2.0 PHASE I WORK

During Phase I of this program, BioSafe fabricated a pilot demonstration of the first stage of our Fluidized Bed Treatment (FBT) process. Figure 2.1-1 is a process flow diagram of the Phase I unit, while Figures 2.1-2 and 2.1-3 are photographs of the system. This unit had a nominal throughput rate of 20 to 40 pounds-per-hour and demonstrated that the FBT process effectively stripped the organic contaminants from the sediment allowing for subsequent processing in the second stage to yield a Lo-Btu gas product.

2.1 Phase I Unit Process Description

The Phase I pilot unit consisted of a four-inch diameter screw feeder powered by a variable speed motor capable of feeding up to 50 pounds-per-hour of high-moisture sediment material. The screw feeder introduces the sediment into the lower portion of a six-inch diameter fourteen foot high chamber, the lower two feet containing refractory sand that has been fluidized by a combination of steam and nitrogen. In a full-scale system, steam would be used exclusively, however in this application, the combination was used for more accurate control of the fluidization velocity.

The lower six-foot of the chamber was heated by ceramic electric heaters mounted on the external surface of the chamber. These heaters had a combined rating of approximately 70,000 Btu/hour, and maintain the fluid bed at 1200 to 1400 ^{o}F.

The refractory sand was sieved to a particle size between 0.063 and 0.125 inches and loaded into the lower two feet of the fluidized bed. Fluidization was provided by a variety of gases all of which were heated using electric surface heaters mounted on the feed lines. During heatup, compressed air was used. Upon reaching the operating temperature of 1400 ^{o}F in the fluid zone, the air flow was reduced and replaced with steam or nitrogen. In all cases during operation the fluidization medium was inert to ensure that any oxidation of the feed material within the system was minimized. The fluidizing medium was regulated to a flow rate of 7 to 12 cfm as measured by a rotameter on the outlet of the system.

The feed material is continuously introduced at a rate of 20 to 30 pounds-per-hour (the feed rate was determined by the ability of the heaters to maintain temperature) into the bottom of the bed where it is immediately heated to 1200 to 1400 ^{o}F and the organic contaminants are stripped off. The organic materials and steam travel to the top of the vessel where entrained solids are released, and the vapor phase with a minimum of entrained particles (generally materials smaller than one micron), exit the vessel.

The primary fluid bed effluent was further polished by a cyclone that again removes potential entrained solids, and the resulting particle-free stream was cooled in two stages. In the full embodiment of the FBT process, a second stage fluidized bed operating at elevated temperatures is installed here where the vapor would be further cracked to yield the Lo-Btu gas.

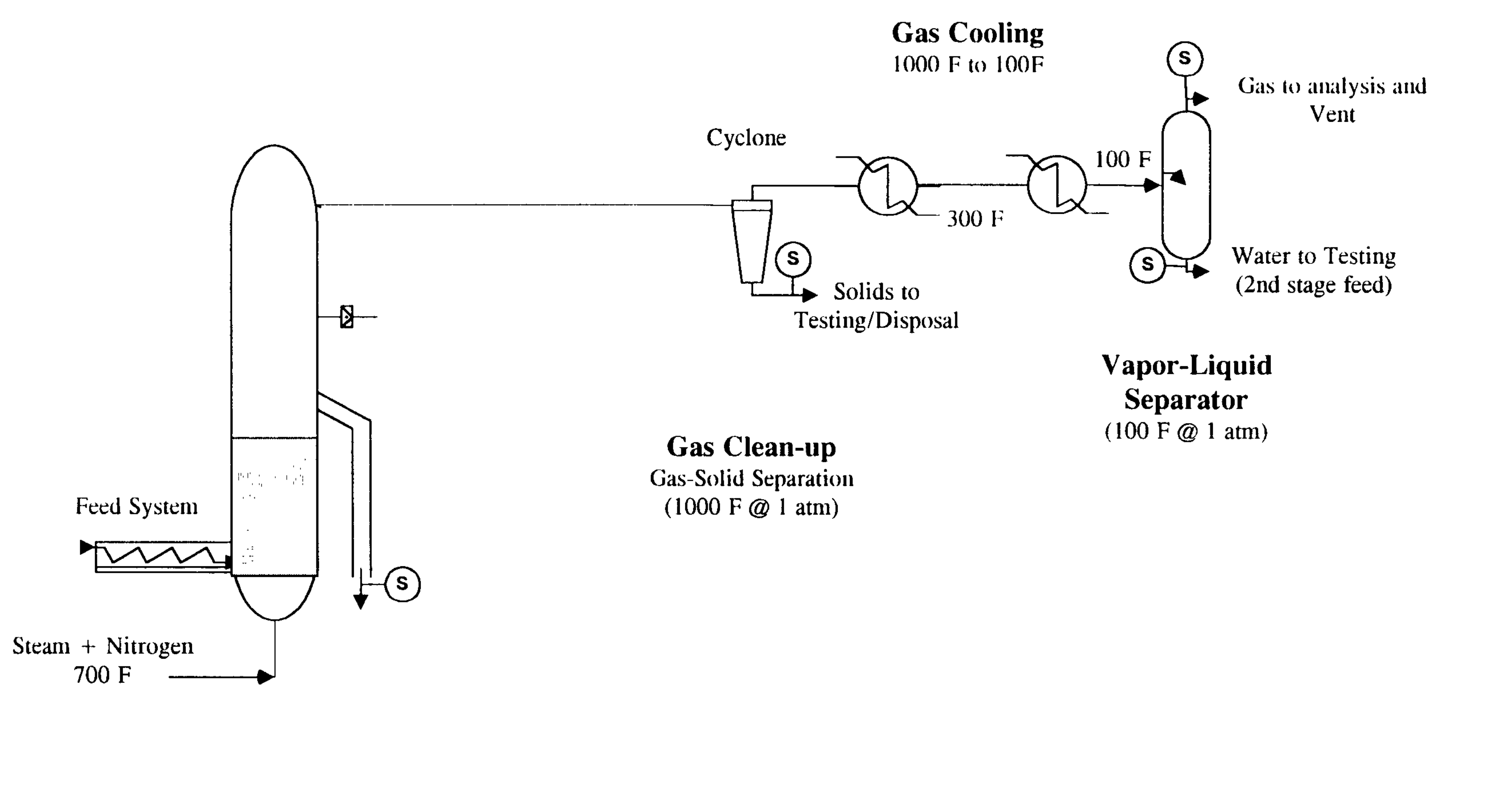

FIGURE 2.1-1
BioSafe FBT Process
(first stage steam stripping)

