

Table 3 - 14
Hazen Research, Inc.
Cement-Lock Pilot Plant
Emission Summary - Particulate Size

Location	Outlet	Outlet
Run	1	2
Date	11/23/96	11/23/96
Time Period	0150-1420	1950-2120
Particulate Size		
Size Range (Microns)	% in size range	% in size range
0-1.5	100	0
1.5 - 2.0	0	0
2.0 - 3.3	0	0
3.3 - 6.5	0	0
6.5 - 9.9	0	0
9.9 - 14.5	0	0
14.5 - 21	0	0
21 - 34	0	0
> 34	0	0