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PRE-INVESTIGATION CORRECTIVE MEASURES SCREENING REPORT

NAVAL STATION ROOSEVELT ROADS PUERTO RICO

CONTRACT TASK ORDER 0223

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EXECUTIVE SUMMARY

Introduction

This report presents the the Pre-investigation Evaluation of Corrective Measure Technologies for Selected Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico. The SWMUs and AOCs evaluated are those that require investigation under the Resource Conservation and Recovery Act (RCRA) Draft Corrective Action Permit. A complete list of these SWMUs and AOCs is provided in Table ES-1.

Until 1993, environmental activities at NSRR, exclusive of underground storage tanks, were conducted in compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations under the Department of the Navy's (DoN's) Installation Restoration (IR) Program. At this point, a Draft RCRA Permit, as required by the Resource Conservation and Recovery Act of 1976 and the Hazardous and Solid Waste Amendments of 1984, was issued to NSRR for Operations of the Defense Reutilization and Marketing Office (DRMO). Environmental activities at NSRR, exclusive of underground storage tanks, are now being conducted under RCRA guidelines.

The United States Environmental Protection Agency (USEPA) has conducted a RCRA Facility Assessment (RFA) (A.T. Kearney, 1988). In 1993, an additional inspection was performed (TRC, 1993). A number of SWMUs and AOCs at NSRR were identified and selected as sites requiring a RCRA Facilities Investigation (RFI). This document is one of the management plans associated with RFI activities.

This report is designed to satisfy the Draft Corrective Action Requirements (Appendix A, Section IV) for NSRR. It identifies 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. The report also identifies field data requirements for the RFI to facilitate the evaluation and selection of the final corrective measure or measures.

The scope of this report differs somewhat from a traditional Evaluation of Corrective Measures Technologies Report. This report incorporates the voluminous amount of environmental data that has been generated during previous investigations. The USEPA has reviewed much of this data already, although some of the more recent data associated with the

TABLE ES-1

SWMUs/AOCs MEDIA SUBJECT TO CORRECTION ACTION REQUIREMENTS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

SWMU/AOC	Ground-water	Soil	Surface Water/ Sediment	RFI Type
#1 Former Cremator Disposal Site	Yes	Yes	Yes	Full
#2 Langley Drive Disposal Site	Yes	Yes	Yes	Full
#3 Base Landfill	Yes	Yes	Yes	Full
#6 Building 145	No	Yes	No	First Phase
#9 Tank 212-217 Sludge Burial Pits	Yes	Yes	Contingent	Full
#10 Substation 2/Bldg. 90	Contingent	Yes	Contingent	First Phase
#11 Old Power Plant/Bldg. 38	Yes	Yes	Yes	Full
#12 Fire Training Pit Oil/Water Separator	No	Yes	No	First Phase
#13 Old Pest Control Shop/Bldg. 258	Contingent	Yes	Yes	First Phase
#14 Fire Training Pit Area	Contingent	Yes	No	First Phase
#19 Bldg. 121 - Discarded Pesticide Storage Area	Contingent	Contingent	No	Contingent
#23 Oil Spill Separator Tanks	Contingent	Yes	No	First Phase
#24 Oil Spill Oil/ Water Separator & Adjoining Pad	No	Yes	No	First Phase
#25 DRMO Storage Yard	No	Yes	No	First Phase
#26 Building 544 Area	No	Yes	No	First Phase
#31 Waste Oil Collection Area/ Bldg. 31 & 2022	No	Yes	No	First Phase
#32 PWD Storage Yard/ Battery Collection	No	Yes	No	First Phase
#37 Waste Oil Storage Area/Bldg. 200	No	Yes	No	First Phase
#39 Bldg. 3158/ Former Battery Drain Area	No	Yes	No	First Phase
#45 PCB Spill Area/ Old Power Plant	Yes	Yes	Yes	Full
#46 Pole Storage Yard Covered Pad	No	Yes	No	First Phase
#51 New AIMD Storage Pad/ Bldg. 379	No	Yes	No	First Phase
AOC #B/ Bldg. 25	Yes	Yes	No	Full
AOC #C/ Transformer Storage Pad	No	Yes	No	First Phase

Supplemental Investigation (Baker, 1993; see Section 3.0) the USEPA has not had the opportunity to review as yet.

This report presents the environmental data since it has an impact on the selected scope of work that will be conducted at the SWMUs/AOCs that were former IR Program sites. It is the intent of this document to utilize this existing data to identify environmental media that will require additional investigation and the scope of the required investigations. The planned scope of work for each SWMU/AOC is included to facilitate early agreement on approach between the Department of the Navy and the USEPA in order to reach the remediation stage more quickly.

NSRR occupies part of the northern side of the east coast of Puerto Rico, along Vieques Passage, with Vieques Island lying to the east about 10 miles off the harbor entrance. The north entrance to NSRR is about 35 miles east along the coast road (Route 3) from San Juan. The closest large town is Fajardo (population about 37,000), which is about 10 miles north of NSRR off Route 3. Ceiba (population about 17,000) adjoins the west boundary of NSRR.

SWMU/AOC Descriptions

A complete list of SWMUs/AOCs to be included in the RFI is presented in Table ES-1. This table also lists the RFI requirements for each SWMU/AOC. RFI requirements include:

- First-phase soil RFI -- The purpose of a first-phase RFI is to assess whether there have been releases from these SWMUs/AOCs whose history of use or present condition suggest the possibility. The first-phase RFI differs from a full RFI in the extent and degree of investigations required.

- Full RFI -- Full RFIs will be conducted where releases were established during previous investigations. The purpose of the full RFI is to determine the nature, rate and direction of migration, and extent of migration of hazardous waste or hazardous constituents.

- Contingent -- Status pending other results of activities (interim remedial action, first phase RFI closure, etc.).

A general description of each SWMU/AOC is presented in the following subsections.

SWMU 1 - Former Cremator Disposal Site

The Army Cremator disposal area is located south of the intersection of the access road to the Ammo Pier and Langley Drive, west and southwest of the Navy Exchange and Bowling Alley, and near the Ensenada Honda Mangrove Swamp (NEESA, 1984). This SWMU operated from the early 1940s until the early 1960s and was the main station landfill during this time. Waste material was disposed of by piling, burning and compacting (A.T. Kearney, Inc., 1988). An estimated 100,000 tons of waste including scrap metal, inert ordnance, batteries, tires, appliances, cars, cables, dry cleaning solvent cans, paint cans, gas cylinders, construction debris, dead animals, and residential waste was disposed of at this site (NEESA, 1984). No reliable information exists regarding the amounts of material present in the disposal area that could be hazardous; however, in 1984, the IAS team estimated that as much as 1,000 tons of hazardous material could be present in the area (NEESA, 1984).

SWMU 2 - Langley Drive Disposal Site

The Langley Disposal Site, which is located along Langley Drive approximately 2,000 feet north of the Navy Exchange Complex and 300 feet east of the drive towards Ensenada Honda, operated as a landfill from approximately 1939 to 1959 (NEESA, 1984). The Navy documents this unit as having been used for the disposal of both hazardous and nonhazardous wastes (A.T. Kearney, Inc., 1988).

SWMU 3 - Base Landfill

The Base Landfill (IR Site 7) is located south of the Industrial Area Wastewater Plant (Building 1758) and was operated since the early 1960s. The landfill covers 85 acres, and is separated into several different disposal areas (A.T. Kearney, Inc., 1988). Based on the limited amount of information that exists with regard to the landfill, discrete areas were identified in the IAS as disposal areas. Some of these "areas" are undetectable from the ground. Methods of disposal involved the excavation of a trench to the water table, filling the trench with waste, spreading and compacting the waste with a bulldozer, then covering the waste with soil. It is estimated that from 40 to 60 tons of waste per day were disposed of in the past (A.T. Kearney, Inc., 1988). Wastes that were disposed of at this SWMU include, residential wastes, scrap metal, cables, paint waste, solvents, PCBs, OTTO Fuel II, Agentine, Askarel, pesticides, lubricating oil, unlabeled 55-gallon drums, dead animals, inert ordnance,

digested sludge, construction debris, asbestos, and possibly Super Tropical Bleach (STB), a decontaminating agent (NEESA, 1984).

SWMU 6 - Building 145

This SWMU comprises IR Site 11. The building is a bunker, approximately 60 yards long, 7 feet high, and 8 feet wide with three openings to the surface through the roof. The openings are covered with dilapidated wood structures. There is one entrance at ground level. The 1984 IAS team reported the presence of approximately sixty 55-gallon drums, one hundred 5-gallon pails, and a number of other small containers (NEESA, 1984). The condition of the containers ranged from being intact and neatly stacked to randomly placed and leaking (A.T. Kearney, Inc., 1988). The 1984 IAS Report stated that the drums and other containers had been in the building for sometime, probably since 1957. Some of the materials identified by the IAS team included spray paint, olive drab paint, black boot polish and some adhesives (NEESA, 1984). The IAS team concluded that the majority of the material (approximately 2,000 gallons) could be classified as hazardous (NEESA, 1984).

SWMU 9 - Tank 212-217 Sludge Burial Pits

This SWMU consists of eight fuel storage tanks. Tanks 212 through 215 are located north of Forrestal Drive along Manila Bay Road. Tanks 216 and 217 are located on a hilltop about 4,000 feet southeast of tanks 212 through 215, north of Forrestal Drive (NEESA, 1984). This SWMU comprises IR Site 13.

SWMU 10 - Substation 2/Building 90

This SWMU comprises IR Site 15, where electrical transformers were formerly repaired, resulting in PCB containing transformer oils being poured on the ground. The soils at this SWMU are being investigated and remediated under the IRP (Section 4.8). Further RFI activities at this SWMU are contingent on the results of this investigation/remediation.

SWMU 11 - Old Power Plant/Building 38

According to the 1984 RFA report, Building 38 was a 60-megawatt steam turbine facility that generated power from the early 1940s through 1949. The facility used Bunker C fuel, which was stored in two 50,000-gallon reinforced concrete tanks located directly northwest of the

building. (NEESA, 1984). In the 1979s, Bunker C fuel was observed in manholes near Building 38 during heavy rainfalls. Bunker C fuel was also discharged to the Enlisted Beach through the old cooling water outlet for the Power Plant (NEESA, 1984).

SWMU 12 - Fire Training Pit Oil/Water Separator

This SWMU began operations in 1983; however, the 1984 IAS report does not address this SWMU. The first mention of this SWMU is in the 1988 RFA report. According to the RFA, the fire training pit oil/water separator is an inground concrete tank that measures approximately 7 feet x 30 feet x 10 feet deep. Waste oils are burned at the Fire Training Pit during training exercises, the excess of which is collected in the oil/water separator. Water from this unit is pumped to the Sewer Drainage System (SWMU 38) to be processed by one of the Naval Station wastewater treatment plants. Oils from this unit are pumped back into the Fire Training Pit (SWMU 14). The VSI team observed a ground level opening that was covered by heavy grating. The VSI team also noted an area of dead grass, adjacent to the oil/water separator, and oil stains on the curbing and guardrail uprights (A.T. Kearney, Inc., 1988).

SWMU 13 - Old Pest Control Shop/Building 258

This SWMU comprises IR Site 18. The IAS report describes this SWMU as the following:

- The pest control shop was located at Building 258 from the late 1950s through 1983. Pesticides were stored in Building 258 and also on the parking apron. In 1976, a 55-gallon drum of Malathion, which was stored outside the building, ruptured and the contents spilled onto the ground, eventually washing into the drainage ditch in back of the building. This same ditch received rinse waters from the cleaning of pesticide equipment over a storm drain which discharged to the ditch. Excess pesticides were also poured into this ditch. Past environmental engineering surveys cite numerous aquatic kills due to pesticides entering the ditch. The area surrounding the building is devoid of vegetation, although the drainage ditch does not show any signs of stressed vegetation.

- Pesticides used in the past include DDT, Paris Green, maldane, malathion, and chlordane. There is no information available, either from records or interviewees, regarding the amounts or concentrations of the pesticides used (NEESA, 1984).

SWMU 14 - Fire Training Pit Area

This SWMU comprises IR Site 17. The IAS report indicated the following about SWMU 14:

- The crash crew training area was operated by the Air Operations Department from early 1960s through 1983.

- Two unlined pits were used in the past for fire fighting training. The first pit, which was approximately 40 feet in diameter, was used from the early 1960s through the beginning of 1983. Assuming 20 years of operation, about 120,000 gallons of waste solvents, fuels, and oils were placed in the pits and set on fire for fire fighting training. Also burned were wood, trash, plastic, fuel filter elements, oily rags, and other debris. The fires were extinguished using aqueous film-forming foam (AFFF) and potassium bicarbonate (Purple K). Past aerial photographs show drainage from this pit to the ditch along the runway shoulder. The new fire training pit was built at the same location as the old pit. When the new pit was built, all of the oil-stained, contaminated soil was excavated and most likely disposed of in the base landfill.

- The second pit was used temporarily during the construction of the new fire training pit in 1983. This unlined gravel pit has a diameter of 200 feet and was used approximately six times. Approximately 3,000 gallons of waste fuel, oil, and solvents were burned in this area. Only small amounts of fuel were allowed to soak into the ground (NEESA, 1984).

SWMU 23 - Oil Spill Separator Tanks

Located approximately 100 feet inshore from the fuel pier are three oil spill separator tanks which process waste pumped in from the Ships Waste Off-load Barges (SWMU 22). The oil spill separator tanks are large steel boxes that are underlain by a concrete pad with an 8-inch curb (A.T. Kearney, Inc., 1988). Each box has a pipe that extends out laterally from the bottom.

After the water settles to the bottom of the tank, a valve on the pipe is opened, and the contents are allowed to spill out until all the water has been removed. The separated oil is then transferred to the Oil Spill Oil/Water Separator (SWMU 24). This added process of separation is necessary because the majority of liquid pumped up by Donuts (SWMU 21) and

SWOBs (SWMU 22) consists of sea water. Each oil spill separator tank is constructed of steel and, according to facility representatives, has a 2,000-gallon capacity (A.T. Kearney, Inc., 1988).

SWMU 24 - Oil Spill Oil/Water Separator and Adjoining Pad

According to the 1988 RFA report, the oil spill oil/water separator is a below ground structure built of concrete with steel grating covering the top at ground level (A.T. Kearney, Inc., 1988). Facility representatives reported to the VSI team that the oil/water separator has a capacity of 1,500 gallons. This unit receives discharge from the Oil Spill Separator Tanks (SWMU 23). After separation, the waste oil is removed by DRMO. The final disposal of wastewater was not determined by the VSI team (A.T. Kearney, Inc., 1988). The VSI team also did not determine if an overflow control device existed at this SWMU. They did not observe any sign of a release at the time of the VSI.

SWMU 25 - DRMO Storage Yard

This unit is an area measuring approximately 40 feet x 100 feet and is located immediately adjacent to the Ignitable Storage Facility (SWMU 18) (A.T. Kearney, Inc., 1988). In 1988, a facility representative stated to the VSI team that this unit was used for hazardous waste storage prior to the use of the Ignitable Storage Facility (SWMU 18) and DRMO Hazardous Waste Storage Facility (SWMU 17) (A.T. Kearney, Inc., 1988). A facility representative told the VSI team that this SWMU was being used to store hazardous materials at the time of the inspection. Evidence of past release was observed during the VSI. Several oil stains, the largest measuring approximately 20 feet in diameter, were observed (A.T. Kearney, Inc., 1988).

SWMU 26 - Building 544 Area

This SWMU is comprised of approximately twenty-five 30-gallon drums, some of which had polyethylene liners (A.T. Kearney, Inc., 1988). The 1988 RFA report indicates that these drums were located behind Building 544 and were surrounded by thick brush (A.T. Kearney, Inc., 1988). The VSI team noted that some of the drums contained engine lubricating oil, and that one of the labels had the number 9150-231-6654 stamped on it (A.T. Kearney, Inc., 1988). The VSI team could not identify the contents in all of the drums because not all of the drums

were labeled. The VSI team also observed a tar-like substance leaking onto the ground (A.T. Kearney, Inc., 1988).

SWMU 31 - Waste Oil Collection Area/Buildings 31 and 2022

This SWMU is part of IR Site 10. According to the 1988 RFA, the Transportation Shop services Public Works Department vehicles inside Building 31 and in the yard just north of the building. Approximately 30 yards from the Transportation Shop warehouse is a concrete pad used for the temporary storage of 55-gallon waste oil drums, although none were present at the time of the VSI. A 6-inch concrete curb surrounds the pad which measures approximately 13 feet by 20 feet. A steel drainage pipe with a broken valve is set into the curbing, and at the time of the 1988 VSI, was in the open position. The yard surrounding this unit is asphalt. No leakage was evident at the time of the VSI; however, with the drain pipe valve broken in the open position any spills on the concrete pad would flow directly onto the Public Works Department yard (A.T. Kearney, Inc., 1988).

SWMU 32 - PWD Storage Yard/Battery Collection Area/Building 31

This SWMU is part of IR Site 10. It consists of a number of batteries that were stored on the bed of a truck and on a pallet on the ground. This SWMU is located approximately 100 yards northeast of the transportation shop warehouse.

SWMU 33 - AIMD Storage Pad/Building 379

According to the 1988 RFA this unit was located outside, against the northern wall of Building 379. It was described to the VSI team by facility representatives as a temporary hazardous waste storage area (A.T. Kearney, Inc., 1988). This storage area was a curbed concrete pad with a manual overflow control valve. The wastes stored at this SWMU were generated by Aircraft Intermediate Maintenance Department (AIMD) maintenance, and according to the IAS report include wastes generated from cleaning, painting, paint stripping, minor calibration, complete overhaul of avionic components, and battery cleaning and recharging operations (A.T. Kearney, Inc., 1988). During their visit, the VSI team observed beryllium waste, hydraulic fluid and solvents generated from aircraft maintenance (A.T. Kearney, Inc., 1988). The VSI team also observed minor amounts of unidentified damp white powder in the grass several feet outside the storage pad.

SWMU 37 - Waste Oil Storage Area/Building 200

According to the 1988 RFA, this unit consisted of nineteen 55-gallon drums resting on wooden pallets, situated on a raised, covered concrete pad behind Hanger 200. The drums were observed by the VSI team to contain waste gasoline and lubricating oil from AIMD operations.

SWMU 39 - Building 3158/Former Battery Drain Area

According to the 1988 RFA, this unit consists of a storage building and covered battery drainage area. This building stores waste batteries and battery acid that are wastes generated by Naval Mobile Construction Battalion (NMCB or "Seabees") operations. The metal battery drain tank (shaped like a funnel) is underlain by a curbed concrete pad. Battery contents are poured into the drain tank and the battery acid is caught below in a container. The curbing around the pad is cracked and stained, indicating that there have potentially been past releases to the soil (A.T. Kearney, Inc., 1988).

SWMU 41 - Seabee Pesticide Rinse Rack

According to the 1988 RFA, this unit was observed during the VSI to be an uncurbed concrete slab measuring approximately 12 feet x 20 feet that is located directly adjacent to the Seabee Pesticide Storage Building (Building 3152). The drain within this slab is made up of four strips (6 inches wide). Each strip runs parallel to and is located within the perimeter of the slab to form an inner rectangular "frame." The drain is covered by steel grating. The VSI team was informed by naval personnel that this unit is most commonly used to rinse out the spray trailer which usually contains a mosquito pesticide (A.T. Kearney, Inc., 1988).

SWMU 46 - Pole Storage Yard Covered Pad

According to the 1988 RFA report, this unit was cited in the NACIP report as a Public Works Department hazardous waste storage area that had been used to store transformers and 55-gallon drums of PCB-contaminated material. The NACIP report further stated that the area showed evidence of oil spillage. A facility representative confirmed that this unit had formerly been used to store transformers during the 1988 VSI. The VSI team observed that this unit was a covered concrete pad, and that it was used for the storage of products including insulators, telephone poles, small cardboard boxes of electrical equipment, and several full 5-gallon pails, one marked as electrical lubricant. The VSI team also noted that the unit was

surrounded by a cyclone fence. Telephone poles were piled near the entrance. No evidence of release was observed by the VSI team (A.T. Kearney, Inc., 1988).

SWMU 50 - Storage Area Behind Building 3166

SWMU 50 consists of an open air, fenced area at the southwest corner of Building 3166, where several 55-gallon containers of assorted materials (one of malathion), plus three transformers, are stored either directly on the ground or on pallets. This SWMU was first identified during the 1993 RFA reinspection. No visual evidences of releases were observed (TRC, 1993).

SWMU 51 - New AIMD Storage Pad/Building 379

SWMU 51 consists of a curbed concrete storage pad located outside Building 379. This storage pad is roofed and enclosed with a cyclone fence. It was first identified during the 1993 RFA reinspection, and is presently utilized by the AIMD facilities in place of SWMU 33. Also present at this SWMU is a 200-gallon tank which touches the storage pad, but is outside the curbed area. The entire pad area is surrounded by asphalt pavement. Oil stains were observed emanating from two drain valves in the curb surrounding this pad, and from the 200-gallon tank located outside the pad curb (TRC, 1993).

Area of Concern (AOC) B - Building 25

This AOC is part of IR Site 10. The 1984 IAS report noted the following:

- Building 25 was used from 1951 until the structure collapsed in 1979 by the Public Works Supply Department for temporary storage of materials to be turned over to DPDO. The entire area around the building was used for open storage of drummed material from at least 1957, according to aerial photographs.

- The entire area in and around the collapsed building is overgrown with vegetation, although historical aerial photographs show the area to be relatively free of vegetation other than ground cover through 1977.

- Materials found in and around Building 25 include 20 to 25 apparently empty to partially filled 55-gallon drums; 10 to 15 5-gallon pails; office furniture; mechanical

devices; construction rubble; industrial gas cylinders; asbestos sheeting; fiberglass buoys; and transformers.

- Of particular interest are the 5-gallon pails, the drums, and a large transformer found at the collapsed building. The compound has a green-colored crust about 1/2-inch thick, encasing a white material with the consistency of semi-dry plaster. A large transformer is lying on its side at the east corner of the building. No evidence of oil leakage was apparent (NEESA, 1984).

Area of Concern C - Transformer Storage Pad

The 1988 RFA report describes this AOC as follows:

- This AOC is comprised of two raised concrete pads that , at the time of the VSI, were used for storage of transformers. During the VSI, 40 transformers were observed to be stored on the storage pad to the south, which measured approximately 20 feet x 50 feet. This pad was covered by ripped canvas stretched over a wooden frame. The north pad was uncovered and contained at least 25 transformers and 20 to 40 batteries. The products stored at this unit were in good condition. Standing oil inside the north pad and release to the soil through a crack in the concrete were observed. Transformers of various sizes were scattered around both the south pad and the north concrete pad.

NATURE AND EXTENT OF CONTAMINATION

A number of environmental investigations have been conducted at NSRR. These include:

- Initial Assessment Study
- Confirmation Study
- RCRA Facility Assessment (RFA)
- RI/FS at Site 15 (SWMU 10)
- RI/FS at Site 16 (SWMUs 11 and 45)
- Summary and Technical Evaluation Review of Work Performed at SWMUs/AOCs (RFA Reinspection)
- Supplemental Investigation

Each of these investigations are discussed in Section 3.0 of this report. Environmental media at each SWMU/AOC are evaluated with respect to the existing information generated during these investigations.

PRE-INVESTIGATION CORRECTIVE MEASURES EVALUATION

Corrective measure technologies have been evaluated on the basis of three broad criteria: effectiveness, implementability and cost. These evaluation criteria are described in the following subsections. An effective, implementable technology at the lowest cost is the most desirable alternative. A wide range of technologies for remediation of soils, groundwater, surface water, and sediments were considered.

Several corrective measures technologies are potentially applicable to minimize health and environmental impacts due to contamination in the soil medium. Literature sources have been reviewed to identify and characterize potential corrective measure technologies. The following general technologies were examined for potential suitability to remediate soils at the Naval Station, Roosevelt Roads.

- No Action
- Institutional Controls
- Containment
- Excavation and Disposal
- Vacuum Extraction
- Soil Washing/Flushing
- Biotreatment
- Solidification/Stabilization
- Vitrification
- Thermal Destruction
- Chemical Dechlorination

Several corrective measures technologies are potentially applicable to minimize health and environmental impacts due to contamination in the groundwater medium. Literature sources have been reviewed to identify and characterize potential corrective measures technologies. The following general technologies were examined for potential suitability to remediate groundwater at the Naval Station, Roosevelt Roads.

- No Action
- Institutional Controls
- Containment
- Collection/Discharge
- Phase Change Separation
- Chemical Processes
- Biotreatment
- Gravity Separation
- Filtration
- Membranes

- Activated Carbon Adsorption
- Ion Exchange

Surface water controls are required in instances where run-off from a site requiring remedial actions may transport contaminants to different locations. Pollutants can either be dissolved or suspended in water and carried to groundwater, other surface waters or off-site land surfaces. Surface water controls are designed to prevent surface waters from becoming contaminated through contact with waste and preventing contaminated surface water from migrating off-site. There are several different methods for control of run-on and run-off.