Figure 2.1-2
FBT Pilot Unit

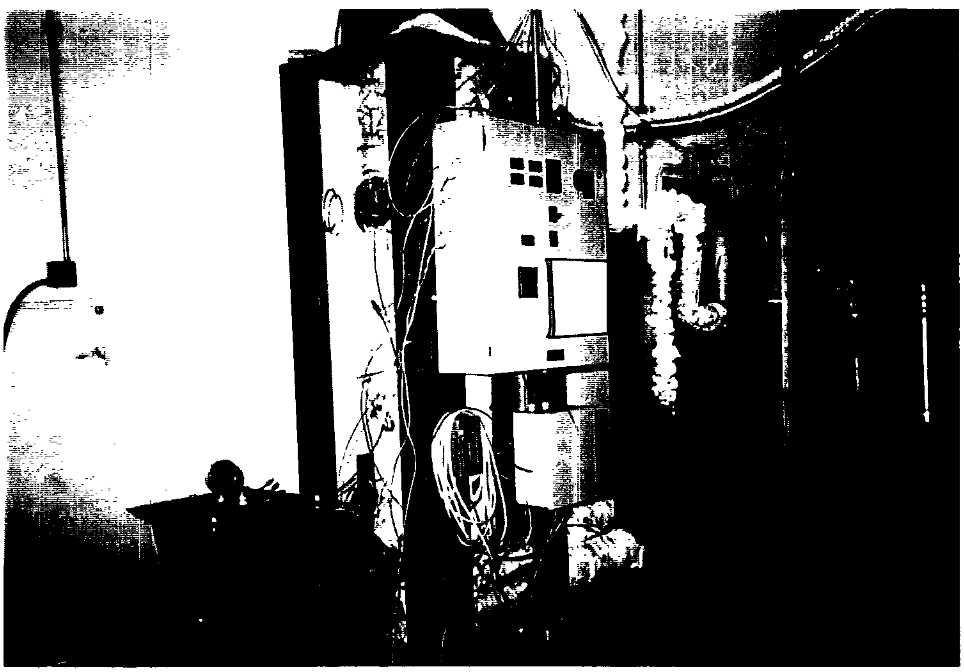

Figure 2.1-3
FBT Pilot Unit

Safety devices/interlocks

The FBT unit was microprocessor controlled and incorporated a variety of remote sensing devices that were alarmed and interlocked to ensure that the system automatically shut down in the event of unplanned transients.

Figure 2.1-4 shows several of the automatic safety features that ultimately prevent the system from unexpected temperature and pressure transients that may cause injury to operators, initiate an unplanned discharge, or damage equipment. The major focus of the safety devices are to prevent the thermal transients (temperature excursions) that increase stresses on equipment. The FBT system was protected by interlocking several key thermocouples such that they can initiate a plant shutdown. There were three thermocouples that are interlocked in this matter. They are located in the fluid bed heated area and discharge line to detect any abnormal increases in temperature. The temperature shutdowns for FBT 1 will set at the following levels:

- 1800 ^{o}F within the fluidized media bed
- 2300 ^{o}F on the exterior fluid bed pipe surface (at the radiant heater face)
- 1600 ^{o}F at the top of the fluid bed (normal operating is 1200-1400 ^{o}F)

The operator also has the ability to initiate an automatic shutdown by the initiation of a single switch if, in their judgment, the unit is approaching an unsafe condition.

As a fail-safe measure, each fluid bed is equipped with a mechanical rupture disk rated at 100 psia that will vent the system in the event of a pressure buildup.

Feed system/Introduction of hazardous waste material

The FBT unit was fed from a day tank/silo that was filled prior to beginning a test, and as required during operations. The tank/silo was a one cubic foot stainless steel unit with a removable top fitted with a carbon filtered vent. The vessel was a live bottom feeding directly into the screw conveyor. The tank was filled with an premeasured amount of feed material prior to each test. It was not opened and refilled while the system was in operation.

The actual feed material was introduced into the fluid bed via a four-inch screw conveyor. The stainless steel screw has a four inch pitch and rotated by a variable speed drive. Typically the unit was operated at one rpm to yield a theoretical feed rate of 20 to 40 pounds-per-minute. During operation, the feed rate was regulated to the maximum amount while maintaining system temperature.

Equipment function and operating conditions

The following table provides a summary of the major equipment function and normal and maximum operating conditions.

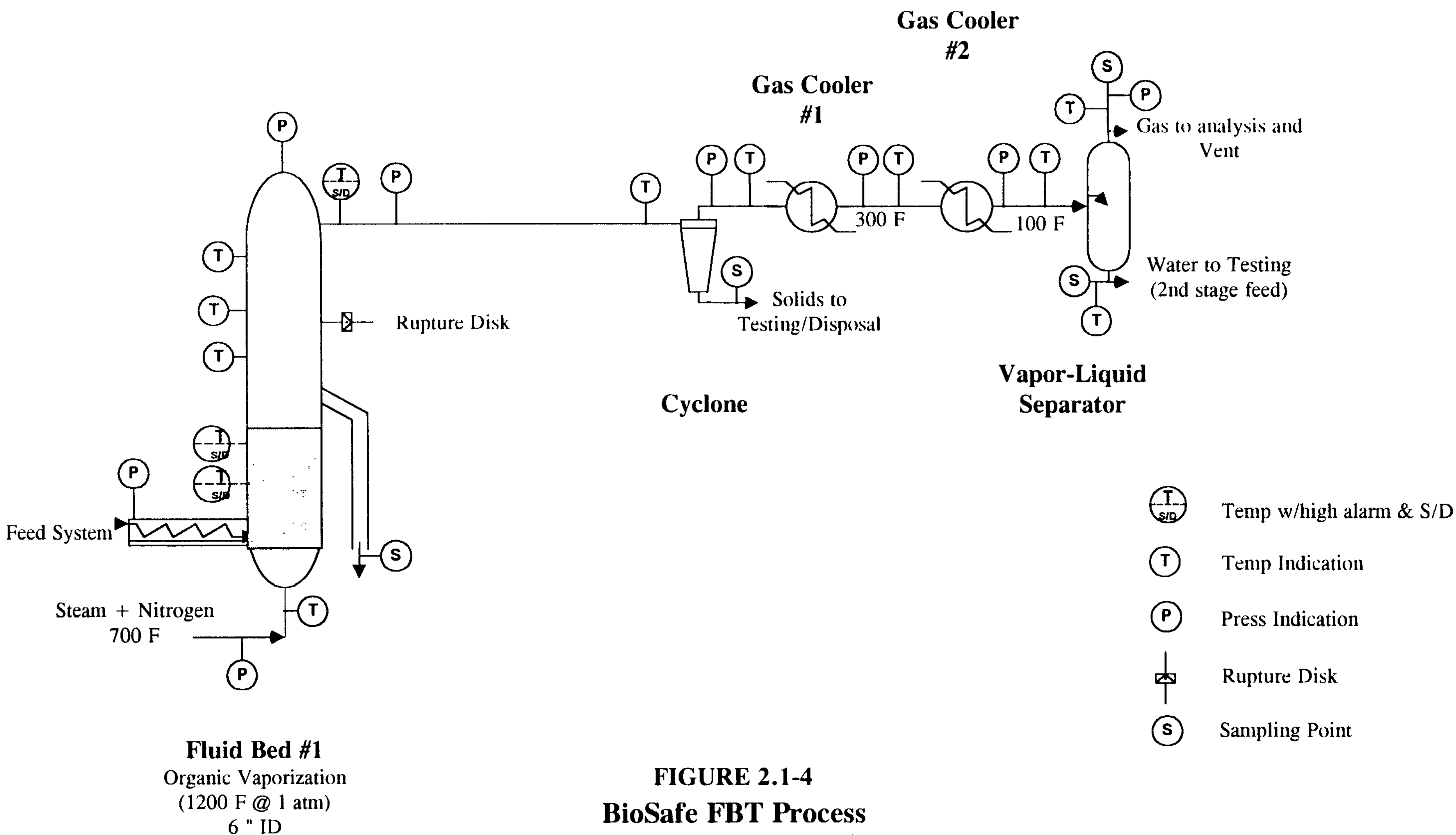

FIGURE 2.1-4

BioSafe FBT Process

(first stage steam stripping)

