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REVISED FINAL
BASIS OF DESIGN

INTERIM CORRECTIVE MEASURE AT SWMU 45
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

CONTRACT TASK ORDER 0296

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1.0 INTRODUCTION

This document presents the Basis of Design for the Interim Corrective Measure at Solid Waste Management Unit (SWMU) 45 (former Installation Restoration Program Site 16), Naval Station Roosevelt Roads, Puerto Rico. This document has been prepared by Baker Environmental, Inc. (Baker) for presentation to the Department of the Navy (DoN), Naval Facilities Engineering Command, Atlantic Division (LANTDIV), under Navy CLEAN Contract Number N62470 (Contract Task Order 0296), and in accordance with LANTDIV's Scope of Work dated January 12, 1995. The Remedial Action Contracts Delivery Order Requirements Package Guide, NEESA 20.2-062 dated June 1992 was used as a guide in preparing this Basis of Design Report.

The DoN is implementing an Interim Corrective Measure remedial action at the SWMU 45 as part of the Installation Restoration (IR) Program for Naval Station Roosevelt Roads. The goal of the remedial action is to remove and remediate contaminated liquids and sludge from two underground storage tanks (USTs), a cooling water intake tunnel, and a cooling water outflow tunnel. The intent of the DoN and the station is to remediate the contaminated material to meet regulatory remediation levels. This corrective measure addresses the contents of the USTs and tunnels only. Groundwater and subsurface soils in the vicinity of these structures will be addressed under future IR work. LANTDIV intends to use a Remedial Action Contractor (RAC) to implement this remedial action. In this document, the terms "RAC" and "Contractor" are used interchangeably.

1.1 Purpose of the Basis of Design

The purpose of the Basis of Design is to present background data on the project, describe the primary elements of the remedial design, recommend design criteria, and present assumptions and any special requirements that may affect the design. This document is not intended to be part of construction plans or specifications to be utilized by the RAC for execution of the remedial action. Baker assumes no responsibility for the use of this report for any purpose other than the intended uses stated above.

1.2 Organization of the Document

This Basis of Design document contains four main sections. Section 1.0 provides introductory information. Section 2.0 presents background information for SWMU 45 including a site description, a site history, a summary of previous investigations, and remediation levels for the contaminated liquids and sludge in the tanks and tunnels. Section 3.0 presents a description of the Interim Corrective Measure, the performance requirements for the corrective measure, and some special considerations for implementing the corrective measure. Finally, Section 4.0 presents the elements of the Interim Corrective Measure by Hazardous, Toxic, and Radiological Waste (HTRW) account numbers.

2.0 BACKGROUND INFORMATION

This section provides background information for the Interim Corrective Measure. This information includes a description of SWMU 45 and its history, a summary of previous investigations, and a description of the remediation levels applicable to the contaminated liquids and sludge in the tanks and tunnels.

2.1 SWMU 45 - Description and History

Former IR Site 16 consists of SWMUs 11 and 45. SWMU 11 is Building 38, the "Bomb-Proof Power Plant," and is not included in the scope of this Interim Corrective Measure. SWMU 45 consists of the area surrounding Building 38. The focus of this Interim Corrective Measure is two 50,000-gallon reinforced concrete USTs, the cooling water outflow tunnel that runs from Building 38 to Ensenada Honda, and the two cooling water intake tunnels that connect Building 38 to Puerca Bay.

Figure 2-1 presents a site location map. SWMU 45 is located in the Forrestal Area of the station on a peninsula surrounded by Ensenada Honda on the west and Puerca Bay on the east. The site is located on the west side of the access road to the station's landfill off Forrestal Drive. The station's landfill is south of Building 38.

Figure 2-2 shows the site features and the surrounding area. As shown, an abandoned incinerator, a boiler shack, and the guardhouse for the landfill gate are located south of Building 38 along the landfill access road. Although it is not shown on Figure 2-2, one of the station's wastewater treatment plants, known as the Forrestal Sewage Treatment Plant (STP), is located southeast of Building 38.

Figure 2-2 also shows the location of the USTs and the tunnels that are the focus of this Interim Corrective Measure. The two 50,000-gallon reinforced concrete USTs lie under a concrete pad north of Building 38. The cooling water intake tunnels run parallel to each other and are separated by about one foot of concrete. Located north of Building 38 and east of the USTs, the tunnels extend from Building 38 to Puerca Bay and can be easily tracked from access points (manholes) located at regularly spaced intervals. The cooling water outflow tunnel that is reported to discharge into

Ensenada Honda is located on the east side of Building 38. The exact route of this tunnel is not currently known. However, the endpoint of the outflow tunnel was reportedly located by divers in 1992 and the approximate location was recorded using Global Positioning System (GPS) techniques. The USTs and tunnels served Building 38 which was a 60-megawatt steam turbine facility that reportedly operated from the early 1940s through 1949. Bunker C fuel was used to power the facility and was stored in the two 50,000-gallon USTs.

From 1956 to 1964, Building 38 was used for transformer maintenance and storage. Transformers were maintained on the northeast corner of the concrete pad which surrounds Building 38. Former station employees have reported dumping transformer oil on the ground around the building.

In the 1970s Bunker C fuel oil was observed in manholes near Building 38 and on the Enlisted Beach during heavy rainfalls. The fuel oil at the beach was attributed to the cooling water outflow tunnel that reportedly discharges to Ensenada Honda. A cleanup contractor was contracted twice to drain the tanks and clean up the spill. No records are currently available documenting the spill cleanup operations or the amount of product recovered.

The site has been subjected to numerous investigations in the intervening years. These investigations prompted the station to perform a removal action (in 1994 and 1995) for polychlorinated biphenyl (PCB) contaminated soil around Building 38, and to plan this Interim Corrective Measure for the USTs and the cooling water tunnels.

2.2 Previous Investigations

This section summarizes the previous investigations that have been conducted at SWMU 45. Figure 2-3 identifies sampling locations and some analytical results for the investigations conducted after 1992. Previous investigations at SWMU 45 include:

- An Initial Assessment Study (IAS) was performed at Site 16 by Greenleaf/Telesca in 1984. The IAS included a records review and personal interviews with station employees who would have knowledge of the site. The IAS determined that there was sufficient evidence that contamination may exist at Site 16 (SMWU 45) to warrant further investigations.

- Environmental Science and Engineering, Inc. (ESE) conducted a Confirmation Study at Site 16 in May 1988. This study included surface soil and sediment sampling. The results indicated that the soil and sediment around Building 38 were contaminated with PCBs and lead. The tanks and tunnels were not sampled as part of this investigation.

- A Resource Conservation and Recovery Act (RCRA) Facility Assessment was prepared by A. T. Kearney, and K. W. Brown and Associates in November 1988. This report was compiled to summarize all operating, closed, or closing RCRA regulated facilities on the station. SWMU 45 is described in this report as a transformer maintenance area. An estimated 1,600 gallons of PCB laden transformer oil were said to be poured on the ground at this site. Further soil sampling and surface water sampling at the outflow tunnel outlet on the Enlisted Beach were recommended.

- Versar, Inc. (Versar) performed a Remedial Investigation/Feasibility (RI/FS) in May 1992. The RI/FS was conducted to determine the extent of PCB and lead contamination in the soils around Building 38 and to provide an evaluation of soil treatment methods. The RI included surface water, sediment, and soil sampling. Wipe and chip samples were also collected on the concrete surface and the manhole entryways to the tunnels. The sampling results indicated that the soil and sediment were contaminated with PCBs. The results also indicated that the surface water and the interior of UST and tunnel manways were contaminated with PCBs and recommended they be investigated and remediated as a separate operable unit. A summary of the analytical results is provided in Table 2-1. The shaded blocks indicate an exceedance of remediation levels.

- In 1992, Baker conducted a supplemental investigation at the station. The purpose was to verify the data obtained during the Confirmation Study, to collect information necessary to adequately prepare RCRA Facility Investigation Work Plans, and to attempt to remove some SWMUs from further consideration. The Building 38 site was included in this supplemental investigation. Surface water

from the intake tunnel and sediments located at the intake point were sampled. The end of the outflow tunnel was located by divers and surveyed using GPS. Sediment and surface water samples were collected from the outlet of the cooling water outflow tunnel in Ensenada Honda. Water samples and sediment samples (where sediment was present) were also taken from manholes in the intake and outflow tunnels.

Analytical results showed that toxaphene in the surface water exceeded Ambient Water Quality Criteria (AWQC) (marine acute and chronic) and Puerto Rico Water Quality Standards (WQS) in one of seven samples. Endosulfan II also exceeded AWQC (marine chronic) and Puerto Rico WQS in the same sample, 16SW184. This sample is from a manhole in the outflow tunnel. In addition, two of the seven surface water samples (16SW186 and 16SW187) exceeded Federal Maximum Contaminant Levels (MCLs) for Aroclor-1260. These samples are from a manhole in the intake tunnel. A summary of the analytical results from this investigation is provided in Table 2-2.

- In November 1993, Baker conducted a geophysical investigation to determine the exact locations of the USTs and cooling water intake and outflow tunnels. Due to the construction of the USTs and tunnels (very thick reinforced concrete), the apparent depth of the tunnels, and other anomalies (buried debris), the geophysical investigation was not successful.

- In December 1993, Baker prepared a Pre-Investigation Corrective Measure Screening Report to evaluate the SWMUs and the Areas of Concern (AOCs) that would require further investigation under the station's RCRA Corrective Action Permit. The report identified the potential corrective measure technologies that may be used on-site or off-site for the containment, treatment, remediation, and/or disposal of contaminated material. This report also identified future field data requirements that would facilitate the evaluation and selection of the final corrective measure. The report made the following conclusions: (1) surface soil had been adequately characterized, (2) a groundwater investigation was contingent on the results of the Interim Remedial Action (soil removal), and (3) sediment had not

been adequately characterized. Additional samples within the tunnels would be required.

- During an unrelated investigation in 1994, the outflow tunnel was breached by a drill rig. One water and one product sample were collected by the station. The analytical results of this sampling are shown in Table 2-1. Neither of these samples exceeded any of the comparison criteria.

- In March 1995, Baker conducted a site inspection, a review of existing drawings, and a sampling of the contents of the two USTs and the cooling water outflow tunnel. One aqueous sample, one product sample, and one sludge sample were collected from Tank No. 1; one aqueous sample and one sludge sample were collected from Tank No. 2. Table 2-3 and the following paragraphs summarize the analytical results from this sampling event.

  Volatiles, including methylene chloride and chlorobenzene, were detected in a majority of the samples. Methylene chloride was also detected in the laboratory blanks, and was therefore not considered to be site related. One aqueous sample, RR38A2, exceeded the Federal MCL for chlorobenzene.

  Two semivolatiles (1,3- and 1,4-dichlorobenzene) were detected in Sample RR38A2 at concentrations of 3J µg/L and 4J µg/L, respectively. 1,4-dichlorobenzene did not exceed the maximum toxicity characteristic concentration.

  Pesticides and herbicides were not detected in either of the sludge samples collected. Aqueous samples were not analyzed for these parameters.

  The PCB Aroclor-1260 was detected in four of the five samples collected. These samples included RR38S1 (1,800 µg/kg), RR38S2 (1,700J µg/kg), RR38P1 (2.20 µg/L), and RR38A1 (0.41J µg/L). Aroclor-1260 was not detected in aqueous sample RR38A2. The sludge samples exceeded industrial and residential risk based criteria (RBCs). None of the samples exceeded the cleanup levels of 2 ppm in a

treated residue or 3 ppb in an aqueous stream, as discussed in the USEPA "Guidance on Remedial Actions for Superfund Sites with PCB Contamination".

Six inorganics (arsenic, barium, lead, mercury, silver, and vanadium) were detected at varying concentrations and frequencies among the four samples submitted for analysis, which included all but the product layer sample in Tank No. 1 (RR38P1). None of the samples exceeded the maximum toxicity characteristic concentrations.

Sludge sample RR38S2 had arsenic and lead concentrations that exceeded residential RBCs. Aqueous sample RR38A1 had a mercury concentration above AWQCs (marine chronic) and a silver concentration above AWQCs (marine chronic and acute) and Puerto Rico WQS. Aqueous sample RR38A2 had lead and mercury concentrations above AWQCs (marine chronic).

Three samples (RR38P1, RR38A1, and RR38A2) were submitted for total petroleum hydrocarbon (TPH) analysis. Two of the three samples (RR38P1 and RR38A1) contained measurable levels of TPH.

The two sludge samples (RR38S1 and RR38S2) were also submitted for analysis of RCRA hazardous waste characteristics (ignitability, corrosivity, and reactivity). Neither of the two samples exhibited any of these characteristics, as identified in 40 CFR Parts 261.21 through 261.23.

A specific gravity test was conducted on the sludge collected from the bottom of the tanks. The specific gravity of the sludge was 1.03, which is slightly heavier than water.

The potential for the tanks and tunnels to be a source of hazardous constituents to the environment is a major concern. The intent of the Interim Corrective Measure is to remove the potential for these structures to be a source of future or continuing hazardous constituent releases.

2.3 Remediation Levels

Remediation levels are concentrations to which contaminated media must be treated or cleaned. For SWMU 45, remediation levels were established for the contaminants of concern that were identified in the tank and tunnel liquid. Remediation levels were also established for the concrete chip samples that will be collected to determine the cleanliness of the tanks and tunnels.

Table 2-4 presents the remediation levels for liquid samples (these levels are shaded). As shown, the most stringent Federal MCL, Puerto Rico WQS, or National Pollutant Discharge Elimination System (NPDES) permit requirement was selected as the remediation level for each liquid contaminant. All of these remediation levels meet the NPDES permit standards for acceptance of the liquid at the Forrestal STP. If any liquid contaminant is detected that is not included in this list, the most stringent federal standard, Commonwealth standard, or NPDES permit requirement will be established as its remediation level.

For concrete chip samples, 50 ppm was selected as the remediation level for PCBs based on the TSCA guidance. 100 ppm was selected as the remediation level for TPH based on guidelines for petroleum contamination in other states in which LANTDIV performs remedial activities.

Remediation levels were not established for the tank and tunnel sludge since it will not be remediated on-site. All sludge will be containerized and shipped to a permitted treatment or disposal facility.

3.0 DESCRIPTION OF THE INTERIM CORRECTIVE MEASURE, PERFORMANCE REQUIREMENTS, AND SPECIAL CONSIDERATIONS

This section presents a description of the remedial actions that will be conducted under the Interim Corrective Measure, and special considerations that will assist in implementing the measure.

3.1 Description of the Interim Corrective Measure and Performance Requirements

The proposed Interim Corrective Measure involves cleaning the USTs and portions of the cooling water tunnels, backfilling the USTs, sealing off manholes, and upgrading the Puerca Bay walkway that extends over the intake tunnels. More specifically, the proposed Interim Corrective Measure includes the following actions and performance requirements:

- Breaching then sealing the two intake tunnels at their intake points in Puerca Bay and at their entrance to Building 38. Cast-in-place concrete will be used as the sealing material and the seals will be water-tight.

- Breaching the outflow tunnel in three locations: near the boiler house, near the former incinerator, and at the tunnel's entrance to Building 38. Sealing the outflow tunnel in two breached locations: near the boiler house and at the tunnel's entrance to Building 38. Cast-in-place concrete will be used as the sealing material and the seal will be water-tight.

- Removing liquids and sludge from the USTs and from the sealed-off sections of the tunnels. Liquids will be transported to an on-site treatment system. The treatment system will be capable of remediating the liquids to the remediation levels specified in Section 2.3. Sampling and analysis will be used to verify that remediation levels have been met. Sludges will be transported to a permitted treatment or disposal facility.

- Cleaning the concrete walls of the USTs and tunnels. Wash fluids may be sent through the on-site treatment system. All by-products of the cleaning process will be handled according to local, Commonwealth, and Federal regulations.

- Backfilling the USTs with an inert lightweight material.

- Installing a water-tight cover on pump pit.

- Sealing the manway entrances to each UST and the manholes in the intake and outflow tunnels. Before sealing occurs, the USTs' and tunnels' cleanliness will be confirmed through sampling and analysis. The sealing material will be cast-in-place concrete and the seals will be water tight.

- Repairing and upgrading the walkway that extends over the intake tunnels.

The outflow tunnel will be sealed prior to where it enters the Roosevelt Roads Landfill, near the boiler house, to eliminate the hazard of excavating in the landfill. The one sediment sample at the end of the outflow tunnel showed slight contamination (methoxychlor 0.39 J µg/kg). Therefore, the entire outflow tunnel will not be addressed under this Interim Corrective Measure.

3.2 Special Considerations

This section presents special considerations, including engineering, logistical, and waste disposal considerations, that apply to this Interim Corrective Measure.

3.2.1 Engineering Considerations

UST and Tunnel Construction: Building 38, the USTs, and the tunnels were designed in 1942 and 1943 to be bomb-proof. The tunnels are at least eight feet below the ground surface and are constructed of one-foot thick reinforced concrete. The USTs are covered with a concrete apron. There is a shock wave dissipation zone between the concrete apron and the top of the USTs. The tops of the USTs are about nine feet below the ground surface and are constructed of one-foot thick reinforced concrete.

Sealing Tunnels: Because the tunnels discharge into Puerca Bay and Ensenada Honda, it should be assumed that they are tidally influenced and that sealing operations would be easier at low tide.

Sealing will provide the contractor with a finite amount of potentially contaminated water to treat. Sealing the tunnels will also prevent cleaning agents or loosened contaminants from entering the surface water.

Cleaning: Cleaning the USTs and tunnels will require pumping and processing all of the liquid from the structures through a system that is capable of separating out the coagulated Bunker C fuel. The sludge was found to have a specific gravity of 1.03 which indicates that it will not float on or easily separate from the water in the USTs and tunnels.