Several corrective measures technologies are potentially applicable to remediation of contamination in sediments associated with surface waters on site. Literature sources were reviewed to identify and characterize potential corrective measure technologies. The following general technologies were examined for potential suitability to remediate sediments at Roosevelt Roads:

- No Action
- Institutional Controls
- Containment
- Excavation and Disposal
- Sediment Washing/Flushing
- Biotreatment
- Solidification/Stabilization
- Thermal Destruction

Corrective measure technologies that are potentially applicable to the contaminated media at NSRR have been identified. Additional technologies may be potentially applicable; however, the listed technologies represent those which appear most promising for application at NSRR given the information currently available. The technologies will be evaluated further as additional information is gathered. With availability of additional information, such as results of a full or first Phase RFI, additional potentially applicable technologies may be included.

RCRA FACILITY INVESTIGATION - ADDITIONAL DATA REQUIREMENTS

The purpose of this section is to provide an outline of the investigatory approach and scope of work for each SWMU requiring a full or Phase I RFI. Details of techniques to be employed during the investigations are not discussed (this will be included in the RFI Field Sampling Plan); however, the level of effort for each site is addressed in terms of numbers of sampling

points for each environmental media of concern. In addition, all the miscellaneous investigations required to provide data for corrective measure evaluation are described.

It is the intent that this section provide the framework for all RFI activities at the NSRR. Developing the general approach and level of effort for investigations at this point in the work plan process allows the early definition of media of concern and the work elements required to address concerns. Establishment of scope at this time should allow the review and approval of subsequent work plans to be easier which will lead to accelerated investigations and movement to any required corrective actions more rapid.

1.0 INTRODUCTION

This report presents the the Pre-investigation Evaluation of Corrective Measure Technologies for Selected Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico. The SWMUs and AOCs evaluated are those that require investigation under the Draft Corrective Action Permit. A complete list of these SWMUs and AOCs is provided in Table 1-1. A map of NSRR with SWMU and AOC locations is presented on Figure 1-1.

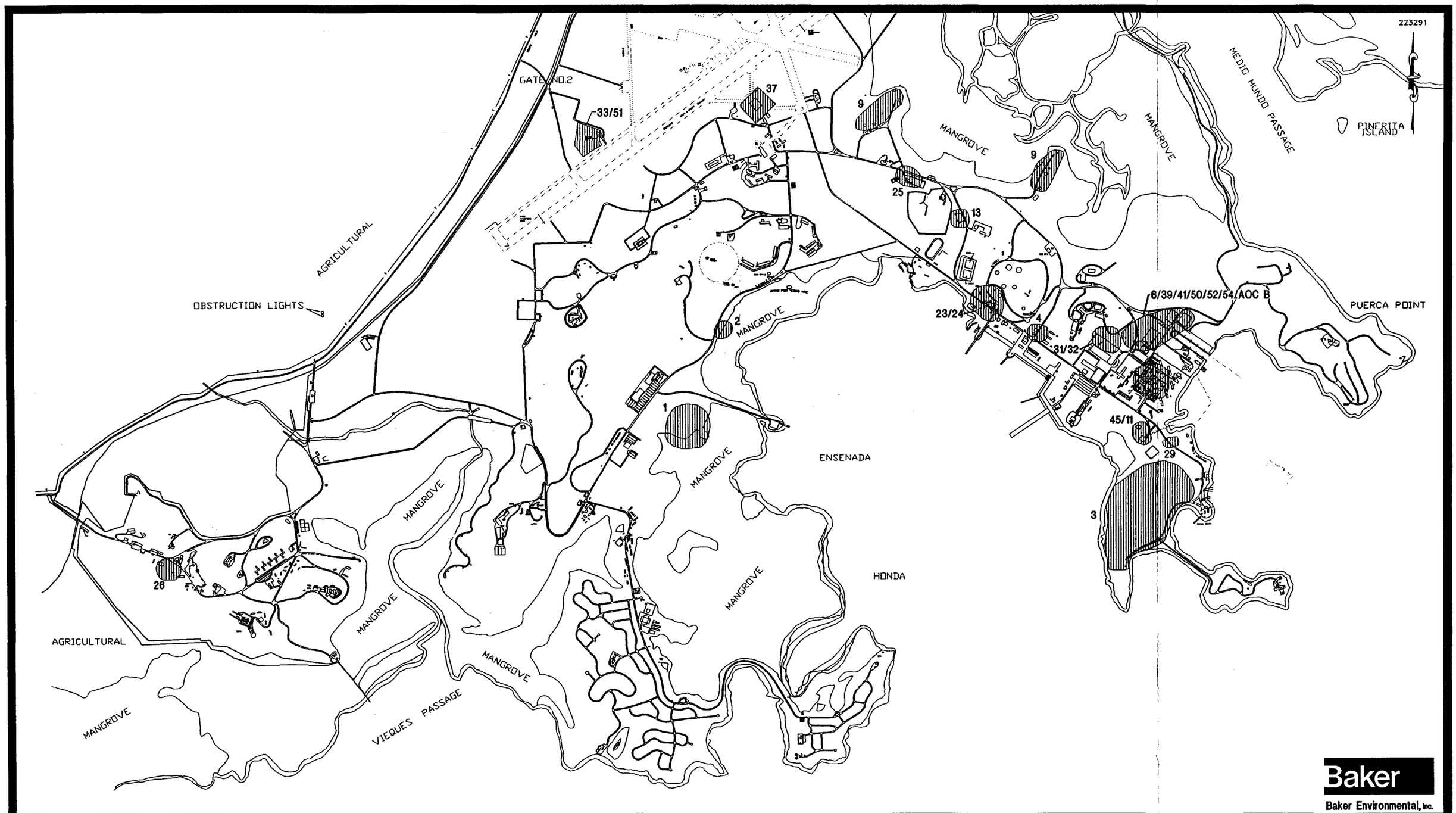
This report has been prepared by Baker Environmental, Inc. (Baker) under the Naval Facilities Engineering Command (NAVFACENGCOM), Atlantic Division (LANTDIV) Contract Number N62470-89-4814, Contract Task Order 0223 (CTO-0223). This CTO includes preparation of management plans for the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at NSRR.

The following sections comprise this report:

1.0 Introduction
2.0 Facility Background
3.0 Nature and Extent of Contamination
4.0 SWMU/AOC Status
5.0 Preinvestigation Corrective Measures Evaluation
6.0 RFI Additional Data Requirements
7.0 Summary
8.0 References

1.1 Regulatory Context of the Document

Until 1993, environmental activities at NSRR, exclusive of underground storage tanks, were conducted in compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations under the Department of the Navy's (DoN's) Installation Restoration (IR) Program. At this point, a Draft RCRA Permit, as required by the Resource Conservation and Recovery Act of 1976 and the Hazardous and Solid Waste Amendments of 1984, was issued to NSRR for operations of the Defense Reutilization and Marketing Office (DRMO). Environmental activities at NSRR, exclusive of underground storage tanks, are now being conducted under RCRA guidelines.



LEGEND

1 SWMU AND/OR AOC

SOURCE: LANTDIV, FEB. 1992

2500 0 1250 2500 5000

1 inch = 2500ft.

FIGURE 1-1
SWMU/AOC LOCATION MAP
NAVAL STATION ROOSEVELT ROADS
CEIBA, PUERTO RICO

The United States Environmental Protection Agency (USEPA) has conducted a RCRA Facility Assessment (RFA) (A.T. Kearney, 1988). In 1993, an additional inspection was performed (TRC, 1993). A number of SWMUs and AOCs at NSRR were identified and selected as sites requiring a RCRA Facilities Investigation (RFI). This document is one of the management plans associated with RFI activities.

1.2 Technical Purpose of the Document

This report is designed to satisfy the Draft Corrective Action Requirements (Appendix A, Section IV) for NSRR. It identifies 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. The report also identifies field data requirements for the RFI to facilitate the evaluation and selection of the final corrective measure or measures.

1.3 Additional Purposes of the Document

The scope of this report differs somewhat from a traditional Evaluation of Corrective Measures Technologies Report. This report incorporates the voluminous amount of environmental data that has been generated during previous investigations. The USEPA has reviewed much of this data already, although some of the more recent data associated with the Supplemental Investigation (Baker, 1993; see Section 3.0) the USEPA has not had the opportunity to review as yet.

This report presents the environmental data since it has an impact on the selected scope of work that will be conducted at the SWMUs/AOCs that were former IR Program sites. It is the intent of this document to utilize this existing data to identify environmental media that will require additional investigation and the scope of the required investigations. The planned scope of work for each SWMU/AOC is included to facilitate early agreement on approach between the Department of the Navy and the USEPA in order to reach the remediation stage more quickly.

2.0 FACILITY BACKGROUND

This facility background section includes a description of the NSRR facility, the general physical setting and descriptions of the individual SWMUs/AOCs addressed in this report.

2.1 Description of the Facility

NSRR occupies part of the northern side of the east coast of Puerto Rico, along Vieques Passage with Vieques Island lying to the east about 10 miles off the harbor entrance. The north entrance to NSRR is about 35 miles east along the coast road (Route 3) from San Juan. The closest large town is Fajardo (population about 37,000), which is about 10 miles north of NSRR off Route 3. Ceiba (population about 17,000) adjoins the west boundary of NSRR.

The NSRR occupies over 33,500 acres, with some of the holdings being prepared for release to the Commonwealth of Puerto Rico. NSRR has administrative and command responsibilities for some operations separated from the main base on Vieques Island.

The primary mission of NSRR is provision of full support for Atlantic Fleet weapons training and development activities.

The site of NSRR was first considered for location of a Naval Base in 1919 when no major facilities existed in the area. No development of the area was undertaken until early in the United States involvement in World War II, with the Naval Operating Base being commissioned in 1943 and finally redesignated a naval station in 1957.

2.2 Physical Setting

The physical setting of NSRR was documented in the 1984 IAS (NEESA Document 13-051). This information is summarized below.

2.2.1 Climatology

The climate of the Roosevelt Roads area is characterized as warm and humid, with frequent showers occurring throughout the year. A major factor affecting the weather is the pattern of trade winds associated with the Bermuda High, the center of which is in the vicinity of 30° North, 30° West. The prevailing wind direction reflects the easterly trade winds. The area

receives a surface flow varying between the northeast to the southeast about 75 percent of the year, and as much as 95 percent of the time in July when the easterly winds are strongest. The differential heating of the land and sea during the day tends to give a more northerly component to the flow on the northern side of the island and a more southerly component on the southern side. During the night, a land breeze causes a prevailing southeasterly flow in the north and a prevailing northeasterly flow over the southern coast. The mean annual wind velocity is 5.5 knots, with a minimum in November and a maximum in August. Gales associated with westward moving disturbances in the trade winds or hurricanes passing either north or south of the area have the highest probability of occurrence from June through October.

Uniform temperatures prevail, with small diurnal ranges as a result of insular exposure and the relatively small land areas. The warmest months are August and September, while the coolest are January and February. Mean annual maximum temperatures range from 82.0° in January to 88.2°F in August. The mean annual minimum temperatures vary from 64.0° in January to 73.2° in June. The highest maximum temperature recorded was 95°F, while the lowest minimum was 59°F. Rain usually occurs at least nine days in every month, with an average of 60 inches per year. A dry winter season occurs from December through April. About 22 thunderstorm-days occur per year, with maximum frequencies of three days per month from May through October.

In late summer, the mean sky cover begins a steady decrease from a monthly maximum average of 6.5-tenths coverage in September to a minimum monthly average of 4.4-tenths coverage in February. From March through August, the monthly average clouds over increases steadily from 4.5- to 6.0-tenths coverage during the period. Over the open sea, a maximum of clouds (usually broken stratocumulus) occurs during early morning, with the skies clearing or becoming scattered with cumulus by afternoon. Completely clear or overcast skies are rare during daylight hours, while clear skies frequently occur at night.

The hurricane season is from mid-June through mid-September; maximum winds exceed 95 knots during severe hurricanes. An average of two tropical storms per year occur in the study area, one of which usually reaches hurricane intensity.

2.2.2 Topography

The regional area of Roosevelt Roads consists of an interrupted, narrow coastal plain with small valleys extending from the Sierra de Luquillo range, which has been severely eroded by streams into valleys several hundreds of feet deep. Slopes of up to 60° are common.

In the immediate area of the station, elevations range from sea level to approximately 295 feet. Immediately to the north of the NSRR boundary, the hills rise abruptly to heights of 800 to 1,050 feet above sea level, with the tallest peak located within two kilometers of the station boundary. There is a series of three hilly areas on the station, two of which separate the southern airfield area from the Port/Industrial, Housing and Personnel Support areas. The third set of hills is in the Bundy area. These ridge lines not only separate sections of the station, but dictate the degree of allowable development. The ridge line south of the airfield provides an excellent barrier which effectively decreases the aircraft-generated noise which reaches the Unaccompanied Enlisted Personnel Housing areas to an acceptable level. Relief is low along the shoreline. Lagoons and mangrove swamps are common.

2.2.3 Geology

The underlying geology of the station area is predominantly volcanic (composed of lava and tuff), as well as sedimentary (rocks derived from discontinuous beds of limestone). These rocks all range in age from early Cretaceous to middle Eocene. The volcanic rocks and interbedded limestones have been complexly faulted, folded, metamorphosed and variously intruded by dioritic rocks. This complex geological structuring occurred sometime after the deposition of the limestone during the middle Tertiary, when Puerto Rico was separated from the other major Antillean Islands by block faulting, and was arched, uplifted and tilted to the northeast. Culebra, Vieques, and the Virgin Islands are part of the Puerto Rican block; they are separated from the main island simply because of the drowning that resulted from the tilting.

In addition to the predominant volcanic and sedimentary rock, the northwestern and western sectors of the base are underlain by unconsolidated alluvial and older deposits from the Quaternary period.

The primary geologic formations on and near NSRR are various beach deposits, alluvium, quartz diorite and granodiorite, quartz keratophyre, the Daguao Formation, and the Figuera Lava. The station is traversed by the Peña Pobre fault zone.

2.2.4 Soils

The soil associations found at the station are predominantly of two types typical of humid areas, namely the Swamps-Marshes Association and the Mabi-Rio-Arriba-Cayagua Association, as well as the Descalabrado-Guayama Association, which is typical of dry areas. In addition, isolated areas of the Caguabo-Mucara-Naranjito Association, the Coloso-Toa-Bajura Association, and the Jacana-Amelia-Fraternidad Association are found at the station.

The Swamps-Marshes and Mabi-Rio-Arriba-Cayagua associations cover over one half of station's surface area and are equally distributed. The remaining area is covered primarily by the Descalabrado-Guayama and Caguabo-Mucara-Naranjito associations.

The Swamps-Marshes Association consists of deep, very poorly drained soils. This association is found in level or nearly level areas that are slightly above sea level but are wet, and when the tide is high, are covered or affected by saltwater or brackish water. The soils are sandy or clayey, and contain organic materials from decaying mangrove trees. They are underlain by coral, shells and marl at varying depths. The high concentration of salt inhibits the growth of all vegetation except mangrove trees, and in small scattered patches, other salt-tolerant plants.

The Mabi-Rio-Arriba-Cayagua Association consists generally of deep, somewhat poorly drained and moderately well-drained, nearly level to moderately steep soils found on foot and side slopes, terraces and alluvial fans. Soils of this association at the station are basically clayey.

The Descalabrado-Guayama Association generally consists of shallow, well-drained, strongly sloping to very steep soils on volcanic uplands. Soils of this association are found primarily in the hilly areas located directly inland and adjacent to the soils of the Swamps-Marshes Association.

The Caguabo-Mucara-Naranjito Association consists generally of shallow and moderately deep, well-drained, sloping to very steep soils on volcanic uplands. This association consists of soils which formed in residual material that weathered from volcanic rocks. This association is represented at the station by soils of the Sabana series, which are found on the side slopes and the hilly terrain west of Langley Drive in the Fort Bundy area. These soils are suited for

pasture and woodland. Steep slopes, susceptibility to erosion and depth to bedrock are the main limitations for farming, and for recreation and urban areas.

The Coloso-Toa-Bajura Association consists of deep, moderately well drained to poorly drained, nearly level soils found on floodplains. This soil association extends along the western boundary of the station and around the airfield. The soils of this association formed in fine-textured and moderately fine-textured sediment of mixed origin on floodplains. The Coloso soils are deep and somewhat poorly drained; the Toa soils are deep and moderately well drained; and the Bajura soils and Maunabo soils are deep and poorly drained. The Reilly soils, also part of this association, are shallow sand and gravel and are excessively drained; they lie adjacent to streams. The minor soils are Talante, Vivi, Fortuna, Vega Alta and Vega Baja. The Talante, Vivi, Fortuna and Vega Baja soils are found on floodplains, while the Vega Alta soils occupy slightly higher positions on terraces.

The Jacana-Amelia-Fraternidad Association consists generally of moderately deep and deep, well-drained and moderately well-drained, nearly level to strongly sloping soils on terraces, alluvial fans and foot slopes. This association is represented at the station by soils of the Jacana series, which consist of moderately deep, well-drained soils found on the foot slopes and low rolling hills along Langley Drive and just east of the airfield. These soils formed in fine-textured sediment and residuum derived from basic volcanic rocks.

2.2.5 Hydrology

The surface waters that flow across the northeastern plain of Puerto Rico, where the Station is located, originate on the eastern slopes of the Sierra de Luquillo mountains. Surface runoff is channeled into various rivers and streams which eventually flow into the Caribbean Sea. The Daguao River and Quebrada Seca Stream (a tributary to Rio Daguao) collect surface waters from the hills immediately north of the station, and in periods of heavy rain, on-station flooding occurs. The Daguao-Quebrada Seca watershed comprises an area of approximately 7.6 square miles (4,900 acres), and the river falls some 700 feet from its source to sea level. Increased development in the Town of Ceiba, especially in areas adjacent to the the station's northern boundary, has significantly increased the surface runoff reaching the station, causing ponding and erosion in the Boxer Drive area. Boxer Drive, for a major portion of its length, is subject to surface water flooding, as are Hangar 200 and AIMD Hangar 379 and adjacent apron areas.

In the low-lying shore areas, seawater flooding results from storms, wind and abnormally high tides. The tidal ranges in the Roosevelt Roads area are rather small, with a maximum spring range of less than three feet. The tides are semidiurnal and have a usual range of about one foot in the main harbor of the station.

Little information exists concerning the geohydrology of NSRR. The only known potential sources of groundwater lie in lenticular beds of clay, sand and gravel, and rock fragments which occur at a depth of less than 30 meters. No wells have been developed on-base from these layers. Some wells had been developed upgradient of the station in Ceiba, some three kilometers from base headquarters, but were abandoned due to high levels of salinity. Table 2-1 is a summary of field parameters (pH, specific conductivity and temperature) measured in NSRR monitoring wells during the Supplemental Investigation (Baker, 1993).

The quality of surface waters is variable, reflecting the drainage area through which the water flows. Generally, surface waters have high turbidities and bio-organics (naturally-occurring organics, such as decay products of vegetable and animal matter) due to the periodic heavy rains which can easily erode soils from steep slopes, exposed areas and disturbed stream beds.

Water from alluvial aquifers along the coast of the station is of a calcium bicarbonate type, and has high concentrations of iron and manganese. The source of these minerals is unknown, but they may be derived from buried swamp or lagoon deposits.

A seawater-freshwater interface is present in the aquifers throughout the coastal areas of Puerto Rico, usually within a short distance inland of the coastline.

The station water treatment plant receives its raw water from the Rio Blanco through a 27-inch reinforced concrete pipe that replaced the old, open channel. The intake is located at the foot of the EI Yunque rain forest. This buried raw water line traverses a distance of 14 miles from the intake to the station boundary. A raw water reservoir is located at the water treatment plant and has a 45-million gallon capacity. Additionally, there are two fire protection storage reservoirs with a total capacity of 520,000 gallons.

The base has been served for over 30 years by the present treatment facility. The plant (Building 88) has a capacity of 4.0 million gallons per day (mgd). Water flows by gravity into a 45 million gallon raw water storage basin from which the plant draws its supply at a rate of

TABLE 2-1

SUMMARY OF FIELD PARAMETERS
NAVAL STATION, ROOSEVELT ROADS, PUERTO RICO

Station	November 10, 1992			November 11, 1992			November 18, 1992		
	pH	SC	T	pH	SC	T	pH	SC	T
05GW01					5,000	29.0			
06GW01					4,500	30.0			
R7GW01							6.88 6.92 6.94	14,500 14,500 14,800	30.1 30.0 30.1
R7GW02		9,000	28.0				7.33 7.34 7.45	10,000 10,000 10,000	28.1 27.6 27.6
R7GW03		45,000	28.0				7.09 7.27 7.13	38,500 38,500 38,500	28.4 28.3 27.9
R7GW04		48,500	28.0				6.61 6.88 6.98	48,000 48,000 48,000	29.5 29.6 29.0
R7GW05		18(1)	32.0				6.89 6.85 6.82	19,000 19,000 19,000	31.9 32.0 32.0
R7GW06		20(1)	30.0				7.05 7.04 7.06	5,000 4,395 4,250	30.0 30.0 29.2
R7GW07		8(1)	32.0				7.32 7.33 7.32	2,050 2,000 2,100	29.5 32.0 31.0
R7GW08		28(1)	30.0				7.49 7.49 7.50	>50,000 >50,000 >50,000	30.0 29.5 29.8
18GW01					12,500	29.0	6.98 6.97 6.98 7.00	9,700 12,000 12,500 12,500	28.8 28.8 29.1 28.9
18GW02					23,000	27.0	6.42 6.49 6.64	26,000 26,500 27,000	29.0 27.7 28.0
18GW03					1,000	29.0	7.91 7.60 7.73	1,000 1,000 1,000	24.6 29.0 29.0

TABLE 2-1 (Continued)

SUMMARY OF FIELD PARAMETERS
NAVAL STATION, ROOSEVELT ROADS, PUERTO RICO

Station	November 19, 1992			November 24, 1992			December 1, 1992		
	pH	SC	T	pH	SC	T	pH	SC	T
05GW01	7.01 6.62 7.25	5,500 5,500 5,000	31.0 31.0 31.0				6.97 7.02 7.01	6,000 6,000 6,000	28.5 28.5 28.5
06GW01	7.09 7.09 7.46	3,100 3,900 3,100	33.0 33.0 33.0						
R7GW01									
R7GW02									
R7GW03				7.06 7.08 7.08	200(1) 200(1) 190(1)	27.9 27.8 27.8			
R7GW04									
R7GW05									
R7GW06				6.94 6.97 6.97	12,000 10,500 10,500	28.5 29.1 29.3			
R7GW07									
R7GW08									
18GW01				6.95 6.94 6.96	12,000 12,030 12,050	28.5 28.0 27.8			
18GW02									
18GW03				7.52 7.60 7.62	1,000 1,000 1,000	30.0 31.0 32.0			

Notes: SC = Specific Conductivity in µmhos/cm at ambient temperature.
T = Temperature (°C)
(1) Instrument error.

1.3 mgd on average. Treatment consists of prechlorination, coagulation sedimentation, filtration and post-chlorination.

The single potable water supply system provides water to all industrial operations at the facility. The water supply is low in hardness, and, therefore, is an excellent source for industrial uses, particularly in boiler operation and maintenance.

Three hundred acres are used for pasture near Gate 1, and are irrigated as needed. Extensive sprinkling of lawns and green areas is evident throughout the base.

2.3 SWMU/AOC Descriptions

A complete list of SWMUs/AOCs to be included in the RFI is presented in Table 1-1. This table also lists the RFI requirements for each SWMU/AOC. RFI requirements include:

- First-phase soil RFI -- The purpose of a first-phase RFI is to assess whether there have been releases from these SWMUs/AOCs whose history of use or present condition suggest the possibility. The first-phase RFI differs from a full RFI in the extent and degree of investigations required.

- Full RFI -- Full RFIs will be conducted where releases were established during previous investigations. The purpose of the full RFI is to determine the nature, rate and direction of migration, and extent of migration of hazardous waste or hazardous constituents.

- Contingent -- Status pending other results of activities (interim remedial action, first phase RFI closure, etc.).

A general description of each SWMU/AOC is presented in the following subsections.

2.3.1 SWMU 1 - Former Cremator Disposal Site

According to the 1984 IAS report the Army Cremator disposal area is located south of the intersection of the access road to the Ammo Pier and Langley Drive, west and southwest of the Navy Exchange and Bowling Alley, and near the Ensenada Honda Mangrove Swamp (NEESA, 1984).

This SWMU operated from the early 1940s until the early 1960s and was the main station landfill during this time. Waste material was disposed of by piling, burning and compacting (A.T. Kearney, Inc., 1988). An estimated 100,000 tons of waste including scrap metal, inert ordnance, batteries, tires, appliances, cars, cables, dry cleaning solvent cans, paint cans, gas cylinders, construction debris, dead animals, and residential waste was disposed of at this site (NEESA, 1984). No reliable information exists regarding the amounts of material present in the disposal area that could be hazardous; however, in 1984, the IAS team estimated that as much as 1,000 tons of hazardous material could be present in the area (NEESA, 1984).

In 1984, the IAS team spotted several large mounds of drums during an overflight. An on-ground visual inspection was attempted, but the vegetation was too dense, and the drums could not be located (NEESA, 1984).