EQUIPMENT	FUNCTION	NORMAL (temp/press)	DESIGN/MAXIMUM (temp/press)
Feed conveyor	transfer material into FBT 1	70 °F / 1 atm	150 °F / 1 atm
FBT 1	volatilize/strip organic material	1400 °F / 1 atm	2000 °F / 5 atm
Gas clean-up (cyclone)	solid/vapor separation	1000 °F/ 1 atm	1500 °F / 5 atm
1st stage cooler	condense tars and high boiling organics	1200 °F/1 atm	1600 °F / 5 atm
2nd stage cooler	condense water	300 °F/ 1 atm	1000 °F / 5 atm
Liquid/vapor separator	stream separation	100 °F/1 atm	400 °F/5 atm

Effluent recovery/sampling

This demonstration of the first stage of the FBT process produced several effluent streams as follows:

MATERIAL	COLLECTION METHOD	DISPOSITION
Bed Solids	Manually removed from fluid bed after shutdown/cooldown	Tested for organic materials and metals
Carryover Solids	Manually removed from cyclone	Tested for organic materials and metals
Vapor Fraction	Collected from vapor-liquid separator	Monitored for CO, H_2, CO_2, CH_4, and C_2+ using on-line GC
Liquid Fraction	Collected from vapor-liquid separator	Tested for organic materials and metals.

2.2 Testing Goals and Approach

The FBT demonstration was conducted through a series of tests of increasing duration and complexity. The plan was to verify mechanical completion and integrity of the plant using simulated feed materials at 30 pounds-per-hour, then introduce actual dredge material and optimize the plant for effective volatilization of the organic material.

The plant optimization process was limited to determining the feed rate that could be maintained while sustaining system temperature within the fluid bed at a sufficient level (1400 °F). The actual performance of the system was then determined by analysis of the end products. The actual analyses performed were complicated and would often take up to one-month to complete, and given the time constraints of the projects, it was not practical to delay each test while waiting for the results of previous tests.

Fundamental to the testing program was the demonstration that the first stage of the process would volatilize the organic constituents at a sufficient level that the resulting ash material could be disposed of as an uncontrolled material. The downstream processing/cracking of the vapor fraction was thought of as a proven technology and its demonstration would be conducted in a subsequent phase of the project.

Based on the above objectives, the following goals were established for this demonstration testing program:

- **Mechanical integrity:** Demonstrate that the pilot plant was mechanically complete and all equipment operated in accordance with design specifications.
- **Materials processing:** Demonstrate that the pilot plant could process 20 to 40 pounds-per-hour of clinical waste reliably through the unit.
- **Reliability:** Demonstrate that the plant could operate for extended periods while processing.
- **Efficacy:** Demonstrate that the plant could effectively process the material while volatilizing the organic constituents.
- **Optimization:** Determine the operational limitations of the plant.
- **Scale-up:** Obtain data for developing the plant design for demonstration and full-scale design.

Approach

The test program included a series of tests of increasing duration and processing difficulty to demonstrate the process.

During operation, volatilization of the organic material is ensured by subjecting the feed material to a sufficient temperature for a sufficient time. The FBT process is designed to operate such that the material is maintained at a temperature of approximately 1400 ^{o}F for a sufficient residence time to vaporize organic materials. Residence time is maintained/controlled by the both the depth of the fluid bed and the flow of the fluidizing medium (in this case Nitrogen and steam). During operation, the feed material is rapidly heated to 1400 ^{o}F, and the organic material vaporized and carried through the system. Within the pilot unit, the depth of the fluid bed as well as the flow rate of the fluidizing medium were held at a constant rate that was determined during preliminary testing, and the feed was controlled to maintain system temperature. The temperature within the fluid bed was constantly measured using thermocouples and was a convenient method to monitor system performance. The control system monitored the temperature at three points within the fluid bed selecting the lowest as the primary control indicator. Optimal operation of the FBT was when the bed temperature was maintained between 1200 and 1400 ^{o}F.

Testing of the plant occurred under less than ideal conditions. Complications included delays in the delivery of key components, as well as several components failing to meet expectations. In addition, several modifications were required to complete the test program, and they were instituted on-site. However, the plant was operated as much as possible during the test period which provided invaluable opportunities for the design team and operators to understand the system and develop the plans for subsequent scale-up designs.

Specific components that were problematic during the testing were the feed conveyor and steam generation system. The feed conveyor was less that satisfactory in its ability to process the material as received. The dredge material was very gelatinous and slipped within the screw flites. The result was that the material was not sufficiently transferred into the fluid bed. Several modifications to the screw flites were attempted , without success. Eventually it was determined that when the feed was mixed with fluidizing sand (25% sand by weight), the feed rate improved.

The initial steam generation system that was supplied for the unit, also was not adequate for processing. Ideally, the process requires a superheated supply at 100 to 150 psi and 1200 to 1400 oF. The available units could only deliver saturated steam at 50 psi. An auxiliary heater was installed, however it did not provide sufficient heat to the steam. Eventually Nitrogen was used as the fluidizing medium. This was supplied as liquid nitrogen which was heated to 60 to 700 $^{\circ}$F at a sufficient flow to fluidize the bed. While the Nitrogen flow was sufficient to fluidize the bed, the disadvantage was that it exited the system as a gas, and diluted the vapor stream making analysis of the effluent gas difficult, if not impossible. However, since the goal of the demonstration was to show volatilization of the organic material, this was not a severe process limitation (the solid residue could be removed and analyzed independently). In future applications the steam generation system must be upgraded.

Following fabrication, the system was subjected to a series of hot and cold tests. These were primarily mechanical tests of the each component of the system as well as tests of the mechanical seals between components. During these tests, all mechanical equipment was operated to verify operation. Any deficiencies in operation or design were corrected, and testing continued. Upon successful completion of the mechanical tests, the team began testing the unit by using surrogate feed material. The surrogate feed consisted of soil, water and motor oil. As operating data were obtained, and the equipment and conditions optimized.