The sludge will also be removed from the USTs and tunnels and containerized. The structures will then be cleaned by scraping, gritblasting, hydroblasting, or steam cleaning. All by-products of the cleaning process will require proper handling according to local, Commonwealth, and Federal regulations.

3.2.2 Logistical Considerations

Mangroves: There are protected mangroves along the shorelines of Ensenada Honda and Puerca Bay. Disturbance to the mangroves must be minimized and any disruption or disturbance of the mangroves would require Army Corps of Engineers approval.

Roadways: The cooling water intake tunnel runs under the landfill access road and the paved road off Forrestal Drive. The landfill access road is used regularly by station refuse haulers. This road also leads to the Forrestal STP. Access to the landfill and the STP must be maintained at all times. The paved road off of Forrestal Drive leads to other facilities on the station and to area beaches and also must remain open.

Utilities: The excavation of the tunnels will require locating and working around the existing utilities which include overhead electric, water, sewage, and phone.

Waste Disposal: There is no RCRA or TSCA disposal facility on the island. Should any wastes resulting from this Interim Corrective Measure require RCRA or TSCA disposal, they will have to be processed and shipped to a permitted facility in the continental United States.

3.2.3 Waste Disposal Requirements

EPA disposal criteria have been compared to the analytical results from the most recent field investigation. Therefore, the recommended treatment methods for the liquid and sludge are as follows:

Liquid: Process liquid removed from the USTs and tunnels through a water treatment system capable of treating the Bunker C fuel, PCBs, metals, and other detected contaminants. Transport the treated liquid via tanker truck to the Forrestal STP. After discussions with the NSRR Water Pollution Branch, it is anticipated that the STP will be able to accept the treated water because a temporary variance to their existing NPDES permit will be submitted and approved prior to any discharge.

Sludge: Characterization testing will be performed when sludge is removed. The sludge could be sent to an approved and permitted petroleum recycling facility on-island if it meets the facility's requirements. Otherwise, the containerized sludge will be disposed of in an approved facility (presumably off-island). The sludge will not be disposed of in the station's landfill.

Waste Concrete: Concrete, if removed from the excavated tunnels, should be washed using the same procedures as the in situ USTs and tunnels. Once clean, the concrete should be disposed of in a facility approved to receive construction debris, such as a concrete mixing facility.

4.0 REMEDIAL ACTION WORK BREAKDOWN STRUCTURE

The following sections of this Basis of Design present the elements of the remedial action by Hazardous, Toxic, and Radiological Waste (HTRW) account numbers as defined in the Remedial Action Contracts Delivery Order Requirements Package Guide, NEESA 20.2-062, June 1992. A proposed construction schedule for the project is provided in Appendix A, and a construction cost estimate is provided under a separate cover.

33.01 Mobilization and Preparatory Work

Mobilization involves the acquisition, delivery, and setup of equipment, material, and personnel to the work site necessary to accomplish the remedial action.

In addition, during the mobilization period, the Contractor shall prepare all necessary pre-construction submittals, as described in Section 01010, "General Paragraphs", of the contract specifications. These specifications allow the Contractor up to sixty (60) days to prepare and submit the necessary pre-construction submittals. Several of the submittals are as follows:

- Work Plan
- Erosion Control Plan
- Environmental Protection Plan
- Site Health and Safety Plan
- Sampling and Analysis Plan

The Contractor will provide temporary facilities, including an equipment staging/decontamination area, a supply storage area, stockpile areas, a treatment facility, and temporary utilities, as necessary to complete the work.

33.01.01.05 Permits

The Contractor will be required to coordinate and obtain any necessary construction permits (such as temporary utility and excavation permits) and clearances prior to the start of construction. The

Contractor will also be responsible for coordinating all required inspections by the station's Public Works Department.

33.02 Monitoring, Sampling, Testing, and Analysis

The Contractor will be required to submit to LANTDIV for approval a Sampling and Analysis Plan (SAP) describing the proposed sampling, analytical, and quality control procedures for the chemical data collected during the performance of work (see Section 01010, "General Paragraphs" of the contract specifications). The SAP will ensure that all analytical data generated are scientifically accurate and legally defensible. The SAP will describe the quantity, frequency, and location of samples to be collected and analyses to be performed.

The type and quantity of air testing will be based on the requirements set forth in the specifications (and the Contractor's Health and Safety Plan [HASP] and Air Monitoring Plan) and as required during the project. All required testing, documentation, and submittal of test results will be the responsibility of the Contractor.

33.02.03 Air Monitoring and Sampling

The Contractor shall develop and implement an Air Monitoring Plan to characterize site air and air within confined work spaces with regard to personnel safety and off-site (perimeter of the active work areas) migration of contaminants as a result of site activities. The Contractor shall perform real-time monitoring for organic vapors with a photoionization detector (PID) or flameionization detector (FID) type volatile organic detector and for explosive atmospheres with an explosimeter. Action levels shall be identified in the Contractor's HASP and Air Monitoring Plan subject to the approval of the Navy Technical Representative (NTR).

High-volume air sampling shall be used to quantify any release of toxic particulates with remedial work at the project site in accordance with Occupational Safety and Health Administration (OSHA) requirements for worker health and safety.

33.02.05 Water Sampling

The Contractor shall collect water samples from the on-site treatment system to monitor the performance of the treatment process. These samples will determine if the discharge requirements are being met and if the equipment performance requirements are being met. One influent sample shall be collected from the treatment system at startup, and every 10 hours of system operation thereafter.

The effluent from the on-site water treatment plant will be sampled on a daily basis. The effluent from the plant will be stored in temporary tanks. A composite sample will be collected from the tanks each day for characterization. The treated water will be stored in the tanks until analytical verification of treatment is received.

33.02.06 Sludge Sampling

The Contractor shall collect sludge samples for chemical analysis from sludge that is removed from the tanks and tunnels during cleaning procedures and any solids generated by the water treatment system. The samples will be analyzed for full toxicity characteristics leaching procedure (TCLP) and RCRA characteristics. One composite sample will be collected from each container of sludge that is generated. The results of these analyses will determine the disposal method.

33.02.09 Testing and Analysis

The walls of the USTs and tunnels will be tested to certify that they are clean. Confirmatory sampling will be conducted using concrete chip samples as described in the technical specifications. The chip samples will be analyzed for TPH using EPA SW-846 Method 418.1 and PCBs using EPA SW-846 Method 8080. The analyses results for the concrete chip samples will be compared to the remediation levels established for TPH and PCBs - 100 ppm and 50 ppm, respectively.

The Contractor shall perform laboratory testing of water and sludge samples collected during remediation activities. The Contractor shall adhere to EPA chain-of-custody procedures during the collection, transport, and analysis of all samples. Laboratory analyses of all samples shall conform with accepted Quality Assurance (QA) requirements.

For cost estimating purposes, it is assumed that water samples will be analyzed for the following parameters:

- Volatile Organic Compounds (VOCs) - EPA SW-846 Method 8240
- Semivolatile Organic Compounds (SVOCs) - EPA SW-846 Method 8270
- Total Petroleum Hydrocarbons (TPHs) - EPA SW-846 Method 418.1
- Pesticides/PCBs - EPA SW-846 Method 8080
- Metals - EPA SW-846 Methods 6010
- Total Organic Halogens (TOX) - EPA SW-846 Method 9020
- Oil & Grease - EPA SW-846 Method 9070

*Note: Should lower detection limits be required, EPA SW-846 Method 7000 should be used.

In addition, it is assumed that influent and effluent treatment plant water will be analyzed for Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD).

For cost estimating purposes, it is assumed that sludge samples will be analyzed for the following parameters:

- TCLP Volatile Organic Compounds (VOCs) - EPA SW-846 Method 8240
- TCLP Semivolatile Organic Compounds (SVOCs) - EPA SW-846 Method 8270
- TCLP Pesticides/PCBs - EPA SW-846 Method 8080
- TCLP Metals - EPA SW-846 Methods 6010
- RCRA Characteristics: Ignitability Method SW-1010, Corrosivity (Method SW-9045), Reactivity (Method SW-9010/9030), Toxicity (Method 6010)
- TOX - EPA SW-846 Method 9020

33.03 Site Work

Site work includes, but is not limited to: 1) constructing temporary facilities such as the equipment staging/decontamination area, supply storage area, stockpile areas, and treatment facility; 2) clearing

and excavating soil above the tunnels; 3) sealing the cooling water tunnels with concrete; 4) delivering and installing the on-site treatment system; 5) pumping liquid and sludge from the USTs and tunnels; 6) cleaning the USTs and tunnels; 7) backfilling the USTs with an inert lightweight material; 8) sealing UST and tunnel manholes with concrete; 9) backfilling excavation areas; 10) manifesting and shipping sludge off-site; 11) installing a water-tight cover on the pump pit; 12) reconstructing the walkway over the cooling water intake tunnel; and 13) restoring the site.

In addition, the Contractor shall be required to install safety and erosion control (silt) fencing in accordance with an approved Erosion Control Plan. The Contractor may dispose of cleared vegetation by chipping and spreading.

33.05 Surface Water Collection and Control

The Contractor shall be required to provide devices or facilities as necessary to prevent surface water from contacting contaminated materials (e.g., contaminated equipment, etc.) during construction activities, and from flowing off-site. The Contractor shall be required to keep all excavated areas dewatered during construction and to collect, sample, analyze, and dispose of any water accumulated in the excavation and staging areas.

33.07 Air Pollution/Gas Collection and Control

The treatment plant may generate some VOC and SVOC emissions to the atmosphere. As a result, a temporary air emissions permit from the Puerto Rico Environmental Quality Board (EQB) will be required. This permit must be in place prior to operating the treatment system.

The excavation and backfilling activities will most likely generate some dust emissions. Soil, haul roads, and other areas disturbed by operations shall be treated with dust suppressants, such as potable water, to minimize emissions. Because the total area of surface disturbance is less than 900 square meters, a dust control permit is not required. Treated wastewater cannot be used for dust control.

33.08 Solids Collection and Containment

Soil excavation shall be performed with appropriate earth moving equipment, such as excavators, bulldozers, and front-end loaders. It is estimated that approximately 1,000 cubic yards of soil will be excavated at the site. Excavated soils will be temporarily stored adjacent to the excavation then reused as backfill for the excavated areas.

33.09 Liquids/Sediment/Sludges Collection and Containment

The Contractor shall provide a decontamination pad at the site to collect liquids from the decontamination of personnel, earth-moving equipment, transportation trucks, and sampling equipment. The decontamination fluids will be treated at the on-site treatment facility.

Liquids within the tanks and tunnels shall be pumped to the on-site treatment facility. After treatment, the liquids shall be transported by a tanker truck to the Forrestal STP. The Contractor must coordinate with the Environmental Engineering Division of the Public Works Department for the discharge of treated water into the Forrestal STP.

Sludges shall be removed from the tanks and tunnels by pumping, washing, and/or manual removal. Sludge generated by the on-site treatment plant shall also be collected and removed. Segments of sludge shall be removed and containerized individually to avoid mixing sludge from remote sections of the tunnels. Sludges will be containerized in drums or an approved containing device.

Lightweight Flowable Fill Material for Tanks

The tank fill shall be inert, low density material that can be poured into the underground storage tanks. The fill material shall have a low density so that future tank entry or removal will be possible. When set, the fill material shall be insoluble; it shall not bleed when immersed in water. An example of a suitable material is low density cellular concrete which is a mixture of cement, water slurry, and a high stability foam (see appendix B). The material shall not be fly ash based.

33.10 Drums, Tanks, and Miscellaneous Demolition and Disposal

No drums or tanks will be demolished. Top portions of the cooling water intake and outflow tunnels will be demolished to provide access to the tunnels. The concrete will be washed and sent to a facility permitted to accept construction debris, such as the off-station concrete mixer facility. Personal protective equipment (PPE) shall be disposed in accordance with EPA Guidance (EPA Publication 9345.3-03FS).

33.13 Physical Treatment

All wastewater, including the water removed from the USTs tunnels, and decontamination fluids, will be sent to the temporary on-site treatment facility. The facility will be staged on the existing concrete pad around Building 38. The treatment units will remove suspended fuel particles, PCBs, and metals. The effluent from the treatment facility will be required to meet the NPDES requirements for the Forrestal STP.

33.19 Disposal (Commercial)

Treated water from the treatment system shall be pumped to a tanker truck then transported to the Forrestal STP. Baker and LANTDIV will jointly prepare the NPDES permit and submit it to the EPA through the station.

Sludge removed during the cleaning of tanks and tunnels, and sludge generated at the on-site treatment facility, shall be containerized and sampled. If sludge samples meet any local permitted facility's requirements, the containerized sludge will be sent to the petroleum recycling facility. If sludge samples do not meet the recycling facility's requirements, the sludge will be disposed in an approved facility off-island. The sludge shall not be disposed in the station landfill.

Fluids generated during the construction activities shall be sent through the on-site treatment system then transported to the Forrestal STP after treatment. The Contractor shall coordinate with the Environmental Engineering Division of the Public Works Department for the modifications to the NPDES permit that are required.

Any rubble, including concrete, excavated during construction activities will be cleaned then disposed at a facility approved to accept construction debris such as the off-site concrete mixer facility.

Miscellaneous non-contaminated waste (e.g., refuse and spent PPE) shall be loaded onto trucks or roll-off containers and transported to a permitted solid waste landfill or other appropriate facility subject to LANTDIV and station acceptance.

The Contractor will supply the station with copies of all manifest and records regarding the disposal activities at the completion of the project.

33.20 Site Restoration

The excavated areas shall be backfilled with the excavated soil regraded to the original contours. Fill materials will be placed and compacted in accordance with the contract specifications. All disturbed areas shall be regraded or reseeded to match original site conditions.

33.21 Demobilization

All temporary facilities, equipment, and supplies acquired for this contract shall be decontaminated and removed from the site upon completion of the remedial action.

Post-construction submittals shall include: 1) a punch list showing correction of all listed items; 2) a letter from the Contractor certifying completion of all contracted work in accordance with the contract conditions, applicable regulations, and standards of practice; 3) a completed project current condition with an as-built survey for the entire site; 4) submittals, in one collated document, of all quality control daily reports, samples, results of the analysis of samples, corrective actions (if required, taken to correct deviations from the plans and specifications that were pre-approved by LANTDIV), and results of corrective actions; and, 5) submittal, in one collated document, of all quality assurance sample results, and corrective actions (if required, taken to correct unacceptable deviations from required quality standards).

The Contractor shall submit to LANTDIV a detailed report summarizing the remedial action, lessons learned, and recommendations for inclusion in future similar contracts.

5.0 REFERENCES

40 Code of Federal Regulations (CFR).

A.T. Kearney, Inc. and K.W. Brown and Associates, Inc., Phase II RCRA Facility Assessment of the U.S. Naval Station Roosevelt Roads Facility, Puerto Rico, November 1988.

Baker Environmental, Inc., Final Engineering Report - Investigation, Characterization, and Interim Corrective Measure of SWMU 45 (Site 16), May 1995.

Baker Environmental, Inc., Draft Pre-Investigation Corrective Measures Screening Report, December 1993.

Environmental Science and Engineering, Inc., Remedial Action Alternatives for the Old Power Plant, Building 38, Site 16. Confirmation Study to Determine Possible Dispersion and Migration of Specific Chemicals, May 1988.

Greeleaf/Telesca, Initial Assessment Study of Naval Station Roosevelt Roads, Puerto Rico, September 1984.

Hazardous Waste Management Permit for U.S. Naval Station Roosevelt Roads, November 1993.

Naval Energy and Environmental Support Activity (NEESA), and Naval Facilities Engineering Command Contractor's Office, Remedial Action Contracts Delivery Order Requirements Package Guide, Parts 1 and 2, June 1992, NEESA 20.2-062.

Puerto Rico Water Quality Standards

Technical Review Committee Meeting Minutes, February 14, 1989.

USEPA, Drinking Water Regulations and Health Advisories.

USEPA, Guidance on Remedial Actions for Superfund Sites with PCB Contamination, EPA 540G-90/007, August 1990.

USEPA Office of Science and Technology, Water Quality Criteria Summary, May 1, 1991.

USEPA Region III, Risk Based Concentration Table, January - June 1995.

Versar, Inc., Remedial Investigation/Feasibility Study for Site 16, May 1988.

TABLES

TABLE 2-1

SURFACE WATER SAMPLE RESULTS
SAMPLED BY VERSAR, 1991
SITE 16 - NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

VERSAR		PCB Concentration, $\mu g/m^2$					
WATER SAMPLE NO.	1016Q	1221Q	1232Q	1242Q	1248Q	1254Q	1260Q
RR16SW01	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	18
RR16SW02	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	54
RR16SWO2D	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	41
RR17SW03	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	13
RR16TW01	5 U	5 U	5 U	5 U	5 U	10 U	170

NOTES:

U = UNDETECTED; NUMERICAL VALUE IS ONE-HALF THE DETECTION LIMIT

SURFACE WATER AND OIL SAMPLE RESULTS
SAMPLED BY NSRR, MAY 1994
SITE 16 - NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

SAMPLE NO.	1 Oil from Cooling Tunnel (ppm)	2 Water from Cooling Tunnel (ppm)
PCB	86	< 0.002

ANALYSES CONDUCTED BY: CARIBTEC LABORATORIES, INC.