In 1988, the RCRA Facility Assessment (RFA) VSI team observed an oily, silver-toned substance floating at the water's edge. Dead mangroves were observed several feet out from the water's edge and extending up and down the shoreline (A.T. Kearney, Inc., 1988). According to a facility representative, this was due to a spill of JP-5 (aviation kerosene) in November of 1986. An area measuring approximately 50 feet in diameter completely devoid of vegetation was found within the boundaries of this unit (A.T. Kearney, Inc., 1984). The area affected by this spill is included in the IR program as Site 14.

In 1988, ESE produced a Confirmation Study report that evaluated the data from two rounds of verification sampling. Five surface water, five sediment and five groundwater samples were collected in each round of sampling.

A total of 21 soil samples and one groundwater sample were collected at this SWMU during the Supplemental Investigation (Baker, 1993).

Geophysical surveys were conducted at this SWMU during the Supplemental Investigation (Baker, 1993). These surveys involved: (1) EMI mapping of contrasts in subsurface material that indicated artificial boundaries, such as trench walls, associated with disposal practices; and, (2) MAG mapping of subsurface metallic objects, usually associated with disposal. A summary of findings appears below.

The traverses followed access lanes cleared by heavy equipment along orientations selected following review of photo-interpretation and map analysis (included in the Supplemental Investigation Report - Appendix A), and according to examination of the exposed parts of the lanes as they were advanced.

Correlation between the disposal features noted by photo-interpretation and the disposal indications found during land-clearing was very high. The indicated disposal features were found on the southwest side in the locations transferred from the aerial photographs to the maps. Similarly, areas indicated by photo-interpretation not to have been used for disposal appeared undisturbed except for top-stripping.

The geophysical interpretation agreed with both the photo-interpretation and the visual inspection of the ground. The geophysical interpretation, however, provided more precise mapping of the disposal feature along the respective traverse line. The geophysical survey also indicated the probable relative concentration of metallic objects in the disposal feature.

2.3.2 SWMU 2 - Langley Drive Disposal Site

The Langley Disposal Site, which is located along Langley Drive approximately 2,000 feet north of the Navy Exchange Complex and 300 feet east of the drive towards Ensenada Honda, operated as a landfill from approximately 1939 to 1959 (NEESA, 1984). The Navy documents this unit as having been used for the disposal of both hazardous and nonhazardous wastes (A.T. Kearney, Inc., 1988).

In 1984, the IAS team performed a site inspection. During the inspection, the IAS team observed partially buried metal and concrete objects, old fuel lines, flexible metal hoses, small containers containing pellets, steel cables, hardened tar, rubble, and ten to fifteen 55-gallon drums that were corroded. The drum contents, usually consisting of a whitish solid with a green outer crust, were exposed (NEESA, 1984). The IAS team estimated the volume of disposed waste to be approximately 1,700 cubic yards, of which approximately 20,000 pounds could be hazardous material.

In 1988, a RFA was performed at this site. The VSI team observed a dump site covering an area of approximately 40 feet x 150 feet. Within the perimeter were lengths of thick cable, broken concrete blocks, ringed metal hoses, and six severely corroded drums. At least one of the drums was filled with a white, damp chalky substance (A.T. Kearney, Inc., 1988).

In 1988, ESE produced a report that evaluated data from two rounds of sampling. Thirty-two soil samples, six sediment, six surface water and one groundwater sample were collected during the two rounds of sampling.

Dense vegetation prevented a detailed inspection during the 1993 RFA reinspection (TRC, 1993).

A total of 16 soil samples and one groundwater sample were collected at this SWMU during the Supplemental Investigation (Baker, 1993).

2.3.3 SWMU 3 - Base Landfill

The Base Landfill (IR Site 7) is located south of the Industrial Area Wastewater Plant (Building 1758) and was operated since the early 1960s. The landfill covers 85 acres, and is separated into several different disposal areas (A.T. Kearney, Inc., 1988). Based on the limited amount of information that exists with regard to the landfill, discrete areas were identified in the IAS as disposal areas. Some of these "areas" are undetectable from the ground. Methods of disposal involved the excavation of a trench to the water table, filling the trench with waste, spreading and compacting the waste with a bulldozer, then covering the waste with soil. It is estimated that from 40 to 60 tons of waste per day were disposed of in the past (A.T. Kearney, Inc., 1988). Wastes that were disposed of at this SWMU include, residential wastes, scrap metal, cables, paint waste, solvents, PCBs, OTTO Fuel II, Agentine, Askarel, pesticides, lubricating oil, unlabeled 55-gallon drums, dead animals, inert ordnance, digested sludge, construction debris, asbestos, and possibly Super Tropical Bleach (STB), a decontaminating agent (NEESA, 1984).

In 1988, an RFA was performed at this SWMU. The VSI team observed one fiberglass drum with a polyethylene liner, and a decaying Volkswagen Beetle (A.T. Kearney, Inc., 1988).

In 1988, ESE produced a report evaluating two rounds of verification sampling and analysis. Eight groundwater monitoring wells were installed, and samples of groundwater were collected and analyzed from each well. In addition, three composite soil samples were collected from the drum ditch (ESE 1988).

Eight groundwater samples were collected from monitoring wells at this SWMU during the Supplemental Investigations (Baker, 1993).

The landfill is still operating and accepting wastes in accordance with EQB regulations. A part of the permitted operation includes regular groundwater monitoring with attendant reporting of results.

2.3.4 SWMU 6 - Building 145

This SWMU comprises IR Site 11. The building is a bunker, approximately 60 yards long, 7 feet high, and 8 feet wide with three openings to the surface through the roof. The openings are covered with dilapidated wood structures. There is one entrance at ground level. The 1984 IAS team reported the presence of approximately sixty 55-gallon drums, one hundred 5-gallon pails, and a number of other small containers (NEESA, 1984). The condition of the containers ranged from being intact and neatly stacked to randomly placed and leaking (A.T. Kearney, Inc., 1988). The 1984 IAS Report stated that the drums and other containers had been in the building for sometime, probably since 1957. Some of the materials identified by the IAS team included spray paint, olive drab paint, black boot polish and some adhesives (NEESA, 1984). The IAS team concluded that the majority of the material (approximately 2,000 gallons) could be classified as hazardous (NEESA, 1984).

In 1988, the RFA Visual Site Inspection (VSI) team reported that Building 145 was empty except for some protective clothing and some water on the floor. There were several old paint covered gloves and pieces of clothing, broken pallets and several empty paint cans outside [the] unit (A.T. Kearney, Inc., 1988). The RFA VSI team indicated that there was no evidence of a release to the environment.

The 1993 RFA reinspection found conditions to be similar to those of 1988 (TRC, 1993).

2.3.5 SWMU 9 - Tank 212-217 Sludge Burial Pits

This SWMU consists of eight fuel storage tanks. Tanks 212 through 215 are located north of Forrestal Drive along Manila Bay Road. Tanks 216 and 217 are located on a hilltop about 4,000 feet southeast of tanks 212 through 215, north of Forrestal Drive (NEESA, 1984). This SWMU comprises IR Site 13.

The 1984 IAS report indicates that these tanks were constructed in 1948 for the storage of AVGAS (aviation gasoline), and that the tanks were cleaned about every five years until 1978. This does not include tanks 210 and 211, which were abandoned in 1950 and probably cleaned only once (NEESA, 1984). This report indicates that cleaning resulted in the removal of 20 to 30 drums (800 to 1,250 gallons) of leaded sludge per tank (NEESA, 1984). The IAS report estimates that between 30,000 and 50,000 gallons of leaded sludge were disposed of at these areas over a 40-year period (NEESA, 1984). This sludge was disposed of in a series of pits 8 feet x 8 feet x 8 feet (A.T. Kearney, Inc., 1988). These pits were located within 300 feet of the tank that was being cleaned. After the sludge settled in the pits, it was covered with three to four feet of soil (A.T. Kearney, Inc., 1988).

The 1988 RFA report indicates a start date of 1940 instead of 1948 as noted in the 1984 IAS report. The VSI team was unable to locate the buried pits during their inspection and the pits remained unlocateable in 1993.

In 1988, ESE performed two rounds of verification sampling at this SWMU. Six sediment samples were collected during each round of sampling (Technical Review Committee Meeting Minutes, 1989). Twelve surface water samples were also collected. Eleven wells were sampled during each round (Technical Review Committee Meeting Minutes, 1989).

2.3.6 SWMU 10 - Substation 2/Building 90

This SWMU comprises IR Site 15, where electrical transformers were formerly repaired, resulting in PCB containing transformer oils being poured on the ground. The soils at this SWMU are being investigated and remediated under the IRP (Section 4.8). Further RFI activities at this SWMU are contingent on the results of this investigation/remediation.

2.3.7 SWMU 11 - Old Power Plant/Building 38

According to the 1984 RFA report, Building 38 was a 60-megawatt steam turbine facility that generated power from the early 1940s through 1949. The facility used Bunker C fuel, which was stored in two 50,000-gallon reinforced concrete tanks located directly northwest of the building. (NEESA, 1984). In the 1979s, Bunker C fuel was observed in manholes near Building 38 during heavy rainfalls. Bunker C fuel was also discharged to the Enlisted Beach through the old cooling water outlet for the Power Plant (NEESA, 1984).

The 1988 RFA report states that this SWMU is TSCA regulated. This was told to the VSI team by a facility representative. Located inside Building 38 is a cyclone fence which surrounds a curbed 8-inch concrete pad. PCB-contaminated items (e.g., old transformers and full 55-gallon drums) are temporarily stored on the concrete pad inside the cyclone fence (A.T. Kearney, Inc., 1988). A Defense Reutilization and Marketing Office (DRMO) contractor disposes these items. The VSI team observed drums that they believed to contain PCB-contaminated soil outside the cyclone fence. The VSI team also observed oil contaminated sorbent inside the fence on the concrete pad (NEESA, 1984). A facility representative told the VSI team that the oil spill inside the fence was from a non-PCB transformer (<50 ppm PCBs) and that laboratory results were pending regarding the contents of the drums located outside of the fence (NEESA, 1984).

In 1988, ESE collected 38 soil samples from the site (9 in Round 1 and 29 in Round 2). These samples were analyzed for PCBs, oil and grease, volatile organic compounds (VOC), ethylene dibromide (EDB), xylenes, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK). In Round 2, an EP toxicity test for lead was completed. The analytical results indicated the presence of PCB and lead contamination at the site. Lead concentrations were less than the EP toxicity standard for lead. Other constituents detected, but not at levels of concern, were MEK as well as oil and grease (Technical Review Committee Meeting Minutes, 1989).

In 1992, Versar prepared a Remedial Investigation/Feasibility Study for this site. During their investigation, Versar collected numerous surface water, sediment, soil, wipe and chip samples. Based on their data and the data collected by ESE in 1988, Versar investigated the feasibility of the three following remedial alternatives:

- Soil excavation, transportation and off-site incineration
- Soil excavation, transportation and off-site land disposal
- Soil excavation and on-site incineration (Versar 1992a)

Of the three, Versar recommended Alternative 2 (soil excavation, transportation, and off-site land disposal).

The 1993 RFA reinspection indicated conditions within the building were similar to those seen in 1988 (TRC, 1993).

Seven surface water and six sediment samples were collected from this SWMU during the Supplemental Investigation (Baker, 1993).

2.3.8 SWMU 12 - Fire Training Pit Oil/Water Separator

This SWMU began operations in 1983; however, the 1984 IAS report does not address this SWMU. The first mention of this SWMU is in the 1988 RFA report. According to the RFA, the fire training pit oil/water separator is an inground concrete tank that measures approximately 7 feet x 30 feet x 10 feet deep. Waste oils are burned at the Fire Training Pit during training exercises, the excess of which is collected in the oil/water separator. Water from this unit is pumped to the Sewer Drainage System (SWMU 38) to be processed by one of the Naval Station wastewater treatment plants. Oils from this unit are pumped back into the Fire Training Pit (SWMU 14). The VSI team observed a ground level opening that was covered by heavy grating. The VSI team also noted an area of dead grass, adjacent to the oil/water separator, and oil stains on the curbing and guardrail uprights (A.T. Kearney, Inc., 1988).

No evidence of releases was seen during the 1993 RFA reinspection (TRC, 1993).

2.3.9 SWMU 13 - Old Pest Control Shop/Building 258

This SWMU comprises IR Site 18. The IAS report describes this SWMU as the following:

- The pest control shop was located at Building 258 from the late 1950s through 1983. Pesticides were stored in Building 258 and also on the parking apron. In 1976, a 55-gallon drum of Malathion, which was stored outside the building, ruptured and the contents spilled onto the ground, eventually washing into the drainage ditch in back of the building. This same ditch received rinse waters from the cleaning of pesticide equipment over a storm drain which discharged to the ditch. Excess pesticides were also poured into this ditch. Past environmental engineering surveys cite numerous aquatic kills due to pesticides entering the ditch. The area surrounding the building is devoid of vegetation, although the drainage ditch does not show any signs of stressed vegetation.

- Pesticides used in the past include DDT, Paris Green, maldane, malathion, and chlordane. There is no information available, either from records or interviewees, regarding the amounts or concentrations of the pesticides used (NEESA, 1984).

In 1988, a RFA was performed at this SWMU. The VSI team noted that a faint but discernible pesticide odor was present behind the building and inside what was then the Diving Club pump room. They did not observe any signs of stressed vegetation. The president of the diving club, Mr. Seufert, reported to the VSI team that club members had decontaminated the inside of the building before occupying it. According to Mr. Seufert, decontamination involved washing the inside walls and floor with bleach before sealing with a vinyl coating. The meeting room was then tiled, but the pump room was not (A.T. Kearney, Inc., 1988).

In 1988, ESE performed two rounds of verification sampling. Fifteen soil samples were collected in Round 1 and analyzed for pesticides at this site. In addition, eight sediment samples were collected at this site (two in Round 1 and six in Round 2) and analyzed for pesticides. A total of eight surface water samples were also collected at this site (two in Round 1 and six in Round 2) and analyzed for pesticides. Three shallow monitoring wells were installed at the site and groundwater samples were collected in Round 2. Groundwater samples were analyzed for pesticides.

Since the 1988 RFA, the building has been demolished. The RFA reinspection of the site found no visible signs of releases (TRC, 1993).

Six groundwater, 11 soil, one surface water and one sediment sample were collected from this SWMU during the Supplemental Investigation (Baker, 1993).

2.3.10 SWMU 14 - Fire Training Pit Area

This SWMU comprises IR Site 17. The IAS report indicated the following about SWMU 14:

- The crash crew training area was operated by the Air Operations Department from early 1960s through 1983.

- Two unlined pits were used in the past for fire fighting training. The first pit, which was approximately 40 feet in diameter, was used from the early 1960s through the beginning of 1983. Assuming 20 years of operation, about 120,000 gallons of waste solvents, fuels, and oils were placed in the pits and set on fire for fire fighting training. Also burned were wood, trash, plastic, fuel filter elements, oily rags, and other debris. The fires were extinguished using aqueous film-forming foam (AFFF) and potassium

bicarbonate (Purple K). Past aerial photographs show drainage from this pit to the ditch along the runway shoulder. The new fire training pit was built at the same location as the old pit. When the new pit was built, all of the oil-stained, contaminated soil was excavated and most likely disposed of in the base landfill.

- The second pit was used temporarily during the construction of the new fire training pit in 1983. This unlined gravel pit has a diameter of 200 feet and was used approximately six times. Approximately 3,000 gallons of waste fuel, oil, and solvents were burned in this area. Only small amounts of fuel were allowed to soak into the ground (NEESA, 1984).

In 1988, a RFA inspection was performed at this SWMU. During the inspection, the VSI team observed that within the concrete curbing of the pit was a metal structure (what appeared to be the tank from a railroad tank car and large pieces of scrap metal) underlain by a layer of ricks which rested on the concrete lining. The metal structure, rocks and concrete curbing were completely black. Immediately adjacent to the pit was an area of darkly stained soil measuring approximately 40 feet by 100 feet. Vegetation was observed to be growing in the stained area adjacent to the pit (A.T. Kearney, Inc., 1988).

The 1993 RFA reinspection found conditions similar to those seen in 1988 (TRC, 1993).

2.3.11 SWMU 23 - Oil Spill Separator Tanks

Located approximately 100 feet inshore from the fuel pier are three oil spill separator tanks which process waste pumped in from the Ships Waste Off-load Barges (SWMU 22). The oil spill separator tanks are large steel boxes that are underlain by a concrete pad with an 8-inch curb (A.T. Kearney, Inc., 1988). Each box has a pipe that extends out laterally from the bottom.

After the water settles to the bottom of the tank, a valve on the pipe is opened, and the contents are allowed to spill out until all the water has been removed. The separated oil is then transferred to the Oil Spill Oil/Water Separator (SWMU 24). This added process of separation is necessary because the majority of liquid pumped up by Donuts (SWMU 21) and SWOBs (SWMU 22) consists of sea water. Each oil spill separator tank is constructed of steel and, according to facility representatives, has a 2,000-gallon capacity (A.T. Kearney, Inc., 1988).

The VSI team noted black staining on the concrete pad, curbing and areas of asphalt around the SWMUs both in 1988 and during the 1993 RFA reinspection (TRC, 1993).

2.3.12 SWMU 24 - Oil Spill Oil/Water Separator and Adjoining Pad

According to the 1988 RFA report, the oil spill oil/water separator is a below ground structure built of concrete with steel grating covering the top at ground level (A.T. Kearney, Inc., 1988). Facility representatives reported to the VSI team that the oil/water separator has a capacity of 1,500 gallons. This unit receives discharge from the Oil Spill Separator Tanks (SWMU 23). After separation, the waste oil is removed by DRMO. The final disposal of wastewater was not determined by the VSI team (A.T. Kearney, Inc., 1988). The VSI team also did not determine if an overflow control device existed at this SWMU. They did not observe any sign of a release at the time of the VSI.

Minor staining around the edge of the separator was observed during the 1993 RFA reinspection (TRC, 1993).

2.3.13 SWMU 25 - DRMO Storage Yard

This unit is an area measuring approximately 40 feet x 100 feet and is located immediately adjacent to the Ignitable Storage Facility (SWMU 18) (A.T. Kearney, Inc., 1988). In 1988, a facility representative stated to the VSI team that this unit was used for hazardous waste storage prior to the use of the Ignitable Storage Facility (SWMU 18) and DRMO Hazardous Waste Storage Facility (SWMU 17) (A.T. Kearney, Inc., 1988). A facility representative told the VSI team that this SWMU was being used to store hazardous materials at the time of the inspection. Evidence of past release was observed during the VSI. Several oil stains, the largest measuring approximately 20 feet in diameter, were observed (A.T. Kearney, Inc., 1988).

During the 1993 RFA reinspection, the area could not be accurately located but may coincide with an area is now used as storage of raw material (TRC, 1993).

2.3.14 SWMU 26 - Building 544 Area

This SWMU is comprised of approximately twenty-five 30-gallon drums, some of which had polyethylene liners (A.T. Kearney, Inc., 1988). The 1988 RFA report indicates that these drums were located behind Building 544 and were surrounded by thick brush (A.T. Kearney, Inc., 1988). The VSI team noted that some of the drums contained engine lubricating oil, and that one of the labels had the number 9150-231-6654 stamped on it (A.T. Kearney, Inc., 1988). The VSI team could not identify the contents in all of the drums because not all of the drums were labeled. The VSI team also observed a tar-like substance leaking onto the ground (A.T. Kearney, Inc., 1988).

In 1992, the Navy conducted a site inspection of this SWMU. The site has changed since the 1988 RFA was issued. Building 544 had been demolished (in approximately 1990). The concrete foundation of Building 544 remains. The drums had been removed. No evidence of stained soil was observed during the 1993 RFA reinspection (TRC, 1993); however, it is possible that the incorrect area was examined.

2.3.15 SWMU 31 - Waste Oil Collection Area/Buildings 31 and 2022

This SWMU is part of IR Site 10. According to the 1988 RFA, the Transportation Shop services Public Works Department vehicles inside Building 31 and in the yard just north of the building. Approximately 30 yards from the Transportation Shop warehouse is a concrete pad used for the temporary storage of 55-gallon waste oil drums, although none were present at the time of the VSI. A 6-inch concrete curb surrounds the pad which measures approximately 13 feet by 20 feet. A steel drainage pipe with a broken valve is set into the curbing, and at the time of the 1988 VSI, was in the open position. The yard surrounding this unit is asphalt. No leakage was evident at the time of the VSI; however, with the drain pipe valve broken in the open position any spills on the concrete pad would flow directly onto the Public Works Department yard (A.T. Kearney, Inc., 1988).

The 1984 IAS report does not specifically discuss SWMU 31 but discusses Building 31. According to the IAS report, the area around Building 31 was used for open storage of drummed material. The IAS report noted the following:

- Near Building 31 approximately 50 drums were found within the vegetation bordering the north side of Building 31 transportation lot. Most of the drums are full to partially

full of unknown contents. The Public Works Department attempted to remove some of these drums; however, the condition of the drums resulted in massive leakage. The spill contaminated a flatbed truck before running onto the ground, staining an approximately 10-foot-diameter circle of soil. An extremely strong creosote or solvent odor was present. These drums and the spill can be easily accessed by base personnel. The spilled material was identified by the Navy as asphalt, and will be sent to Defense Property Disposal Office (DPDO) for sale or reuse. Three drums were not identified and are being held (NEESA, 1984).

In 1988, ESE performed two rounds of verification sampling for IR Site 10 (SWMUs 31 and 32, and AOC B). Groundwater samples were collected from eight wells.

The pad was in full use in 1993 (during the RFA reinspection) and heavy staining both on the pad and around the perimeter was present (TRC, 1993).

Eight soil samples were collected from IR Site 10 during the Supplemental Investigation (Baker, 1993).

2.3.16 SWMU 32 - PWD Storage Yard/Battery Collection Area/Building 31

This SWMU is part of IR Site 10. It consists of a number of batteries that were stored on the bed of a truck and on a pallet on the ground. This SWMU is located approximately 100 yards northeast of the transportation shop warehouse. The 1988 VSI team noted that several dozen batteries were in various stages of decay, but that none of the batteries were corroded to the point of leakage. Most, according to the VSI team, appeared to contain electrolyte. The VSI did not observe any evidence of release.

The 1984 IAS report does not address SWMU 32 specifically, but instead discusses general site conditions around Buildings 25 and 31. The 1984 report notes the following:

- Building 25 was used from 1951 until the structure collapsed in 1979 by the Public Works Supply Department for temporary storage of materials to be turned over to DPDO. According to aerial photographs, the entire area around the building was used for open storage of drummed material from at least 1957.

- The entire area in and around the collapsed building is overgrown with vegetation, although historical aerial photographs show the area to be relatively free of vegetation other than ground cover through 1977. Materials found in and around Building 25 included 20 to 25 apparently empty to partially filled 55-gallon drums; ten to fifteen 5-gallon pails; office furniture; mechanical devices; construction rubble; industrial gas cylinders; asbestos sheeting; fiberglass buoys; and transformers.

- Of particular interest were the 5-gallon pails, the drums, and a large transformer found at the collapsed building. The 5-gallon pails had become corroded, exposing a substance similar to that found at the Langley Drive site. The compound has a green-colored crust about 1/2-inch thick, encasing a white material with the consistency of semi-dry plaster. A large transformer is lying on its side at the east corner of the building. No evidence of oil leakage was apparent.

- Material was also found along the various access roads and consisted of drums, office furniture, asbestos, rubber, and a pole-mounted transformer from which oil has leaked. Some of these areas exhibited stressed vegetation. There are several other areas of disposed material (about five acres) between the access routes. A 1957 photograph was taken by a tenant. Activity shows that the area around Building 145 was used as a general storage area for several hundred drums. During the IAS team's overflight, CONEX containers were also found in a clearing at this area.

In 1988, ESE performed two rounds of verification sampling for IR Site 10 (SWMUs 31 and 32, and AOC B). Groundwater samples were collected from eight wells.

In 1993, the battery storage facility was found to have been moved. The new unit consists of a fiberglass box in which batteries are placed. This box contains any possible leakage.

The 1993 RFA reinspection found no evidence of release in the former SWMU location. It now contains a fiberglass box for battery accumulation and a number of drums containing fuel-contaminated soil (TRC, 1993).

Eight soil samples were collected from IR Site 10 during the Supplemental Investigation (Baker, 1993).

2.3.17 SWMU 33 - AIMD Storage Pad/Building 379

According to the 1988 RFA this unit was located outside, against the northern wall of Building 379. It was described to the VSI team by facility representatives as a temporary hazardous waste storage area (A.T. Kearney, Inc., 1988). This storage area was a curbed concrete pad with a manual overflow control valve. The wastes stored at this SWMU were generated by Aircraft Intermediate Maintenance Department (AIMD) maintenance, and according to the IAS report include wastes generated from cleaning, painting, paint stripping, minor calibration, complete overhaul of avionic components, and battery cleaning and recharging operations (A.T. Kearney, Inc., 1988). During their visit, the VSI team observed beryllium waste, hydraulic fluid and solvents generated from aircraft maintenance (A.T. Kearney, Inc., 1988). The VSI team also observed minor amounts of unidentified damp white powder in the grass several feet outside the storage pad.

In 1988, ESE performed two rounds of verification sampling and analysis.

One soil sample was collected as a background sample in Round 1.

A total of six sediment samples were collected for Site 8 (3 samples during each round).

A total of eight surface waters were collected from Site 8 during both Rounds. Three were collected in Round 1 and five during Round 2.