Actual testing of the dredge material was conducted in two runs. The first occurred over a 4-hour period on February 12, 1996. During this test approximately 40 pounds of material were processed. The residuals form the run were separated according to the instructions from BNL, and the resultant material sent for analysis.

A second test run was completed on February 29, 1996. During this test, the remaining 60 pounds of material was processed and all residuals were sent to BNL for analysis. During the first test, the material was sieved to remove the fluid bed material, and only the resulting "ash" sent to BNL. It was determined that the sample amount was not adequate for analysis, and therefore in subsequent tests all residuals were sent to BNL.

The analytical results used in this report are those from the BNL analysis.

2.3 PROCESS CONFIGURATION

During all testing, the FBT unit was configured as follows:

ITEM	UNIT IN-PLACE	REMARKS
Feed Conveyor	4- inch Screw Conveyor	Feeding mixed sand + dredge Operated at one rpm
Fluid Bed		
Media	Sand 0.063 - 0.125 inch diameter	2 feet in bed
Fluidization	Liquid N_2 heated to 700 °F	10 cfm measured at outlet
Heaters	Electric	70,000 Btu/hr
Cyclone		
Gas Cooler #1	4 ft^2	Cool gas to 300 - 250 °F
Gas Cooler #2	50 ft2	Cool gas to 100 °F
Vapor-Liquid Separator	one liter	
Gas Chromatograph	On line	Samples for CO, H_2, CO_2, CH_4, and C_2+
Control	Heaters controller to bed temperature of 1400 °F	

2.4 TEST PROCEDURES

Initially the system starts empty. Refractory sand is loaded into the system through the viewing ports to a predetermined level (in these tests two feet). The system is then sealed and leak tested by pressurizing with compressed air and applying a soap solution to all mechanical joints. Upon verification of the hydraulic integrity, the hopper was filled with approximately 50 pounds of the subject feed material and sealed. The hopper lid is then again leak checked, and system heatup commenced.

The heaters are all energized under automatic control and the unit is heated to approximately 500 oF. At this time, the compressed air is introduced to the fluid bed to achieve a system exit flow rate of 10 cfm. This value is based on fluidizing the bed and was determined during previous experimentation. The heaters setpoint is adjusted to control the bed temperature to 1400 °F and heatup continues.

When the system is heated and the fluid bed is at operating temperature of 1400 °F, the Nitrogen flow is initiated. The liquid nitrogen is vaporized and heated by passing it through a serpentine pipe that is surrounded by surface heaters. The heaters are similar to those installed around the fluid bed. The heaters elevated the temperature of the Nitrogen to 750 to 800 °F prior to introduction into the fluid bed. The Nitrogen flow is gradually increased while the air is reduced and after approximately ten minutes, the air is shut off.

The system is allowed to equilibrate and once temperatures are stable and at the desired temperatures, the screw conveyor is started at approximately one rpm. This corresponds to a feed rate of approximately 30 pounds-per-hour.

The process continues in operation until the waste in the feed hopper has been processed. This is indicated by a reduction in the accumulation of water in the liquid/vapor separator at the end of the process. In addition, the temperature of the fluid bed will generally show an increase in temperature, although this is not always the case. The operators verify that the processing is complete by momentarily shutting down the Nitrogen flow and opening the feed hopper (after verifying that it is not pressurized), and observing that the material has been processed.

Once the operators verify that all of the feed material has been processed, the hopper is filled partway with fresh refractory material to "push" the material that remains in the screw into the process. The Nitrogen flow is reestablished, and feed screw restarted. The process is operated in this manner for 30 to 60 minutes at which time all the material has been deemed processed.

System shutdown involves deenergizing the electric heaters surrounding the fluid bed. The Nitrogen heaters remain on and flow maintained until the temperature within the fluid bed has decreased to approximately 500 ^{o}F. At that time the Nitrogen flow is gradually replaced with air, the Nitrogen heaters shutdown, and the cooldown completed. This final cooldown is generally conducted be leaving the system overnight with a minimum air flow.

The next morning, the system is opened and the following samples are collected:

- Fluid bed (refractory sand mixed with "ash")
- Standpipe (refractory sand mixed with "ash")
- Cyclone (carried over material - "ash" plus sand fines)

Note that the liquid and gas samples from the liquid/vapor separator are collected during processing.

2.5 RESULTS

Over the two test runs, 100 pounds of sediment was processed. Samples were collected and returned to BNL for analysis. The results of the analyses are summarized in Table 2.5-1.

As shown by the table, the first stage of the FBT demonstrated its ability to volatilize the organic constituents. The analytical results demonstrate that in nearly all cases greater than 90 percent of the material was removed from the sediment residual. Actually since the reported values for most of the results are expressed as a maximum possible value (reported as all values less than), the removal efficiencies were actually better.

It is also interesting to note that several of the results appear ambiguous in that while the higher boiling PCBs were removed with nearly 100 % efficiencies, several lower boiling compounds (Di-n-butylphthalate and Di-n-octylphthalate) were detected in the residual product. These may have been contaminants present in the plastic bags used for containing the samples.

Overall the analytical results support the following conclusions:

- The FBT has demonstrated that it is effective in volatilizing organic materials from sediment materials
- The FBT has demonstrated that it is capable of operating continuously
- The FBT demonstrated that it can process sediment without dewatering

Although the results were promising, there are still two areas of concern in the FBT and its viability for this application. While the process could process the sediment without dewatering within the fluid bed, the screw conveyor was not effective in transporting the material into the bed. After discussions with several manufacturers, it is recommended that the feed screw be replaced with a progressive cavity pump. These types of pumps have tens of thousands of field hours processing materials including drilling sludges, soil slurries, sewage sludge and other similar materials.

The second area in this demonstration that was disappointing was that we were forced to use Nitrogen as a fluidizing medium instead of steam. This was due to the complexity and cost associated with a superheated steam generator at a size to support the pilot operation. The use of nitrogen essentially meant that the gas product from the process was so dilute that the gas chromatograph was essentially useless in analysis. In any later work, it is important to start the procurement cycle early enough to ensure that a steam generator can be obtained.