TABLE 2-2

PESTICIDES/PCB COMPOUNDS DETECTED IN THE SEDIMENT AND SOIL
SAMPLED BY BAKER, NOVEMBER 1992
SITE 16 - NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

	Sediment						Surface Water						
Sample ID Units	16 SED 183 µg/kg	16 SED 184 µg/kg	16 SED 186 µg/kg	16 SED 187 µg/kg	16 SED 190 µg/kg	16 SED 191(DUP) µg/kg	16 SW 183 µg/L	16 SW 184 µg/L	16 SW 186 µg/L	16 SW 187 µg/L	16 SW 188 µg/L	16 SW 191DUP µg/L	16 SW 192 µg/L
BHC, alpha-	2.8 U	26 U	24 U	0.11 J	4.9 UJ	0.11 J	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
BHC, beta-	2.8 U	26 U	24 U	21 U	4.9 U	4.9 U	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
BHC, delta-	2.8 U	26 U	24 U	21 U	4.9 U	4.9 U	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
BHC, gamma-	2.8 UJ	26 U	24 U	21 U	4.9 UJ	0.39 J	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
Heptachlor	2.8 UJ	26 UJ	24 U	21 UJ	4.9 UJ	4.9 UJ	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
Aldrin	2.8 UJ	26 U	24 U	21 U	4.9 UJ	4.9 UJ	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
Heptachlor epoxide	2.8 U	26 UJ	24 U	21 UJ	4.9 UJ	4.9 UJ	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
Endosulfan I	2.8 UJ	26 U	200 B	33 B	4.9 UJ	4.9 U	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
Dieldrin	5.5 UJ	50 UJ	47 UJ	40 UJ	9.6 UJ	9.6 UJ	0.012 UJ	0.012 UJ	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
DDE, 4,4-	5.5 UJ	50 U	47 U	40 U	2.3 JB	2.6 J	0.012 UJ	0.012 UJ	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
Endrin	5.5 U	50 U	47 U	40 U	9.6 U	9.6 U	0.012 UJ	0.012 UJ	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
Endosulfan II	5.5 U	50 U	47 U	40 U	9.6 U	9.6 U	0.012 UJ	0.018 J	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
DDD, 4,4-	5.5 U	50 U	47 U	40 U	9.6 U	9.6 U	0.012 UJ	0.012 UJ	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
Endosulfan sulfate	5.5 U	50 U	47 U	40 U	9.6 U	9.6 U	0.012 UJ	0.012 UJ	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
DDT, 4,4-	5.5 UJ	50 U	47 U	40 U	9.6 U	9.6 U	0.012 UJ	0.012 UJ	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
Methoxychlor	0.59 J	260 UJ	240 UJ	210 UJ	49 UJ	49 UJ	0.062 UJ	0.062 UJ	0.069 U	0.65 U	0.062 UJ	0.062 U	0.066 U
Endrin ketone	5.5 U	50 U	47 U	40 U	9.6 U	9.6 U	0.012 UJ	0.012 UJ	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
Endrin aldehyde	0.18 J	50 U	47 U	40 U	9.6 U	9.6 U	0.012 UJ	0.012 UJ	0.014 U	0.13 U	0.012 UJ	0.012 U	0.013 U
Chlorodane, alpha	2.8 U	13 J	R	150 J	4.9 U	4.9 UJ	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U
Chlordane, gamma	0.21 J	22 J	37 J	21 U	4.9 UJ	0.6 J	0.0062 UJ	0.0062 UJ	0.0069 U	0.065 U	0.0062 UJ	0.0062 U	0.0066 U

TABLE 2-2 (Continued)

PESTICIDES/PCB COMPOUNDS DETECTED IN THE SEDIMENT AND SOIL
SAMPLED BY BAKER, NOVEMBER 1992
SITE 16 - NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

	Sediment						Surface Water						
Sample ID Units	16 SED 183 µg/kg	16 SED 184 µg/kg	16 SED 186 µg/kg	16 SED 187 µg/kg	16 SED 190 µg/kg	16 SED 191(DUP) µg/kg	16 SW 183 µg/L	16 SW 184 µg/L	16 SW 186 µg/L	16 SW 187 µg/L	16 SW 188 µg/L	16 SW 191DUP µg/L	16 SW 192 µg/L
Toxaphene	280 U	2600 U	2400 U	2100 U	490 U	490 U	0.62 UJ	0.62 J	0.69 U	6.5 U	0.62 UJ	0.62 U	0.66 U
Aroclor-1016	55 U	500 U	470 U	400 U	96 U	96 U	0.12 UJ	0.12 UJ	0.14 U	1.3 U	0.12 UJ	0.12 U	0.13 U
Aroclor-1221	110 U	1000 U	960 U	810 U	195 U	190 U	0.25 UJ	0.25 U	0.28 U	2.6 U	0.25 UJ	0.25 U	0.26 U
Aroclor-1232	55 U	500 U	470 U	400 U	96 U	96 U	0.12 UJ	0.12 UJ	0.14 U	1.3 U	0.12 UJ	0.12 U	0.13 U
Aroclor-1242	55 U	500 U	470 U	400 U	96 U	96 U	0.12 UJ	0.12 UJ	0.14 U	1.3 U	0.12 UJ	0.12 U	0.13 U
Aroclor-1248	55 U	500 U	470 U	400 U	96 U	96 U	0.12 UJ	0.12 UJ	0.14 U	1.3 U	0.12 UJ	0.12 U	0.13 U
Aroclor-1254	55 U	500 U	470 U	400 U	96 U	96 U	0.12 UJ	0.12 UJ	0.14 U	1.3 U	0.12 UJ	0.12 U	0.13 U
Aroclor-1260	55 U	R	R	R	21 J	22 J	0.12 UJ	0.12 UJ	1.9 J	18 J	0.12 UJ	0.12 U	0.13 U

NOTES:

U = Compound not detected
J = Estimated value, below method detection limit
B = Compound was found in associated blank

TABLE 2-3

DETECTED CONSTITUENTS
SAMPLED BY BAKER, MARCH 1995
SITE 16 NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Parameters (µg/L)	Sample Number					Toxicity Characteristics (µg/L)	Parameters Exceeding Toxicity Characteristics
	RR38S1 µg/L	RR38S2 µg/L	RR38P1 µg/L	RR38A1 µg/L	RR38A2 µg/L		
Volatiles: Methylene Chloride+	NE	NE	2JB	2JB	3JB	NA	NE
Chlorobenzene	10J	20J	4J	4J	16	100,000	None
Semivolatiles: 1,3-Dichlorobenzene	NE	NE	NE	ND	3J	NA	NE
1,4-Dichlorobenzene	ND	ND	NE	ND	4J	7,500	None
TCLP Pesticides/Herbicides:	ND	ND	NE	NE	NE	NA	NE
PCBs: Aroclor-1260	1,800J*	1,700J*	2.20	0.41J	ND	2,000*(1) 3.0(1)	None
Inorganics: Arsenic	ND	47.0	NE	ND	ND	5,000	None
Barium	206	250	NE	15.4B	19.3	100,000	None
Lead	49.9	527	NE	4.4	11.8	5,000	None
Mercury	ND	ND	NE	0.38	0.24	200	None
Silver	8.7B	ND	NE	6.4B	ND	5,000	None
Vanadium	ND	ND	ND	ND	22	NA	NE
TPH	NE	NE	67,000	2,000	ND	--	--
Ignitibility/Corrosivity/ Reactivity Characteristics	(2)	(2)	NE	NE	NE	(3)	None

TABLE 2-3 (Continued)

DETECTED CONSTITUENTS
SAMPLED BY BAKER, MARCH 1995
SITE 16 NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Note: All concentration are in micrograms/Liter (µg/L)

(1) According to USEPA's "Guidance on Remedial Actions for Superfund Sites with PCB Contamination", PCBs cleanup levels are <2 ppm in a treated residue or 3 ppb in aqueous streams produced during treatment processes.
(2) Sample did not exhibit the chararteristics of ignitibility, corrosivity or reactivity.
(3) Characteristics include those identified in 40CFR Parts 261.21, 261.22, and 261.23.

NA Not Available
ND Not Detected
NE Not Evaluated

\+ Laboratory blank contaminant
* Sample concentration is in µg/kg.
J An estimated value, below method detection limit
B Compound was found in associated blank

TABLE 2-4

REMEDIATION LEVELS FOR LIQUID CONTAMINANTS
SITE 16 - NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

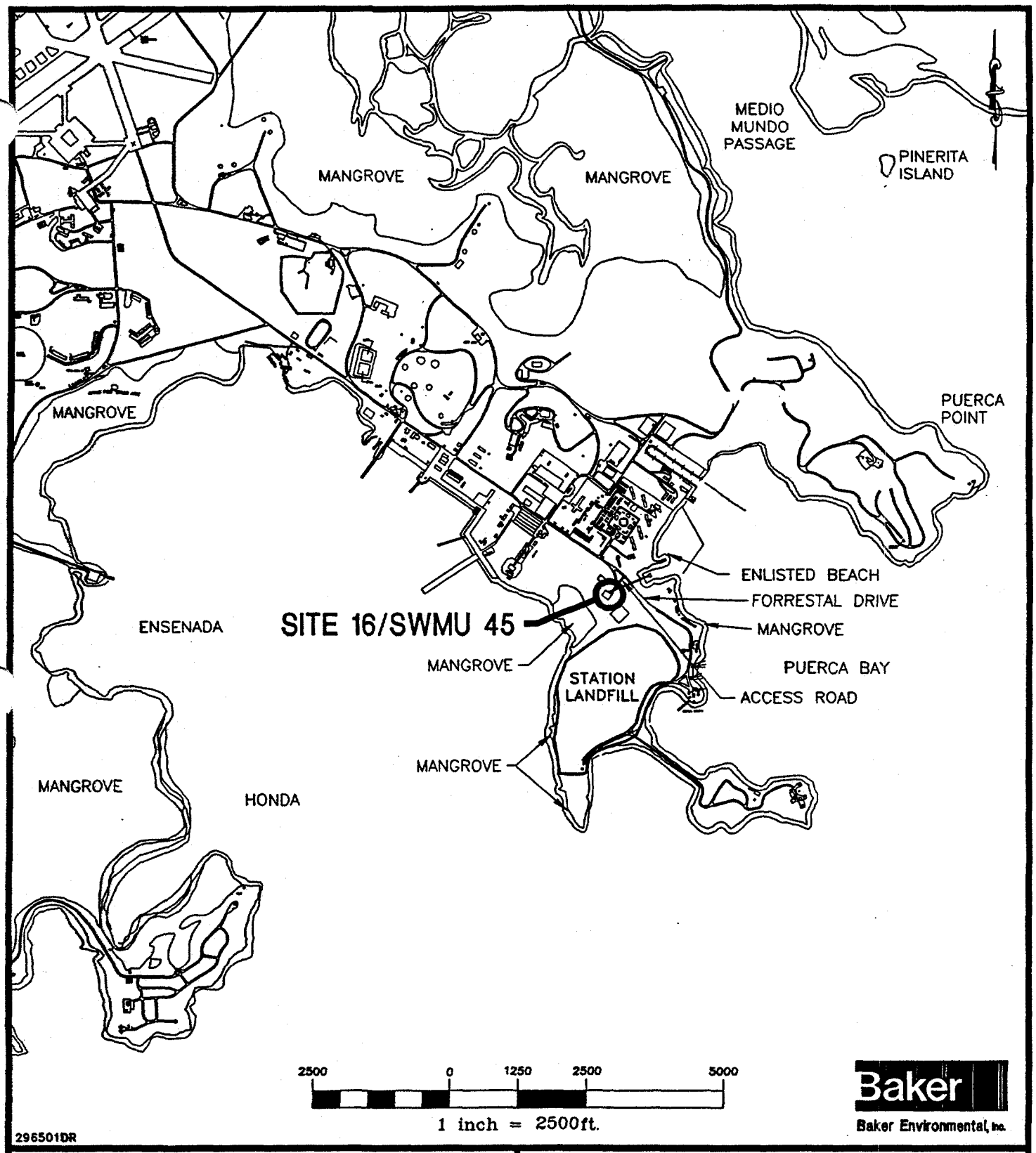
Contaminant of Concern	Remediation Level (µg/L)	Basis of Remediaiton Level
Volatiles:		
Chlorobenzene	5	Federal MCL
Semivolatiles:		
1,3 -Dichlorobenzene	600	Federal MCL
1,4 -Dichlorobenzene	75	Federal MCL
Pesticides/PCBs:		
alpha-BHC[1]	0.2	Federal MCL
gamma-BHC[1]	0.2	Federal MCL
alpha-Chlordane[2]	0.0046	Puerto Rico WQS
gamma-Chlordane[2]	0.0046	Puerto Rico WQS
4,4'-DDE	0.00024 (as DDT and metabolites)	Puerto Rico WQS
Endosulfan I[3]	0.0087	Puerto Rico WQS
Endosulfan II[3]	0.0087	Puerto Rico WQS
Endrin aldehyde[4]	0.0023	Puerto Rico WQS
Methoxychlor	0.02	Puerto Rico WQS
Toxaphene	0.0002	Puerto Rico WQS
Aroclor-1260[5]	0	Forrestal STP NPDES Permit
Inorganics:		
Arsenic	50	Federal MCL
Barium	1000	Puerto Rico WQS
Lead	15	Puerto Rico WQS
Mercury	1	Puerto Rico WQS
Silver	2	Puerto Rico WQS
TPH	--	--

References:

Puerto Rico Water Quality Standards, coastal/estuarine waters
Federal MCLs (Drinking Water Regulations and Health Advisories, USEPA, November 1994)
Forrestal Sewage Treatment Plant National Pollutant Discharge Elimination System (NPDES) Permit

[1] Lindane used as a surrogate
[2] Chlordane used as a surrogate.
[3] Endosulfan used as a surrogate
[4] Endrin used as a surrogate
[5] As polychlorinated biphenyls
[6] 1,4-Dichlorobenzene used as a surrogate
µg/L = micrograms per liter
MCL = Maximum Contaminant Level
TPH = total petroleum hydrocarbons
WQS = Water Quality Standards

FIGURES



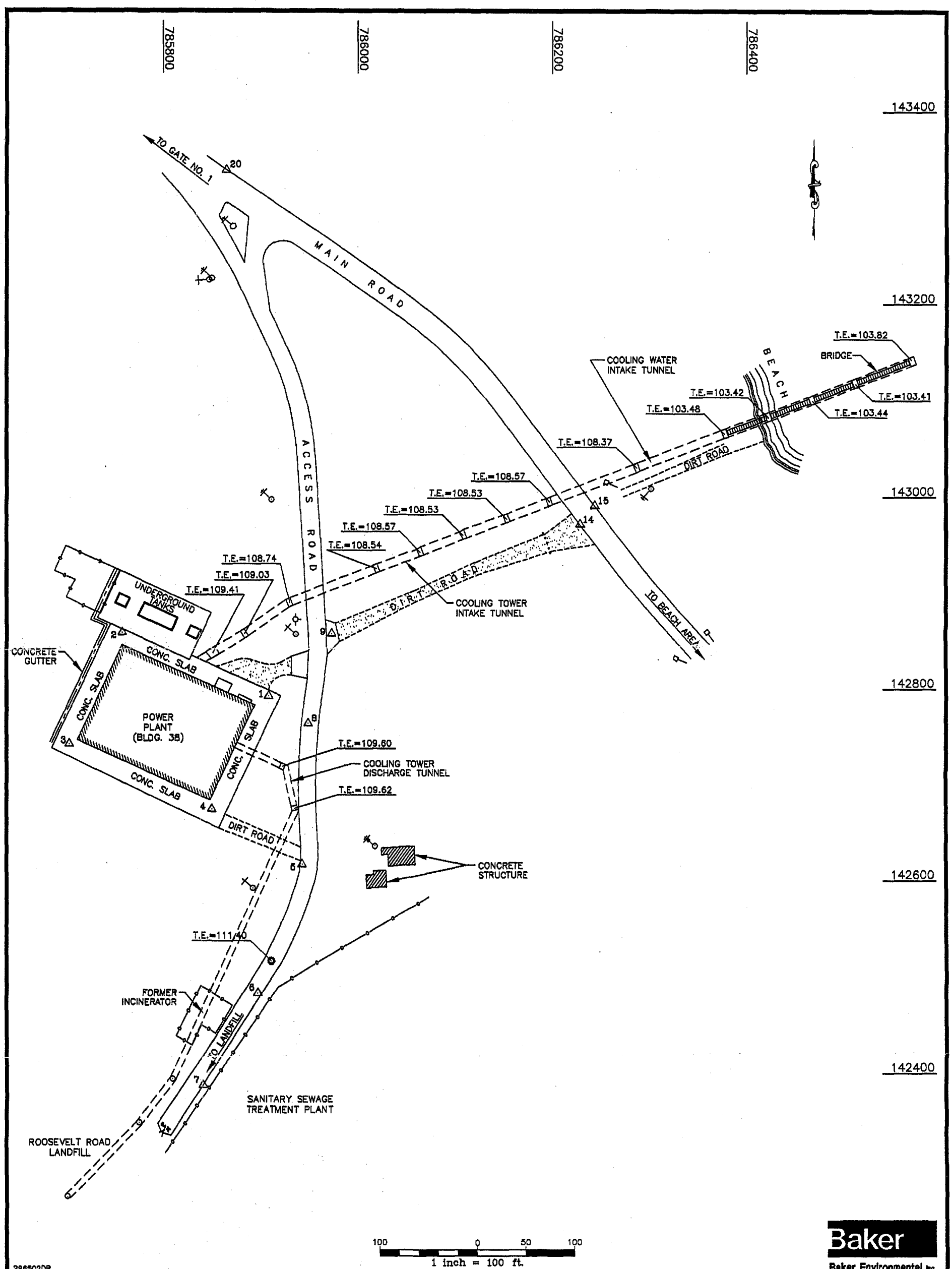
LEGEND

◇ BUILDING

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-1
SITE LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