The 1993 RFA reinspection found the unit empty with some minor staining present in the center of the pad (TRC, 1993). The impacted area is now covered by a building (see Section 6).

2.3.18 SWMU 37 - Waste Oil Storage Area/Building 200

According to the 1988 RFA, this unit consisted of nineteen 55-gallon drums resting on wooden pallets, situated on a raised, covered concrete pad behind Hanger 200. The drums were observed by the VSI team to contain waste gasoline and lubricating oil from AIMD operations.

During the 1988 VSI, minor oil stains were observed on the concrete pad, and a minor area on the nearby grass was observed to have stressed vegetation (A.T. Kearney, Inc., 1988).

In 1988, ESE performed two rounds of verification sampling and analysis.

One soil sample was collected as a background sample in Round 1. This sample was analyzed for oil and grease, lead, VOA, xylene, MEK, and EDB.

A total of six sediment samples were collected for Site 8 (3 samples during each round).

A total of eight surface waters were collected from Site 8 during both Rounds. Three were collected in Round 1 and five during Round 2.

During the 1993 RFA reinspection, the area was found to be well managed. A minor area of stressed vegetation was seen at the rear of the unit. Fresh soil from the area yielded measurable organic vapors (TRC, 1993).

2.3.19 SWMU 39 - Building 3158/Former Battery Drain Area

According to the 1988 RFA, this unit consists of a storage building and covered battery drainage area. This building stores waste batteries and battery acid that are wastes generated by Naval Mobile Construction Battalion (NMCB or "Seabees") operations. The metal battery drain tank (shaped like a funnel) is underlain by a curbed concrete pad. Battery contents are poured into the drain tank and the battery acid is caught below in a container. The curbing around the pad is cracked and stained, indicating that there have potentially been past releases to the soil (A.T. Kearney, Inc., 1988).

The Navy, during a site visit in March 1992, observed no visible signs of release to the soils. This area is no longer used for storage of spent batteries.

The area is no longer used for battery storage according to the 1993 RFA reinspection. It is now employed to store flammable materials. The original pad could not be found (TRC, 1993).

2.3.20 SWMU 41 - Seabee Pesticide Rinse Rack

According to the 1988 RFA, this unit was observed during the VSI to be an uncurbed concrete slab measuring approximately 12 feet x 20 feet that is located directly adjacent to the Seabee Pesticide Storage Building (Building 3152). The drain within this slab is made up of four strips (6 inches wide). Each strip runs parallel to and is located within the perimeter of the slab to form an inner rectangular "frame." The drain is covered by steel grating. The VSI

team was informed by naval personnel that this unit is most commonly used to rinse out the spray trailer which usually contains a mosquito pesticide (A.T. Kearney, Inc., 1988).

The VSI team did not determine if the expired pesticides were washed down the drain of the SWMU or were sent to DRMO. The VSI team did not observe any signs that would indicate a release into the environment (A.T. Kearney, Inc., 1988).

The site is presently unused. Recent dye testing indicates the drain for this unit flows to the base sanitary sewer system which discharges to a permitted outfall (TRC, 1993). Based on this information, SWMU 41 will be removed from the draft permit.

2.3.21 SWMU 46 - Pole Storage Yard Covered Pad

According to the 1988 RFA report, this unit was cited in the NACIP report as a Public Works Department hazardous waste storage area that had been used to store transformers and 55-gallon drums of PCB-contaminated material. The NACIP report further stated that the area showed evidence of oil spillage. A facility representative confirmed that this unit had formerly been used to store transformers during the 1988 VSI. The VSI team observed that this unit was a covered concrete pad, and that it was used for the storage of products including insulators, telephone poles, small cardboard boxes of electrical equipment, and several full 5-gallon pails, one marked as electrical lubricant. The VSI team also noted that the unit was surrounded by a cyclone fence. Telephone poles were piled near the entrance. No evidence of release was observed by the VSI team (A.T. Kearney, Inc., 1988).

During the 1993 RFA reinspection, the pad was observed to be clean with only some wire present (TRC, 1993).

2.3.22 SWMU 50 - Storage Area Behind Building 3166

SWMU 50 consists of an open air, fenced area at the southwest corner of Building 3166, where several 55-gallon containers of assorted materials (one of malathion), plus three transformers, are stored either directly on the ground or on pallets. This SWMU was first identified during the 1993 RFA reinspection. No visual evidences of releases were observed (TRC, 1993).

2.3.23 SWMU 51 - New AIMD Storage Pad/Building 379

SWMU 51 consists of a curbed concrete storage pad located outside Building 379. This storage pad is roofed and enclosed with a cyclone fence. It was first identified during the 1993 RFA reinspection, and is presently utilized by the AIMD facilities in place of SWMU 33. Also present at this SWMU is a 200-gallon tank which touches the storage pad, but is outside the curbed area. The entire pad area is surrounded by asphalt pavement. Oil stains were observed emanating from two drain valves in the curb surrounding this pad, and from the 200-gallon tank located outside the pad curb (TRC, 1993).

2.3.24 Area of Concern (AOC) B - Building 25

This AOC is part of IR Site 10. The 1984 IAS report noted the following:

- Building 25 was used from 1951 until the structure collapsed in 1979 by the Public Works Supply Department for temporary storage of materials to be turned over to DPDO. The entire area around the building was used for open storage of drummed material from at least 1957, according to aerial photographs.

- The entire area in and around the collapsed building is overgrown with vegetation, although historical aerial photographs show the area to be relatively free of vegetation other than ground cover through 1977.

- Materials found in and around Building 25 include 20 to 25 apparently empty to partially filled 55-gallon drums; 10 to 15 5-gallon pails; office furniture; mechanical devices; construction rubble; industrial gas cylinders; asbestos sheeting; fiberglass buoys; and transformers.

- Of particular interest are the 5-gallon pails, the drums, and a large transformer found at the collapsed building. The compound has a green-colored crust about 1/2-inch thick, encasing a white material with the consistency of semi-dry plaster. A large transformer is lying on its side at the east corner of the building. No evidence of oil leakage was apparent (NEESA, 1984).

The 1988 RFA VSI team observed that Building 25 had collapsed. They also noted the following:

- It appeared that the majority of material stored there consisted of old clothing, empty wooden boxes and small empty shells. No sign of release was noted during the VSI; however, it is possible that some amount of material was completely covered by vines and could not be observed during the VSI (A.T. Kearney, Inc., 1988).

Eight soil samples were collected from IR Site 10 during the Supplemental Investigation (Baker, 1993).

2.3.25 Area of Concern C - Transformer Storage Pad

The 1988 RFA report describes this AOC as follows:

- This AOC is comprised of two raised concrete pads that , at the time of the VSI, were used for storage of transformers. During the VSI, 40 transformers were observed to be stored on the storage pad to the south, which measured approximately 20 feet x 50 feet. This pad was covered by ripped canvas stretched over a wooden frame. The north pad was uncovered and contained at least 25 transformers and 20 to 40 batteries. The products stored at this unit were in good condition. Standing oil inside the north pad and release to the soil through a crack in the concrete were observed. Transformers of various sizes were scattered around both the south pad and the north concrete pad.

The 1993 RFA reinspection indicated that the site remains as found in 1988 except more transformers are present (TRC, 1993). Site representatives indicated that transformer removal was imminent (within 30 days).

3.0 NATURE AND EXTENT OF CONTAMINATION

A number of environmental investigations have been conducted at NSRR. These include:

- Initial Assessment Study
- Confirmation Study
- RCRA Facility Assessment (RFA)
- RI/FS at Site 15 (SWMU 10)
- RI/FS at Site 16 (SWMUs 11 and 45)
- Summary and Technical Evaluation Review of Work Performed at SWMUs/AOCs (RFA Reinspection)
- Supplemental Investigation

Each of these investigations are discussed below.

3.1 Initial Assessment Study (IAS)

As part of a Navy-wide program to manage past disposal sites through the Naval Assessment and Control of Installation Pollutants (NACIP) initiated in September 1980, NSRR was designated for an Initial Assessment Study (IAS) of its environment in March 1982 by the Naval Energy and Environmental Support Activity (NEESA), Port Hueneme, California.

The IAS was conducted in 1983 and 1984 by Greenleaf/Telesca Planners, Engineers, Architects (Miami, Florida) and by Ecology and Environment (Buffalo, New York). The IAS consisted of a records search at various government agencies, national and regional archives, and USGS; an on-site survey; and personnel interviews. The study identified sixteen sites that warranted further study under the NACIP Program.

3.2 Confirmation Study (CS)

In May 1986, the CS was performed by Environmental Science and Engineering (ESE) of Gainesville, Florida. Fifteen of the sixteen potentially contaminated sites identified in the IAS were investigated as part of this study; the last site had been cleaned up prior to this study. Two rounds of samples were collected from these sites by ESE. The Confirmation Study Report was completed by April 1988 and indicated that 14 sites required additional effort under the NACIP program.

The results of the CS are presented below.

3.2.1 SWMU 1 - Former Cremator Disposal Site

In 1988, ESE produced a Confirmation Study report that evaluated the data from two rounds of verification sampling. Five surface water, five sediment and five groundwater samples were collected in each round of sampling. The sediment samples contained isolated, low levels of pesticides, and elevated levels of antimony, selenium and methylene chloride (Technical Review Committee Meeting Minutes, 1989). The surface water samples revealed several metals that exceeded ambient water quality criteria. Groundwater samples indicated thallium, copper, arsenic, chromium (total and hexavalent) and selenium in levels that exceeded primary drinking water standards. Low levels of organic compounds were also detected in some of the groundwater samples (Technical Review Committee Meeting Minutes, 1989).

3.2.2 SWMU 2 - Langle Drive Disposal Site

In 1988, ESE produced a report that evaluated data from two rounds of sampling. Thirty-two soil samples, six sediment, six surface water and one groundwater sample were collected during the two rounds of sampling. Elevated levels of lead were found in some soil samples (Technical Review Committee Meeting Minutes, 1989). During Round 2, two soil samples were analyzed for EP Toxicity for lead only. The results of these analyses indicated that the soil samples did not exhibit sufficient levels of lead in the extract to be classified as hazardous waste. Elevated levels of total chromium, copper and selenium were detected in surface water samples (Technical Review Committee Meeting Minutes, 1989).

3.2.3 SWMU 3 - Base Landfill

In 1988, ESE produced a report evaluating two rounds of verification sampling and analysis. Eight groundwater monitoring wells were installed, and samples of groundwater were collected and analyzed from each well. In addition, three composite soil samples were collected from the drum ditch (ESE 1988). The ESE report indicates that only low levels of oil and grease were detected in the soil samples. The report also indicated that low levels of organic compounds, as well as metals concentrations exceeding drinking water criteria were detected in the groundwater samples collected during both rounds of sampling (ESE 1988).

3.2.4 SWMU 9 - Tank 212-217 Sludge Burial Pits

In 1988, ESE performed two rounds of verification sampling at this SWMU. Six sediment samples were collected during each round of sampling (Technical Review Committee Meeting Minutes, 1989). According to ESE, oil and grease were detected in each round, but levels were not significant when shipping activities in the area were considered. Lead was also detected in both rounds, but not in significant levels (Technical Review Committee Meeting Minutes, 1989). Low levels of volatile organic compounds were detected in Round 2, but not in Round 1. Twelve surface water samples were also collected. Two of the six Round 1 samples indicated low levels of oil and grease. Oil and grease were not detected in any Round 2 surface water samples. Low levels of lead were detected in all Round 2 surface water samples. Eleven wells were sampled during each round (Technical Review Committee Meeting Minutes, 1989). During Round 1, four wells contained significant levels of fuel-derived organic constituents. During Round 2, only two of the four wells continued to show significant fuel-derived organic constituents.

3.2.5 SWMU 11 - Old Power Plant/Building 38

In 1988, ESE collected 38 soil samples from the site (9 in Round 1 and 29 in Round 2). These samples were analyzed for PCBs, oil and grease, volatile organic compounds (VOC), ethylene dibromide (EDB), xylenes, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK). In Round 2, an EP toxicity test for lead was completed. The analytical results indicated the presence of PCB and lead contamination at the site. Lead concentrations were less than the EP toxicity standard for lead. Other constituents detected, but not at levels of concern, were MEK as well as oil and grease (Technical Review Committee Meeting Minutes, 1989).

3.2.6 SWMU 12 - Fire Training Pit Oil/Water Separator

In 1988, ESE performed two rounds of verification sampling. Fifteen soil samples were collected in Round 1 and analyzed for pesticides at this site. Several pesticides, including chlordane were detected in the surficial soils in the area adjacent to Building 258. In addition, eight sediment samples were collected at this site (two in Round 1 and six in Round 2) and analyzed for pesticides. Chlordane and other pesticides were detected in the sediment samples collected from the drainage ditch which conveys storm water runoff from the site. A total of eight surface water samples were also collected at this site (two in Round 1 and six in Round 2)

and analyzed for pesticides. Chlordane and other pesticides were detected in the surface water samples collected from the drainage ditch which conveys storm water runoff. Three shallow monitoring wells were installed at the site and groundwater samples were collected in Round 2. Groundwater samples were analyzed for pesticides. A low concentration of DDD (0.0017 µg/L) was detected in one of the three monitoring wells at the site (Technical Review Committee Meeting Minutes, 1989).

3.2.7 SWMU 31 - Waste Oil Collection Areal Buildings 31 and 2022

In 1988, ESE performed two rounds of verification sampling for IR Site 10 (SWMUs 31 and 32, and AOC B). Groundwater samples were collected from eight wells. The results of the analyses indicated that presence of low levels of organic compounds and the presence of some metals at levels that exceeded primary drinking water standards and ambient water quality criteria.

3.2.8 SWMU 32 - PWD Storage Yard/Battery Collection Area/Building 31

In 1988, ESE performed two rounds of verification sampling for IR Site 10 (SWMUs 31 and 32, and AOC B). Groundwater samples were collected from eight wells. The results of the analyses indicated that presence of low levels of organic compounds and the presence of some metals at levels that exceeded primary drinking water standards and ambient water quality criteria.

3.2.9 SWMU 33 - AIMD Storage Pad/Building 379

In 1988, ESE performed two rounds of verification sampling and analysis.

One soil sample was collected as a background sample in Round 1. This sample was analyzed for oil and grease, lead, VOA, xylene, MEK, and EDB. Elevated levels of oil and grease (8.21 mg/kg) were detected in this soil sample.

A total of six sediment samples were collected for Site 8 (3 samples during each round). Oil and grease levels ranged from 59-4740 mg/kg.

A total of eight surface waters were collected from Site 8 during both Rounds. Three were collected in Round 1 and five during Round 2. Significant levels of oil and grease (ranging

from 5 to 102 μ/L) were found in Round 1 samples. Oil and grease were not detected in Round 2 samples. The levels of oil and grease detected were attributed to Building 200 (Technical Review Committee Meeting Minutes, 1989).

3.2.10 SWMU 37 - Waste Oil Storage Area/Building 200

Eight soil samples were collected from IR Site 10 during the Supplemental Investigation (Baker, 1993). Organic contaminants were present in trace concentrations. A risk assessment conducted as part of the Supplemental Investigation indicated that there is no threat to human health or the environment associated with this media.

In 1988, ESE performed two rounds of verification sampling and analysis.

One soil sample was collected as a background sample in Round 1. This sample was analyzed for oil and grease, lead, VOA, xylene, MEK, and EDB. Elevated levels of oil and grease (8.21 mg/kg) were detected in this soil sample.

A total of six sediment samples were collected for Site 8 (3 samples during each round). Oil and grease levels ranged from 69-4740 mg/kg.

A total of eight surface waters were collected from Site 8 during both Rounds. Three were collected in Round 1 and five during Round 2. Significant levels of oil and grease (ranging from 5 to 102 μg/L) were found in Round 1 samples. Oil and grease were not detected in Round 2 samples (Technical Review Committee Meeting Minutes, 1989).

3.3 RCRA Facility Assessment (RFA)

A RFA was conducted at NSRR in 1988 by A.T. Kearney, Inc. (Alexandria, Virginia) for the USEPA.

The RFA was conducted to identify SWMUs and AOCs and assess the potential for release of hazardous wastes and hazardous constituents from these units to the environment. The description of SWMUs and AOCs and the assessment of potential for release was based upon a Preliminary Review (PR) of existing information and a Visual Site Inspection (VSI) of the facility. The primary source of existing information was the Region II office of the

Environmental Protection Agency in New York City, New York. The VSI was conducted August 15 through 22, 1988.

Roosevelt Roads covers an area greater than 33,500 acres and provides general support for numerous tenant activities. Those SWMUs and AOCs identified in this report were concluded to be representative of waste management activities at NSRR. Areas (including process areas, storage facilities, etc.) not observed during the VSI were situated indoors (i.e., fully enclosed) which prevents any possible releases to environmental pathways, and/or had no documented release to the environment associated with them.

Further actions were suggested at 25 of the 47 SWMUs and 4 AOCs. Suggested further actions include soil sampling, groundwater investigations, surface water, and sediment sampling, verification of unit integrity, requests for additional information, suggestions of better facility management, and referral to another agency.

3.4 RI/FS at IR Site 15 (SWMU 10)

An RI/FS was conducted at IR Site 15 by Versar, Inc. (Versar) in 1992.

Versar performed the RI/FS to develop viable remedial alternatives for known polychlorinated biphenyl-contaminated (PCB-contaminated) soil at IR Site 15. This RI/FS was performed according to criteria in the National Contingency Plan (NCP) and guidelines stipulated by the U.S. Environmental Protection Agency (USEPA) in RI/FS guidance documents.

The RI determined that sediment and soil surrounding the immediate area of Substation No. 2 and the transformer pads is contaminated with PCBs at concentrations exceeding ARARs. The depth of contamination is at least 1 foot; however, the presence of coral at a depth of 1 foot prevented deeper sampling. This RI/FS focuses on the soil/sediment operable unit. An estimated 235 cubic yards of soil/sediment were reported to require remediation.

The FS for Site 15 identified three remedial alternatives that survived screening for all nine CERCLA criteria for evaluating and selecting remedial alternatives: overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness and permanence; short-term effectiveness; reduction of mobility, toxicity, and volume; implementability; cost; local government acceptance; and community acceptance. Those alternatives that survived screening are:

Alternative A - soil excavation, shipment, and off-site incineration; Alternative B - soil excavation, shipment, and off-site landfill, and Alternative C - soil excavation and on-site incineration.

Other alternatives were eliminated from consideration for the following reasons: technology not proven at or near full scale; technology not feasible; technology not applicable, not demonstrated, or not commercially available for testing or destroying PCB solid waste; or technology potentially applicable, but requires a successful laboratory or pilot field tests to demonstrate viability.

The remedial technology Versar recommended for Site 15 was Alternative B - soil excavation, shipment, and off-site landfill.

3.5 RI/FS at IR Site 16 (SWMUs 11 and 45)

An RI/FS was conducted at IR Site 16 by Versar in 1992.

Versar performed the RI/FS to develop viable remedial alternatives for known PCB-contaminated soil and concrete at IR Site 16, the Old Power Plant, Building No. 38.

The RI determined that concrete surfaces, and sediment and soil surrounding the immediate area of the Old Power Plant and the transformer pads were contaminated with PCBs at concentrations exceeding ARARs. Additionally, surface water and wipe samples collected from the cooling water tunnel and underground storage tank manways clearly indicate that these areas were contaminated with PCBs and required further investigation as separate operable units. The depth of contamination is at least 1 foot; however, the presence of coral at a depth of 1 foot prevented deeper sampling at that time. The RI/FS focused on the soil/sediment operable unit. An estimated 986 cubic yards of soil/sediment were reported to require remediation; 20,000 square feet of concrete were reported to require remediation.

The FS for Site 16 identified three remedial alternatives that survived screening for all nine CERCLA criteria for evaluating and selecting remedial alternatives: overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements; long-term effectiveness and permanence; cost; local government acceptance; and community acceptance. Those alternatives that survived screening are: Alternative A -

soil excavation, shipment, and off-site incineration; Alternative B - soil excavation, shipment, and off-site landfill, and Alternative C - soil excavation and on-site incineration.

Other alternatives were eliminated from consideration for the following reasons: technology not proven at or near full scale; technology not feasible; technology not applicable, not demonstrated, or not commercially available for testing or destroying PCB solid waste; or technology potentially applicable, but requires a successful laboratory or pilot field tests to demonstrate viability.

The remedial technology Versar recommended for Site 16 was Alternative B - soil excavation, shipment, and off-site landfill.

3.6 Supplemental Investigation

Baker conducted a Supplemental Investigation of selected IR sites at NSRR in 1993. Field activities were conducted in late 1992. The subject sites were:

Site 5 - Army Cremator Disposal Area
Site 6 - Langley Drive Disposal Area
Site 7 - Station Landfill
Site 10 - Building 25 Storage Area
Site 13 - Tanks 210-217
Site 14 - Ensenada Honda Shoreline and Mangroves
Site 16 - Old Power Plant, Building 38
Site 18 - Building 128, Pest Control Shop and Surrounding Area

IR Site 1 (Quebrada Disposal Site) and IR Site 2 (Mangrove Disposal Site) are both located on Vieques Island. These sites were investigated as part of the Supplemental Investigation. These sites are CERCLA sites and not included in the Draft RCRA Part B Permit, Corrective Action Module III. Therefore, no further discussion will be included on these sites.

These sites correspond to the following SWMUs/AOCs listed on the draft RCRA Corrective Action Permit for NSRR:

Site 5 - SWMU 1
Site 6 - SWMU 2
Site 7 - SWMU 3
Site 10 - SWMUs 31 and 32, AOC B
Site 13 - SWMU 9

Site 16 - SWMUs 11 and 45
Site 18 - SWMU 13

The Supplemental Investigation included the following activities:

- Photo-interpretation and map analysis
- Geophysical investigation
- Wellhead tests
- Soil sampling and analysis
- Groundwater sampling and analysis
- Surface water/sediment sampling and analysis
- Quantitative risk assessment

The analytical sequences for each matrix, regardless of site, included VOC - volatile organic compounds of the Target Compound List (TCL); SVOC - semivolatile organic compounds of the TCL; P/PCB - pesticide and polychlorinated biphenyl compounds of the TCL; TAL - metals and cyanide of the Target Analyte List. Quality control of analyses was specified at NEESA Level D, equivalent to CLP procedures at EPA Level 4.

The complete Supplemental Investigation Report is presented in Appendix A. Analytical results for Sites 7, 16, and 21 (not included in the original report) are presented in Appendix B. The results of the Supplemental Investigation are summarized in the subsections which follow.

The results of the Supplemental Investigation for each SWMU are summarized below.

SWMU 1 - Former Cremetor Disposal Site

A total of 21 soil samples and one groundwater sample were collected at this SWMU during the Supplemental Investigation (Baker, 1993). Trace organic contaminants were detected in each media. The results of a risk assessment conducted as part of the Supplemental Investigation indicate that there is no threat to human health or the environment associated with these media.

SWMU2 - Langley Drive Disposal Site

A total of 16 soil samples and one groundwater sample were collected at this SWMU during the Supplemental Investigation (Baker, 1993). Organic contaminants were detected in each media. The results of a risk assessment conducted as part of the Supplemental Investigation indicate that there is no threat to human health or the environment associated with these media.

SWMU 3 - Base Landfill

Eight groundwater samples were collected from monitoring wells at this SWMU during the Supplemental Investigations (Baker, 1993). Trace concentrations of organic contaminants were detected.

SWMU 11 - Old Power Plant/Building 38

Seven surface water and six sediment samples were collected from this SWMU during the Supplemental Investigation (Baker, 1993). Organic contaminants were detected in both media.

SWMU 12 - Fire Training Pit Oil/Water Separator

Six groundwater, 11 soil, one surface water and one sediment sample were collected from this SWMU during the Supplemental Investigation (Baker, 1993). Organic contaminants were detected in all media. A risk assessment conducted as part of the Supplemental Investigation indicated that there is no threat to human health or the environment associated with these media.

SWMU 31, 32 and AOC B (IR Site 10)

Eight soil samples were collected from IR Site 10 during the Supplemental Investigation (Baker, 1993). Organic contaminants were present in trace concentrations. A risk assessment conducted as part of the Supplemental Investigation indicated that there is no threat to human health or the environment associated with this media.