Table 2.5-1
Analytical Results

Analyte	Units	Raw Sediment	Solid Product			Removal	Remarks
		(mean)	2/12/96	2/29/96	Mean	(%)	
Total Organic Carbon	%(wt (dry)	7.32	0.74	0.06	0.40	94.5	
Semivolatile Compounds							
Phenol	ug/kg (dry)	638	42.2	35.9	39.1	93.9	Product < stated result
bis(2-Chloroethyl) ether	ug/kg (dry)	755	55.8	47.5	51.7	93.2	Raw & product < stated result
2-Chlorophenol	ug/kg (dry)	692	35.8	34.9	35.4	94.9	Raw & product < stated result
1,3-Dichlorobenzene	ug/kg (dry)	507	32.2	25.3	28.8	94.3	Raw & product < stated result
1,4-Dichlorobenzene	ug/kg (dry)	517	30.2	24.6	27.4	94.7	Raw & product < stated result
1,2-Dichlorobenzene	ug/kg (dry)	573	32.4	24.6	28.5	95.0	Raw & product < stated result
Benzyl alcohol	ug/kg (dry)	1378	141.1	68	104.6	92.4	Raw & product < stated result
2,2-oxybis(1-Chloropropane)	ug/kg (dry)	884	63.1	30.9	47.0	94.7	Raw & product < stated result
2-Methylphenol	ug/kg (dry)	875	5	41.5	23.3	97.3	Raw & product < stated result
3/4-Methylphenol	ug/kg (dry)	1390	50.5	38.8	44.7	96.8	Product < stated result
N-Nitroso-di-n-propylamine	ug/kg (dry)	1092	78.8	46.6	62.7	94.3	Raw & product < stated result
Hexachloroethane	ug/kg (dry)	1245	70.3	33.9	52.1	95.8	Raw & product < stated result
Nitrobenzene	ug/kg (dry)	570	43.7	21.2	32.5	94.3	Raw & product < stated result
Isophorone	ug/kg (dry)	334	24.4	13.7	19.1	94.3	Raw & product < stated result
2-Nitrophenol	ug/kg (dry)	1055	58.2	46.5	52.4	95.0	Raw & product < stated result
2.4-Dimethylphenol	ug/kg (dry)	717	46.6	27.5	37.1	94.8	Raw & product < stated result
bis(2-Chloroethoxy)methane	ug/kg (dry)	632	46.9	31.4	39.2	93.8	Raw & product < stated result
Benzoic acid	ug/kg (dry)	1335	68.9	72.9	70.9	94.7	Raw & product < stated result
2,4-Dichlorophenol	ug/kg (dry)	684	43	30.3	36.7	94.6	Raw & product < stated result
1,2,4-Trichlorobenzene	ug/kg (dry)	623	37.9	20.1	29.0	95.3	Raw & product < stated result
Naphtalene	ug/kg (dry)	2729	14.1	12	13.1	99.5	Product < stated result
4-Chloroaniline	ug/kg (dry)	1003	34.5	23.3	28.9	97.1	Product < stated result
Hexachlorobutadiene	ug/kg (dry)	711	53.6	19.4	36.5	94.9	Raw & product < stated result
4-Chloro-3-methylphenol	ug/kg (dry)	839	50.7	40.3	45.5	94.6	Raw & product < stated result
2-Methylnaphthalene	ug/kg (dry)	2304	21.6	14.5	18.1	99.2	Product < stated result
Hexachlorocyclopentadiene	ug/kg (dry)	68	49.2	23.2	36.2	46.8	Raw & product < stated result
2,4,6-Trichlorophenol	ug/kg (dry)	843	52.1	26.9	39.5	95.3	Raw & product < stated result
2,4,5-Trichlorophenol	ug/kg (dry)	798	47.6	28.6	38.1	95.2	Raw & product < stated result
2-Chloronaphthalene	ug/kg (dry)	370	19.3	15.6	17.5	95.3	Raw & product < stated result
2-Nitroaniline	ug/kg (dry)	1092	76.2	33.6	54.9	95.0	Raw & product < stated result
Dimethylphthalate	ug/kg (dry)	312	16.8	10.7	13.8	95.6	Raw & product < stated result
2,6-Dinitrotoluene	ug/kg (dry)	1388	70.7	49.5	60.1	95.7	Raw & product < stated result
2,4-Dinitrotoluene	ug/kg (dry)	1011	45	38	41.5	95.9	Raw & product < stated result
Acenapthylene	ug/kg (dry)	1289	13.2	9	11.1	99.1	Product < stated result
3-Nitroaniline	ug/kg (dry)	1350	62.3	64.6	63.5	95.3	Raw & product < stated result
Acenapthene	ug/kg (dry)	1042	23.7	16	19.9	98.1	Product < stated result
2,4-Dinitrophenol	ug/kg (dry)	2467	127.4	125	126.2	94.9	Raw & product < stated result
4-Nitrophenol	ug/kg (dry)	1618	60.5	40.7	50.6	96.9	Raw & product < stated result
Dibenzofuran	ug/kg (dry)	1172	13.6	10.1	11.9	99.0	Product < stated result
Diethylphthalate	ug/kg (dry)	276	14	9.7	11.9	95.7	Raw & product < stated result
4-Chlorophenyl-phenylether	ug/kg (dry)	540	32.8	19.5	26.2	95.2	Raw & product < stated result
Flourene	ug/kg (dry)	1389	17.5	13	15.3	98.9	Product < stated result
4-Nitroaniline	ug/kg (dry)	1319	51.9	67.8	59.9	95.5	Raw & product < stated result
4,6-Dinitro-2-methylphenol	ug/kg (dry)	1731	82	66.2	74.1	95.7	Raw & product < stated result