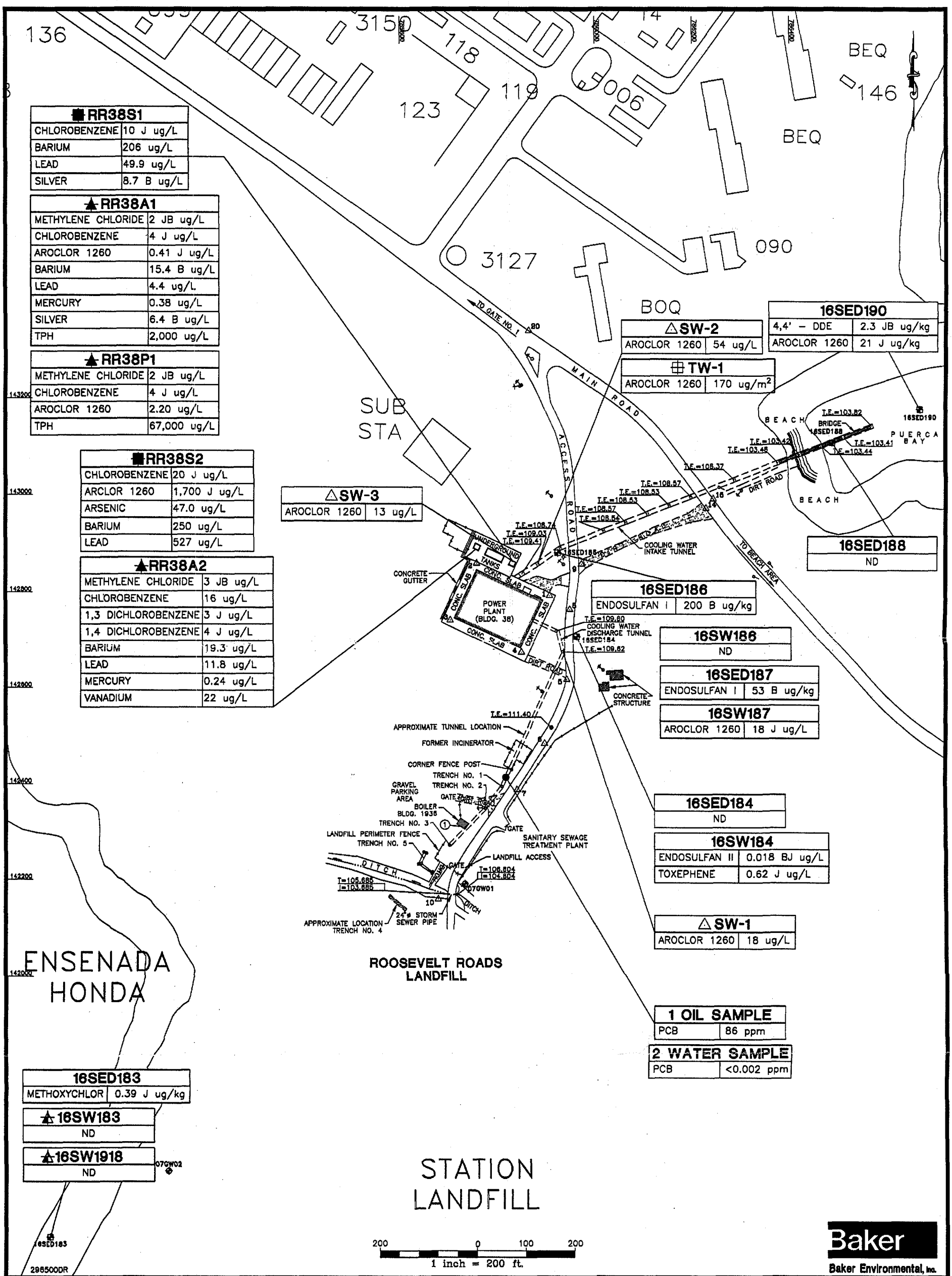
LEGEND

- T.E.=108.54 — MANHOLE LOCATION (WITH ELEVATION)
- CHAIN LINK FENCE
- ELECTRIC POLE
- ELECT. POLE WITH TRANSFORMER
- ELECTRIC POLE (CONC.)
- TELEPHONE POLE
- SANITARY SEWER MANHOLE
- FIRE HYDRANT
- CONTROL STATION
- SIGN
- GRAVEL

FIGURE 2-2
UST AND TUNNEL LOCATION PLAN

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

00186 DB12



LEGEND

- △ – VERSAR SURFACE WATER SAMPLE, 1992
- ⊞ – VERSAR WIPE SAMPLE, 1992
- ■ – BAKER SEDIMENT SAMPLE, NOVEMBER 1992
- ▲ – BAKER SURFACE WATER SAMPLE, NOVEMBER 1992
- ■ – BAKER SEDIMENT SAMPLE, MARCH 1995
- ▲ – BAKER TANK WATER SAMPLE, MARCH 1995
- ● – NSRR SAMPLE, MAY 1994
- ND – NOT DETECTED

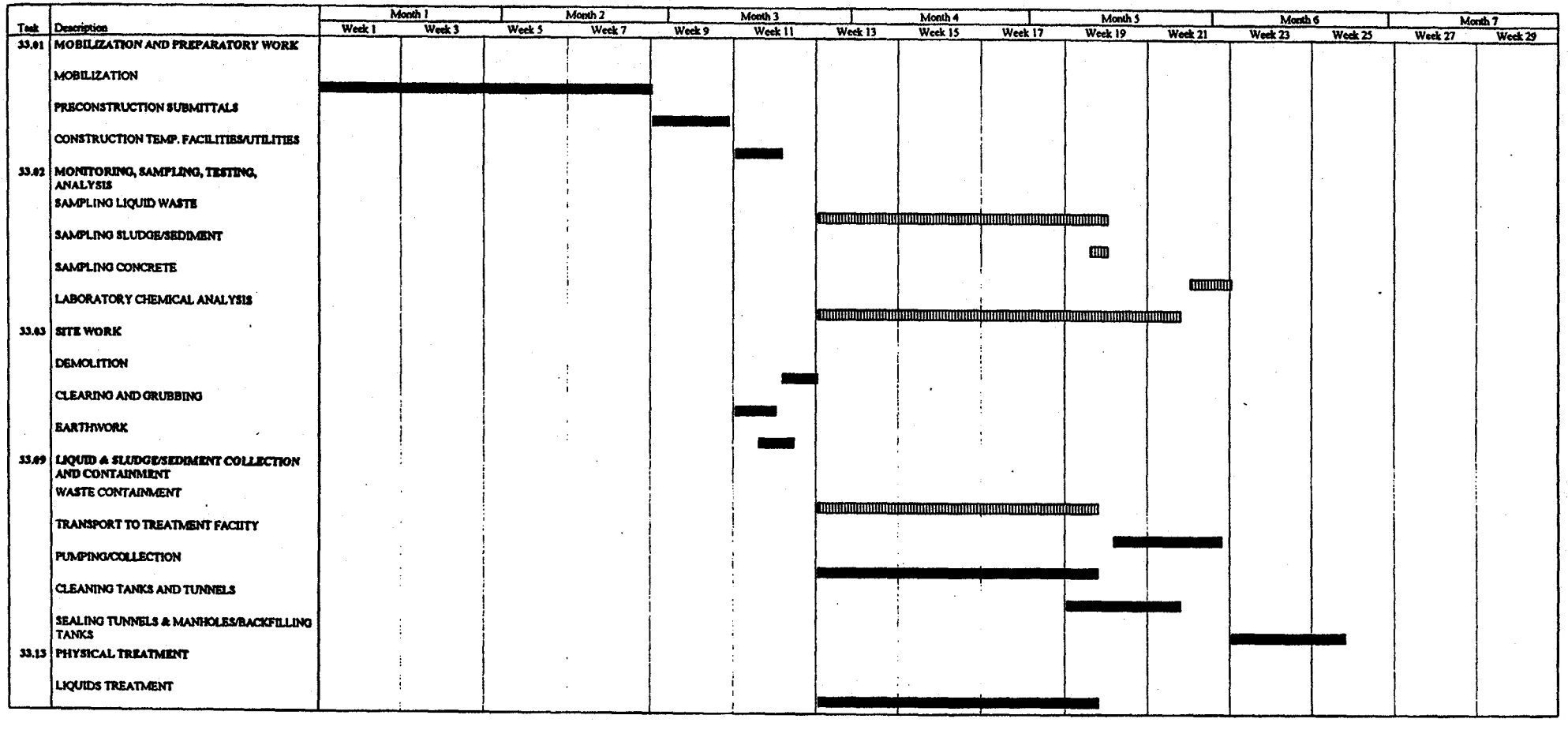
SOURCE: LANTDIV, OCT. 1991

FIGURE 2-3
SAMPLING LOCATIONS AND ANALYTICAL RESULTS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

APPENDIX A
CONSTRUCTION SCHEDULE

PROJECT CONSTRUCTION SCHEDULE
INTERIM CORRECTIVE MEASURE SWMU 45/SITE 16
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO



Intermittent - as required for completion of work

PROJECT CONSTRUCTION SCHEDULE
INTERIM CORRECTIVE MEASURE SWMU 45/SITE 16
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Task	Description	Month 1		Month 2		Month 3		Month 4		Month 5		Month 6		Month 7	
		Week 1	Week 3	Week 5	Week 7	Week 9	Week 11	Week 13	Week 15	Week 17	Week 19	Week 21	Week 23	Week 25	Week 27	Week 29
33.19	DISPOSAL (Commercial)															
	DISPOSAL FEES AND TAXES										◆					
33.20	SITE RESTORATION															
	REVEGETATION AND PLANTING											▬				
	REPAIR AND UPGRADE WALKWAY															
33.21	DEMOBILIZATION															
	REMOVE TEMPORARY FACILITIES AND UTILITIES											▬				
	DEMOBILIZATION OF CONSTRUCTION EQUIPMENT												▬			
	POST CONSTRUCTION SUBMITTALS													▬	▬	
33.99	DISTRIBUTIVE COSTS															
	INITIAL TREATMENT PLANT START-UP AND TESTING					◆										

Intermittent - as required for completion of work

APPENDIX B
COST ESTIMATE ASSUMPTIONS

S.O. No. CTO 296 Design

Subject: Interim Corrective Measure at SWMU 45, NSRR, Puerto Rico

Sheet No. 1 of 3

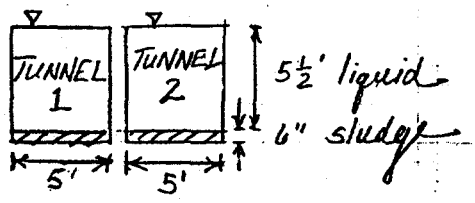
Quantity Estimations

Drawing No. —

Computed by JLB Checked By CMC Date 8-8-95

Baker

INTAKE TUNNELS...

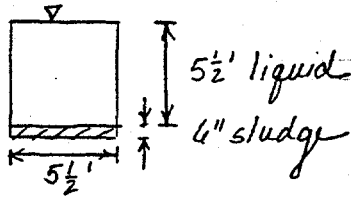


• length of each tunnel is 600'

Quantity of liquid = 2(5')(5.5')(600') = 33,000 cf

Quantity of sludge = 2(5')(0.5')(600') = 3,000 cf

OUTFLOW TUNNEL...



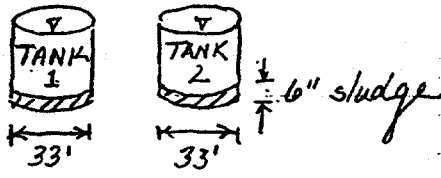
• length of tunnel is 475'

Quantity of liquid = (5.5')(5.5')(475') = 14,400 cf

Quantity of sludge = (5.5')(0.5')(475') = 1,300 cf

STORAGE TANKS...

• each tank holds 50,000 gal



Quantity of liquid = (Tank volume) − (sludge volume)

$= 2(50{,}000\,gal)\left(\frac{1\,cf}{7.48\,gal}\right) - 855\,cf$

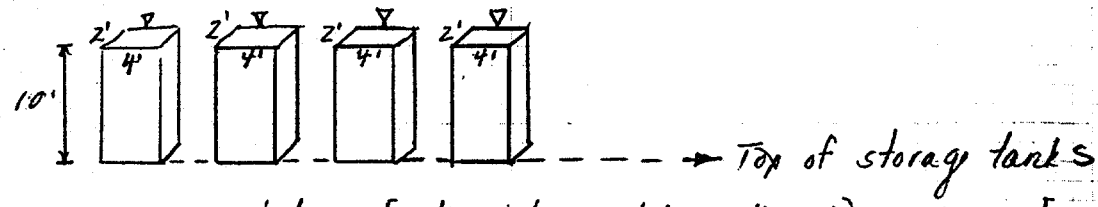
$= 12{,}500\,cf$

Quantity of sludge $= 2\pi(16.5')^2(0.5) = 855\,cf$

S.O. No. CTO 296 Design
Subject: Interim Corrective Measure at SWMU 45, NSRR, Puerto Rico
Quantity Estimations
Sheet No. 2 of 3
Drawing No. —
Computed by TLB Checked By CMC Date 7.8.95

Baker

MANHOLES TO STORAGE TANKS ...



Quantity of liquid = 4(2')(4')(10') = 320 cf

TANK & TUNNEL CLEANING FLUIDS ...

- Assume the quantity of washing fluid occupies a 1' depth in the tanks and tunnels.

Intake tunnels : 2(1')(5')(600') = 6,000 cf
Outflow tunnel : (5.5')(1')(475') = 2,612 cf
Storage tanks : $2\pi(16.5')^2(1')$ = 1,710 cf
Manholes : 4(2')(4')(1') = 32 cf
Total = 10,350 cf

Quantity of liquid = 10,350 cf

TOTAL QUANTITIES TO BE TREATED/DISPOSED ...

Liquid = [33,000 + 14,400 + 12,500 + 320 + 10,350] cf
= **70,570 cf**

Sludge = [3,000 + 1,300 + 855] cf
= **5,155 cf**

S.O. No. CTO 296 Design

Subject: Interim Corrective Measure at SWMU 45, NSRR, Puerto Rico

Quantity Estimations

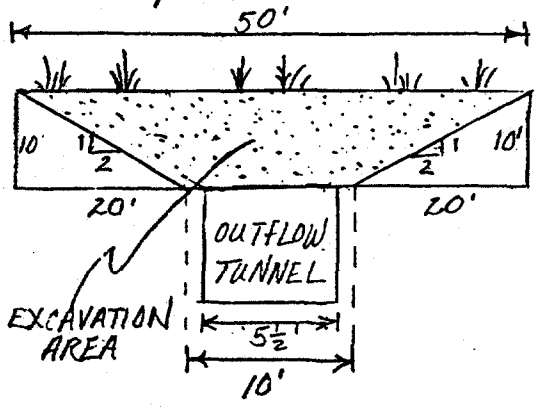
Sheet No. 3 of 3

Drawing No. —

Computed by JLB Checked By CMC Date 8.8.95

Baker

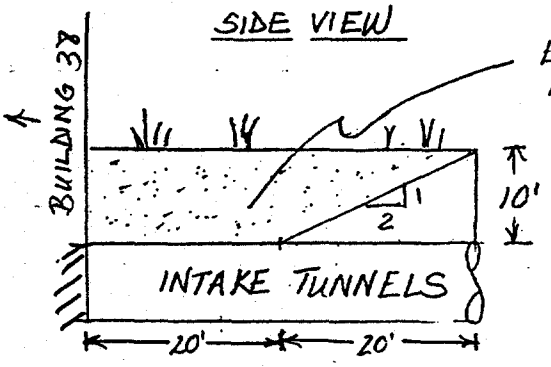
QUANTITY OF SOIL TO BE EXCAVATED ...



• assume there will be three excavations along the outflow tunnel; each excavation will be 15' wide along the length of the tunnel.

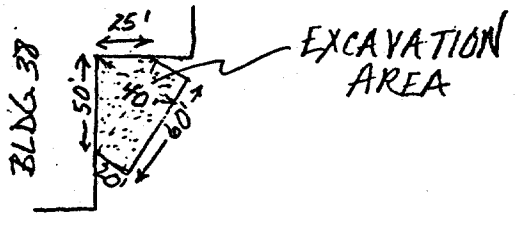
$$\text{Excavation quantity} = 3\left[\frac{(10)(20)(15)}{2} + \frac{10(20)(15)}{2} + (10)(10)(15)\right] = 13{,}500 \text{ cf}$$

SIDE VIEW



• assume there will be one 60' wide excavation 40' along the intake tunnels from where they connect to Building 38; the excavation will be 10' deep.

PLAN VIEW



$$\text{Excavation quantity} = 2\left(\frac{(10)(20)(20)}{2}\right) + (20)(20)(10) + \tfrac{1}{2}(50)(25)(10)$$

$$= 4{,}000 + 4{,}000 + 6{,}250 = 14{,}250 \text{ cf}$$

$$\text{Total excavation quantity} = 13{,}500 + 14{,}250 = \boxed{27{,}750 \text{ cf}}$$

MICHAEL BAKER JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: SWMU 45 Tank & Tunnel cleaning Naval Station Roosevelt Roads Puerto Rico

S.O. No.: CTO 296 Design

DATE: 8-8-95

CONTRACT NO.:

To: Louis Rodriguez

Repres.: Induchem Environmental

Phone No.: 809-720-6868

From: Tara Beckman

Repres.: Baker Environmental

Phone No.: 412-269-2040

Subject: Cleaning...

Environmental Quality Board

For Bunker C fuel, they use "Superwash" (approved by EQB; it's biodegradable). They will either hydroblast or use a "hot C" vapor pressure cleaner & triple rinse.

Tanks w/ manhole access are a confined space so airline/respirators are required - creates time limitation.

They're located in San Juan, about 1 hr. from the Naval Station.

He will fax me a cost estimate for tanks & tunnels by tomorrow.