The following excerpt is the summary section of this report:

> In general, many of the SWMUs/AOCs have significant gaps in the data base which results in incomplete characterization, and precludes making decisions or taking effective remedial action. This commonly results from the following:
>
> - Lack of inadequate number of samples collected.
> - Inadequate type(s) of analyses.
> - Not all potentially impacted media were investigated.
> - Not enough information was available to make any conclusions.
> - Not enough information has been gathered to prepare a remedial design.
>
> For example, at SWMU 1, sampling of the area that was completely devoid of vegetation was never performed. At SWMU 11, sampling was done for PCBs only. Sampling did not include lead and MEK even though these contaminants were detected in earlier sampling events. In another example, SWMU 45, numerous surface water, sediment, soil, wipe and chip samples were collected. But, groundwater was not investigated even though there was reason to believe it could be impacted. In some cases conclusions or recommendations could not be made due to lack of any information.
>
> Numerous SWMUs/AOCs were also effectively characterized. These SWMUs/AOCs have been adequately addressed either because there were no significant operations or releases related to the SWMU, or because the SWMU has been decommissioned. For instance, SWMU 5 consisted of dumpsters. Because no hazardous material was handled at these sites and because they are maintained, no further action is necessary. SWMU 21, Donuts 1-4, is an example of where the site has been adequately addressed because the SWMUs are no longer in operation. One issue that affects all SWMUs/AOCs is that background samples were not collected in the vicinity of the SWMUs/AOCs in question.
>
> The site visit was conducted between June 1 and June 4, 1993. During this visit, TRC discovered five new SWMUs. TRC also discovered that some SWMUs had been relocated. For example, SWMU 33, AIMD Hazardous Waste Storage Pad, had been moved to the other side of the AIMD Building. The new area was considered a new SWMU (SWMU 55). Some additional SWMUs were observed to need additional work. AOC C, Transformer Storage Area, for example, was heavily stained and had evidence of releases. Other SWMUs were observed to be clean (visually) and were recommended for no further action. For example, SWMU 42, Water Treatment Plant Sludge Lagoons, had no staining, stressed vegetation, odors, or any other sign that would indicate a release. As a result, no further action was recommended at this SWMU. It should be noted, however, that TRC's site visit was a visual inspection and that the "absence of evidence" does not necessarily mean the "evidence of absence." This should be considered when needs for corrective action are determined (TRC, 1993).

3.7 Summary and Technical Review of Work Performed at SWMUs/AOCs

TRC Environmental Corporation (TRC) prepared this summary report for USEPA in 1993 to assess the investigation and/or remedial work done on the 51 SWMUs and AOCs at NSRR. This has been referred to as the RFA reinspection.

This included a review of all available technical documents presenting the remedial investigation and corrective measures conducted at the facility and a site visit (conducted June 1-4, 1993).

3.7.1 Summary of the Supplemental Investigation

The objectives of the Supplemental Investigation were to:

1. Verify the data collected during the Confirmation Study (CS) by developing a defensible database;

2. Collect limited data for preparation of a RCRA Facilities Investigation (RFI) at certain sites; and,

3. Provide usable and defensible data for developing the RFI.

The relevant findings, presented as the conclusions of the Supplemental Investigation, are:

- Adequate information is available for characterization of Sites 5, 6, 10, 14, and 18.

- Further investigations of site conditions are unnecessary, considering the absence of risk calculated from the available information.

These conclusions and recommendations refer mainly to the Sites 5, 6, 10, 14, and 18 which were, at the time of this investigation, under review for design of an RFI. The information for the remaining sites was submitted to the programs relevant to those sites (e.g., UST program). Analytical results for these additional sites are provided in Appendix B.

4.0 SWMU/AOC STATUS

This section presents a summary of SWMU/AOC status with respect to existing information. It also includes a discussion of media requiring corrective measures (if any) at each SWMU/AOC.

4.1 First Phase RFI SWMUs/AOCs

There are a number of SWMUs/AOCs at NSRR that, according to the Draft Corrective Action Permit, will require a first phase RFI. These SWMUs/AOCs are listed on Table 4-1. They were selected for first phase RFI due to the limited information regarding possible releases at these sites.

First phase RFIs are limited to sampling and analysis of certain environmental media, primarily soil. The purpose of the first phase RFI is to assess whether there have been releases from these SWMUs/AOCs. The first phase RFI differs from a full RFI in the extent and degree of investigations required. Pending the results of the first phase RFI, a full RFI may be required for the SWMUs/AOCs listed in Table 4-1.

4.2 SWMU 1 - Army Cremator Disposal Site (IR Site 5)

4.2.1 Site Status

The Draft Corrective Action Permit has identified this SWMU as requiring a full RFI including soil, groundwater, and surface water/sediment samples. Soil and groundwater samples were collected from this SWMU during the Supplemental Investigation. Laboratory analytical results for these samples are included in Tables 4-2 and 4-3. Complete results of the Supplemental Investigation are provided in Appendix A (Supplemental Investigation Report).

The sample analytical results indicate the following:

Groundwater

VOC were not detected. SVOC data are unreliable, but do not indicate significantly high concentrations. Pesticides were found as a trace concentration of heptachlor. Inorganic cations of the TAL in the dissolved fraction (the part of the sample relevant to groundwater

TABLE 4-1

SWMUs REQUIRING FIRST PHASE RFI

SWMU	Name
6	Building 145
12	Fire Training Pit Oil/Water Separator
13	Old Pest Control Shop/Building 258
14	Fire Training Pit Area
23	Oil Spill Separator Tanks
24	Oil Spill Oil/Water Separator and Adjoining Pad
25	DRMO Storage Yard
26	Building 544 Area
29	Industrial Area Wastewater Plant
31	Waste Oil Collection Area/Buildings 31 and 2022
32	PWD Storage Yard/Battery Collection Area/Building 31
33	AIMO Storage Pad/Building 379
37	Waste Oil Storage Area/Building 200
41	Seabee Pesticide Rinse Rack
46	Pole Storage Yard Covered Pad
50	Storage Area Behind Building 3166
51	New AIMO Storage Pad/Building 379
52	Drum Storage Pad Near Building 3158
55	Area of Concern C

TABLE 4 - 2
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 1 (IR SITE 5) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	05 GW 101A	05 GW 101B	05 SS 126	05 SS 127	05 SS 128	05 SS 129	05 SS 130
UNITS	ug/L	ug/L	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
VOLATILES							
Acetone	NA	NA	73 J	160 J	170 UJ	12 U	38 J
Carbon disulfide	NA	NA	14	21	10	10	18
Methylene chloride	NA	NA	31 U	19 U	35 U	51 NA	28 U
PESTICIDES/PCBs							
BHC,beta-	0.05 U	NA	2 U	1.9 U	2 U	2.1 U	21 U
BHC,delta-	0.05 U	NA	0.097 U	1.9 U	2 UJ	0.19 J	21 UJ
BHC,gamma-	0.05 U	NA	2 U	1.9 U	2 U	2.1 U	21 U
Chlordane,gamma-	0.05 U	NA	2 U	1.9 U	2 UJ	2.1 UJ	21 U
DDD,4,4-	0.1 U	NA	1.8 J	3.7 U	0.26 J	4.1 U	180 NJ
DDE,4,4-	0.1 U	NA	5.5	0.49 J	2.2 J	1.2 J	480 J
DDT,4,4-	0.1 U	NA	2.1 J	0.31 NJ	2.9 J	2.6 J	3500 CD
Dieldrin	0.1 UJ	NA	3.8 UJ	3.7 U	3.9 U	4.1 U	40 U
Endosulfan I	0.05 U	NA	2 U	1.9 U	2 U	2.1 U	21 U
Endrin	0.1 U	NA	0.12 NJ	3.7 U	3.9 U	0.39 J	40 U
Endrin aldehyde	0.1 U	NA	3.8 U	3.7 U	3.9 U	4.1 U	40 U
Heptachlor	0.0032 J	NA	2 UJ	1.9 UJ	2 UJ	2.1 UJ	21 U
Heptachlor epoxide	0.05 U	NA	2 U	1.9 U	2 U	2.1 U	21 U
Methoxychlor	0.5 UJ	NA	0.44 NJ	19 U	21 UJ	21 U	210 U
SEMIVOLATILES							
Bis(2-ethylhexyl)phthalate	3 J	NA	1500 U	1500 U	1500 U	1500 U	430 J

Qualifiers:

C - results were confirmed by GC/MS

D - parameter identified in an analysis at a secondary dilution factor

J - estimated value

NA - not analyzed

NA* - No Action, sample result for the contaminant is not qualified with any blank qualifiers

NJ - presumptive evidence for the presence of the parameter at an estimated value

U - not detected

UJ - reported quantitation limit is estimated

TABLE 4 - 2 (cont.)
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 1 (IR SITE 5) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	05 SS 131	05 SS 132	05 SS 133	05 SS 134DUP (05 SS 133)	05 SS 135	05 SS 136	05 SS 137DUP (05 SS 136)
UNITS	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
VOLATILES							
Acetone	12 U	48 J	260 J	120 J	13 U	54 J	47 J
Carbon disulfide	10	10	2 J	3 J	6 U	3 J	6
Methylene chloride	19 U	29 U	27 U	31 U	8	28 U	17 U
PESTICIDES/PCBs							
BHC,beta-	20 U	2.1 UJ	2.1 U	2.1 U	2.1 U	2 U	2 U
BHC,delta-	20 U	2.1 UJ	2.1 U	2.1 U	2.1 U	2 U	2 U
BHC,gamma-	20 U	2.1 UJ	2.1 U	2.1 U	2.1 U	2 U	2 U
Chlordane,gamma-	20 U	2.1 UJ	2.1 U	0.086 J	2.1 UJ	2 U	2 U
DDD,4,4-	44 NJ	4.1 UJ	0.23 J	1 NJ	4 U	3.8 U	3.8 U
DDE,4,4-	210	0.63 J	1.2 J	5.8	4 U	3.8 U	3.8 U
DDT,4,4-	1500 CD	0.49 J	1.2 J	5.4	4 U	3.8 U	3.8 U
Dieldrin	38 U	4.1 UJ	4.2 U	4.2 U	4 U	3.8 U	3.8 U
Endosulfan I	20 U	2.1 UJ	2.1 U	2.1 U	2.1 U	2 U	2 U
Endrin	38 U	4.1 UJ	4.2 U	4.2 U	4 U	3.8 U	3.8 U
Endrin aldehyde	38 U	4.1 UJ	4.2 U	4.2 U	4 U	3.8 U	3.8 U
Heptachlor	20 U	2.1 NJ	2.1 UJ	2.1 UJ	0.12 J	2 UJ	2 UJ
Heptachlor epoxide	20 U	2.1 UJ	2.1 U	2.1 U	2.1 U	2 U	2 UJ
Methoxychlor	200 U	21 UJ	22 UJ	22 UJ	21 U	20 U	20 U
SEMIVOLATILES							
Bis(2-ethylhexyl)phthalate	1500 U	1500 U	1700 U	1900	1600 UJ	400 J	440 J

Qualifiers:

C - results were confirmed by GC/MS

D - parameter identified in an analysis at a secondary dilution factor

J - estimated value

NA - not analyzed

NA* - No Action, sample result for the contaminant is not qualified with any blank qualifiers

NJ - presumptive evidence for the presence of the parameter at an estimated value

U - not detected

UJ - reported quantitation limit is estimated

TABLE 4 - 2 (cont.)
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 1 (IR SITE 5) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	05 SS 138	05 SS 139	05 SS 142	05 SS 143	05 SS 140C Background	05 SS 140D Background	05 SS140E Background
UNITS	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
VOLATILES							
Acetone	83 J	12 UJ	NA	NA	NA	NA	NA
Carbon disulfide	6 U	6 U	NA	NA	NA	NA	NA
Methylene chloride	6 U	6 U	NA	NA	NA	NA	NA
PESTICIDES/PCBs							
BHC,beta-	1.9 UJ	2 U	1.1 J	2.2 U	1.9 U	1.8 U	1.8 U
BHC,delta-	1.9 U	2 UJ	0.86 J	2.2 U	1.9 U	1.8 U	1.8 U
BHC,gamma-	1.9 UJ	2 U	0.13 NJ	2.2 U	1.9 UJ	1.8 UJ	1.8 UJ
Chlordane,gamma-	1.9 U	2 U	4.2 J	2.2 U	1.9 UJ	1.8 U	0.24 J
DDD,4,4-	3.7 U	3.8 U	8.2 U	0.75 NJ	3.6 U	3.5 U	3.6 U
DDE,4,4-	3.7 U	3.8 UJ	8.2 U	4.3 U	3.6 UJ	3.5 UJ	3.6 U
DDT,4,4-	0.11 NJ	3.8 U	8.2 U	4.3 U	0.2 J	0.16 J	3.6 U
Dieldrin	3.7 UJ	3.8 UJ	4.2 UJ	2 J	3.6 U	3.5 U	3.6 U
Endosulfan I	1.9 UJ	2 UJ	1.5 NJ	2.8 NJ	1.9 UJ	1.8 UJ	1.8 UJ
Endrin	3.7 U	3.8 U	8.2 UJ	4.3 U	0.12 J	3.5 U	3.6 U
Endrin aldehyde	3.7 U	3.8 U	8.2 U	4.3 U	3.6 U	0.14 J	3.6 U
Heptachlor	1.9 UJ	2 U	0.42 J	2.2 U	1.9 U	1.8 U	1.8 UJ
Heptachlor epoxide	1.9 U	2 U	4.2 UJ	0.46 NJ	1.9 UJ	1.8 U	1.8 U
Methoxychlor	19 UJ	20 UJ	1.5 J	22 UJ	19 U	1.9 UJ	0.23 NJ
SEMIVOLATILES							
Bis(2-ethylhexyl)phthalate	1500 U	420 J	NA	NA	NA	NA	NA

Qualifiers:

C - results were confirmed by GC/MS

D - parameter identified in an analysis at a secondary dilution factor

J - estimated value

NA - not analyzed

NA* - No Action, sample result for the contaminant is not qualified with any blank qualifiers

NJ - presumptive evidence for the presence of the parameter at an estimated value

U - not detected

UJ - reported quantitation limit is estimated

TABLE 4 - 3

INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER AND SOIL

SWMU 1 (IR SITE 5) - NAVAL STATION ROOSEVELT ROADS

PUERTO RICO

SAMPLE ID	05 GW 101A	05 GW 101B	05 SS 126	05 SS 127	05 SS 128	05 SS 129	05 SS 130
UNITS	ug/L	ug/L	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
INORGANICS							
Aluminum	598 J	79.9 U	17100	6240	18200	40700	22600
Antimony	47.2 U	47.2 U	11.1 U	10.6 U	11.5 U	11 U	11.2 U
Barium	164 B	155 B	180	144	143	166	174
Beryllium	0.6 U	0.6 U	0.73 B	0.2 B	1.2	0.86 B	1.2
Cadmium	2.8 U	2.8 U	1.3	0.63 U	1.4	1.7	1.7
Calcium	158000	145000	9110	5430	6030	12500	8360
Chromium	10.3 UJ	10.3 UJ	13.9 J	2.8 J	16.4 J	35.7 J	24.2 J
Cobalt	9.6 U	9.6 U	16	18.8	24.8	23.8	24.1
Copper	5.9 B	6.8 B	131 J	53.3 J	57.4 J	106 J	68.5 J
Iron	857 J	51.8 B	31700	8630	41500	48800	47900
Lead	1.8 U	1.8 U	39.6 *	5.9 *	9.1 *	4.6 *	18.1 *
Magnesium	150000	143000	4550	5510	3710	5730	3550
Manganese	162 J	97.7	381 J	620 J	1140 J	848 J	994 J
Nickel	18.7 U	18.7 U	9.3 B	4.2 U	4.6 U	13.3	10
Potassium	1220 U	1180 U	315 U	245 U	299 U	371 U	430 U
Selenium	2.4 UJ	4.8 U	0.56 UJ	0.54 UJ	0.59 UJ	0.56 UJ	0.57 UJ
Silver	6.3 U	6.3 U	1.7 B	1.7 B	1.5 U	1.5 U	1.5 U
Sodium	1040000 J	1030000 J	1220	750 B	1400	2810	1640
Thallium	1.5 UJ	16.5 J	0.35 UJ	0.34 U	0.37 U	0.35 U	0.36 U
Vanadium	41.7 B	20.3 B	112 J	39.1 J	210 J	223 J	239 J
Zinc	25.8	12.1 U	84.9	28.6	31.9	42.2	63.8

Qualifiers:

B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit

J - estimated value

NA - not analyzed

U - not detected

UJ - reported quantitation limit is estimated

* - duplicate analysis is greater than control limit

TABLE 4 - 3 (cont.)
INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 1 (IR SITE 5) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	05 SS 131	05 SS 132	05 SS 133	05 SS 134DUP (05 SS 133)	05 SS 135	05 SS 136	05 SS 137DUP (05 SS 136)
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
INORGANICS							
Aluminum	6920	8220	12800	9430	38500	14000	32800
Antimony	11.4 U	11.9 U	12.1 U	12.1 U	5.9 J	3 J	3.2 J
Barium	123	143	114	195	131	385	366
Beryllium	0.84 B	0.69 B	0.96 B	0.72 B	1.3	0.9 B	1 B
Cadmium	0.72 B	0.71 U	0.9 B	0.72 U	4.6	2.4	4.2
Calcium	6320	10800	5660	11200	3420	2210	2750
Chromium	14.9 J	20.5 J	33.3 J	21.3 J	19.5	9.6	15.3
Cobalt	22.5	34.6	35.5	33.8	24.5	16.5	17.5
Copper	25.8 J	91.6 J	141 J	93.6 J	35.3	31.6	45.4
Iron	19400	13300	25900	17900	69900	38600	62200
Lead	4.7 *	2 *	3.1 *	25.4 *	2.1 J	2 J	1.9 J
Magnesium	3360	5600	6910	5340	5250	5350	6310
Manganese	876 J	776 J	971 J	1450 J	1170	508	407
Nickel	4.9 B	18.8	20.8	17.5	4.7 U	4.5 U	4.4 U
Potassium	316 U	462 U	606 U	569 U	742 B	580 B	633 B
Selenium	0.58 UJ	0.61 UJ	0.62 UJ	0.62 UJ	0.6 U	0.57 U	0.56 UJ
Silver	1.6 B	2.3 B	1.6 U	1.6 U	1.1 UJ	1.1 UJ	1.1 UJ
Sodium	730 B	3700	3010	2230	2440 J	4370 J	4830 J
Thallium	0.36 U	0.38 U	0.38 U	0.38 U	0.38 UJ	0.36 UJ	0.35 UJ
Vanadium	131 J	108 J	160 J	116 J	195	134	176
Zinc	20.2	31.6	44.7	68.8	44.2	28.5	37.3

Qualifiers:
B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit
J - estimated value
NA - not analyzed
U - not detected
UJ - reported quantitation limit is estimated
* - duplicate analysis is greater than control limit

TABLE 4 - 3 (cont.)
INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 1 (IR SITE 5) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	05 SS 138	05 SS 139	05 SS 142	05 SS 143	05 SS 140C Background	05 SS 140D Background	05 SS140E Background
UNITS	mg/Kg	mg/Kg	ug/Kg	ug/Kg	mg/Kg	mg/Kg	mg/Kg
INORGANICS							
Aluminum	9180	17700	NA	NA	6880	8720	5770
Antimony	2.3 U	2.3 U	NA	NA	10.6 U	10.6 U	10.6 U
Barium	46.5	132	NA	NA	92.5	141	101
Beryllium	0.69 B	0.63 B	NA	NA	0.39 B	0.46 B	0.42 B
Cadmium	1.3 UJ	1.3 UJ	NA	NA	0.63 U	0.63 U	0.63 U
Calcium	2920	6000	NA	NA	4520	4730	3390
Chromium	13.5	51.7	NA	NA	9 J	8 J	5.8 J
Cobalt	16.6	16	NA	NA	15.6	19.3	15.8
Copper	19.9	33.4	NA	NA	19.6 J	28.8 J	16.1 J
Iron	19700	27200	NA	NA	10300	12700	9250
Lead	1.9 J	1.6 J	NA	NA	4.1 *	4.7 *	3.1 *
Magnesium	4720	10200	NA	NA	2930	2860	2470
Manganese	735	656	NA	NA	696 J	976 J	764 J
Nickel	4.3 U	10.8	NA	NA	4.2 U	4.2 U	5.2 B
Potassium	320 B	205 U	NA	NA	1020 B	923 B	1310
Selenium	0.55 UJ	0.55 UJ	NA	NA	0.54 UJ	0.6 J	0.54 UJ
Silver	1 UJ	1 UJ	NA	NA	1.9 B	1.4 U	2.4
Sodium	4840 J	6520 J	NA	NA	500 U	575 U	507 U
Thallium	0.34 UJ	0.34 UJ	NA	NA	0.34 U	0.34 U	0.34 UJ
Vanadium	84.5	80.7	NA	NA	43.4 J	49.4 J	44.4 J
Zinc	18.8	49.4	NA	NA	24.6	38.6	22.4

Qualifiers:
B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit
J - estimated value
NA - not analyzed
U - not detected
UJ - reported quantitation limit is estimated
* - duplicate analysis is greater than control limit

transport and to consumption of groundwater) are in the range expected to be seen in groundwaters occupying shoreline deposits developed from a ferromanganous, igneous rock.

Soil

VOC were found in trace to moderate concentrations (acetone, carbon disulfide and methylene chloride) in all samples from the disposal area; the highest concentrations (station 05SS104 with samples 05SS133 and 05SS134) were found near the disposal trenches identified in the aerial photographs, by the geophysical survey and by inspection of the ground. Acetone, carbon disulfide and methylene chloride are common laboratory contaminants. SVOC data are unreliable, but do not indicate significantly high concentrations. P/PCB were found in trace to high concentrations; the highest concentration (4,4'-DDT) was found at one station (05SS103 with samples 05SS130 and 05SS131) sited in a disposal trench. Inorganic cations of the TAL are in the range expected to be seen in unconsolidated material developed from a ferromanganous, igneous rock.

4.2.2 Media Potentially Requiring Corrective Measures

In accordance with the Draft Corrective Action Permit (Module III, Section A.4, page 23) results of the Supplemental Investigation can be used to satisfy RFI requirements for this SWMU. The results of these analyses indicate the following:

- Soil at this SWMU has been adequately characterized. Twenty-one soil samples were collected. Laboratory analytical results indicate that there is no risk to human health or the environment associated with this media.

- Groundwater at this SWMU has not been adequately characterized. One groundwater sample was collected. A trace level of heptachlor (0.0032J) was the only organic contaminant detected in this sample. Additional groundwater samples will be required to fully characterize this media.

- Surface water/sediment at this SWMU has been adequately characterized. Surface water/sediment samples were collected during the Supplemental Investigation at nearby IR Site 14. Laboratory analytical results indicate that there is no risk to human health or the environment associated with this media.

4.3 SWMU 2 - Langley Drive Disposal Site (IR Site 6)

4.3.1 Site Status

The Draft Corrective Action Permit has identified this SWMU as requiring a full RFI including soil, groundwater and surface water/sediment samples. Soil and groundwater samples were collected from this SWMU during the Supplemental Investigation. Analytical results are included in Tables 4-4 and 4-5. Complete results of the Supplemental Investigation are provided in Appendix A (Supplemental Investigation Report).

The sample analytical results indicate the following:

Groundwater

VOC were not detected. SVOC data are unreliable, but do not indicate significantly high concentrations. P/PCB were not found. Inorganic cations of the TAL in the dissolved fraction (the part of the sample relevant to groundwater transport and to consumption of groundwater) are in the range expected to be seen in groundwaters occupying shoreline deposits developed from a ferromanganous, igneous rock.

Soil

VOC were found as acetone, benzene, 2-butanone, ethylbenzene, methylene chloride, toluene and (o-,m-,p-)xylene in trace to moderate concentrations; the highest concentrations were found in samples 06SS142 from station 06SS101, 06SS145 from station 06SS103, 06SS147 from station 06SS104, 06SS150 and 06SS151 from station 06SS105, and 06SS153 and 06SS154 from station 05SS106 (stations 06SS101, 103 and 105 are off the front slope of the disposal face; stations 06SS102, 104 and 106 are within the disposal area). SVOC data are unreliable, but do not indicate significantly high concentrations. P/PCB were found randomly in trace to low concentrations. Inorganic cations of the TAL are in the range expected to be seen in unconsolidated material in a coastal margin developed from a ferromanganous, igneous rock.