Table 2.5-1
Analytical Results

Analyte	Units	Raw Sediment	Solid Product			Removal	Remarks
		(mean)	2/12/96	2/29/96	Mean	(%)	
N-Nitrosodiphenylamine	ug/kg (dry)	566	26.9	18.6	22.8	96.0	Raw & product < stated result
4-Bromophenyl-phenylether	ug/kg (dry)	1016	44	24.2	34.1	96.6	Raw & product < stated result
Hexachlorobenzene	ug/kg (dry)	779	33.3	18.6	26.0	96.7	Raw & product < stated result
Pentachlorophenol	ug/kg (dry)	1039	45.1	33.9	39.5	96.2	Raw & product < stated result
Phenathrene	ug/kg (dry)	6586	11	8.7	9.9	99.9	Product < stated result
Anthracene	ug/kg (dry)	3702	11	8.5	9.8	99.7	Product < stated result
Di-n-butylphthalate	ug/kg (dry)	1226	18.1	95.4	56.8	95.4	
Fluoranthene	ug/kg (dry)	10324	9.4	5.6	7.5	99.9	Product < stated result
Pyrene	ug/kg (dry)	7102	7.8	5.8	6.8	99.9	Product < stated result
Butylbenzylphthalate	ug/kg (dry)	1473	15.3	10.7	13.0	99.1	Product < stated result
3 3-Dichlorobenzidine	ug/kg (dry)	288	29.1	17.6	23.4	91.9	Raw & product < stated result
bis-2-ethylhexylphthalate	ug/kg (dry)	48630	17.2	24.1	20.7	100.0	
Benzo(a)anthracene	ug/kg (dry)	4484	10	6.6	8.3	99.8	Product < stated result
Chrysene	ug/kg (dry)	4564	11.2	6.7	9.0	99.8	Product < stated result
Di-n-octylphthalate	ug/kg (dry)	rejected	9.1	5.6	7.4	#VALUE!	Rejected
Benzo(b)fuoranthene	ug/kg (dry)	2922	13.5	6.7	10.1	99.7	Product < stated result
Benzo(k)fuoranthene	ug/kg (dry)	1107	15.4	7.5	11.5	99.0	Product < stated result
Benzo(a)pyrene	ug/kg (dry)	2550	15.2	7.9	11.6	99.5	Product < stated result
Indeno(123-cd)pyrene	ug/kg (dry)	1075	17.4	9.2	13.3	98.8	Product < stated result
Dibenz(a,h)anthracene	ug/kg (dry)	397	22.8	13.4	18.1	95.4	Product < stated result
Benzo(g,h,i)perylene	ug/kg (dry)	1254	20.6	10.7	15.7	98.8	Product < stated result
Benzo(e)pyrene	ug/kg (dry)	2125	16	7.9	12.0	99.4	Product < stated result
Perylene	ug/kg (dry)	948	16.7	8.8	12.8	98.7	Product < stated result
Polychlorinated Biphenyls							
2-mono	ug/kg (dry)	57	0.01	0.03	0.02	100.0	
4,4-Di	ug/kg (dry)	64	0.009	0.02	0.01	100.0	
2,4,4-Tri	ug/kg (dry)	168	0.01	0.06	0.03	100.0	
2,2,5,5-Tetra	ug/kg (dry)	269	0.02	0.08	0.05	100.0	
3,3,4,4-Tetra	ug/kg (dry)	14	0.001	0.002	0.002	100.0	
2,3,4,4,5-Penta	ug/kg (dry)	6	0.001	0.001	0.001	100.0	
2,3,3,4,4-Penta	ug/kg (dry)	67	0.004	0.01	0.009	100.0	
3,3,4,4,5-Penta	ug/kg (dry)	0.5	0	0.0013	0.0007	99.9	Product < stated result
2,3,3,4,4,5-Hexa	ug/kg (dry)	17	0.001	0.0018	0.0014	100.0	Product < stated result
3,3,4,4,5,5-Hexa	ug/kg (dry)	nd	0	0.002	0.001	#VALUE!	Raw & product < stated result
2,2,3,4,4,5,5-Hepta	ug/kg (dry)	73	0.004	0.01	0.007	100.0	
2,2,3,3,4,4,5,5-Octa	ug/kg (dry)	17	0.001	0.003	0.0019	100.0	Product < stated result
2,2,3,3,4,4.5,5,6-Nona	ug/kg (dry)	12	0	0.004	0.0018	100.0	Product < stated result
Deca	ug/kg (dry)	7	0	0.004	0.002	100.0	Product < stated result

Table 2.5-1
Analytical Results

Analyte	Units	Raw Sediment (mean)	Solid Product 2/12/96	Solid Product 2/29/96	Solid Product Mean	Removal (%)	Remarks
PCB Totals							
-Mono	ug/kg (dry)	16	0.03	0.05	0.04	99.8	
-Di	ug/kg (dry)	379	0.08	0.1	0.1	100.0	
-Tri	ug/kg (dry)	728	0.1	0.3	0.2	100.0	
-Tetra	ug/kg (dry)	1588	0.09	0.4	0.2	100.0	
-Penta	ug/kg (dry)	1237	0.04	0.3	0.2	100.0	
-Hexa	ug/kg (dry)	809	0.03	0.1	0.06	100.0	
-Hepta	ug/kg (dry)	295	0.009	0.2	0.01	100.0	
-Octa	ug/kg (dry)	96	0.001	0.006	0.003	100.0	
-Nona	ug/kg (dry)	20	0	0.004	0.0018	100.0	Product < stated result
Chlorinated Pesticides and Herbicides							
Pesticides							
a-BHC	ug/kg (dry)	14.5	1.7	1.7	1.7	88.3	Raw & product < stated result
a-Chlorddane	ug/kg (dry)	14.5	1.7	1.7	1.7	88.3	Raw & product < stated result
Aldrin	ug/kg (dry)	75	1.7	1.7	1.7	97.7	Product < stated result
beta-BHC	ug/kg (dry)	14.5	1.7	1.7	1.7	88.3	Raw & product < stated result
delta-BHC	ug/kg (dry)	14.5	1.7	1.7	1.7	88.3	Raw & product < stated result
4,4-DDD	ug/kg (dry)	162	3.3	3.3	3.3	98.0	Product < stated result
4,4-DDE	ug/kg (dry)	151	3.3	3.3	3.3	97.8	Product < stated result
4,4-DDT	ug/kg (dry)	28.9	3.3	3.3	3.3	88.6	Raw & product < stated result
Dieldrin	ug/kg (dry)	74	3.3	3.3	3.3	95.5	Product < stated result
Endrin	ug/kg (dry)	28.9	3.3	3.3	3.3	88.6	Raw & product < stated result
Endrin aldehyde	ug/kg (dry)	28.9	3.3	3.3	3.3	88.6	Raw & product < stated result
Endrin ketone	ug/kg (dry)	14.5	3.3	not run	1.7	88.3	Raw & product < stated result
Endosulfan I	ug/kg (dry)	28.9	1.7	1.7	1.7	94.1	Raw & product < stated result
Endosulfan II	ug/kg (dry)	28.9	3.3	3.3	3.3	88.6	Raw & product < stated result
Endosulfan Sulfate	ug/kg (dry)	14.5	3.3	3.3	3.3	77.2	Raw & product < stated result
g-BHC (Lindane)	ug/kg (dry)	14.5	1.7	1.7	1.7	88.3	Raw & product < stated result
g-Chlordane	ug/kg (dry)	14.5	1.7	1.7	1.7	88.3	Raw & product < stated result
Heptachlor	ug/kg (dry)	14.5	1.7	1.7	1.7	88.3	Raw & product < stated result
Heptachlor epoxide	ug/kg (dry)	14.5	1.7	1.7	1.7	88.3	Raw & product < stated result
Methoxychlor	ug/kg (dry)	144.5	17	17	17	88.2	Raw & product < stated result
Toxaphene	ug/kg (dry)	1445.2	167	167	167	88.4	Raw & product < stated result
Chlorinated Herbicides							
2,4-D	mg/kg (dry)	0.2	0.2	not run	0.2	0.0	Raw & product < stated result
2,4,5-TP (Silvex)	mg/kg (dry)	0.05	0.05	not run	0.05	0.0	Raw & product < stated result
2,4,5-T	mg/kg (dry)	0.05	0.05	not run	0.05	0.0	Raw & product < stated result