Approx. $ 200,000

PREPARED BY Tara Beck TITLE Asst. Engr. I PAGE 1 OF 1

OP-3C
10/92

United States
Environmental Protection
Agency

Office of
Research and Development
Cincinnati, OH 45268

EPA/540/R-94/525a
December 1994

EPA

SITE Technology Capsule
InPlant Systems, Inc. SFC 0.5 Oleofiltration System

Introduction

In 1980, the U.S. Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, committed to protecting human health and the environment from uncontrolled hazardous waste sites. CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) in 1986. SARA mandates the implementation of permanent solutions and the use of alternative treatment technologies or resource recovery technologies, to the maximum extent possible, to clean up hazardous waste sites.

State and Federal agencies, as well as private parties, are now exploring a growing number of innovative technologies for treating hazardous wastes. The sites on the National Priorities List total over 1,200 and comprise a broad spectrum of physical, chemical, and environmental conditions requiring varying types of remediation. The U.S. Environmental Protection Agency (EPA) has focused on policy, technical, and informational issues related to exploring and applying new remediation technologies to Superfund sites. One such initiative is EPA's Superfund Innovative Technology Evaluation (SITE) Program, which was established to accelerate development, demonstration, and use of innovative technologies for site cleanups. EPA SITE Technology Capsules summarize the latest information available on selected innovative treatment and site remediation technologies and related issues. These capsules are designed to help EPA remedial project managers, EPA on-scene coordinators, contractors, and other site cleanup managers understand the types of data and site characteristics needed to effectively evaluate a technology's applicability for cleaning up Superfund sites.

This Capsule provides information on the InPlant Systems, Inc. (InPlant) Oleofiltration technology, a technology developed to separate suspended, emulsified, and a portion of dissolved hydrocarbons from water. The Oleofiltration technology was evaluated under EPA's SITE Demonstration Program at a former oil reprocessing facility in June 1994. This Capsule presents the following information:

- Abstract
- Technology Description
- Technology Applicability
- Technology Limitations
- Process Residuals
- Site Requirements
- Performance Data
- Technology Status
- Disclaimer
- Sources of Further Information
- References

Abstract

Oleofiltration is an innovative hydrocarbon recovery technology that utilizes amine-coated, oleophilic granules to separate suspended and mechanically emulsified hydrocarbons from aqueous solutions. The granules are also reported to separate several types of chemical emulsions and to reduce concentrations of dissolved hydrocarbons. The technology was developed by Exxon Research and Engineering Company and manufactured under exclusive license and patent by InPlant of Houston, Texas. North

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

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American Technologies Group, Inc. (NATGI) is the sole marketer of the technology.

The InPlant SFC System combines an innovative, vertical-fin, coalescing separator and a patented, amine-coated, ceramic granule filtration system (the Oleofilter) into one unit, capable, according to InPlant, of treating virtually any insoluble hydrocarbon/water mixture. When the hydrocarbon/water mixture entering the granules contains less than 500 milligrams/liter (mg/L) of total recoverable petroleum hydrocarbons (TRPH) and less than 50 mg/L of suspended solids, InPlant claims that the SFC System will produce a treated water effluent that contains 15 mg/L or less of TRPH. SFC Systems operate at atmospheric pressure and are available in sizes capable of treating 2.2 to 44 gallons per minute (gpm). For treatment of larger flow rates (up to 1,000 gpm), the coalescing unit is manufactured as a separate stand-alone component from the Oleofilter. The Oleofilters designed to treat larger flow rates operate under low pressure [less than 30 pounds per square inch (psi)]. The units can be operated independently or installed in series on a single skid. The latter configuration provides the same treatment capabilities as the SFC System.

The SFC 0.5 System was evaluated under the EPA SITE Demonstration Program at a former oil reprocessing facility in Pembroke Park, Florida. This Superfund site has a layer of free product (waste oil) floating on groundwater that is contaminated with a variety of organic and inorganic constituents. Demonstration activities were initiated on June 2, 1994 and were concluded on June 18, 1994. The SFC 0.5 System has a treatment capacity of 2.2 gpm. The waste oil recovered for the demonstration was significantly more viscous than the oil collected for the pre-demonstration treatability study. Consequently, the feed stream to the SFC System was thinned with virgin, lighter weight motor oil and then emulsified with site groundwater using an air-powered inline blender. The unit was evaluated over five separate operating cycles ("runs"). The feed stream was the same for all runs except Run 4. The feed stream for Run 4 was a 3-to-1 mixture of thinned oil to kerosene emulsified in groundwater. The TRPH concentration in the feed stream for Run 4 was two to five times higher than the concentrations for the other runs. These differences in Run 4 were implemented in an attempt to resolve filter back-flushing difficulties associated with treating a very viscous oil.

The first critical objective of the demonstration was to evaluate whether the SFC System could remove at least 90 percent of the TRPH from the emulsified oil/water influent stream. Data indicate that the SFC System met this goal for all runs except Run 4.

The second critical objective was to determine whether the SFC System could reduce TRPH concentrations in the treated water exiting the system to 15 mg/L or less. When data are combined and evaluated for the runs where the system operated within normal design parameters (Runs 1 and 5), this goal was met. For the other runs, the 15 mg/L threshold was exceeded.

The third critical objective was to evaluate the effectiveness of the oleophilic granules by comparing the TRPH concentration in the oil/water emulsion before and after passing through the granules. Combined data for the runs with similar feed streams (Runs 1, 2, 3, and 5) show the granules achieved a 95 percent reduction in TRPH concentration. A 65 percent reduction in TRPH was obtained in Run 4.

Several noncritical objectives were evaluated for the demonstration. One of these objectives was evaluation of the relative effectiveness of the SFC System hydrocarbon-capturing components. Results indicate that the coalescing separator accounted for 45 to 62 percent of the total TRPH removed; the oleophilic granules removed the corresponding 55 to 38 percent.

Another noncritical objective was to evaluate the ability of the SFC System to remove suspended solids (measured as non-filterable residue, NFR) from the oil/water influent. NFR removal ranged from 27 percent to 58 percent; NFR values in the oil/water influent were generally below 50 mg/L.

The ability of the SFC System to remove selected semivolatile organic compounds (SVOCs) was another noncritical objective. SVOC concentrations in the oil/water influent for Runs 1, 2, 3, and 5 were too low to support any conclusions about removal effectiveness. Run 4 had higher SVOC concentrations in the oil/water influent. For this run, 75 percent removal of naphthalene and 81 percent removal of 2-methylnaphthalene were achieved.

During the demonstration, the SFC System did not achieve steady-state operating conditions. The lack of steady-state conditions apparently resulted from treating the unexpectedly high-viscosity oil during a short-duration evaluation of the technology. This situation precluded the evaluation of two noncritical objectives. An evaluation of the effectiveness of the coalescing separator at segregating oil from water, as determined by the percent water in the concentrated oil effluent,

could not be made since the increased agitation that occurred during backflushing resulted in overflowing of backflushing water into the concentrated oil effluent stream. An acceptable materials mass balance closure could not be achieved since the amount of oil retained in the unit was not constant across the runs.

Technology Description

SFC systems, which contain only one internal moving part (a liquid-level control float), are designed to be explosion-proof and are operated at atmospheric pressure. Figure 1 shows the configuration and cross-sectional view of the liquid flow through the SFC 0.5 System. The hydrocarbon/water mixture (oil/water influent stream) feeds into the top of the unit through Port A, moves downward inside the outer shell, and flows upward past the vertical-fin coalescing separator. Free-floating and emulsified hydrocarbons passing over the coalescing fins combine with droplets already adsorbed on the fins' surface.

The hydrocarbon droplets continue to increase in size until the buoyancy of the droplets overcomes the adsorptive forces. The droplets then release from the fins, float toward the top of the unit, and are discharged from the system through Port B as the concentrated oil effluent stream. Final hydrocarbon filtration occurs as the remaining emulsified and dissolved hydrocarbons flow upward through the center of the unit and gravity flow through the bed of amine-coated, oleophilic granules. The majority of remaining hydrocarbons attach to the granules, and the treated water (treated water effluent stream) exits the system through Port C.

When the Oleofilter becomes saturated with hydrocarbons and suspended solids (InPlant states that 15 to 20 liters of hydrocarbons can be retained by 100 liters of oleophilic granules), the granule bed regenerates itself automatically by backflushing. Backflushing is activated when the system reaches a set pressure differential across the bed. The pressure drop that initiates backflushing can be adjusted by the operator to optimize filtration time, while preventing filter breakthrough.

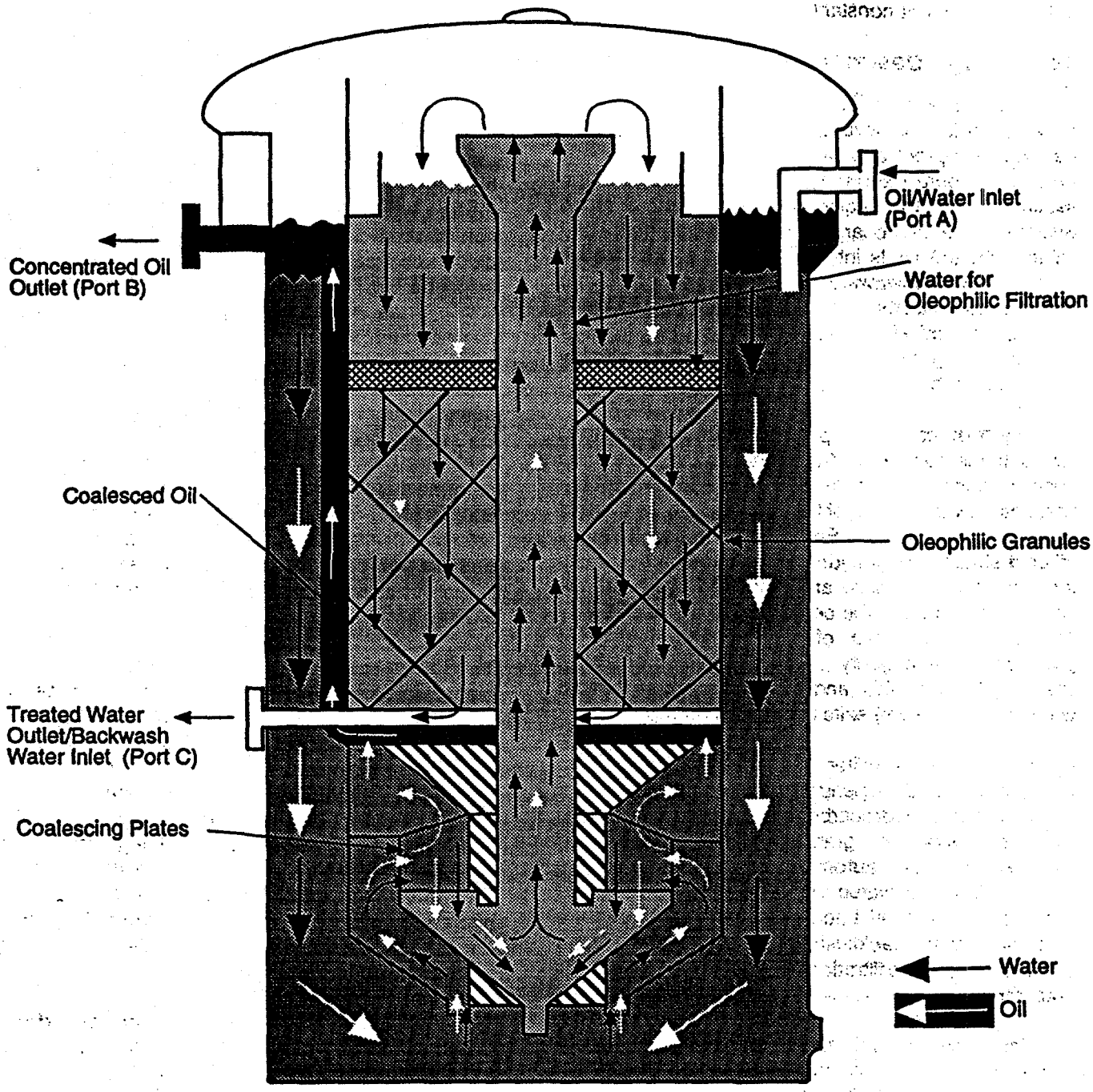
The backflush cycle takes 20 minutes. Water for backflushing is pumped into the bottom of the system through Port C. During the first 4 minutes of the backflush cycle, only water is introduced. During the next 8 minutes, both air (supplied by an external compressor) and water are flushed through the filter. The air increases the agitation that physically strips the hydrocarbons from the granules. During the last 8 minutes of the backflush cycle, a water only rinse is performed. The backflush water flow rate is equal to the nominal throughput of the filter (2.2 gpm for the SFC 0.5 System), and the air flow rate is 0.3 standard cubic feet per minute (scfm) per gpm of water flow (0.66 scfm for the SFC 0.5 System). Therefore, the amount of air exiting the SFC 0.5 System during backflushing is approximately 5 scf. The hydrocarbon/water mixture generated during backflushing (backflush water effluent stream) gravity flows from Port D near the top of the unit (not shown in Figure 1) to a sump or holding tank. The coalesced hydrocarbons within the mixture typically separate within 10 to 30 minutes and can be reprocessed through the SFC System, leaving only the concentrated hydrocarbons to be recycled or disposed of.

Although the design of the vertical-fin coalescing separator within the SFC System is novel, the amine-coated oleophilic granules are the innovative component of the system. The granules separate emulsions not treatable by conventional oil/water separators. The oleophilic granules use a montmorillonite (clay) base that has been heated to 800°C [1]*. The high temperature decomposes the montmorillonite into an aluminum silicate that assumes a crystalline, ceramic structure. The aluminum silicate is then crushed into granules with diameters between 0.6 and 1 millimeter.

The granules are subsequently treated to attach the oleophilic amine (see Figure 2). Through a series of substitution reactions, an amine molecule bonds to a silica atom, leaving a long hydrophobic (and oleophilic) chain ($C_{18}H_{33}$) to which hydrocarbons are attracted [2, pp. 15-16]. As the filtration process continues, hydrocarbons flowing past the granules agglomerate with the amine-attracted hydrocarbons, forming droplets. The hydrocarbons remain attached to the amine, while the separated water exits the system. The magnitude of hydrocarbon uptake is inversely proportional to the compounds' solubility in water and is controlled by a partitioning process [3, p. 2054].

During backflushing, the hydrocarbon droplets and hydrocarbon-laden solids are physically stripped from the amines and, along with other entrained solids, exit the unit with the backflushing water. The hydrocarbons in the backflushing water are predominantly coalesced and now can be removed by conventional oil/water separation techniques. InPlant has installed several systems where the hydrocarbon/

*[Reference Number, Page Number]



Note: The backwash water outlet (Port D) is not shown in this view.
Source: Adapted from SFC 0.5x Operating Manual, 1992.

Figure 1. SFC 0.5 Oleofiltration System Configuration.

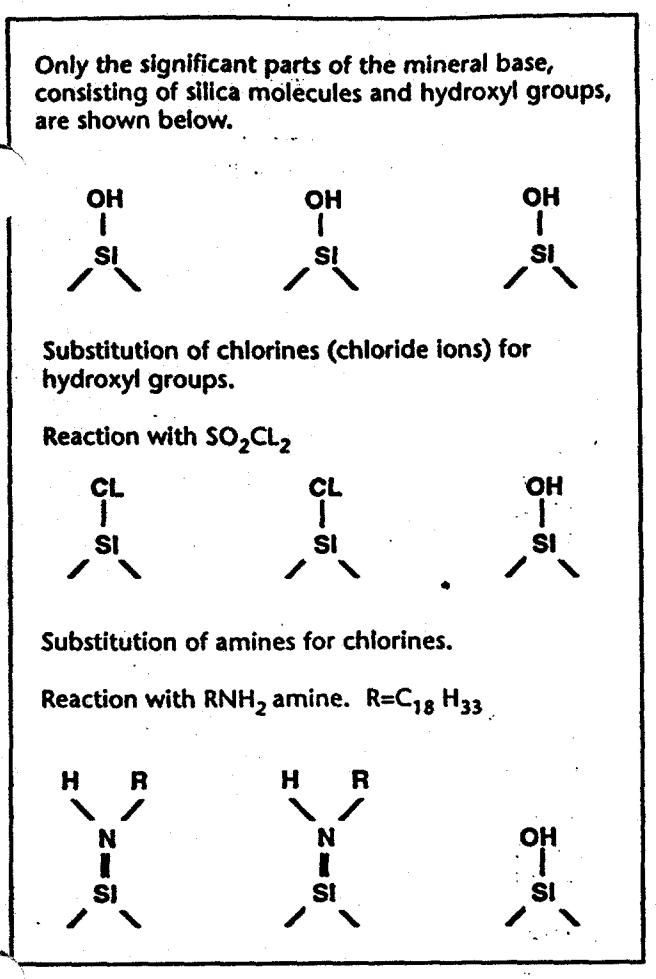


Figure 2. Generation of oleophilic amine-coated granules. Source: [2]

water mixture from backflushing is fed back into the system, and the coalesced hydrocarbons are removed by the vertical-fin coalescing separator. Any emulsified hydrocarbons are captured by the oleophilic granules. This approach eliminates the need for disposal of the hydrocarbon/water mixture resulting from backflushing.

Technology Applicability

The SFC System is reportedly capable of treating virtually an insoluble hydrocarbon/water mixture. The stated advantage of this technology over other oil/water separation techniques is its ability to separate mechanical and several types of chemical emulsions. InPlant claims that the SFC System can remove TRPH from hydrocarbon/water emulsions to levels below 15 mg/L when the emulsion reaching the granules contains less than 500 mg/L TRPH and less than 50 mg/L of suspended solids. According to InPlant, the amine-coated granules have been proven effective on a wide variety of hydrocarbons including gasoline; crude oil; diesel; benzene, toluene, ethylbenzene, and xylene (BTEX) compounds; and polynuclear aromatic hydrocarbons (PAHs). The granules reportedly also remove chlorinated hydrocarbons such as pentachlorophenol (PCP), polychlorinated biphenyls (PCBs), and trichloroethane (TCA), as well as vegetable and animal oils.