TABLE 4 - 4 (cont.)
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 2 (IR SITE 6) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	06 SS 147	06 SS 148	06 SS 149DUP (06 SS 148)	06 SS 150	06 SS 151	06 SS 152DUP (06 SS 151)
UNITS	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
VOLATILES						
Acetone	370 J	99 J	62 J	560 J	450 J	NA
Benzene	6 U	6 U	6 U	10 U	7 U	NA
Butanone,2-	12 UJ	12 UJ	12 UJ	20 UJ	14 UJ	NA
Carbon disulfide	3 J	6 U	6 U	10 U	7 U	NA
Ethylbenzene	6 U	6 U	6 U	10 U	7 U	NA
Methylene chloride	39 U	23	15	40	27	NA
Toluene	6 U	6 U	6 U	10 U	7 U	NA
Xylene, o-	6 U	6 U	6 U	10 U	7 U	NA
Xylenes, m-, p-	6 U	6 U	6 U	10 U	7 U	NA
PESTICIDES/PCBs						
Aldrin	2.2 U	2.2 U	2.1 U	2.4 U	2.4 U	2.5 U
BHC,alpha-	2.2 U	2.2 U	2.1 U	2.4 U	2.4 U	2.5 U
BHC,beta-	2.2 U	2.2 U	0.48 J	2.4 U	2.4 UJ	0.43 NJ
BHC,delta-	2.2 U	2.2 U	2.1 U	2.4 U	2.4 U	2.5 U
BHC,gamma-	2.2 U	2.2 U	2.1 U	2.4 U	2.4 UJ	2.5 U
Chlordane,alpha-	2.2 UJ	2.2 U	2.1 U	2.4 UJ	2.4 U	2.5 U
DDD,4,4-	4.2 U	4.3 U	4 U	4.7 UJ	4.7 U	4.8 U
DDE,4,4-	4.2 U	4.3 U	4 U	4.7 U	0.68 J	4.8 U
DDT,4,4-	4.2 UJ	4.3 U	4 U	0.74 J	1.7 J	0.22 NJ
Dieldrin	4.2 U	4.3 U	4 U	4.7 U	0.064 NJ	0.44 J
Endosulfan I	2.2 U	2.2 U	2.1 U	2.4 U	2.4 UJ	2.5 U
Endosulfan II	4.2 U	4.3 U	4 U	4.7 U	0.33 J	4.8 U
Endosulfan sulfate	4.2 U	4.3 U	4 U	4.7 U	4.7 U	4.8 U
Endrin	4.2 U	4.3 U	4 U	4.7 U	4.7 U	0.31 J
Endrin aldehyde	4.2 U	4.3 U	4 U	4.7 U	4.7 U	4.8 U
Endrin ketone	4.2 U	4.3 U	4 U	4.7 U	4.7 U	4.8 U
Heptachlor	0.11 J	2.2 UJ	2.1 U	2.4 UJ	2.4 UJ	2.5 U
Heptachlor epoxide	2.2 U	2.2 U	2.1 U	2.4 U	2.4 U	2.5 U
Methoxychlor	22 U	22 U	21 U	24 U	25 UJ	25 U

Qualifiers:
J - estimated value
NJ - presumptive evidence for the presence of the parameter at an estimated value
U - not detected
UJ - reported quantitation limit is estimated
E - concentration exceeds calibration range of GC/MS instrument
R - result is rejected and unusable

TABLE 4 - 4 (cont.)
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 2 (IR SITE 6) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	06 SS 147	06 SS 148	06 SS 149DUP (06 SS 148)	06 SS 150	06 SS 151	06 SS 152DUP (06 SS 151)
UNITS	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
SEMIVOLATILES						
Anthracene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Benzo(a)anthracene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Benzo(a)pyrene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Benzo(b)fluoranthene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Benzo(g,h,i)perylene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Benzo(k)fluoranthene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Bis(2-ethylhexyl)phthalate	1500 U	1600 U	1600 U	2700 U	3300	NA
Carbazole	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Chrysene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Di-n-butylphthalate	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Dibenzo(a,h)anthracene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Fluoranthene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Indeno(1,2,3-cd)pyrene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Phenanthrene	1500 U	1600 U	1600 U	2700 U	1800 U	NA
Pyrene	1500 U	1600 U	1600 U	2700 U	1800 U	NA

Qualifiers:
J - estimated value
NJ - presumptive evidence for the presence of the parameter at an estimated value
U - not detected
UJ - reported quantitation limit is estimated
E - concentration exceeds calibration range of GC/MS instrument
R - result is rejected and unusable

TABLE 4 - 4 (cont.)
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 2 (IR SITE 6) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	06 SS 153	06 SS 154	06 SS 155C Background	06 SS 155D Background	06 SS 155E Background
UNITS	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
VOLATILES					
Acetone	220 J	350 EJ	NA	NA	NA
Benzene	7 U	1 J	NA	NA	NA
Butanone,2-	13 UJ	13 J	NA	NA	NA
Carbon disulfide	7 U	R	NA	NA	NA
Ethylbenzene	7 U	2 J	NA	NA	NA
Methylene chloride	32	300 EJ	NA	NA	NA
Toluene	7 U	18 J	NA	NA	NA
Xylene, o-	7 U	3 J	NA	NA	NA
Xylenes, m-, p-	7 U	5 J	NA	NA	NA
PESTICIDES/PCBs					
Aldrin	0.27 J	2.1 U	2.2 U	2.2 U	1.9 U
BHC,alpha-	2.1 U	2.1 U	2.2 U	2.2 U	1.9 U
BHC,beta-	2.1 U	2.1 U	2.2 U	2.2 U	1.9 U
BHC,delta-	2.1 U	2.1 U	2.2 U	2.2 U	1.9 U
BHC,gamma-	2.1 U	2.1 U	2.2 U	2.2 U	1.9 U
Chlordane,alpha-	2.1 U	1.5 NJ	2.2 UJ	2.2 U	1.9 UJ
DDD,4,4-	4 U	4.1 U	4.3 U	4.2 U	3.7 U
DDE,4,4-	4 U	4.1 U	4.3 U	4.2 U	0.8 J
DDT,4,4-	4 U	4.1 UJ	0.92 U	4.2 U	0.82 J
Dieldrin	4 U	4.1 U	4.3 U	4.2 U	3.7 U
Endosulfan I	2.1 U	2.1 U	2.2 UJ	2.2 U	1.9 U
Endosulfan II	4 U	4.1 U	4.3 UJ	4.2 U	3.7 U
Endosulfan sulfate	4 U	4.1 U	4.3 U	4.2 U	3.7 U
Endrin	4 U	1.6 J	0.11 J	4.2 U	3.7 U
Endrin aldehyde	4 U	4.1 U	4.3 U	4.2 U	3.7 U
Endrin ketone	4 U	4.1 U	4.3 U	4.2 U	3.7 U
Heptachlor	2.1 UJ	2.1 UJ	2.2 UJ	2.2 UJ	1.9 UJ
Heptachlor epoxide	2.1 U	0.35 J	0.13 NJ	2.2 U	1.9 U
Methoxychlor	21 U	21 U	22 U	22 U	19 U

Qualifiers:
J - estimated value
NJ - presumptive evidence for the presence of the parameter at an estimated value
U - not detected
UJ - reported quantitation limit is estimated
E - concentration exceeds calibration range of GC/MS instrument
R - result is rejected and unusable

TABLE 4 - 4 (cont.)
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 2 (IR SITE 6) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	06 SS 153	06 SS 154	06 SS 155C	06 SS 155D	06 SS 155E
			Background	Background	Background
UNITS	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
SEMIVOLATILES					
Anthracene	1700 U	1400 U	NA	NA	NA
Benzo(a)anthracene	1700 U	1400 U	NA	NA	NA
Benzo(a)pyrene	1700 U	1400 U	NA	NA	NA
Benzo(b)fluoranthene	1700 U	1400 U	NA	NA	NA
Benzo(g,h,i)perylene	1700 U	1400 U	NA	NA	NA
Benzo(k)fluoranthene	1700 U	1400 U	NA	NA	NA
Bis(2-ethylhexyl)phthalate	1700 U	630 J	NA	NA	NA
Carbazole	1700 U	1400 U	NA	NA	NA
Chrysene	1700 U	1400 U	NA	NA	NA
Di-n-butylphthalate	1700 U	1400 U	NA	NA	NA
Dibenzo(a,h)anthracene	1700 U	1400 U	NA	NA	NA
Fluoranthene	1700 U	1400 U	NA	NA	NA
Indeno(1,2,3-cd)pyrene	1700 U	1400 U	NA	NA	NA
Phenanthrene	1700 U	1400 U	NA	NA	NA
Pyrene	1700 U	1400 U	NA	NA	NA

Qualifiers:
J - estimated value
NJ - presumptive evidence for the presence of the parameter at an estimated value
U - not detected
UJ - reported quantitation limit is estimated
E - concentration exceeds calibration range of GC/MS instrument
R - result is rejected and unusable

TABLE 4 - 5
INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 2 (IR SITE 6) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	06 GW 101A	06 GW 101B	06 SS 141	06 SS 142	06 SS 143	06 SS 145
UNITS	ug/L	ug/L	mg/Kg	mg/Kg	mg/Kg	mg/Kg
INORGANICS						
Aluminum	1200	48.9 J	21600	12400	20000	15100
Antimony	47.2 U	47.2 U	17.9 J	21.4 J	6.3 J	20.1 J
Arsenic	3 U	3 U	17.5	21.4	1.2 U	19.6
Barium	22.5 U	35.2 U	156	25.1 U	100	410
Beryllium	1.5 B	0.6 U	0.47 B	0.82 B	0.51 B	0.77 B
Cadmium	2.8 U	2.8 U	8.7	9.3	2.1 UJ	3.9
Calcium	62500	58700	51900	15900	9920	48200
Chromium	10.4 UJ	10.4 UJ	59.8	110	19	40.6
Cobalt	15.5 UJ	15.5 UJ	10.7 B	6.9 U	23.7	16.8
Copper	5.1 UJ	8.5 J	5850	1490	227	739
Iron	1730	14.5 UJ	168000	238000	43400	38000
Lead	1.5 UJ	1.8 U	1210 J	546 J	130 J	4760 J
Magnesium	80700	77500	9980	14600	12200	10900
Manganese	R	R	972	766	808	596
Mercury	0.2 UJ	0.2 UJ	0.15 U	0.3 U	0.15 U	0.45
Nickel	7.8 UJ	7.8 UJ	49.9	108	10.2 B	19.4
Potassium	2180 U	2250 BU	1540 B	3690	2760	2350
Selenium	4.8 J	9.2 J	0.75 U	2.1 J	0.92 U	0.7 U
Sodium	801000 J	786000 J	13100 J	50100 J	13100 J	4940 J
Vanadium	30 J	17.9 J	90.6	145	118	122
Zinc	20.2 J	16.5 B	3350	592	200	1440

Qualifiers:
B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated

TABLE 4 - 5 (cont.)
INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 2 (IR SITE 6) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	06 SS 146	06 SS 147	06 SS 148	06 SS 149DUP (06 SS 148)	06 SS 150	06 SS 151
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
INORGANICS						
Aluminum	18600	1660 J	7220 J	13700 J	36600 J	38600 J
Antimony	19.8 J	2.4 UJ	2.4 UJ	2.4 UJ	4 UJ	2.8 UJ
Arsenic	18.7	3.3	0.95 B	1.7 B	1.2 U	1.5 J
Barium	509	24 B	32.4 B	41.9 B	189	213
Beryllium	0.57 B	0.15 U	0.16 B	0.22 B	1.5 B	1.3 B
Cadmium	5	1.3 UJ	1.3 UJ	1.3 UJ	6.3	5.1
Calcium	61000	487000	20100 B	337000	6460	10700
Chromium	39.4	6.1	15.4	21.7	13.5	2.8
Cobalt	15.7	2.3 U	3.5 B	4.9 B	45.5	14.1
Copper	774	4.3 B	13.2	17.6	136	86.3
Iron	44900	4040 J	9050 J	16000 J	107000 J	84100 J
Lead	5850 J	3.1	7.4	3.4	7.5	5
Magnesium	12700	3290	5890	8250	5450	10900
Manganese	601	75.5	212	458	1090	245
Mercury	0.68	0.12 U	0.1 U	0.09 U	0.16 U	0.13 U
Nickel	17.4	4.6 UJ	4.5 UJ	4.6 UJ	7.6 UJ	5.3 UJ
Potassium	2200	347 BU	549 BU	788 B	676 BU	1200 B
Selenium	0.72 J	0.59 UJ	0.58 UJ	0.59 UJ	0.98 UJ	0.68 UJ
Sodium	7540 J	2800 J	3830 J	5630 J	7830 J	11300 J
Vanadium	116	9.3 B	22.8	33.7	386	257
Zinc	2010	8.3	24.3	33.8	89.2	80.7

Qualifiers:
B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated

TABLE 4 - 5 (cont.)
INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER AND SOIL
SWMU 2 (IR SITE 6) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	06 SS 152 DUP (06 SS 151)	06 SS 153	06 SS 154	06 SS 155C Background	06 SS 155D Background	06 SS 155E Background
UNITS	ug/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
INORGANICS						
Aluminum	NA	23900 J	22800 J	20600 J	27200 J	24100 J
Antimony	NA	2.6 UJ	2.9 J	3.8 J	3 J	2.8 J
Arsenic	NA	6.9	10.5	0.83 U	0.82 U	0.78 U
Barium	NA	263	173	78.2	83.1	129
Beryllium	NA	0.41 B	0.42 B	1.4	1.4	1.7
Cadmium	NA	1.5 UJ	1.5 UJ	3.3	3.9	2.7
Calcium	NA	166000	154000	2760	1880	16000
Chromium	NA	42.7	26.4	33	40.7	37.4
Cobalt	NA	11.5 B	14.2	40.1	41.1	82.3
Copper	NA	77.8	60.7	48.8	54.5	47.5
Iron	NA	20800 J	24400 J	53200 J	62700 J	63600 J
Lead	NA	77.4	89.5	3.8	5.6	8.6
Magnesium	NA	8600	9220	4690	4740	3960
Manganese	NA	842	615	1010	598	3130
Mercury	NA	0.12 U	0.13 U	0.12 U	0.13 U	0.12 U
Nickel	NA	12 J	5.1 UJ	5.2 UJ	5.1 UJ	14.3 J
Potassium	NA	2000	1880	331 BU	375 BU	363 BU
Selenium	NA	0.64 UJ	0.65 UJ	0.67 UJ	0.66 UJ	0.62 UJ
Sodium	NA	6900 J	7470 J	4150 J	5630 J	2810 J
Vanadium	NA	65.8	70.5	230	210	256
Zinc	NA	206	102	35.5	40.7	39.1

Qualifiers:
B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated

4.3.2 Media Potentially Requiring Corrective Measures

In accordance with the Draft Corrective Action Permit (Module III, Section A.5, page 23) results of the Supplemental Investigation can be used to satisfy the RFI requirements for this SWMU. The results of these analyses indicate the following:

- Soil at this SWMU has been adequately characterized. Sixteen soil samples were collected. Laboratory analytical results indicate that there is no risk to human health or the environment associated with this media.

- Groundwater at this SWMU has not been adequately characterized. One groundwater sample was collected. Although no contaminants were detected in this sample, additional groundwater samples will be required to fully characterize this media.

- Surface sediment at this SWMU has been adequately characterized. Two sediment samples were collected along the Ensenada Honda Shoreline (IR Site 14). Laboratory analytical results indicate that there is no risk to human health or the environment associated with this media.

4.4 SWMU 3 - Base Landfill (IR Site 7)

4.4.1 Site Status

The Draft Corrective Action Permit has identified this SWMU as requiring a full RFI including soil, groundwater, and surface water/sediment samples. Groundwater samples were collected from this SWMU during the Supplemental Investigation. Analytical results are included in Appendix B.

The sample analytical results indicate that trace VOC contamination (1,2-DCE at 7 µg/L) was present in a groundwater sample collected from one monitoring well (7GW05) at this SWMU.

4.4.2 Media Potentially Requiring Corrective Measures

In accordance with the Draft Corrective Action Permit (Module III, Section A.5, page 23) results of the Supplemental Investigation can be used to satisfy the RFI requirements for this SWMU. The results of these analyses indicate the following:

- Groundwater at this SWMU is currently being monitored in accordance with the landfill operating permit. These analytical results will satisfy the RFI requirement for groundwater at this SWMU. In addition to these samples, eight groundwater samples were collected during the Supplemental Investigation.

- Surface sediment at this SWMU has not been adequately characterized. During the Supplemental Investigation, one sediment sample was collected along the western boundary of the site in association with sampling activities at nearby Site 16. Trace levels of methyoxychlor (0.39 J µg/kg) were detected in this sample. Additional surface sediment samples will be required to fully characterize this media.

- Due to the constant motion of the surface water surrounding this SWMU (tides, waves) it is not expected that surface water sample analysis will provide usable data representative of SWMU conditions.

- The SWMU is currently an active landfill. Soil samples will not be collected since samples would be of waste or cover and not provide meaningful information. This media does not require evaluation.

4.5 SWMU 9 - Tanks 212-217 Disposal Pits (IR Site 13)

4.5.1 Site Status

The Draft Corrective Action Permit has identified this SWMU as requiring an RFI encompassing soils and groundwater, and contingent on the results, investigations may also be required for surface water and sediments. This SWMU specifically encompasses disposal pits associated with the USTs at IR Site 13 (not the USTs themselves) The disposal pits have not been located, either through review of background documents and photographs or during site visits.

4.5.2 Media Potentially Requiring Corrective Measures

The results of investigations conducted at this SWMU to date indicate the following:

- Soils at this SWMU have not been adequately characterized. A geophysical investigation will be required in an effort to determine the location of the pits. If the pit locations are determined, soil samples will be required at these locations.

- Groundwater at this SWMU has not been adequately characterized. There are currently 12 monitoring wells throughout IR Site 13. Additional wells will be installed in the vicinity of the disposal pits (if discovered). Groundwater samples will be collected.

4.6 SWMU 10 - Building 90 (IR Site 15)

4.6.1 Site Status

A RI/FS has been conducted at this site (Versar, 1992). An Interim Remedial Action under the DoN IR Program is currently underway at this SWMU. In accordance with the Draft Corrective Action Permit (Module III, Section E.4, page 35) RFI requirements (soil, groundwater, surface water/sediment) are contingent on the results of the Interim Remedial Action.

An Interim Remedial Action (IRA) under the DoN IR Program is currently underway at this SWMU. The objective of the IRA is to remove all soils which exceed the established cleanup level of 10 ppm PCBs. The DoN has forwarded to US EPA Region III the project specification dated 12 July 1993, project plans and work plans dated 15 May 1993, and the project QA/QC plan dated 27 December 1993. The above referenced documents satisfy the Draft Corrective Action Permit, Module III, Section B.6, page 26. In accordance with the Draft Correction Action Permit, further RFI requirements are contingent on the results of the Interim Remedial Action.

4.6.2 Media Potentially Requiring Corrective Measures

Contingent on the results of the Interim Remedial Action. This SWMU will not be further addressed in this report.

4.7 SWMU 11 - Building 38 (IR Site 16)

4.7.1 Site Status

A RI/FS has been conducted at this site (Versar, 1992). An Interim Remedial Action under the DoN IR Program is currently underway for the soils at this SWMU. In accordance with the Draft Corrective Action Permit (Module III, Section E.4, page 35) RFI requirements for soil are contingent on the results of the Interim Remedial Action. The Interim Remedial Action is also designed to remediate soils at the adjacent SWMU 45 (PCB Spill Area/Old Power Plant) also located at IR Site 16.

The Draft Corrective Action Permit has indicated that this SWMU will require an RFI encompassing groundwater and the surface water/sediment associated with the cooling-water tunnel. In addition, an RFI will be required for the soils associated with two USTs located on site.

Historical base drawings indicate that there are two cooling water tunnels at this SWMU, one extending east and the other extending west from Building 38. The east tunnel has been located in the field. Surface water (and sediment) samples were collected from access ways along this tunnel during the RI/FS (Versar, 1992 and the Supplemental Investigation. Laboratory analytical results are included in Appendix B.

The west tunnel has not been located in the field despite a geophysical investigation being conducted at this SWMU (Baker, 1993). The geophysical report will be included with the RFI project plans.

An Interim Remedial Action (IRA) under the DoN IR Program is currently underway at this SWMU. The objective of the IRA is to remove all soils which exceed the established cleanup level of 10 ppm PCBs. The DoN has forwarded to US EPA Region III the project specification dated 12 July 1993, project plans and work plans dated 15 May 1993, and the project QA/QC plan dated 27 December 1993. The above referenced documents satisfy the Draft Corrective Action Permit, Module III, Section B.6, page 26. In accordance with the Draft Correction Action Permit, further RFI requirements are contingent on the results of the Interim Remedial Action.

4.7.2 Media Potentially Requiring Corrective Measures

Results of investigations conducted at this SWMU, to date, indicate the following:

- Surface soil at this SWMU has been adequately characterized. The soil sequence in this area is very thin (less than one foot). It overlies consolidated bedrock (limestone). This medial was extensively sampled during RI/FS activities (Versar, 1992). An Interim Remedial Action is currently underway on soils at this SWMU. Potential releases from the USTs will be evaluated in association with the groundwater investigation.

- Groundwater investigation is contingent on the results of the Interim Remedial Action.

- Surface sediment at this SWMU has not been adequately characterized. Additional samples within the underground cooling tunnels will be required.

- The interior and exterior walls of Building 38 are currently designated for remediation.

4.8 SWMU 13 - Building 258 - Former Pest Control Shop (IR Site 18)

4.8.1 Site Status

The Draft Corrective Action Permit has identified this SWMU as requiring an RFI encompassing soil and sediments in the adjoining drainage ditch and, contingent on the results, investigations may be required for groundwater. Soil, surface water/sediment and groundwater samples were collected during the Supplemental Investigation. Laboratory analytical results for these samples are presented in Tables 4-6 and 4-7. The complete results of the Supplemental Investigation are included in Appendix A.

TABLE 4 - 6
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER, SOIL, SURFACE WATER AND SEDIMENT
SWMU 13 (IR SITE 18) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	18 GW 101	18 GW 102	18 GW 103	18 GW 169	18 SS 172	18 SS 173	18 SS 174
UNITS	ug/L	ug/L	ug/L	ug/L	ug/Kg	ug/Kg	ug/Kg
VOLATILES							
Acetone	15 J	19 J	13 J	10 U	17 U	17 U	230
Butanone,2-	10 U	10 U	10 U	10 U	R	R	R
Carbon disulfide	3 J	2 J	5 U	5 U	3 J	9 U	6 U
Tetrachloroethene	5 U	5 U	5 U	5 J	6 U	9 U	6 U
Toluene	5 U	5 U	5 U	5 U	6 U	9 U	6 U
PESTICIDES/PCBs							
Chlordane,alpha-	0.0064 U	0.0064 U	0.0064 U	NA	24 J	4.1 J	13 J
Chlordane,gamma-	0.0064 U	0.0064 U	0.0064 U	NA	23 J	3.7 J	14 UJ
DDD,4,4-	0.013 U	0.013 U	0.013 U	NA	140 J	38 J	160 J
DDE,4,4-	0.013 U	0.013 U	0.013 U	NA	380 J	53 J	150 J
DDT,4,4-	0.013 U	0.013 U	0.013 U	NA	1300 EJ	320 J	4500 EJ
Endosulfan I	0.0064 U	0.0064 U	0.0064 U	NA	4.6 UJ	3.6 UJ	14 UJ
SEMIVOLATILES							
Benzo(a)anthracene	20 UJ	21 U	20 U	NA	1500 U	3400 U	1600 U
Benzo(a)pyrene	20 UJ	21 U	20 U	NA	1500 U	3400 U	1600 U
Benzo(b)fluoranthene	20 UJ	21 U	20 U	NA	1500 U	3400 U	1600 U
Bis(2-ethylhexyl)phthalate	23 UJ	2 J	20 U	NA	460 J	1700 J	1600 U
Chrysene	20 UJ	21 U	20 U	NA	1500 U	3400 U	1600 U
Fluoranthene	20 UJ	21 U	20 U	NA	1500 U	3400 U	1600 U
Indeno(1,2,3-cd)pyrene	20 UJ	21 U	20 U	NA	1500 U	3400 U	1600 U
Pyrene	20 UJ	21 U	20 U	NA	1500 U	3400 U	1600 U

Qualifiers:
E - concentration exceeds calibration range of GC/MS instrument
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated

TABLE 4 - 6 (cont.)
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER, SOIL, SURFACE WATER AND SEDIMENT
SWMU 13 (IR SITE 18) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	18 SS 175	18 SS 176	18 SS 177	18 SS 178DUP (18 SS 177)	18 SS 179	18SS181C Background	18SS181D Background
UNITS	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
VOLATILES							
Acetone	55 J	76 U	310 J	32 U	61 U	NA	NA
Butanone,2-	14 U	12 U	R	R	11 U	NA	NA
Carbon disulfide	8 U	6 U	6 U	3 J	6 U	NA	NA
Tetrachloroethene	7 U	6 U	6 U	6 U	6 U	NA	NA
Toluene	7 U	6 U	6 U	6 U	6 U	NA	NA
PESTICIDES/PCBs							
Chlordane,alpha-	2.6 UJ	0.24 UJ	0.24 UJ	0.23 UJ	5.2 J	0.22 UJ	0.22 UJ
Chlordane,gamma-	2.6 UJ	0.24 UJ	0.24 UJ	0.23 UJ	5 J	0.22 UJ	0.22 UJ
DDD,4,4-	5.1 J	0.47 UJ	0.47 UJ	0.71 J	11 J	0.42 UJ	0.42 UJ
DDE,4,4-	9.4 J	4.7 J	1.2 J	1.6 J	40 J	6.5 J	17 J
DDT,4,4-	120 J	3.4 J	1.1 J	1.2 J	36 J	4.2 J	6 J
Endosulfan I	2.6 UJ	0.24 UJ	0.24 UJ	0.23 UJ	0.23 UJ	0.22 UJ	0.22 UJ
SEMIVOLATILES							
Benzo(a)anthracene	1800 U	1600 U	1500 U	1600 U	310 J	NA	NA
Benzo(a)pyrene	1800 U	1600 U	1500 U	1600 U	350 J	NA	NA
Benzo(b)fluoranthene	1800 U	1600 U	1500 U	1600 U	660 J	NA	NA
Bis(2-ethylhexyl)phthalate	1100 J	600 J	350 J	1600 U	1500 U	NA	NA
Chrysene	1800 U	1600 U	1500 U	1600 U	450 J	NA	NA
Fluoranthene	1800 U	1600 U	1500 U	1600 U	240 J	NA	NA
Indeno(1,2,3-cd)pyrene	1800 U	1600 U	1500 U	1600 U	260 J	NA	NA
Pyrene	1800 U	1600 U	1500 U	1600 U	300 J	NA	NA

Qualifiers:
E - concentration exceeds calibration range of GC/MS instrument
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated

TABLE 4 - 6 (cont.)
ORGANIC COMPOUNDS DETECTED IN THE GROUNDWATER, SOIL, SURFACE WATER AND SEDIMENT
SWMU 13 (IR SITE 18) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	18SS181E Background	18 SW 108	18 SED 182
UNITS	ug/Kg	ug/L	ug/Kg
VOLATILES			
Acetone	NA	18	730
Butanone,2-	NA	10 U	390 J
Carbon disulfide	NA	5 U	19 U
Tetrachloroethene	NA	5 U	19 UJ
Toluene	NA	5 U	68 J
PESTICIDES/PCBs			
Chlordane,alpha-	0.23 UJ	0.017	160 J
Chlordane,gamma-	0.23 UJ	0.0066 U	180 J
DDD,4,4-	0.44 UJ	0.076	4700 EJ
DDE,4,4-	3.4 J	0.092	550 J
DDT,4,4-	3.7 J	0.013 U	490 J
Endosulfan I	0.23 UJ	0.0066 U	230 J
SEMIVOLATILES			
Benzo(a)anthracene	NA	23 U	5100 U
Benzo(a)pyrene	NA	23 U	5100 U
Benzo(b)fluoranthene	NA	23 U	5100 U
Bis(2-ethylhexyl)phthalate	NA	2 J	1100 J
Chrysene	NA	23 U	5100 U
Fluoranthene	NA	23 U	5100 U
Indeno(1,2,3-cd)pyrene	NA	23 U	5100 U
Pyrene	NA	23 U	5100 U

Qualifiers:
E - concentration exceeds calibration range of GC/MS instrument
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated

TABLE 4 - 7
INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER, SOIL, SURFACE WATER AND SEDIMENT
SWMU 13 (IR SITE 18) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	18 GW 101A	18 GW 101B	18 GW 102A	18 GW 102B	18 GW 103A	18 GW 103B	18 SS 172
UNITS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/Kg
Aluminum	518 J	39.2 UJ	3850	53 J	5550 J	39.2 UJ	24100 J
Arsenic	3 UJ	3 UJ	3.1 J	3 UJ	3 UJ	3 UJ	0.69 UJ
Barium	22.5 UJ	22.5 UJ	1120	1120	22.5 UJ	22.5 UJ	57.3
Beryllium	1.1 J	0.81 J	1.1 B	0.6 U	1.2 J	0.8 UJ	0.47 B
Cadmium	2.8 UJ	2.8 UJ	2.8 U	2.8 U	2.8 UJ	2.8 UJ	1.1
Calcium	238000 J	245000 J	425000	388000	9030 J	7000 J	14600
Chromium	5.9 UJ	5.9 UJ	10.4 UJ	10.4 UJ	20.4 J	5.9 UJ	17.1 J
Cobalt	15.5 UJ	15.5 UJ	15.5 UJ	15.5 UJ	15.5 UJ	15.5 UJ	23.4
Copper	5.1 UJ	7 J	20.9 J	5.1 UJ	30.6 J	5.1 UJ	77.4 J
Iron	1020 J	14.5 UJ	20200	144000	6810 J	86.7 J	35000 J
Lead	1.8 UJ	1.8 UJ	106 J	9 U	1.8 UJ	1.8 UJ	7.8
Magnesium	211000 J	217000 J	298000	541000	9020 J	5620 J	18300
Manganese	482 J	369 J	10000	9610	345 J	230 J	762 J
Mercury	2.8 J	1.4 J	0.2 UJ	0.2 UJ	0.2 UJ	0.2 UJ	0.1 U
Nickel	7.8 UJ	7.8 UJ	7.8 UJ	7.8 UJ	7.8 UJ	7.8 UJ	22
Potassium	7440 J	7870 J	35100	34000	3040 J	2990 U	647 U
Sodium	2000000 J	1920000 J	4600000 J	4570000 J	205000 J	198000 J	1580 J
Vanadium	8.5 UJ	8.5 UJ	8.5 UJ	14.3 UJ	22.2 J	8.5 UJ	89.2
Zinc	22 J	16 J	187 J	12.1 U	26 J	12.1 UJ	87 J

Qualifiers:
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated
B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit
E - concentration exceeds calibration range of GC/MS instrument

TABLE 4 - 7 (cont.)
INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER, SOIL, SURFACE WATER AND SEDIMENT
SWMU 13 (IR SITE 18) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	18 SS 173	18 SS 174	18 SS 175	18 SS 176	18 SS 177	18 SS 178DUP (18 SS 177)	18 SS 179
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Aluminum	19700 J	3760 J	3210 J	8560 J	20800 J	1810 J	10900 J
Arsenic	1 UJ	2.3 J	2.9 J	79.1 J	16.4 J	30.2 J	2.5 J
Barium	109	33.8 B	16.4 B	34.9 B	89.2	59.6	27.2 B
Beryllium	0.47 B	0.15 U	0.17 U	0.14 U	0.53 B	0.4 B	0.18 B
Cadmium	0.97 U	0.68 U	0.77 U	0.67 U	1.1 B	1 B	0.7 B
Calcium	10600	466000	475000	317000	60000	9560	306000
Chromium	34 J	6.9 J	7.8 J	10.2 J	15.2 J	15.4 J	13.2 J
Cobalt	26.1	4.1 B	2.6 U	6.7 B	29.8	24.4	5.9 B
Copper	33.5 J	22.7 J	14.3 J	49.8 J	61.2 J	56.1 J	33.5 J
Iron	30800 J	7480 J	5670 J	12400 J	28800 J	24000 J	15600 J
Lead	17.1	10.8	1.5	1.6	4.7	6.9	15.6
Magnesium	19000	6120	4930	5720	13600	11900	6510
Manganese	857 J	130 J	102 J	378 J	1260 J	904 J	206 J
Mercury	0.16 U	0.12 U	0.15 U	0.1 U	0.1 U	0.11 U	0.11 U
Nickel	26.9	4.6 U	5.2 U	4.4 U	16.3	16.3	9.1
Potassium	270 U	397 U	341 U	493 U	457 U	550 U	741 U
Sodium	4940 J	3610 J	3040 J	2570 J	1520 J	1610 J	2410 J
Vanadium	95.3	20.6 J	16.1 J	45.2	98.7	79.9	45
Zinc	87.8 J	28.5 J	10.3 J	21 J	77.7 J	76.7 J	55.7 J

Qualifiers:
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated
B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit
E - concentration exceeds calibration range of GC/MS instrument

TABLE 4 - 7 (cont.)
INORGANIC CHEMICALS DETECTED IN THE GROUNDWATER, SOIL, SURFACE WATER AND SEDIMENT
SWMU 13 (IR SITE 18) - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	18 SS 181C		18 SS 181D		18 SS 181E		18 SW 108		18 SED 182	
	Background		Background		Background					
UNITS	mg/Kg		mg/Kg		mg/Kg		ug/L		mg/Kg	
Aluminum	4030	J	12300	J	16000	J	42.9	U	14100	J
Arsenic	0.85	J	1.1	J	0.86	J	3	U	2.3	UJ
Barium	24.7	B	60.5		79.9		35.2	U	95	B
Beryllium	0.13	U	0.29	B	0.59	B	0.6	U	0.46	U
Cadmium	0.6	U	0.72	B	1.1		2.8	U	2.3	B
Calcium	341000		165000		94600		42900		62900	
Chromium	7.1	J	11.8	J	15.6	J	4.9	U	24.7	J
Cobalt	2.5	B	16.8		18.6		9.6	U	21.2	B
Copper	18.9	J	39.9	J	35.1	J	5.1	U	133	J
Iron	6360	J	22300	J	30000	J	682		25300	J
Lead	20.9		57.8		16.1		1.8	U	83.8	
Magnesium	3750		5680		6750		6780		9120	
Manganese	145	J	605	J	562	J	104		479	J
Mercury	0.1	U	0.11	U	0.11	U	0.2	U	0.35	U
Nickel	4	U	6	B	9.2		18.7	U	16.5	B
Potassium	276	U	307	U	473	U	2720	B	1130	B
Sodium	1590	J	1480	J	1110	J	23400		1330	J
Vanadium	18.3	J	65.7		97.6		19.3	U	99.8	
Zinc	21.2	J	52.5	J	62.9	J	12.1	U	361	J

Qualifiers:
J - estimated value
NA - not analyzed
R - result is rejected and unusable
U - not detected
UJ - reported quantitation limit is estimated
B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit
E - concentration exceeds calibration range of GC/MS instrument

The sample analytical results indicate the following:

Groundwater

VOC were present as trace concentrations of acetone, carbon disulfide and tetrachloroethene. SVOC data are unreliable, but do not indicate significantly high concentrations. P/PCB were not found. Inorganic cations of the TAL in the dissolved fraction (the part of the sample relevant to groundwater transport and to consumption of groundwater) are in the range expected to be seen in groundwaters occupying unconsolidated colluvium developed from a ferromanganous, igneous rock.

Soil

VOC were found as trace to moderate concentrations of acetone and carbon disulfide; the highest concentrations were of acetone in samples 18SS174 from station 18SS102 and 18SS177 from station 18SS103, both of which stations being on the downslope side of the foundation of Building 128. SVOC data are unreliable, but do not indicate significantly high concentrations. P/PCB were found randomly in trace to high concentrations. Inorganic cations of the TAL are in the range expected to be seen in unconsolidated material in a coastal margin developed from a ferromanganous, igneous rock.

Surface Water

A sample of standing water was taken from the drainage ditch between Forrestal Drive and the foundation for Building 128.

VOC was found only as acetone in low concentration. SVOC data are unreliable, but do not indicate significantly high concentrations. P/PCB were found as trace concentrations of 4,4'-DDE and 4,4'-DDT. Inorganic cations of the TAL are in the range expected to be seen in rainwaters moving across and through unconsolidated, colluvial material in a coastal margin developed from a ferromanganous, igneous rock.

Sediments/terrestrial

A sample of the sediment at the surface water station was taken. VOC were present as moderate to high concentrations of acetone and 2-butanone, and a moderate concentration of

toluene. SVOC data are unreliable, but do not indicate significantly high concentrations. pesticides are present in trace to high concentrations, the highest being of 4,4'-DDD.

4.8.2 Media Potentially Requiring Corrective Measures

In accordance with the Draft Corrective Action Permit (Module III, Section A.5, page 23) results of the Supplemental Investigation can be used to satisfy the RFI requirements for this SWMU. The results of these analyses indicate the following:

- Soil, groundwater, and surface water/sediment have been adequately characterized at this SWMU. Sampling results indicate that there is no threat to human health or the environment with these media.

4.9 SWMU 45 - Soils Outside Building 38 (IR Site 16)

4.9.1 Site Status

The Draft Corrective Action Permit has indicated that this SWMU will require a full RFI. This SWMU along with SWMU 11 comprise IR Site 16. An Interim Remedial Action, described in Section 4.9.1, is being conducted at this site. The Interim Remedial Action is designed to include soils at SWMU 45.

4.9.2 Media Potentially Requiring Corrective Measures

Contingent on the results of the Interim Remedial Action. Refer to Section 4.9.

4.10 AOC B - Former Building 25 Site (Part of IR Site 10)

4.10.1 Site Status

The Draft Corrective Action Permit has identified this SWMU as requiring an RFI encompassing soil (both surrounding the Old Building 25 area and the soils underlying the remaining brick floor surface) and groundwater. Soil samples were collected from the perimeter of the former Building 25 during the Supplemental Investigation. Laboratory analytical results for these samples are presented in Tables 4-8 and 4-9. The complete results of the Supplemental Investigation are included in Appendix A.

TABLE 4 - 8
ORGANIC COMPOUNDS DETECTED IN THE SOIL
IR SITE 10 - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	10 SS 156	10 SS 158DUP (10 SS 156)	10 SS 159	10 SS 161	10 SS 163	10 SS 165C Background	10 SS 165D Background	10 SS 165E Background
UNITS	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
VOLATILES								
Carbon disulfide	21 U	15 U	7 U	7 J	39 J	NA	NA	NA
Methylene chloride	27 U	32 U	29 U	20 U	98 J	NA	NA	NA
Toluene	6 U	6 U	5 U	6 UJ	3 J	NA	NA	NA
Xylene, m-, p-	6 U	6 U	5 U	6 UJ	2 J	NA	NA	NA
PESTICIDES\PCBs								
BHC,beta-	0.24 UJ	0.24 UJ	0.23 UJ	0.24 UJ	0.22 UJ	0.29 UJ	0.7 J	0.30 UJ
DDE,4,4-	0.46 UJ	0.47 UJ	0.45 UJ	3.7 J	0.43 UJ	0.56 UJ	2.9 J	0.93 J
DDT,4,4-	0.46 UJ	0.47 UJ	0.45 UJ	2.4 J	0.43 UJ	0.56 UJ	1.8 J	0.57 UJ
Endosulfan sulfate	0.46 UJ	0.47 UJ	0.54 J	0.46 UJ	0.43 UJ	0.56 UJ	0.52 UJ	0.57 UJ
Methoxychlor	2.4 UJ	2.4 UJ	2.3 UJ	1.5 UJ	2.2 UJ	2.9 UJ	3.8 J	0.59 UJ
SEMIVOLATILES								
Acenaphthene	1500 U	1500 U	84 J	1500 U	1300 U	NA	NA	NA
Anthracene	1500 U	1500 U	110 J	1500 U	1300 U	NA	NA	NA
Benzo(a)anthracene	1500 U	1500 U	510 J	460 J	360 J	NA	NA	NA
Benzo(a)pyrene	1500 U	1500 U	310 J	260 J	350 J	NA	NA	NA
Benzo(b)fluoranthene	1500 U	1500 U	620 J	790 J	830 J	NA	NA	NA
Benzo(g,h,i)perylene	1500 U	1500 U	150 J	200 J	1300 UJ	NA	NA	NA
Bis(2-chloroisopropyl)ether	1500 U	1500 U	450 J	1500 U	550 J	NA	NA	NA
Bis(2-ethylhexyl)phthalate	310 J	1500 U	250 J	160 J	130 J	NA	NA	NA
Chrysene	1500 U	1500 U	800 J	500 J	370 J	NA	NA	NA
Dibenzo(a,h)anthracene	1500 U	1500 U	1400 U	160 J	1300 UJ	NA	NA	NA
Fluoranthene	1500 U	1500 U	970 J	1100 J	530 J	NA	NA	NA
Indeno(1,2,3-cd)pyrene	1500 U	1500 U	270 J	340 J	1300 UJ	NA	NA	NA
Phenanthrene	1500 U	1500 U	490 J	470 J	310 J	NA	NA	NA
Pyrene	1500 U	1500 U	730 J	750 J	810 J	NA	NA	NA

Qualifiers:
J - estimated value
NA - not analyzed
R - rejected value
U - not detected
UJ - reported quantitation limit is estimated

TABLE 4 - 9
INORGANIC CHEMICALS DETECTED IN THE SOIL
IR SITE 10 - NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SAMPLE ID	10 SS 156	10 SS 158DUP (10 SS 156)	10 SS 159	10 SS 161	10 SS 163	10 SS 165C Background	10 SS 165D Background	10 SS 165E Background
UNITS	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Aluminum	17500	20600	21100	18900	7560	11400	10100	9910
Arsenic	0.67	0.68 U	1.1 B	0.67 U	4.8 J	1.1 B	1.5 J	0.85 B
Barium	67.1	74.4	122	82.4	28.2 B	148	48 B	84.8
Beryllium	0.37 B	0.44 B	0.4 B	0.29 B	0.37 B	1.4	0.33 B	0.92 B
Cadmium	1.2 UJ	1.2 UJ	2.5	2.6	1.2 UJ	1.5 UJ	1.4 UJ	2
Calcium	10100	9460	40900	53100	191000	6450	89500	13800
Chromium	18.4	22.8	15.4	15	29.9	5.6	3	7
Cobalt	21.7	21.6	24.8	14.1	7.3 B	133	15.7	38.8
Copper	162	169	98.5	62.9	19.2	90.1	27.1 U	65.7
Iron	20700	21300 J	31500 J	29300 J	8860	37900 J	10600 J	24800 J
Lead	2.5	3.8	61.1	39.2	26.7	7.1	5.1	6.4
Magnesium	8020	8040	10200	8880	4620	2880	3870	2730
Manganese	694	654	954	545	200	5030	518	1970
Mercury	0.09 U	0.09 U	0.18	0.11 U	0.1 U	0.12 U	0.11 U	0.13 U
Nickel	16.4	17.1	12.8	9.4	6.8 B	7.6 B	5.8 B	5.2 U
Potassium	596	716 J	1930 J	2620 J	606 J	489 J	504 J	504 J
Selenium	0.54 U	0.54 U	0.52 U	0.53 U	0.52 UJ	1.3 B	0.61 UJ	0.71 J
Silver	1.4 U	1.9 B	2 B	1.4 U	1.8 B	1.7 U	1.6 U	2 B
Sodium	4300	4850 J	2390 J	1820 J	1700 J	2060 J	2080 J	1890 J
Vanadium	76.5	84.6	116	101	59.7	210	62.1	148
Zinc	112	118	202	136	49.2	48.9	22.1	39.9

Qualifiers:

B - value is greater than the Instrument Detection Limit but less than the Contract Required Detection Limit

J - estimated value

U - not detected

UJ - reported quantitation limit is estimated

The sample analytical results indicate the following:

Soil

VOC are largely absent from Site 10 samples; a trace concentration of carbon disulfide was found in one sample, and trace concentrations of toluene and (m-,p-)xylene with low concentrations of carbon disulfide and methylene chloride were found in another. SVOC data are unreliable, but do not indicate significantly high concentrations. Pesticides were found randomly in trace to low concentrations. Inorganic cations of the TAL are in the range expected to be seen in unconsolidated, colluvial material developed from a ferromanganous, igneous rock.

4.10.2 Media Potentially Requiring Corrective Measures

Investigations conducted at this SWMU, to date, indicate the following:

- Soils have not been adequately characterized. The Draft Corrective Action Permit specifies that soil samples from beneath the floor of the former Building 25 be collected. Samples from beneath the floor were not collected during the Supplemental Investigation.

- Groundwater has not been adequately characterized. No groundwater samples were collected from this area during the Supplemental Investigation (there are currently no monitoring wells in this area). Groundwater samples will be required.

5.0 PRE-INVESTIGATION CORRECTIVE MEASURES EVALUATION

5.1 Introduction

Corrective measure technologies have been evaluated on the basis of three broad criteria: effectiveness, implementability and cost. These evaluation criteria are described in the following subsections. An effective, implementable technology at the lowest cost is the most desirable alternative.

A wide range of technologies for remediation of soils, groundwater, surface water, and sediments were considered. These corrective measure technologies are described briefly in Section 5.2.

In Section 5.3, data needs by corrective measures to be satisfied by the RFI are discussed. These data needs are presented both in terms of data needs by technology and by site.

5.1.1 Effectiveness

Effectiveness measures the ability of each technology to minimize impact on human health and the environment. Criteria to determine effectiveness include: reliability, durability and proven performance in meeting clean-up standards. Reliability is the ability of a technology to meet treatment goals under varying conditions. A technology may be only reliable for a narrow set of conditions or reliable under a wide range of operating conditions. As a technology becomes less reliable, the potential effectiveness of the technology becomes more and more restricted. Durability indicates maintenance of a remediated state. For a treatment process, durability implies that the products will not spontaneously resume a contaminated state. For a containment technology, durability refers to the continued integrity of the containment structures.

Effectiveness may be implied for technologies with proven past performance in meeting applicable clean-up standards. While case histories are valuable, it is important to note any differences between reported site conditions and conditions at the subject site that may impact effectiveness. Unproven technologies have unproven effectiveness.

Overall effectiveness can only be measured against applicable media protection standards which are not yet established. For the purposes of this screening, effectiveness was assumed

where site conditions and proven past performance allow. However, a more thorough examination of effectiveness can be carried out during the Corrective Measures Study once standards are determined. For this report, the effectiveness of a technology was rated effective, moderately effective, or not effective.

5.1.2 Implementability

Implementability is related to the ability of achieving treatment at this specific site. Criteria to evaluate implementability include: ease of application, waste compatibility with treatment or construction materials, treatability of waste, site specific constraints, permitting considerations, and recycling considerations. For this report, the implementability of a technology was rated implementable, moderately implementable, or not implementable.

The following factors influence the implementability of a potential remediation technology.

5.1.2.1 Application of Technology

The implementability of a technology may be controlled by the ability to apply the technology in general or at a certain site. Equipment availability, manpower availability, utility availability, vendor access, long-term requirements, and acceptability of the technology can all influence technology implementability, particularly at the facility location on the island of Puerto Rico. Acceptability of the technology is a key consideration. An effective technology may not be implementable due to public policies. Installation of equipment on and off-site influence the applicability of the technology.

5.1.2.2 Waste Compatibility With Treatment or Construction Materials

Implementability of a technology is influenced by compatibility between the waste and the treatment agents, the equipment material and/or the containment structures material. Waste constituents that are aggressive (e.g. corrosive) to equipment and structures may cause leaks, spills, or equipment failure and unplanned downtime. Incompatibilities between wastes and treatment agents may cause scaling or plugging due to unplanned precipitation, incomplete treatment due to carry over or inactivation, or formation of explosive mixtures and/or toxic byproducts.

5.1.2.3 Waste Treatability

Technologies that require extensive waste treatability studies may not be readily implementable. Extensive pilot testing may be required to demonstrate the effectiveness of the technology. Even when the effectiveness has been demonstrated, implementability of the technology may not be readily accepted by local authorities due to their unfamiliarity with the technology. These factors need to be considered when evaluating a technology.

5.1.2.4 Site Specific Constraints

These factors are numerous and can vary widely within a site or from one site to another. This is particularly true in the case of NSRR, which is located on the island of Puerto Rico. Installation of wells, excavation of soil, dredging of sediments, location of treatment facilities, and consideration of containment of groundwater are all affected by site specific constraints.

5.1.2.5 Waste Minimization and Recycling

Technologies that reduce the volume of waste or enable recycling the waste are preferable in light of minimizing the quantity of waste with the potential to impact human health and the environment. In addition, land disposal restrictions, (e.g. there are no landfills on the island of Puerto Rico permitted to accept hazardous waste) limited capacity at off-site treatment facilities, and the beneficial use of recycled material may allow waste minimization and recycling options to become more implementable then some conventional technologies.

5.1.2.6 Permitting

Permitting may be an issue in selecting a technology. For example, obtaining an on-site permit for incineration may cause delays in implementation of the technology whereas, removal and transportation to the waste to a permitted incineration facility may be more readily accomplished. Also, there are currently no landfills on the island of Puerto Rico which are permitted to accept hazardous waste.

5.1.3 Cost

Costs have a major impact on suitability of a technology. In general, the best alternative is the lowest cost, most effective and readily implementable technology. However, in many cases, there may be a trade off in cost and implementability.

For the purpose of this initial corrective measures screening, costs will be considered relative to the other technologies being evaluated for remediation of a given medium. Relative costs will be presented as high, medium or low, based on historical and literature information. Further definition of costs can be made by providing costs for low, medium and high ranges. For surface water and groundwater treatment, general units are dollars per thousand gallons treated. For soils and sediments, the general units are dollars per tons of soil treated.

For groundwater and surface water, low costs are defined as $0 - $2.00 per 1,000 gallons treated; medium costs range from $2.00 to $8.00 per 1,000 gallons; and high costs range from values any greater than $8.00 per 1,000 gallons treated. These costs are based on a nominal treatment flow rate of 100 gallons per minute. The dollars values include operating and capital costs for each technology. Total costs of cleanup are estimated by using the volume of media treated throughout the life of the cleanup project.

For soils and sediments, low costs are defined as $0 - $100 per ton; medium costs as $100 - $400 per ton; and high costs as greater than $400 per ton. These costs are based on nominal cleanup volumes of 10,000 tons. The dollar values include operating and capital costs for each technology.

In all cases, these values are general and are only based on historical information for large cleanup sites. In reality, costs may vary by several factors due to site specific constraints such as treatment volumes, treatment objectives, and the location of the facility in Puerto Rico. More detailed cost estimates may involve obtaining vendor and equipment cost information, consideration of mobilization and utility fees, and sizing of equipment. Due to the large number of technologies being assessed, relative cost estimates appeared most applicable to current evaluations.

Since only relative costs are considered in the current screening, the impact of the cost criterion on the preliminary selection process is less than that of the effectiveness and implementability criteria. As technology evaluations proceed through the next corrective

measures screening and the CMS, cost estimates will be more detailed and the impact of the cost criterion will become more significant.

5.2 Corrective Measures Technologies

5.2.1 Soils Corrective Measures Technologies

Several corrective measures technologies are potentially applicable to minimize health and environmental impacts due to contamination in the soil medium. Literature sources have been reviewed to identify and characterize potential corrective measure technologies. The following general technologies were examined for potential suitability to remediate soils at the Naval Station, Roosevelt Roads.

- No Action
- Institutional Controls
- Containment
- Excavation and Disposal
- Vacuum Extraction
- Soil Washing/Flushing
- Biotreatment
- Solidification/Stabilization
- Vitrification
- Thermal Destruction
- Chemical Dechlorination

In this section, brief, general reviews of potentially applicable soils corrective measures technologies are presented, followed by site-specific evaluations based on currently available information.