Table 2.5-1
Analytical Results

Analyte	Units	Raw Sediment	Solid Product			Removal	Remarks
		(mean)	2/12/96	2/29/96	Mean	(%)	
Dioxins and Furans							
2378-TCDD	ng/kg (dry)	42	0.9	0.6	0.8	98.1	Product < stated result
12378-PeCDD	ng/kg (dry)	60	1.4	1.1	1.3	97.8	Product < stated result
123478-HxCDD	ng/kg (dry)	49	1.6	0.9	1.3	97.3	Product < stated result
123678-HxCDD	ng/kg (dry)	142	1.3	0.8	1.1	99.2	Product < stated result
123789-HxCDD	ng/kg (dry)	134	1.3	0.8	1.1	99.2	Product < stated result
1234678-HpCDD	ng/kg (dry)	2092	4.5	204	3.5	99.8	
OCDD	ng/kg (dry)	17463	12.3	10.7	11.5	99.9	
2378-TCDF	ng/kg (dry)	340	4.3	0.6	2.45	99.3	
12378-PeCDF	ng/kg (dry)	311	1.3	0.9	1.1	99.6	
23478-PeCDF	ng/kg (dry)	148	1.9	0.9	1.4	99.1	
123478-HxCDF	ng/kg (dry)	1303	5.8	0.4	3.1	99.8	
123678-HxCDF	ng/kg (dry)	464	1.9	0.6	1.3	99.7	Product < stated result
234678-HxCDF	ng/kg (dry)	186	2.5	0.6	1.54	99.2	
123789-HxCDF	ng/kg (dry)	23	1.2	0.9	1.1	95.2	Product < stated result
1234678-HpCDF	ng/kg (dry)	4968	7.7	1.8	4.8	99.9	
1234789-HpCDF	ng/kg (dry)	110	1.1	1.1	1.1	99.0	Product < stated result
OCDF	ng/kg (dry)	4418	3.3	0.5	1.9	100.0	
Total Dioxins							
-TCDD	ng/kg (dry)	246	0.9	0.6	0.8	99.7	Product < stated result
-PeCDD	ng/kg (dry)	378	1.8	1.1	1.45	99.6	Product < stated result
-HxCDD	ng/kg (dry)	1370	2.3	2.1	2.2	99.8	
-HpCDD	ng/kg (dry)	4450	9.7	5.9	7.8	99.8	
Total Furans							
-TCDF	ng/kg (dry)	2372	20.9	0.9	10.8	99.5	
-PeCDF	ng/kg (dry)	2853	20.6	0.9	10.8	99.6	
-HxCDF	ng/kg (dry)	5175	16.1	1	8.6	99.8	
-HpCDF	ng/kg (dry)	6068	9.9	1.8	5.9	99.9	
Metals							
Ag	mg/kg (dry)	18	1.5	0.4	0.9	95.0	
As	mg/kg (dry)	33	3	0.8	1.9	94.2	
Be	mg/kg (dry)	0.56	0.2	0.2	0.2	64.3	Raw & product < stated result
Cd	mg/kg (dry)	37	2.3	0.7	22.5	39.2	
Cr	mg/kg (dry)	377	40.5	4.6	55	85.4	
Cu	mg/kg (dry)	1172	101	9	22.6	98.1	
Ni	mg/kg (dry)	297	41.4	3.8	27	90.9	
Pb	mg/kg (dry)	617	46.2	7.8	0.8	99.9	
Sb	mg/kg (dry)	10	0.77	0.8	0.8	92.0	
Se	mg/kg (dry)	3	1	1	1	66.7	Product < stated result
Tl	mg/kg (dry)	2.8	1	1	1	64.3	Raw & product < stated result
Zn	mg/kg (dry)	1725	167	17	92.1	94.7	Product < stated result
Hg(total)	mg/kg (dry)	1	0.09	not run	0.04	96.0	Product < stated result

Table 2.5-1
Analytical Results

Analyte	Units	Raw Sediment	Solid Product			Removal	Remarks
		(mean)	2/12/96	2/29/96	Mean	(%)	
Metals (TCLP)							
Arsenic	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Barium	mg/L (extract)	0.5	0.5	0.5	0.5	0.0	Raw & product < stated result
Cadmium	mg/L (extract)	0.01	0.06	0.01	0.04	-300.0	Raw < stated result
Chromium	mg/L (extract)	0.03	0.01	0.01	0.01	66.7	Product < stated result
Lead	mg/L (extract)	0.05	0.16	0.05	0.11	-120.0	Raw < stated result
Mercury	mg/L (extract)	0.001	0.001	0.001	0.001	0.0	Raw & product < stated result
Selenium	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Silver	mg/L (extract)	0.01	0.01	0.01	0.01	0.0	Raw & product < stated result
Organo-Cl-Pesticides (TCLP)							
Chlordane	mg/L (extract)	0.005	0.005	0.005	0.005	0.0	Raw & product < stated result
Endrin	mg/L (extract)	0.0005	0.0005	0.0005	0.0005	0.0	Raw & product < stated result
Heptachlor	mg/L (extract)	0.0005	0.0005	0.0005	0.0005	0.0	Raw & product < stated result
Heptachlor epoxide	mg/L (extract)	0.0005	0.0005	0.0005	0.0005	0.0	Raw & product < stated result
Lindane (g-BHC)	mg/L (extract)	0.0005	0.0005	0.0005	0.0005	0.0	Raw & product < stated result
Methoxychlor	mg/L (extract)	0.001	0.001	0.001	0.001	0.0	Raw & product < stated result
Toxaphene	mg/L (extract)	0.01	0.01	0.01	0.01	0.0	Raw & product < stated result
Cl Herbicides (TCLP)							
2,4-D	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
2,4,5-TP (Silvex)	mg/L (extract)	0.01	0.01	0.01	0.01	0.0	Raw & product < stated result
Volatile Organics (TCLP)							
Benzene	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
Carbon tetrachloride	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
Chlorobenzene	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
Chloroform	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
1,4-Dichlorobenzene	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
1,2-Dichloroethane	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
1,1-Dichloroethane	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
Methyl ethykl ketone	mg/L (extract)	5	5	5	5	0.0	Raw & product < stated result
Tetrachloroethene	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
Trichloroethene	mg/L (extract)	0.2	0.2	0.2	0.2	0.0	Raw & product < stated result
Vinyl chloride	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result