The ability of the oleophilic granules to separate hydrocarbon/water emulsions and reduce dissolved hydrocarbon concentrations to levels consistent with other secondary treatment systems indicates the potential for the SFC System to be used in conjunction with other treatment technologies. Site remediation techniques, such as steam injection-vapor extraction and soil flushing, can generate hydrocarbon/water emulsions that must be treated. Pumps used in transferring oily water also can produce emulsions that must be separated prior to further treatment. The SFC System can be employed in these and other applications including the remediation of contaminated groundwater, in-process oil/water separation, wastewater filtration, onsite waste reduction and recovery, and bilge and ballast water treatment.

When used as a component of a treatment train, the technology can significantly reduce hydrocarbon loading to other downstream treatment equipment such as air strippers and carbon filtration units. This reduced loading results in increased on-line time and decreased operating and maintenance costs for the treatment train. Depending on local pretreatment standards, treated water exiting the SFC System may be acceptable for introduction to the sanitary sewer system without further treatment.

Table 1 addresses the performance of the SFC System based upon the nine evaluation criteria used for decision-making in the Superfund feasibility study (FS) process. If the SFC System is used as a component in a treatment train, evaluation of the entire train also should be performed.

Technology Limitations

The Oleofiltration technology concentrates contaminants by separating free, emulsified, and some dissolved hydrocarbons from water. Although the toxicity of the water phase decreases, the toxicity and mobility of the concentrated hydrocarbons are unchanged. The concentrated hydrocarbons must then be further treated or disposed. Even under ideal conditions, the treated water typically will contain between 4 and 15 mg/L of TRPH, requiring further treatment prior to release at some sites.

Although the oleophilic granules are relatively durable, collision between granules during filtration and

Table 1. Nine Evaluation Criteria for the SFC System

Evaluation Criteria	Performance
Overall Protection of Human Health and the Environment	• Provides both short-term and long-term protection by reducing contaminants in groundwater. • Prevents further groundwater contamination and offsite migration caused by emissions during treatment. • Demonstrated capability of reducing TRPH concentrations in oil/water mixtures to 15 mg/L. • Concentrates but does not destroy contaminants.
Compliance with Federal applicable or relevant and appropriate requirements (ARARs)	• Effluent needs to be treated further to meet Federal Drinking Water Standards if it is to be re-injected directly into the ground. • Effluent may meet pretreatment standards for release to the local publicly-owned treatment plant (POTW). • May have to meet substantive requirements of a Resource Conservation and Recovery Act (RCRA) treatment permit if treating hazardous wastes. • May have to meet substantive requirements of a Clean Air Act (CAA) permit for air discharge during backflushing if volatile organic compounds (VOCs) are present. • Concentrated oil effluent may be regulated under the Toxic Substances Control Act (TSCA) if polychlorinated biphenyls (PCBs) are present.
Long-Term Effectiveness and Performance	• Residuals treatment or recycling may be required (effluent water, concentrated oil, oily water from backflushing).
Reduction of Toxicity, Mobility, or Volume through Treatment	• The technology concentrates contaminants, reducing waste volume, but does not change the contaminants' mobility or toxicity.
Short-Term Effectiveness	• Community and workers will be protected because the system is almost entirely self-contained.
Implementability	• Most systems are shipped pre-assembled or as modules that are easily connected. • Pretreatment of feed stream is typically not required. • System is explosion-proof. • If VOCs are present, a release (5 to 106 scfm) of contaminated air will occur during backflushing. • Additional treatment options may be needed for residuals. • Oleophilic granules usage life is shortened if treating solutions with pH>10.5 (granules become brittle) or chlorinated solvents with concentrations >100 mg/L (weakens amine bonds). • Backflush initiation needs to be adjusted, if treating oils of various viscosities, to prevent breakthrough prior to backflushing.
Cost	• The cost to remediate 50 million gallons of contaminated groundwater (22-gpm system with 95% on-line time) is approximately $2.57 per thousand gallons.
State Acceptance	• Since this system will most often be used as a component in a treatment train, acceptance is tied to overall treatment acceptability.
Community Acceptance	• Should be generally acceptable to the public since emissions during treatment are minimal.

backflushing results in breakage. Broken granules that are small enough to pass through the retention screen are discharged from the system during backflushing. Assuming a backflush frequency of every 10 hours, InPlant states that approximately 8 percent of the granules must be replaced every 12 months of operation.

InPlant reports that the oleophilic granules are sensitive to two chemical conditions, both of which shorten the operational life of the granules. Treatment of solutions having a pH greater than 10.5 for extended periods of time makes the granules more brittle. The increased breakage caused by this condition is estimated to be an additional 4 percent every 12 months of operation. Treatment of solutions with chlorinated solvents present in concentrations greater than 100 mg/L weakens the amine bonds. A similar attrition rate (an additional 4 percent every 12 months) is reportedly caused by prolonged treatment of these solutions.

The SFC System is reportedly less effective in treating chemical emulsions containing anionic surfactants than other types. Anionic surfactants affect the ability of the granules' amine coating to attract and retain hydrocarbons. InPlant states that use of SFC Systems for the treatment of hydrocarbon/water emulsions created by anionic surfactants resulted in TRPH concentrations in the treated water of 50 to 80 mg/L. Although not evaluated during the SITE demonstration, the granules reportedly are more effective at removing hydrocarbons from chemical emulsions containing cationic or nonionic surfactants.

Although the SFC System appears to effectively treat oils of varying viscosities and densities, adjustments to the backflushing cycle must be made to reduce the amount of operator oversight required. The pressure at which the backflushing cycle is initiated must be adjusted to maximize filtration time while preventing breakthrough of the hydrocarbons prior to backflushing. During the SITE demonstration, the SFC System apparently exhibited breakthrough prior to backflushing when a kerosene and oil mixture was used as the feed oil. InPlant reportedly has implemented modifications to the system that allow in-field adjustment of the pressure at which backflushing is initiated. These modifications, combined with periodic monitoring of system performance, should eliminate the difficulties.

Treatment of high viscosity oils may foul the granules, preventing effective backflushing. InPlant claims that the use of hot water for backflushing or the addition of a steam coil attachment to the system will reduce the viscosity of most retained oils and allow normal backflushing. During the SITE demonstration, all but one of the runs used a very viscous oil that had been thinned with virgin motor oil. Performance of Runs 1, 2, and 3 resulted in fouling of the granules, which had to be removed, washed in mineral spirits, and reinstalled. Subsequent use of the hot water (approximately 200°F) increased the effectiveness of the backflushing. Treatability studies encompassing the full range of oil properties at a site, along with provisions for hot water backflushing, if indicated, should resolve backflushing difficulties.

According to InPlant, when the TRPH concentration in the pre-granule water exceeds 500 mg/L, the TRPH concentration in the treated water effluent may exceed 15 mg/L. Run 4 of the demonstration had an average TRPH concentration in the pre-granule water of 1,242 mg/L. The treated water effluent contained an average concentration of 39 mg/L (these averages do not include concentrations measured after filter breakthrough). This reduction represents a 97 percent removal of TRPH. Pilot-scale treatability testing prior to full-scale implementation should determine the ability of the unit to meet site-specific performance goals.

Process Residuals

The SFC System generates three process streams: treated water, concentrated contaminants (during the demonstration this wastestream was a concentrated waste oil), and hydrocarbon-laden water from backflushing. Additionally, if the feed stream contains volatile organic compounds (VOCs), air emissions will be generated during backflushing. Under optimum conditions, the treated water will reportedly contain between 4 and 15 mg/L of TRPH. Therefore, this process stream may need to be further treated with a tertiary process onsite or transported offsite for further treatment. The concentrated hydrocarbon effluent stream can be transported and disposed of offsite. If the concentrated hydrocarbon is waste oil and meets the waste oil specifications of 40 CFR 279, it can be used as fuel. Two options exist for the water from backflushing. This water can be fed back into the system where the coalesced hydrocarbons will be removed and the water filtered. Alternately, the water from backflushing can be transported offsite for treatment and disposal.

Depending on the size of the SFC System, air emissions during backflushing range from 5 to 106 scf. If the feed stream contains VOCs, a percentage of them will become entrained in the backflushing air and exit through the top of the system. Depending on the types and concentrations of VOCs and applicable regulations,

emissions controls such as carbon filters may be required.

Site Requirements

Site requirements for the operation of the SFC System include a level area, electricity, water, and compressed air. The SFC System must be operated on a level, non-shifting surface. A 9-square-yard pad of 6-inch reinforced concrete will support the largest SFC units. Additional space for storage of backflush influent and effluent water must be available. If potable water is used for backflushing, water lines or a service for filling the water tank between backflushes must be available. A water tank, with capacity in excess of the backflush volume, must be provided. Storage capacity for the concentrated hydrocarbons and treated water must be available (if the water is not being treated or discharged immediately). Electrical power, consisting of 4 kilovolt-amp (kVA), 460/230-volt, 3-phase service must be available to operate the largest SFC Systems. Smaller systems require 40-amp, 220-volt service. Alternately, electrical power could be supplied by an onsite mobile generator.

Current designs of the SFC System use pneumatic controllers, requiring approximately 0.5 scfm of compressed air. Additionally, the backflushing cycle requires compressed air to increase agitation of the granules. A source of compressed air capable of producing a volumetric flow rate of 15 scfm and a minimum air pressure of 100 psi will supply sufficient air for both purposes on any size SFC System. InPlant has recently begun replacing pneumatic controllers with programmable logic controllers on SFC Systems.

Depending on the viscosity of the oil, hot water or steam may be required for effective backflushing. A portable hot water washer or steam generator therefore may be required.

Performance Data

The SFC Oleofiltration System was accepted into the SITE Demonstration Program in December 1992. The Petroleum Products Corporation (PPC) Superfund site in Pembroke Park, Florida was chosen as the demonstration site. Accidental releases during the operation of this former oil reprocessing facility resulted in the deposition of approximately 29,000 gallons of free product (waste oil) on the groundwater surface. The groundwater underneath the oil is contaminated with a variety of organic and inorganic constituents.

Prior to the demonstration, samples of oil from the site were sent to NATGI for treatability studies. Aliquots of the oil were combined with different volumes of water, mixed with a blender, and poured through separatory funnels containing oleophilic granules. Samples of the water exiting the funnels were analyzed for oil and grease by NATGI using EPA Method 413.1 [4]. Results of the study, presented in Table 2, showed the granules to be effective at removing oil and grease from the oil/water emulsions.

Table 2. NATGI Treatability Study Results

Six one liter samples of groundwater were contaminated with 20, 100, 300, 500, 2,000, and 10,000 mg/L of oil respectively, mechanically emulsified with a high-speed mixer for 1 minute, and manually poured into separatory funnels containing approximately 0.5 liter of amine-coated ceramic granules. The effluent (output) was analyzed for Oil and Grease using EPA Method 413.1.[4]

Input (mg/L)	Output (mg/L)	Percent Removal (mg/L)
20	2.5	87.5
100	4.0	96.0
300	5.0	98.3
500	3.1	99.4
2,000	3.6	99.8
10,000	2.5	99.9

The SFC 0.5 Oleofiltration System (2.2 gpm) was evaluated during the SITE demonstration in June 1994 at the PPC site. Since the site did not have significant amounts of oil emulsified in water, an artificial feed, consisting of recovered waste oil emulsified in the contaminated groundwater, was formulated to test the system. The contaminated groundwater was obtained by diverting a small stream from the site's full-scale remediation system. This groundwater feed exited the bottom of the full-scale oil/water separator, passed through a flow meter, and entered an air-powered inline blender used to create the emulsion to be used in the demonstration.

The feed oil was collected from a sump where the viscous oil had risen to the surface. Approximately 30 gallons of highly viscous oil were mixed with 15 gallons of 10W-30-weight motor oil to reduce the viscosity of the oil. The mixed oil had an average viscosity of 56.3 centistokes (cs). A peristaltic pump was used to deliver the oil through a feed line to the inline blender. The inline blender then created the oil/water emulsion that was fed into the system. After passing through the SFC System, the treated water effluent was returned to the full-scale oil/water separator. Although the SFC System was reportedly capable of reprocessing the oil/water

mixture resulting from backflushing, the water layer from backflushing was returned to the full-scale oil/water separator. The concentrated oil effluent and the oil layer from backflushing were stored in drums for offsite disposal.

Samples were collected from the groundwater feed, oil feed, emulsified oil/water influent, water prior to entering the granules (pre-granule water), treated water effluent, backflushing effluent, and concentrated oil effluent.

The demonstration consisted of five separate runs. Runs 1, 2, 3, and 5 used the mixed feed oil. Run 4 used a 3-to-1 mixture of the previously mixed oil to kerosene. The feed oil for Run 4 had an average viscosity of 30.1 cs. Samples were collected for TRPH analysis using EPA Method 418.1 [4]. Additional samples were collected and analyzed for NFR, SVOCs, and percent water using EPA Method 160.2 [4], EPA Method 8270 [5], and ASTM Method D95-83 [6]. The average TRPH concentrations for the oil/water influents ranged from 322 to 2,802 mg/L.

Due to operational difficulties associated with filter backflushing, only one complete run (Run 1) was accomplished. Runs 2 and 3 were shortened because the backflushing cycle preceding each run did not clean the granules sufficiently to allow the pressure differential across the granule bed to reset to InPlant's specifications of zero inches of mercury (in. Hg). The backflush triggering pressure of 16 in. Hg was consequently reached sooner. The operational difficulties were apparently caused by the high viscosity and solids content of the feed oil, which were different from the oil provided to InPlant for the treatability studies. InPlant claims that adjustments prior to unit delivery and the addition of a steam coil attachment would have resolved the difficulties.

Run 4 was terminated when visible oil appeared in the treated water effluent. Analytical results confirmed that filter breakthrough had occurred. Run 5 was terminated when the level of pre-granule water in the unit had risen to the height where it was discharging through the backflush water outlet. Additionally, it was thought that visible oil appeared again in the treated water effluent (analytical results indicated that this conclusion was inaccurate). Table 3 presents TRPH results for the oil/water influent, pre-granule water, and treated water effluent for all five runs. Table 4 presents results for NFR, naphthalene, and 2-methylnaphthalene for the oil/water influent and treated water effluent. Results from the first sample collected in each run have not been presented since the collection time (t = 10 minutes) was less than the calculated residence time of the unit (i.e., water entering the unit at initiation of the run had not yet reached the treated water sample port). Table 5 presents a summary of project objectives, results, and conclusions for the demonstration.

Due to operational differences among some of the runs, demonstration data have been evaluated using several scenarios. Since Runs 1, 2, 3, and 5 used the same feed oil, data from these runs were pooled and evaluated together. Within this group, only Runs 1 and 5 were initiated with the granules backflushed sufficiently for the initial pressure differential across the granule bed to approach InPlant's specification of zero in. Hg. Consequently, evaluation of demonstration objectives state a result for the pooled data from Runs 1, 2, 3, and 5 (13 data points), and a result for the pooled data from Runs 1 and 5 only (8 data points).

Since Run 4 used a different type of feed oil and oil feed rate, data from this run were evaluated separately. During this run, the concentration of TRPH present in the pre-granule water exceeded InPlant's stated limitation of 500 mg/L. Consequently, the demonstration objective of achieving 15 mg/L or less in the treated water effluent was not evaluated. Additionally, InPlant claims that the pressure differential across the granule bed at which backflushing was triggered (16 in. Hg) was set to accommodate the 500 mg/L maximum TRPH concentration, and the higher concentration was responsible for the apparent filter breakthrough. Accordingly, Run 4 was evaluated using the data for the entire run (5 data points) and also using only the data prior to filter breakthrough (3 data points).

The SFC System did not achieve steady-state operating conditions during the demonstration. This situation precluded the evaluation of two noncritical objectives. An evaluation of the effectiveness of the coalescing separator at segregating oil from water, as determined by the percent water in the concentrated oil effluent, could not be made since the increased agitation that occurred during backflushing resulted in overflowing of backflushing water into the concentrated oil effluent stream. An acceptable materials mass balance closure could not be achieved since the amount of oil retained in the unit was not constant across the runs.

InPlant has provided performance data from a bench-scale study of the ability of the oleophilic granules to remove TRPH, BTEX, and PAHs [7]. The study, conducted on tank water bottoms from a condensate tank at a bulk petroleum storage and transfer facility in The Netherlands, achieved petroleum hydro-carbon concentrations in the outlet samples of 1.43 and 2.49 mg/L for times t=10 minutes and t=105

Table 3. Summary of TRPH Analyses

Run	Elasped Time (min)	Influent Concentration (mg/L)	Pre-granule Concentration (mg/L)	Effluent Concentration (mg/L)
1	60	842	691	29.4
1	120	989	499	20.3
1	180	1240	651	13.8
1	240	1120	445	10.9
1	300	1170	487	17.4
2	30	366	301	16.8
2	60	322	227	32.2
2	90	484	261	25.7
3	20	988	386	25.0
3	40	981	137	20.7
4	45	1991	1260	43.3
4	90	2680	997	26.7
4	135	2004	1470	47.5
4	180	2802	1302	484
4	240	1630	955	1470
5	45	681	456	17.2
5	75	NA	351	14.7
5	105	565	191	7.4
5	135	2448	189	10.1

NA - Not analyzed by laboratory.

Table 4. Summary of NFR and Specific SVOC Analyses

Run	Influent NFR (mg/L)	Effluent NFR (mg/L)	Influent Naphthalene (µg/L)	Effluent Naphthalene (µg/L)	Influent 2-Methylnaphthalene (µg/L)	Effluent 2-Methylnaphthalene (µg/L)
1	19	14	13	10 u	11	10 u
1	11	6	***	***	***	***
1	18	7	12	10 u	10	10 u
1	24	6	***	***	***	***
1	20	11	6 j	10 u	5 j	10 u
2	30	14	12	10 u	7 j	10 u
2	23	14	***	***	***	***
2	26	13	12	10 u	7 j	10 u
3	31	10	13	10 u	7 j	10 u
3	37	16	***	***	***	***
4	32	17	210	10 u	320	10 u
4	19	29	***	***	***	***
4	40	20	250	25	410	21
4	34	21	***	***	***	***
4	24	12	100	90	140	130
5	29	9	39 j	20	38 j	14
5	22	9	***	***	***	***
5	23	9	20	10 u	15	10 u
5	20	6	***	***	***	***

u below detection limits
j estimated value
*** no sample collected

Table 5. Summary of Project Objectives, Results, and Conclusions

Objective	Results[1]	Conclusions
Critical Objectives		
Evaluate claim of 90% minimum removal of TRPH[2] from oil/water emulsion.	The overall TRPH removals were: 98% - Runs 1,2,3, and 5 (98% - Runs 1 and 5 only) 81% - Run 4, all data (98% - Run 4, data prior to breakthrough)	Runs 1, 2, 3, and 5 met the objective. Runs 1 and 5 met the objective. Overall objective not met for Run 4 using all data. Objective met for Run 4 using data prior to breakthrough.
Evaluate claim of 15 mg/L maximum TRPH concentration in effluent. (Test hypothesis that sample mean is not statistically significant from 15 mg/L at the 90% confidence interval.)	The average effluent concentrations were: 18.7 mg/L - Runs 1,2,3, and 5 (15.7 mg/L - Runs 1 and 5) 414.3 mg/L - Run 4, all data (39.2 mg/L - Run 4, data prior to breakthrough)	The average of Runs 1, 2, 3, and 5 is statistically different from the objective. The average of Runs 1 and 5 is not statistically different from the objective. For Run 4, the TRPH concentration in the pre-granule water exceeded the developer's stated limits. Therefore, no conclusions about this objective are stated for Run 4.
Determine TRPH removal effectiveness of oleophilic granules.	The TRPH removals of granules were: 95% - Runs 1,2,3, and 5 (96% - Runs 1 and 5) 65% - Run 4, all data (97% Run 4, data prior to breakthrough)	The granules were able to significantly reduce TRPH concentrations.
Noncritical Objectives		
Determine the relative contributions to TRPH removal of the coalescing unit and oleophilic granules. (Determine percentage of total TRPH removal accomplished by the coalescing unit and by granules.)	The TRPH removals for coalescing unit: 61% - Runs 1,2,3, and 5 (62% - Runs 1 and 5) 57% -Run 4, all data (45% - Run 4, data prior to breakthrough) The TRPH removals for granules were: 39% - Runs 1,2,3, and 5 (38% - Runs 1 and 5) 43% - Run 4, all data (55% - Run 4, data prior to breakthrough)	For Runs 1, 2, 3, and 5, the coalescing unit removed more TRPH than the granules by a factor of 1.56. For Runs 1 and 5, the coalescing unit removed more TRPH than the granules by a factor of 1.63. For Run 4 using all data, the coalescing unit removed more TRPH than the granules by a factor of 1.32. For Run 4 prior to breakthrough, the granules removed more TRPH than the coalescing unit by a factor of 1.22.
Evaluate the SFC System's ability to remove suspended solids from the oil/water influent.	The NFR[3] removals were: 57% - Runs 1,2,3, and 5 (58% - Runs 1 and 5) 34% - Run 4, all data (27% - Run 4, data prior to breakthrough)	For Runs 1, 2, 3, and 5 and Runs 1 and 5, the NFR removal was significant. The NFR removal was less for Run 4 using all data and for Run 4 using data prior to breakthrough.
Examine the difference in % moisture between feed oil and oil effluent.	Could not be evaluated as system did not reach steady-state conditions during demonstration.	No conclusions can be made regarding the ability of the coalescing unit to produce a low-moisture, concentrated oil stream.
Evaluate the ability of the SFC System to remove naphthalene, 2-methylnaphthalene and 1,2-dichlorobenzene.	The SVOC[4] removals were: 75% - Naphthalene for Run 4, all data 81% - 2-Methylnaphthalene for Run 4, all data	No conclusions can be made regarding the removal of specific SVOCs for Runs 1, 2, 3, and 5 due to low influent concentrations. The SFC System significantly removed both naphthalene and 2-methylnaphthalene during Run 4. (1,2-dichlorobenzene was not present above detection limit.)
Determine whether mass balance closures of 80 to 120% can be achieved for TRPH and total materials.	Mass balance closures were not possible due to lack of steady-state conditions.	No conclusions can be made regarding either TRPH or total mass balance closure.
Establish a +50 to -30% treatment cost estimate	Cost for treating 50,000,000 gallons of water (95% on-line time) is $2.57 per 1,000 gallons	Cost estimates are highly dependent on site-specific factors. Actual costs may vary significantly.

1 Indicated results obtained by combining data from specified Runs (e.g., "Runs 1 and 5" indicates data pooled from those Runs only)
2 TRPH is total recoverable petroleum hydrocarbons (EPA Method 418.1)
3 NFR is non-filterable residue (a measure of suspended solids)
4 SVOC is semivolatile organic compound

minutes, respectively. The study also indicated effective removal of PAHs but less effective removal of BTEX.

Technology Status

The SFC System is currently being used in industrial applications including:

- Treatment of process water at a laboratory in Oildale, California
- Treatment of wash water effluent at a car wash - the effluent reportedly meets the pretreatment water standards for Santa Clara, California
- Treatment of wash rack waste water in Ventura, California
- Treatment of storm water runoff in order to meet National Pollution Discharge Elimination System (NPDES) regulations in Houston, Texas

Disclaimer

Although the technology conclusions presented in this report may not change, the data have not been reviewed by EPA Risk Reduction Engineering Laboratory Quality Assurance personnel.

Sources of Further Information

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Technologies and Products

ETEC™

Enzyme-Catalyzed Metabolic Remediation
Emerging Technologies International

The Challenge

The U.S. EPA has identified bioremediation as the most cost effective remediation process available today for soils and sludges containing organic contamination. They have conducted numerous studies over the past years to fully define the capabilities and problems associated with the technology.

Final analysis indicates that bioremediation is, in fact, extremely effective in remediating most hydrocarbon contaminated sites. The two most frequent drawbacks to application of the technology are the lack of availability of the hydrocarbon to the bacteria and the long time frame required for biodegradation to occur.

When hydrocarbons are trapped in moderate-to-high clay content soils, there is no way for the bacteria to penetrate the clays to affect remediation. Soils of low organic carbon content, such as those typically found in subsurface environments, have a higher capacity to adsorb organic compounds. The longer a contaminant is present in a soil, the closer the bond between the organic matter and the soil. Thus, it is difficult to nearly impossible for conventional bioremediation to be effective when hydrocarbons are trapped in these low permeability soils and clays. The problem, again, is not with the bacteria, but with the availability of the contaminant to the bacteria.

The rate of degradation depends on several additional factors including, the number and type of naturally occurring bacteria, temperature, food source, availability of oxygen, and balance between the food source and the number of naturally occurring bacteria.

The Solution

The ETEC™ process addresses every aspect of bacteriological activity and is designed to enhance and accelerate the natural bio-degradation process.

The ETEC™ System is an accelerated remedial process which can be employed on site in totally enclosed, fixed biocells, directly in-situ, or through bio-injection to depths of 40-feet or more. The proprietary process overcomes traditional limitations by using an enzyme complex and biosurfactants to perform two very important functions.

1) They temporarily break down the physiochemical bonds between the clay lenses by neutralizing the electric charge. This drastically improves permeability and releases the trapped hydrocarbons contaminants.

2) The enzyme system chemically binds to hydrocarbons to make a preferred food source, resulting in enzyme-catalyzed metabolic remediation, which significantly accelerates the remediation process. In most projects completed to date, contamination was reduced to below action levels within 30 days.

The emphasis is on accelerated destruction of contaminants on-site through bio-oxidation. The ETEC™ process uses a full line of proprietary remedial agents to do this task, each of which are specific to individual soil and contaminant characteristics such as size, depth, density, and severity. In most cases indigenous bacteria are employed for selective degradation.

Our line of enhanced biological cleanup weapons is unique in the world today, offering considerable versatility in application, and considerable cost savings over competing cleanup methods. ETEC™ products are suitable for use in temperatures ranging from sub-freezing to more than 100 degrees (F). They may be used in areas with PH values below 4.5 and above 8.5, and will withstand salinity levels (in water) to at least 35 grams/liter. These products may be applied directly, via spraying or tilling, or other means as may be desirable.

Application of our unique line of products to the cleanup of organic compounds, such as petroleum spills, results in a continuous reduction process, taking place over several days to a few weeks, culminating in a near to

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complete transformation of the hazardous material into simpler, environmentally benign substances such as water, carbon dioxide, and cell mass. In many applications, the resulting end products are absorbed into the food chain of other animals or plants already in the area and effectively disappear.

The introduction of colonies of microbes into the environment for the purpose of removing unwanted substances does not result in secondary disposal problems. The organisms multiply rapidly to the extent of the available food supply (e.g. oil), and diminish in proportion to the remaining supply as the unwanted products are removed from the environment. As the available food supply decreases, the supplied organisms die out and become food for other naturally occurring plants or animals. In other words, the end result is a complete (or nearly complete) disappearance of both the unwanted substance and the bioremediation agent until the levels reach those normally found in the natural environment.

ETEC™ natural organisms are completely safe, and present none of the political or technical problems encountered with the use of genetically engineered organisms. Remember that each of these organisms already occurs naturally in our environment, and cannot become a hazard in and of themselves. Every product is designed to combat a specific problem or range of problems.

Bacteriological process

To understand the unique capabilities of the enzyme, requires a basic knowledge of the process of metabolic degradation of organics by microbes.

Bacterial cells are bound by a plasma membrane about 100 angstroms thick, or approximately 10 billionths of a meter, far below the resolution of a light microscope. The structure of the plasma membrane is double layered, with both proteins and phospholipids combined in a peculiar lamellar structure. Phospholipids have a hydrophilic, or water-loving, portion and a hydrophobic, or water-fearing, portion. It's the phospholipids' structure that produced the double-layered structure of the plasma membrane. The hydrophilic head of the molecule is turned toward the aqueous environments both inside and outside the cell while the hydrophobic tails are turned inward. The double-layered membrane is an efficient mechanism for segregating the contents of the cell from the outside world. The protein component of the membrane contributes to its hydrophilic nature and provides for its flexibility.

During the process called autolys, the cell wall is destroyed by the enzymes, releasing the internal content of the cell.

Petroleum hydrocarbons mostly belong to family of organic chemicals called Alkanes. The aerobic biological mechanism for alkane metabolism is composed of both long and short chain hydrocarbons and occurs monoterminally to the corresponding alcohol, aldehyde, and monobasic fatty acid.

The enzymes produced by the bacteria cause the transformation of the substrate (hydrocarbons) into specific end products by cleaving the long chain hydrocarbons. The primary alcohol derived from alkane oxidizes to become the corresponding aldehyde by alcohol dehydrogenase and the aldehyde oxidizes to become a fatty acid by aldehyde dehydrogenase. The end products of these reactions are fatty acids, carbon dioxide and water.

In nature, this process is usually quite slow since the enzymes are encapsulated within the cell. While one enzyme can effect changes in as many as one million hydrocarbon molecules per minute, the survival rate of the enzyme itself is very short -- often limited to just a few hours. Due to this, implementing biological breakdown of hydrocarbons required the cultivation of large colonies of live bacteria. With the development of the ETEC™ stabilized enzyme process this is no longer the case.

The Stabilized Enzyme as a Catalyst

Understanding the role of the enzyme in metabolic degradation of hydrocarbons, ETI, through their associate scientists, has developed a process to separate the enzymes from the bacteria and stabilize and concentrate them in a crystal form. These enzymatic compounds are extracted from bacteria in the Tuman Picora region of Siberia. They were identified by Russian scientists who were drawn by their ability to consume pools of oil which appear as natural seeps in the oil-saturated region.

During the natural autolys process, the destruction of the cell wall by self-produced enzymes occurs. This releases the internal content of the cell. This mixture compromises enzymes, aminoacids, and biosurfactants. ETI, in preparing the ETEC™ formulas, separate and

concentrate the enzymes and biosurfactants in a crystal form. This multienzyme complex is the "active part" of living bacteria.

In a stabilized form, the enzymes have a shelf life of several months. Reconstituted, they remain active for approximately three weeks. They have proved effective in temperatures from 32 degrees F to as high as 122 Degrees F. They may be used in areas with pH values from 4.5 to 8.5 and will stand salinity to at least 35 grams/liter.

When applied to hydrocarbons, the stabilized enzyme cleaves the long chains of the hydrocarbons, essentially cold cracking oils, tars, etc.

What actually happens after the application of multienzyme complex and biosurfactant?

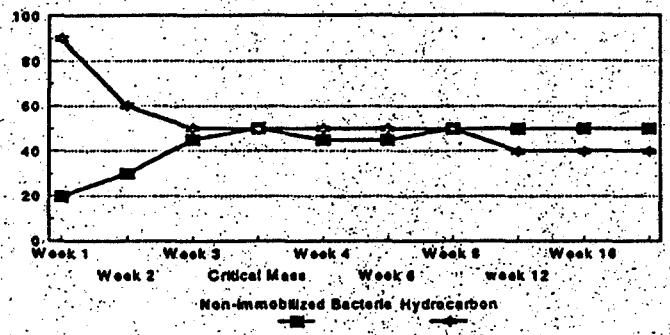
When the preparation is applied on a hydrocarbon-based product, the enzyme action starts immediately on the substrate. Enzymes use carbohydrates or any biomass on the hydrocarbons. This offers the naturally occurring bacteria direct access to the hydrocarbon molecular walls. The enzyme also promotes the release of fatty acids from engulfing carbohydrates which help lift and emulsify the hydrocarbons. During these reactions the present aminoacids promote the quick growth of natural bacterial population. This biopreparation causes breakdown of the hydrocarbon molecule. Once the outer molecular walls of the hydrocarbons are emulsified, the hydrocarbons are readily accessible to the large number of natural bacteria that have been quickly produced within the biopreparation.

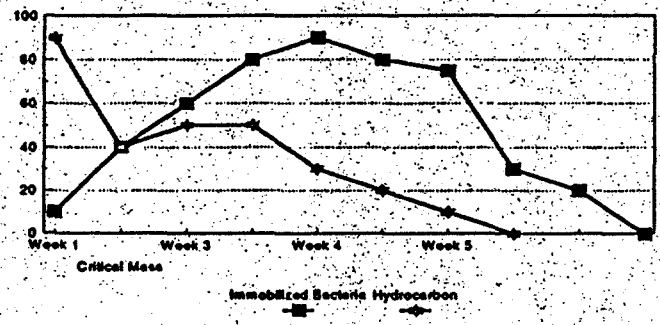
The natural or cultured bacteria and enzymes attach to the hydrocarbon which forms the transition state complex. The transition state complex is the emulsification and engulfing of the hydrocarbon by the non-toxic enzyme bacterial product complex. The emulsified hydrocarbon is completely broken down, engulfed and released as fatty acids, carbon dioxide and water. The result is total destruction of hydrocarbons measured in days or weeks instead of months.

The ETEC™ and Kera-Pac Solution:

Bioremediation is an exacting science and one important factor to successful accelerated bioremediation is the ability to reach and maintain critical mass or the state where there is a higher population of bacteria than hydrocarbons. As indicated in the illustration below, if critical mass in not maintained remediation time is greatly affected and usually drags out to a year or more.

ETI has developed a immobilization technology that allows critical mass to be obtained rapidly, and maintained





throughout the remediation process.

The special properties of the ETEC™ Kera-Pac immobilization technology form a strong and highly permeable structure, making it possible to accomplish the same environmental effects as a cocoon for living bacteria. This method of immobilization is quite different from those methods that utilize substances whereby the bacteria merely adheres to an immobilization media. The Kera-Pac technology protects the enzymes or bacteria from an unfavorable outside environment, yet promotes the transportation of the nutrient substratum, or products of metabolism.

One of the specific advantages of the Kera-Pac tech-

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nology, is the creation of high concentrations of living bacteria in the working area, and the reproduction of living bacteria within this "cocoon." The Kera-Pac immobilization method makes it possible to develop biological preparations with its characteristics set in advance. A natural hydrocarbon oxidizing bacterial strain is used as a base to create a line of biocompositions with the desired characteristics, such as buoyancy and high sorption capacity, making it highly effective in both soil and water remediation application. Our Russia scientist and biologists who developed the process are world leaders in the field of bacteria immobilization, providing an advanced technology with applications in the bioremediation and pharmaceutical industries.

Immersing bacteria immobilized with the Kera-Pac methodology in a liquid medium, activates the bacterial cells, starting their growth and reproduction, and utilizes the contaminants as their source of food energy. Once critical biomass is reached, the Kera-Pac discharges the cells into the contaminate stream. Incubation in an enriched media, such as hydrocarbons on water, or in soil, results in a population explosion of the fixed cells, ejecting the free cells from the Kera-Pac and into the contaminated substrate.

Utilizing the Kera-Pac immobilization system vs. the commonly applied method of simple inoculation of free cells into a contaminated waste stream, has numerous advantages:

* Bacteria are fixed (immobilized) and then attached to the sorbent material.
* Allows continual inoculation, negating the cost of continuous replacement.
* Acts as an incubator, permitting bacterial growth and discharge.
* Introduction of immobilized bacteria promotes its dominance in the media.
* Biosorbent media is permanently enriched via absorption.
* Technology promotes system stability and productivity.
* Kera-Pac liquid form enhances operations of filter medias, bioreactors, etc.
* Imbedding Kera-Pac immobilized bacteria in sorbents increases oxygen transfer rates at the oil/water surface interface in the case of soil and marine pollution.
* Characterized by very high rates of efficiency (> 50% over non-immobile.)