Table 2.5-1
Analytical Results

Analyte	Units	Raw Sediment	Solid Product			Removal	Remarks
		(mean)	2/12/96	2/29/96	Mean	(%)	
Semi-Volatile Organics (TCLP)							
Hexachloroethane	mg/L (extract)	0.1	0.1	not run	0.1	0.0	Raw & product < stated result
Nitrobenzene	mg/L (extract)	0.1	0.1	not run	0.1	0.0	Raw & product < stated result
Hexachlorobutadiene	mg/L (extract)	0.1	0.1	not run	0.1	0.0	Raw & product < stated result
2,4-Dinitrotoluene	mg/L (extract)	0.1	0.1	not run	0.1	0.0	Raw & product < stated result
Hexachlorobenzene	mg/L (extract)	0.1	0.1	not run	0.1	0.0	Raw & product < stated result
2,4,6-Trichlorophenol	mg/L (extract)	0.1	0.1	not run	0.1	0.0	Raw & product < stated result
2,4,5-Trichlorophenol	mg/L (extract)	0.1	0.1	not run	0.1	0.0	Raw & product < stated result
Pentachlorophenol	mg/L (extract)	0.25	0.25	not run	0.25	0.0	Raw & product < stated result
Pyridine	mg/L (extract)	0.25	0.25	not run	0.25	0.0	Raw & product < stated result
o-Cresol	mg/L (extract)	0.1	0.1	nd	0.1	0.0	Raw & product < stated result
m,p-Cresols	mg/L (extract)	0.1	0.1	nd	0.1	0.0	Raw & product < stated result
Total Cresols	mg/L (extract)	0.1	0.1	nd	0.1	0.0	Raw & product < stated result
PAHs (TCLP)							
Naphthalene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
2-Methylnaphthalene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Acenapthylene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Acenaphthene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Dibenzofuran	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Fluoranthene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Pyrene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Benzo(b)fluoranthene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Benzo(k)fluoranthene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Benzo(a)pyrene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Indeno(1,2,3-cd)pyrene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Dibenzo(a,h)anthracene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Benzo(ghi)parylene	mg/L (extract)	0.1	0.1	0.1	0.1	0.0	Raw & product < stated result
Dioxins/Furans (TCLP)							
2378-TCDD	ng/L (extract)	0.003	not run	0.08	0.08	-2566.7	Raw < stated result
12378-PeCDD	ng/L (extract)	0.007	not run	0.1	0.1	-1328.6	Raw < stated result
123478-HxCDD	ng/L (extract)	0.007	not run	0.1	0.1	-1328.6	Raw < stated result
123678-HxCDD	ng/L (extract)	0.006	not run	0.01	0.01	-66.7	Raw < stated result
123789-HxCDD	ng/L (extract)	0.006	not run	0.01	0.01	-66.7	Raw < stated result
1234678-HpCDD	ng/L (extract)	0.007	not run	0.01	0.01	-42.9	
OCDD	ng/L (extract)	0.03	not run	0.01	0.01	66.7	

Table 2.5-1
Analytical Results

Analyte	Units	Raw Sediment	Solid Product			Removal	Remarks
		(mean)	2/12/96	2/29/96	Mean	(%)	
2378-TCDF	ng/L (extract)	0.002	not run	0.07	0.07	-3400.0	Raw < stated result
12378-PeCDF	ng/L (extract)	0.004	not run	0.09	0.09	-2150.0	Raw < stated result
23478-PeCDF	ng/L (extract)	0.004	not run	0.08	0.08	-1900.0	Raw < stated result
123478-HxCDF	ng/L (extract)	0.005	not run	0.01	0.01	-100.0	
123678-HxCDF	ng/L (extract)	0.003	not run	0.008	0.008	-166.7	Raw < stated result
234678-HxCDF	ng/L (extract)	0.005	not run	0.01	0.01	-100.0	
123789-HxCDF	ng/L (extract)	0.005	not run	0.01	0.01	-100.0	Raw < stated result
1234678-HpCDF	ng/L (extract)	0.009	not run	0.007	0.007	22.2	
1234789-HpCDF	ng/L (extract)	0.007	not run	0.01	0.01	-42.9	Raw < stated result
OCDF	ng/L (extract)	0.009	not run	0.01	0.01	-11.1	Raw < stated result
Total Dioxins (TCLP)							
-TCDD	ng/L (extract)	0.003	not run	0.008	0.008	-166.7	Raw < stated result
-PeCDD	ng/L (extract)	0.007	not run	0.01	0.01	-42.9	Raw < stated result
-HxCDD	ng/L (extract)	0.006	not run	0.01	0.01	-66.7	Raw < stated result
-HpCDD	ng/L (extract)	0.01	not run	0.01	0.01	0.0	
Total Furans (TCLP)							
-TCDF	ng/L (extract)	0.002	not run	0.007	0.007	-250.0	Raw < stated result
-PeCDF	ng/L (extract)	0.004	not run	0.009	0.009	-125.0	Raw < stated result
-HxCDF	ng/L (extract)	0.01	not run	0.01	0.01	0.0	
-HpCDF	ng/L (extract)	0.009	not run	0.08	0.08	-788.9	
PCBs (TCLP)							
2-mono	ug/L (extract)	0.03	0.000004	0.00006	0.00003	99.9	Product < stated result
4,4-Di	ug/L (extract)	0.003	0.00003	0.0002	0.0001	96.7	
2,4,4-Tri	ug/L (extract)	0.006	0.00003	0.0005	0.0003	95.0	Product < stated result
2,2,5,5-Tetra	ug/L (extract)	0.003	0.0005	0.0004	0.0002	93.3	
3,3,4,4-Tetra	ug/L (extract)	0.0002	0.00001	0.00006	0.00004	80.0	Product < stated result
2,3,4,4,5-Penta	ug/L (extract)	0.0001	0.00001	0.00007	0.00004	60.0	Product < stated result
2,3,3,4,4-Penta	ug/L (extract)	0.001	0.00001	0.0002	0.0001	90.0	Product < stated result
3,3,4,4,5-Penta	ug/L (extract)	0.00004	0.00001	0.00007	0.00004	0.0	Raw & product < stated result
2,3,3,4,4,5-Hexa	ug/L (extract)	0.0003	0.00002	0.00009	0.00006	80.0	Product < stated result
3,3,4,4,5,5-Hexa	ug/L (extract)	0.00006	0.00002	0.00001	0.00006	0.0	Raw & product < stated result
2,2,3,4,4,5,5-Hepta	ug/L (extract)	0.002	0.00004	0.0004	0.0002	90.0	Product < stated result
2,2,3,3,4,4,5,5-Octa	ug/L (extract)	0.0004	0.00003	0.0001	0.00007	82.5	Product < stated result
2,2,3,3,4,4,5,5,6-Nona	ug/L (extract)	0.0002	0.00005	0.0001	0.00008	60.0	Raw & product < stated result
Deca	ug/L (extract)	0.0001	0.00006	0.0002	0.0001	0.0	Raw & product < stated result

Table 2.5-1
Analytical Results

Analyte	Units	Raw Sediment	Solid Product			Removal	Remarks
		(mean)	2/12/96	2/29/96	Mean	(%)	
PCB Totals							
-Mono	ug/L (extract)	0.03	0.000004	0.00006	0.00003	99.9	Product < stated result
-Di	ug/L (extract)	0.04	0.00008	0.0002	0.0001	99.8	
-Tri	ug/L (extract)	0.04	0.00003	0.0008	0.0004	99.0	Product < stated result
-Tetra	ug/L (extract)	0.02	0.0002	0.002	0.0009	95.5	Product < stated result
-Penta	ug/L (extract)	0.02	0.00005	0.001	0.0006	97.0	Product < stated result
-Hexa	ug/L (extract)	0.01	0.0001	0.0008	0.0005	95.0	
-Hepta	ug/L (extract)	0.006	0.00004	0.0004	0.0002	96.7	Product < stated result
-Octa	ug/L (extract)	0.002	0.00003	0.0001	0.00007	96.5	Product < stated result
-Nona	ug/L (extract)	0.00002	0.00005	0.0002	0.0001	-400.0	Raw & product < stated result