Within the framework of this innovative technology, Emerging Technologies International offers a line of aggressive, contaminant reducing biological compositions that are characterized by their uniform structures containing strains of biodegrading bacteria which may be immobilized utilizing the Kera-Pac technology.

ETEC™ Products

Our ETEC™ product line consists of our proprietary strain of hydrocarbon oxidizing bacteria in several forms, including "hot paste", lyophilized (freeze dried), as well as our Kera-Pac immobilization process. These may be immobilized with the necessary nutrients such as nitrogen, phosphorous, and trace elements utilizing the Kera-Pac technology. The carrier is PH balanced to support microbial development. The composition of our Kera-Pac immobilization technology is entirely natural in origin, and absorbs the target contaminants (petroleum hydrocarbons). A general description of each of these seven (7) formulations is as follows, with the Kera-Pac trademark denoting utilization of the proprietary strains in their immobilized form:

ETEC - A1 Formulated in hot paste form, ETEC-A1 is also the basis for manufacturing all of our other products. ETEC-A1 is typically applied in the remediation of hydrocarbon contaminated soils and waters.

ETEC - A2 Formulated as a dry powder preparation where the bacterial cells are dried by lyophilization or freeze drying. ETEC-A2 is in a convenient form for easy transportation and extended storage of large quantities of product, and is used for similar applications as ETEC-A1.

ETEC - A3 Is the immobilized proprietary strain of

Pseudo-monas, in conjunction with the Kera-Pac technology, and was specifically formulated for the remediation of large oil spills on marine waters where an oil film exists. ETEC/ Kera-Pac-A3 is formulated to be highly buoyant and provides an excellent interface with the contaminated water media.

ETEC - A4 Developed specifically for the remediation of soils contaminated with oil, products, or toxic organic substances utilizing the Kera-Pac immobilization technology. The toxic biodegradation process is accompanied with a positive change in the structure of the solid, yielding increased fertility.

ETEC - A5 Is a special formulation of bacteria in immobilized form combined with components that absorb oil and oil products. ETEC-A5 is particularly suited as a First Response to large scale marine oil spills, and is also suited for applications in sorbent columns for the remediation of industrial waste water.

ETEC - A6 Is a self recovery biosorbent and immobilized bac-teria formulation characterized by its condensed form and extremely high rate of efficiency. This process is used in aqueous environments through use in sorbent column processes.

ETEC - A7 Is a proprietary bacteria in immobilized form and in combination with minerals, Nitrogen and Phosphorous, and is well suited to low oxygen conditions.

ETEC - BSF is a bacterial derived biosurfactant. This derivative from the hydrocarbon oxidizing bacterial family emulsifies hydrocarbon molecules and makes them accessible to large numbers of indigenous microorganisms. ETEC-BSF is an excellent biostimulator when applied to hydrocarbon contaminated soil or water. Its surfactant action breaks down hydrocarbon molecules. It can be used by itself or in conjunction with other ETEC products.

ETEC-MZC is the top of the ETEC product line. ETEC MZC stands tall as the latest breakthrough technology created by our scientists. It is a multi-enzyme complex capable of turning hydrocarbons into fatty acids. ETEC-MZC's action comes from bacteria that oxidize hydrocarbons. The MZC complex acts directly on hydrocarbon molecules, When the complex comes in contact with hydrocarbons, it generates a chain or sequence of biochemical reactions.

The Kera-Pac immobilization process and the ETEC bacterial product line can be specifically formulated for specialized uses through modification. This makes it possible to select the most effective strains and configurations, with the following advantages:

* Metabolizing petroleum hydrocarbons on water (salt or fresh).
* Soil remediation of petroleum hydrocarbons and toxic wastes (i.e., wood preservatives, etc.)
* A combination of bacteria fixed to oleophilic sorbents, which are particularly well suited in the immediate response to marine oil spills.
* As an accelerator in contaminant degrading filter media and waste water columns.

The ETEC™ enzyme-catalyzed metabolic remediation system is effective in a variety of mediums including sludge, mud, clay and mixed media. In most projects to date, the emphasis has been on treating soils with a high clay matrix since that is the most difficult medium to penetrate and successfully remediate. In most cases, the sites treated with the ETEC™ system have been reduced to closure levels within 30 days.

This technology is applicable to any site contami-

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nated with organics where non-permeability is a factor. Examples include military installations, wood treating facilities, oil processing facilities -- any type of project where hydrocarbons are trapped in a clay or similar matrix.

Advantages Over Alternate Technologies

The ETEC Enzyme Catalyzed Metabolic Remediation process offers several advantages over competing technologies.

- More cost effective due to accelerated treatment time,
- Elimination of long term liabilities,
- Minimal disturbance to existing site,
- Effective in low permeability soils,
- On-site destruction of contaminants, with no disposal,
- Industrially and environmentally safe,
- Hydrocarbon compounds are degraded to CO2 and H_2O.
- Extension of naturally occurring biological oxidation process,
- Can be used for chronic contamination,
- Regulatory encouragement.

ETEC PRODUCTS ARE EFFECTIVE ON THE FOLLOWING COMPOUNDS OR CONTAMINANTS

Oil Products & Crudes	Aliphatic Compounds	Aromatic Compounds	Pesticides
Gasoline	Methanol	Creosote	Sevin
Diesel Fuels	Ethanol	Pentachlorophenol	DDT
Bunker C	Ethylene Glycol	Ethylbenzene	Dalapon
Jet Fuels	Aircraft Deicing	Methyl Napthalene	
Av Gas	Fluids	Toluene	
Motor Oils	Antifreeze	Xylene	
Lubricants	Propylene Glycol	Benzene & Anthracene	
Hydraulic Fluids		Phathalic Acid	
Oil Sludges		Diethyl Ether	

MICHAEL BAKER JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: SUPMU 45 Tank & tunnel cleaning NSRR, Puerto Rico

S.O. No.: CTO 296 Design

DATE: 8-8-95

CONTRACT NO.:

To: Tom Fasmin

Repres.: Aprotek

Phone No.: 916-364-6145

From: Tara Buckman

Repres.: BEI

Phone No.: 412-269-2040

Subject: Oleofiltration unit & Enzyme Catalyzed Metabolic Remediation ... (Remediation of Bunker C fuel in water)

Oleofiltration → Lease $1,000-2,000/mos + shipping + 1 Aprotek technician to set up

Purchase $20,000-$30,000

2½-100 gpm. → each unit is capable of handling this range; can connect >1 unit in parallel.

Units come in manual O&M style & automated O&M style

O&M includes backflushing w/ water and changing chips every 15 & 18 months.

Unit can sit outside / unprotected

Enzyme Remediation →

+ Aprotek technician to set it up.

- enzyme cost: $1-2/gal of water
- Throw in enzymes
- need air compressor or pump to circulate enzyme & water mixture
- Remediation complete in 3-4 days

PREPARED BY Tara Buckman TITLE Asst. Engr. I PAGE 1 OF 1

OP-3C
10/92

MICHAEL BAKER JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: SUMU 45
Tank & tunnel cleaning
NSRR, Puerto Rico

S.O. No.: CTO 296 Design
DATE: 5-15-95
CONTRACT NO.:

To: Frank Tinblin
Repres.: Hart Lake Environmental

From: Conan Casadei
Repres.: Baker Environmental, Inc.

Phone No.: 412-643-1755

Phone No.: 412-269-2004

Subject: After checking with API, they suggested the following treatment system:

API settling basin, carbon unit, small DAF unit used as an API.

20 gpm: $20,000

50 gpm: $25,000

PREPARED BY Tom Buck TITLE Asst. Engr I PAGE 1 OF 1

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SPECIFICATION

MEARL GEOCELL LOW DENSITY [illegible]

SCOPE OF WORK: The certified MEARL GEOCELL applicator shall furnish labor, materials, equipment and supervision for the installation of MEARL GEOCELL in accordance with the drawings and specifications.

2. MATERIALS:
   - 2.1 MEARL GEOFOAM LIQUID CONCENTRATE shall be supplied by The Mearl Corporation, Roselle Park, N.J. MEARL GEOFOAM LIQUID CONCENTRATE shall comply with the standard specifications of ASTM C 869 when tested in accordance with ASTM C 796.
   - 2.2 Portland cement shall comply with ASTM C 150, Type I, II or III.
   - 2.3 Mixing water shall be potable and free from deleterious amounts of acids, alkali, salts, oils and organic materials which would adversely affect the setting or strength of the MEARL GEOCELL.
   - 2.4 Admixtures for reducing water, accelerating set, etc., may be used when specifically approved by The Mearl Corporation and in accordance with its recommendations.
   - 2.5 Other additives such as flyash may be used when specifically approved by The Mearl Corporation.
3. MIX DESIGN: Mix design shall be in accordance with The Mearl Corporation's recommendations for a cast density at point of placement of _____ pcf ± _____ pcf with a minimum compressive strength of _____ psi at 28 days.
4. MIXING AND PLACING: MEARL GEOCELL shall be job site batched, mixed and placed with equipment (foam generator, mixer and pump) approved by The Mearl Corporation.
5. TESTING: Four (4) test specimens shall be taken at the point of placement for each 100 cubic yards of MEARL GEOCELL. Specimens shall be prepared, handled, cured and tested for compressive strength in accordance with ASTM C 495.
6. SPECIAL CONSIDERATIONS: Contact The Mearl Corporation for design assistance, application and placement recommendations.

MEARL GEOCELL LOW DENSITY [illegible]

TYPICAL PHYSICAL PROPERTIES

CATEGORY	DENSITY, AS CAST		DENSITY, AIR DRY		MINIMUM COMPRESSIVE STRENGTH		MINIMUM BEARING CAPACITY TONS/sf
	±3 pcf	±50 kg/m³	±3 pcf	±50 kg/m³	psi	MPa	
I	21	335	17	270	20	0.13	1.4
II	27	435	22	350	40	0.27	2.9
III	33	530	27	430	80	0.55	5.8
IV	39	625	33	530	120	0.87	8.6
V	45	720	38	610	160	1.10	11.5
VI	48 & Over	770 & Over	41 & Over	660 & Over	300	2.07	21.6

Actual properties will depend on cement used, water-cement ratio, curing conditions and other variables as dictated by job conditions.

The Mearl Corporation
220 W. Westfield Avenue, Roselle Park, N.J. 07204
(908) 245-9500 FAX (908) 245-6469
(212) 924-8170

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The Mearl Corporation
FOAM AND CHEMICALS DIVISION

TECHNICAL BULLETIN

MEARL GEOCELL

LOW DENSITY CELLULAR CONCRETE FOR GEOTECHNICAL APPLICATIONS

COEFFICIENT OF PERMEABILITY*	CATEGORY II	CATEGORY IV
MAXIMUM CAST DENSITY, PCF	30	42
COEFFICIENT OF PERMEABILITY, k, cm/sec		
@ EFFECTIVE CONFINING STRESS, 2.5 PSI	4.7×10^{-5}	1.5×10^{-6}
@ EFFECTIVE CONFINING STRESS, 18 PSI	1.9×10^{-5}	5.4×10^{-7}

* AS DETERMINED BY METHOD OF U.S. ARMY CORPS OF ENGINEERS, EDM 1110-2-1906 AND ASTM D 2434.

WATER ABSORPTION*	CATEGORY II	CATEGORY III	CATEGORY IV
MAXIMUM CAST DENSITY, PCF	30	36	42
% WATER ABSORPTION AFTER 120 DAYS, MAXIMUM	20	16	14

*LONG TERM TOTAL IMMERSION AS PERCENT OF CAST DENSITY PER METHOD OF ASTM C 796.

SHEAR MODULUS, G AND YOUNG'S MODULUS, E	CATEGORY II	CATEGORY III
MAXIMUM CAST DENSITY, PCF	30	36
SHEAR MODULUS, G, PSI (1)	27,670	41,800
YOUNG'S MODULUS, E, PSI (2)	67,500	101,990

(1) AS DETERMINED BY METHOD OF ASTM D 4015 AT CONFINING STRESS OF 3 PSI
(2) YOUNG'S MODULUS CALCULATED ON THE BASIS OF A POISSON'S RATIO: $u = 0.22$ and $E = 2G(1 + u)$

RESISTANCE TO RAPID FREEZING AND THAWING *

NUMBER OF FREEZE-THAW CYCLES	RELATIVE "E" PERCENT AT CAST DENSITY	
	CATEGORY II 30 PCF	CATEGORY IV 40 PCF
30	98	98
80	90	95
120	86	90
330	70	79

*AS DETERMINED BY METHOD OF ASTM C 666 MODIFIED TO ALLOW FOR THE INSULATING PROPERTIES OF MEARL GEOCELL

GM 409/5.91

220 W. Westfield Avenue, P.O. Box 208, Roselle Park, N.J. 07204 Phone (908) 245-9500 • (212) 924-8170 • FAX (908) 245-6469

The Mearl Corporation
FOAM AND CHEMICALS DIVISION

TECHNICAL BULLETIN

MEARL GEOCELL LOW DENSITY CELLULAR CONCRETE

Projects installed by:
ACCURATE ENGINEERED CONCRETE PRODUCTS
HAVERHILL, MA

1. **Super Stop & Shop – Northampton, MA**
   Gannet Reality Trust
   Volume: 15,750 cu yds
   Average Density: 35 pcf
   Engineer: GZA
   Application: load relief for a 74,000 sq ft building

2. **Wellesley Extension Sewer Replacement – Needham/Dedham, MA**
   Massachusetts Water Resource Authority
   Volume: 3700 cu yds
   Average Density: 30 pcf
   Engineer: SEA - Cambridge, MA
   Application: fill an abandoned sewer line approximately 2 mi long

3. **Park Avenue Tunnel – New York, NY**
   Metro North, MTA
   Volume: 3500 cu yds
   Average Density: 30 pcf
   Engineer: Kaiser Envirodyne
   Application: fill voids behind brick arch tunnel

4. **Square One Mall – Saugus, MA**
   New England Developers
   Volume: 2130 cu yds
   Average Density: 30 pcf
   Engineer: GZA
   Application: void fill/load relief

5. **Back Bay Station – Boston, MA**
   Massachusetts Bay Transit Authority
   Volume: 1400 cu yds
   Density: 35 pcf
   Engineer: MBTA
   Application: reduce the load over subway station and permit landscaping on the surface

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6. **Rt. Bridge Catskills – Mechanicsville, NY**
NY State DOT
Volume: 1225 cu yds
Average Density: 35 pcf
Engineer: NY - DOT
Application: ground stabilization for bridge approach

7. **Prudential Star Market – Boston, MA**
Prudential Management
Volume: 700 cu yds
Average Density: 35 pcf
Engineer: GZA
Application: void fill over Mass Pike, I-90

8. **Liberty State Park – NJ**
State of New Jersey
Volume: 700 cu yds
Average Density: 70 pcf
Engineer: Sidney M.Johnson and Associates
Application: stabilize wood pier being attacked by sea worms

9. **Route 9 Bridges – Northampton, MA**
Massachusetts – DOT
Volume: 600 cu yds
Average Density: 35 pcf
Engineer: MA DOT
Application: installed over peat bog to stabilize new roadway

10. **Trout Brook Bridge Approach – Brockton, MA**
Massachusetts DOT
Volume: 360 cu yds
Average Density: 35 pcf
Engineer: MA - DOT
Application: ground stabilization for bridge approach

11. **Millstone Nuclear Power Plant – Niantic, CT**
North East Utilities
Volume: 250 cu yds
Average Density: 25 pcf
Engineer: NorthEast Utilities
Application: filling decommissioned steam generators from Units 1 & 2 to enable shipment to S. Carolina for burial

12. **Yankee Rowe Nuclear Power Plant – Rowe, MA**
Yankee Atomic Electric Co.
Volume: 220 cu yds
Average Density: 25 pcf
Engineer: NorthEast Utilities/Chem-Nuclear
Application: filling decommissioned steam generators Units 1,2,3, & 4 to enable shipment to S. Carolina for burial

MICHAEL BAKER JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: SWMU 45 Tank & tunnel cleaning Naval Station Roosevelt Roads, Puerto Rico

S.O. No.: CTO 296 Design

DATE: 12-7-95

CONTRACT NO.:

To: Tom Fuemmaier

Repres.: Mearl Corp.

Phone No.: 908-245-9500

From: Jane Buckman

Repres.: Baker Environmental

Phone No.: 412-269-2040

Subject: Flowable, low density cellular concrete...

Mearl can ship the foam by sea or by air to Puerto Rico. The sandy-mix cement can be brought in Puerto Rico. (foam + cement = cellular concrete)

He estimates the total cost to be $60/cy. (This includes increased cost for cement in Puerto Rico.) → install labor included

Foam is shipped in drums: 1.4 cf/gal

To mix cement & foam, a foam generator ($4,000 ea.) is required. Mearl can also ship one of these. → T80-20

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MICHAEL BAKER JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: SWMU 45
NSRR, Puerto Rico
Tank & tunnel cleaning

S.O. No.: CTO 296
DATE: 12-8-95
CONTRACT NO.:

To: Roadway Volume Services
Repres.: Todd Nettline
Phone No.: 1-800-920-1000
1-800-468-5739

From: Tina Buckman
Repres.: Baker
Phone No.: 412-269-2040

Subject: Transporting foam for tank fill to South Florida...
(from Roselle Park, NJ)
1 28' trailer (max. of 24,000 lbs) → $1,795
2 28' trailers (max. of 48,000 lbs) → $3,360

Transporting foam from South Florida to Puerto Rico overseas...
~~$3,300~~ $2,042

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