5.2.1.1 No Action

The use of no action as a treatment technology allows the contaminated soil to exist without intervention. The potential for contact between vegetation, animals, or other receptors and the contaminated soil may not be mitigated by this option. In addition, it is possible that contaminants within the soil will migrate upon contact with surface waters, infiltrating waters, or groundwater or upon volatilization of volatile contaminants if the no action

technology is used. However, migration may not occur if one or more of the following conditions exists:

- The natural soils have low permeability and effectively contain the contaminated volume.
- The natural soils have attenuating properties for the specific contaminants.
- The contaminant-specific partition coefficient favors soil over permeant.

No action may be appropriate if the potential for direct receptor contact is low, such as in cases where soil contamination occurs below a sufficiently thick layer of uncontaminated surficial soils, and where the potential for contaminant migration is low as well.

Implementation of no action may be feasible in certain instance as a conditional remedy. A conditional remedy is one which may be adequate to protect human health and the environment under the present site conditions; however, provisions must be made to allow remediation at some time in the future, such as SWMU/AOC shut-down or sale of property. It is anticipated that long-term monitoring would be necessary to verify if the above-mentioned conditions remained.

5.2.1.2 Institutional Controls

Soil corrective measures known as institutional controls consist of administrative actions to limit receptor contact. Such actions include land use restrictions, deed restrictions, fencing, and access restrictions. Use of institutional controls allows contamination to exist, as does using no action, although institutional controls may limit direct receptor contact. The potential for contaminant migration remains unchanged when applying institutional controls, and the same considerations regarding migration as were discussed under Section 5.2.1.1, No Action, apply. Thus, institutional actions are appropriate when site conditions minimize the potential for contaminant migration.

Generally, this technology involves minimal effort and cost to implement. On-site controls require least effort due to property ownership and existing organizational structure through which restrictions may be mandated.

Another type of institutional control is applying with the USEPA for delisting a specific hazardous waste. If the application is accepted, the contaminated soils may be disposed as a nonhazardous waste.

Institutional controls are judged as being ineffective in limiting migration from contaminated soil on-site. However, because they may be appropriate for certain SWMUs and AOCs, they will be retained for further consideration.

5.2.1.3 Containment

Capping and barrier trench (e.g., slurry wall) techniques are typical means of containing contaminated soils. Both technologies are applicable to a variety of sites.

Capping

Containment of contaminated soil can be accomplished via capping, a well-established and reliable technology. Capping involves covering buried waste materials to eliminate direct contact with surface water and to minimize infiltration to limit migration of contaminants. Caps are predominantly constructed from impermeable or low-permeability materials that tend to retain their integrity despite moderate settling. In addition, long-term maintenance requirements are generally few (USEPA, 1985).

Application of capping is appropriate when contaminated soils are neither excavated nor treated in place. Generally, capping is effective when subsurface contamination is above the groundwater table, extensive or when removal would cause significant ecologic or health and safety hazards. Capping may be utilized alone, in combination with barrier trenches, or as part of a multimedia treatment which may facilitate remediation of groundwater and surface water contamination as well as soil contamination. Additionally, cap design includes a gas collection system if wastes to be contained may generate gases, which may minimize contaminant releases to the air (USEPA, 1985).

Depth to groundwater is a parameter which may be significant in assessing effectiveness of capping at minimizing contaminant migration. If the water table contacts the contaminated portion of the soils being capped and the contaminants are water soluble, then capping alone may not prevent migration. Establishing the depth to groundwater is even more significant

when capping is used to alleviate groundwater contamination as well as containing soil contamination (USEPA, 1985).

Durability of caps varies with cap design, materials of construction, and exposure to wet/dry or freeze/thaw cycles. Under ideal conditions, geomembrane covers are expected to function adequately for 20 years. Geomembrane life may extend considerably beyond that time, but to what extent is uncertain. When a geomembrane and low permeability (e.g., clay) layer are used together, predictions of up to 100-year design life are projected. Concrete and asphaltic caps are subject to cracking, although such cracks may be repaired (sealed with tar). Projected life of concrete and asphaltic caps is 50 years (USEPA, 1985).

Many capping materials are installed with standard construction equipment, such as haul trucks to supply purchased or borrow materials, bulldozers for placement and spreading, compactors for densification, and graders for shaping to final design specifications.

Long-term maintenance of caps varies with individual selection of materials and design, although general requirements are low. One significant requirement is sampling and maintenance at the associated groundwater monitoring wells which are used to assess the integrity of the cap over time. Periodic inspections are often required to investigate settlement, ponding of liquids, erosion, and invasion by deep-rooted vegetation (USEPA, 1985).

Both multi-layered caps and single-layer caps are used. Typical construction of a multi-layered cap consists of the following (from bottom to top) (USEPA, 1985):

- Foundation layer - Acts to support the weight of the entire cap. Depending on grain-size, a geotextile may be installed above the foundation layer.

- Low permeability layer - Minimizes contact between infiltration and wastes. If used in conjunction with a geomembrane, the low permeability layer acts to limit contact if geomembrane is damaged and allows passage of infiltrating waters.

- Geomembrane - Prevents contact between infiltration and wastes. Often used in conjunction with a low permeability layer which controls further infiltration, if geomembrane is damaged.

- Drainage layer - Conducts flow of infiltrating waters away from impermeable or low permeability layers. Constructed of permeable fill materials or geosynthetics.

- Geotextile - Prevents clogging of drainage layer due to piping from vegetative layer.

- Vegetative layer - Provides media for vegetative growth and depth to prevent frost damage to impermeable or low permeability layers.

- Vegetation - Facilitates evapotranspiration and protects against erosion.

Capping is generally an effective and implementable technology for minimizing impacts on health and the environment from on-site contaminated soils. The depth to water table, taken in conjunction with the depth of contamination in the soils, is an important parameter in assessing the effectiveness of this technology at limiting contaminant migration. Capping may be appropriate at any of the on-site landfills and/or additional areas, if widespread soil contamination is encountered.

Implementability of capping is generally quite simple, except for contaminated sites where buildings or other obstructions exist nearby or over top of them. Additionally, capping may be limited by the availability of capping materials on the island of Puerto Rico. Maneuverability of construction equipment used to place capping materials may be limited to the point of rendering this technology infeasible if existing structures impede the proposed capping site. Other potentially contaminated SWMUs and AOCs have monolithic covers, e.g., concrete or asphalt pads, directly above the contaminated sites. While such obstructions do not prevent access to capping the sites, they may increase the difficulty of implementation. Alternatively, buildings and monolithic covers may already provide some measure of protection against contaminant migration and may reduce the application of capping to: assessing the integrity of the existing structure, sealing the slab (with bitumen or urethane, for example), and installing/operating monitoring wells.

Capping is typically available at the medium range of costs for soils technologies, although some cost variation with design, materials availability, and materials selection will occur. This is particularly true in light of the facility location on the island of Puerto Rico. Capping is generally cost-effective over excavation if the contamination is extensive. Thus, for more detailed evaluations, the contaminated volume must be identified.

Since capping is appropriate for at least some of the contaminated soils sites being considered, it will be retained for further evaluation.

Barrier Trenches

Barrier trenches present another form of containment, with the intention of preventing groundwater contact with contaminated soils. Barrier trenches may be used in conjunction with caps to further minimize contaminant migration, particularly in cases where a shallow water table results in direct groundwater contact with contaminated soils. The related technology of grouting is included, although its application to waste sites is limited (USEPA, 1985).

The most common type of barrier trench is the soil-bentonite slurry wall. Other types of barriers such as sheet piles can be used. Cement-bentonite walls also are available, although less common. Slurry walls are constructed in a vertical trench that is excavated under a slurry. The slurry, which is typically a mixture of bentonite and water, behaves as a drilling fluid. It acts to hydraulically support the walls of the trench, and furthermore, it forms a filter cake on the walls that minimizes seepage. After completion, the trench is backfilled with a bentonite-soil mixture (USEPA, 1985). The benefits over sheet piles or cement-bentonite walls are long-term effectiveness and cost, respectively.

To construct a slurry wall, excavation is generally accomplished by backhoe. The bentonite slurry is introduced after the trench has been opened and before the water table is contacted. Backfilling operations occur concurrently with excavation. Once a sufficient length of trench has reached its design depth, bentonite slurry is mixed with soil by bulldozer until uniform. Mixing is accomplished either in a small mixing area located next to the open trench or at a large central mixing area. The backfill is then lowered to the bottom of the trench by clamshell until it slopes to the surface. As the trench advances, backfill may be pushed into place by bulldozer and allowed to flow down the slope. The backfill displaces the bentonite slurry as construction continues, but it should not extend into the excavation area (USEPA, 1985).

The backfill is allowed to set for up to several weeks. Desiccation and cracking typically occur in the top few feet of the slurry wall during this period. Affected material is excavated and replaced with a compacted earthen layer. Traffic caps are placed as needed to complete the

construction. Installation of slurry walls rarely impacts worker health and safety, unless excavation into contaminated materials occurs (USEPA, 1985).

Two types of vertical configurations and three types of horizontal configurations are available. Vertically, the slurry wall may be "keyed in", that is, the bottom end is excavated into a low permeable layer, or hanging, which extends only partway into the water table. Keyed in construction is by far more common for containment of contaminated soils. Hanging slurry walls are more effective barriers for floating contaminants, such as oils, or for migrating gases (USEPA, 1985).

Horizontally, slurry walls may be placed upgradient of groundwater flow, downgradient of groundwater flow, or completely surrounding the contaminated soil site. Placement of slurry walls surrounding the soil site is the most common configuration. Upgradient placement may be effective at preventing groundwater contact with contaminated soils as well; however, downgradient placement is more typically used with hanging slurry walls to collect oils and other floating contaminants. With the placement of slurry walls completely surrounding the contaminated soil site, both infiltration of groundwater and leachate migration are limited. Collection of leachate from within the walls is typically practiced to prevent a hydraulic gradient outward from the site. If such a slurry wall is used in conjunction with a cap, removal of leachate will be minimized, if not eliminated (USEPA, 1985).

Soil-bentonite slurry walls are most common due to the following characteristics (USEPA, 1985):

- lowest cost installation
- widest chemical compatibility
- lowest permeability

However, soil-bentonite slurry walls also have the highest compressibility, lowest strength, and require a nearly level-graded surface for placement. When use of soil-bentonite walls is precluded, cement-bentonite slurry walls may be used. Cement-bentonite walls achieve moderate strength and, as such, may be used in widely varying elevations. In addition, the size of the mixing area is greatly reduced since cement-bentonite slurry is used both to excavate the trench and to fill the trench. After the trench is excavated, the slurry remains and is allowed to set up. For still greater strength, concrete panels may be used, either as

reinforcement for a cement-bentonite slurry wall or independently as a complete cut-off wall (USEPA, 1985).

Compatibility of slurry walls with the materials contained is essential for effective contaminant migration control. Soil-bentonite slurry walls are not compatible with certain chemicals, including (USEPA, 1985):

- strong acids and bases
- strong brines
- some organic chemicals

If this technology is selected, permeability tests with backfill material and site leachate and/or groundwater will be necessary during the CMS to establish compatibility.

Little long-term maintenance is associated with slurry walls. Generally, groundwater levels within and outside of the slurry wall are monitored, and ancillary equipment (e.g., caps, extraction wells), if present, is maintained (USEPA, 1985).

The cost of employing slurry walls is typically relatively low, depending on subsurface soils, backfill material, and size of wall (USEPA, 1985). Additional costs associated with the lack of necessary material on the island of Puerto Rico may be incurred.

Slurry walls are moderately effective and can be implemented with moderate difficulty. In addition, slurry walls are available at relatively low cost. However, slurry walls are not effective alone at minimizing impacts on health and the environment due to the potential for contaminant migration with infiltration of surface waters through the highly permeable surficial soils. In conjunction with caps, slurry walls may be appropriate for contaminated soils sites where the contamination extends into the groundwater.

Because slurry wells can be effectively implemented in conjunction with caps, this technology will be retained for further consideration.

5.2.1.4 Excavation and Disposal

Excavation and disposal are widely practiced as soil remediation techniques. They are especially useful in removing "hot spots" (i.e., small areas with high contaminant

concentrations), followed by other treatment technologies for the remaining less contaminated materials. Excavation and disposal permanently remove the potential at the site for receptor contact with contaminated soils and contaminant migration. In addition, excavation removes the need for long-term monitoring, as long as all contaminated materials are removed. Excavation may also be used to consolidate contaminated areas or recover contaminated soils for treatment by other technologies rather than disposal (USEPA, 1985).

Excavation is applicable to all sites; however, the cost becomes prohibitive at great depths or when used in complex hydrogeologic environments. In addition, other constraints to the practical use of excavation exist, such as the RCRA land disposal restrictions. For example, there are currently no landfills on the island of Puerto Rico that are permitted to accept hazardous waste. This may require shipment of hazardous waste off the island. Finally, the ultimate disposition of excavated material, i.e., treatment, disposal, shipment off the island, or reuse, will impact its cost-effectiveness (USEPA, 1985).

Excavation equipment ranges from small units, such as a 1/4-cubic-yard (cy) backhoe, to large units, such as a 20 cy dragline. In addition, bulldozers and loaders are commonly used for excavation. Other excavating equipment, such as trenchers, belt loaders, and wheel bucket excavators, are available, but are not as versatile in waste site excavation (USEPA, 1985).

Backhoes are more appropriate for trenching than for excavation over an extensive area. Backhoes generally require a level surface at grade to operate from. To achieve greater depths, a "working bench" of sufficient size can be constructed below grade to allow the backhoe to operate from while excavating the soil adjacent to the working bench (USEPA, 1985).

Cranes and draglines can be used for deeper excavations over larger areas than the ones typically handled by backhoes. They are most successful over large land areas with loosely compacted soils. Cranes and draglines are inappropriate for explosive materials and very toxic materials (USEPA, 1985).

Off-site disposal of excavated material requires hauling, possibly manifests, and compliance with any other applicable state and federal regulations. Disposal of excavated wastes off-site may have long-term liability associated with it arising from potential human health and environmental impacts due to practices at the off-site facility. Thorough investigation of a potential off-site facility's record-keeping practices, reputation, operating practices, insurance

coverage, and permit limitations is prudent to minimize the potential for liability. Off-site disposal by landfilling can be very expensive depending on the type of treatment, if any, required prior to landfilling.

Excavation

Excavation of contaminated soils is judged as effective and implementable for a number of SWMUs and AOCs. However, the implementation of excavation may be more difficult if monolithic covers or buildings and other structures are present nearby or over the contaminated site. Excavation through monolithic covers is feasible, and will need to be assessed on a SWMU-specific basis.

Medium costs are associated with excavation, provided the contamination is accessible and near the surface. Extent of contamination must be identified at all potentially contaminated sites prior to conducting a detailed assessment.

On-Site Disposal

On-site disposal of excavated contaminated soils is effective at preventing impacts to health and the environment; however, RCRA land disposal restrictions likely will prevent the on-site land disposal or require extensive treatment prior to landfilling.

Off-Site Disposal

Since off-site disposal is appropriate for management of excavated contaminated soils, it will be retained for further consideration.

Based on RCRA land disposal restrictions and treatment requirements, this technology will be limited to wastes without specified treatment technologies and which are treated to required treatment standards. Otherwise, off-site disposal of excavated material is both effective and implementable. The cost of utilizing this technology is typically high, although the costs vary with the required treatment of the materials disposed. Implementability of off-site disposal depends on potential treatment requirements based on RCRA land disposal restrictions and the proximity of a permitted facility with sufficient capacity to handle the contaminated soils. There are currently no landfills on the island of Puerto Rico that are permitted to accept

hazardous wastes. In addition, liability is only being transferred from the current site to the off-site disposal area.

5.2.1.5 Vacuum Extraction

Vacuum extraction is the most commonly used technology among the soil vapor extraction techniques. Clean air is injected into the contaminated soil and extracted through a vapor recovery or extraction well when laden with VOCs. An air blower is typically used both to inject the clean air and to provide a vacuum to extract the vapor stream. Within the soil, volatile compounds partition between the air and water located in the void spaces between particles. Upon application of a vacuum to remove the existing air from the voids, the equilibrium is disturbed between the vapor and liquid states of the volatile constituents. The VOCs will preferentially move into the vapor phase to try and reestablish equilibrium. As the VOC-laden air is removed and replaced with fresh, the process will continue to remove residual volatiles (USEPA, 1990a).

Vacuum extraction is most suitable for permeable, unsaturated soils, such as sands, gravels, and coarse silts. Low diffusion rates and insufficient pore interconnections minimize the use of vacuum extraction for clays.

Several operating parameters that impact the effectiveness of this process are (USEPA, 1990a):

- Air extraction rates - higher extraction rates increase removal rates; however, they also increase operating costs
- Extraction well spacing and configuration - additional wells provide greater air flow, although they also increase capital costs
- Control of water infiltration
- Pumping deviations - temporarily stopping air flow allows time for chemicals to diffuse into the vapor phase, thus allowing removal at higher concentrations.

The air removed from the soils is treated prior to discharge. It may be passed through a vapor-liquid separation process, such as condensation or distillation. Other possibilities include activated carbon adsorption, incineration, and recycle as fuel (USEPA, 1990a).

While not a conventional technology, vacuum extraction has been demonstrated at two Superfund sites and at one other site through the SITE program. Contaminants treated at these sites included TCE and carbon tetrachloride (USEPA, 1990a).

Factors that impact implementability of this technology include (USEPA, 1990a):

- Contaminant volatility - vapor pressure, Henrys' Law constant, air/water partition coefficient, solubility

- Soil properties - permeability, porosity, organic carbon content, soil moisture content, and particle size distribution

- Volume and shape of contamination

- Accessibility to site

Options are available that increase soil temperature to increase contaminant volatility. These techniques include steam stripping, radio frequency heating, and microwave heating.

Remediation by vacuum extraction is permanent. Highly volatile constituents will be removed more efficiently than less volatile compounds. For sites contaminated by several different waste types, those that are not highly volatile may require a different treatment in another step (USEPA, 1990a). As an in situ technology, vacuum extraction does not adversely effect nearby structures (Kill, Undated).

As shown on Table 5-1, vacuum extraction is effective for removing volatiles from contaminated soils on site. On semivolatiles, vacuum extraction is only moderately effective. For all other known or suspected contaminants on site, vacuum extraction is ineffective.

Implementability of this technology has been assessed as high; however, the shape and extent of contamination impact its application. Furthermore, the treatability of the waste needs to be established in order to fully assess implementability. Information required to estimate treatability include the contaminant's: vapor pressure, Henry's Law constant, air/water partition coefficient, and solubility. Due to the nature of vacuum extraction, it may be suitable to sites that are inaccessible by excavation or capping technologies, provided ancillary equipment such as extraction wells, can be adequately placed.

TABLE 5-1
POTENTIALLY APPLICABLE CORRECTIVE MEASURES TECHNOLOGIES
U.S. NAVAL STATION ROOSEVELT ROADS
CEIBA, PUERTO RICO

Technology	SWMU #1	SWMU #2	SWMU #3	SWMU #9	SWMU #11	AOC #B
SOILS:						
No Action	X	X	X	X	(1)	X
Institutional Controls	X	X	X	X		X
Containment:						
Capping	X	X		X		X
Barrier trenches	X	X	X	X		X
Excavation and Disposal:						
Excavation		X		X		X
On-Site Disposal		X		X		X
Off-Site Disposal		X		X		X
Vacuum Extraction				X		X
Soil Washing/Flushing		X		X		X
Biotreatment				X		X
Solidification/Stabilization		X				
Vitrification						
Thermal Destruction:						
Thermal Destruction				X		X
Low-Temperature Thermal Desorption				X		X
Chemical Dechlorination						X

(1) - Remediation of the PCB-contaminated soil in the vicinity of Building 38 is currently being performed.
(2) - Groundwater remediation will be initiated shortly at SWMU #11.
(3) - Shaded areas indicate that no Corrective Action is required under the permit.

TABLE 5-1
POTENTIALLY APPLICABLE CORRECTIVE MEASURES TECHNOLOGIES
U.S. NAVAL STATION ROOSEVELT ROADS
CEIBA, PUERTO RICO
(CONTINUED)

Technology	SWMU #1	SWMU #2	SWMU #3	SWMU #9	SWMU #11	AOC #B
GROUNDWATER:						
No Action	X	X	X	X	(2)	X
Institutional Controls						
Alternate Water						
Relocation						
Containment/Collection:						
Capping	X	X		X		X
Barriers		X	X	X		X
Trenches		X	X	X		X
Extraction Wells		X	X	X		X
Treatment Technologies						
Evaporation/Distillation						
Air Stripping			X	X		
Freeze Crystallization						
Sparging			X	X		
pH Adjustment		X	X			X
Precipitation		X	X			X
Chlorination Reaction						
Chemical Reduction						
Chemical Oxidation		X	X			
Advanced Oxidation			X	X		
Hydrolysis						
In-Situ Chemical						
Biotreatment			X	X		
Density Separation				X		
Filtration		X	X	X		X
Membranes						
Activated Carbon			X	X		
Ion Exchange						X
Deep Well Injection						

(1) - Remediation of the PCB-contaminated soil in the vicinity of Building 38 is currently being performed.
(2) - Groundwater remediation will be initiated shortly at SWMU #11.
(3) - Shaded areas indicate that no Corrective Action is required under the permit.

TABLE 5-1
POTENTIALLY APPLICABLE CORRECTIVE MEASURES TECHNOLOGIES
U.S. NAVAL STATION ROOSEVELT ROADS
CEIBA, PUERTO RICO
(CONTINUED)

Technology	SWMU 1	SWMU 2	SWMU 3	SWMU 9	SWMU 11	AOC #B
SURFACE WATER:						
No Action	X	X	X	X	X	(3)
Institutional Controls	X	X	X	X	X	
Diversion:						
Dikes						
Channels						
Chutes						
Capping						
Grading	X	X	X	X	X	
Collection/Discharge:						
Ditches		X	X			
Basins		X	X			
Treatment Technologies:						
Phase Change Separation						
Chemical Processes						
Biotreatment			X			
Density Separation						
Filtration		X	X			
Membranes						
Carbon Adsorption			X			
Ion Exchange						

(1) - Remediation of the PCB-contaminated soil in the vicinity of Building 38 is currently being performed.
(2) - Groundwater remediation will be initiated shortly at SWMU #11.
(3) - Shaded areas indicate that no Corrective Action is required under the permit.

TABLE 5-1
POTENTIALLY APPLICABLE CORRECTIVE MEASURES TECHNOLOGIES
U.S. NAVAL STATION ROOSEVELT ROADS
CEIBA, PUERTO RICO
(CONTINUED)

Technology	SWMU 1	SWMU 2	SWMU 3	SWMU 9	SWMU 11	AOC #B
SEDIMENTS:						
No Action	X	X	X	X	X	
Institutional Controls	X	X	X	X	X	
Containment:						
Inert						
Active						
Sealant						
Grouting						
Exacavation and Disposal:						
Dredging		X			X	
On-Site Disposal		X			X	
Off-Site Disposal		X			X	
Sediment Washing/Flushing		X			X	
Biotreatment					X	
Solidification/Stabilization		X			X	
Vitrification					X	
Thermal Destruction					X	
Low-Temp Thermal Desorption						
KPEG					X	

(1) - Remediation of the PCB-contaminated soil in the vicinity of Building 38 is currently being performed.
(2) - Groundwater remediation will be initiated shortly at SWMU #11.
(3) - Shaded areas indicate that no Corrective Action is required under the permit.

Costs associated with vacuum extraction are in the medium range of soils technologies. In particular, capital and operating costs for ancillary equipment, such as quantity of extraction wells, vapor/liquid separators, and air pollution control devices following treatment strongly impact overall costs. Availability of this equipment and shipment costs to the island of Puerto Rico will also impact overall costs.

Vacuum extraction is appropriate for many of the contaminated soils sites being considered. As such, it will be retained for further consideration.

5.2.1.6 Soil Washing/Flushing

Treatment of contaminated soils by washing/flushing takes advantage of elutriation to remove contaminants from the site. Extraction and dissolution also utilize the technique of elutriation, although these processes generally are applied to excavated material. As such, the various elutriation processes are addressed in this section as one technology. Ex-situ soil washing involves thorough mixing of solvent and soil in a self-contained tank. In situ soil washing/flushing is accomplished by flooding the site with an appropriate washing solution, collecting the elutriate, and treating, disposing, or recycling the collected solution (USEPA, 1990a).

Spray towers may be used to apply the flushing solution to the soil. The soils overlying the contamination, and the contaminated zone itself, must be saturated with solvent. Collection of the elutriate is necessary to prevent uncontrolled migration. Solution collection may be accomplished through a series of shallow wells or subsurface drains (USEPA, 1990a). (See Section 5.2.2 Groundwater for a more detailed description of collection methods.)

Three interactions between solvent and solute may result in mobilization of contaminants (USEPA, 1990a):

- Solubilization
- Formation of emulsions
- Chemical reaction

Numerous washing solutions are available. It is important to select a solution that is appropriate for the contaminant(s) present at the site. Various flushing solutions and some of the solutes they may mobilize are listed in the following (USEPA, 1990a):

- Water
- Acidic aqueous solutions (sulfuric, hydrochloric, nitric, phosphoric, carbonic) - removes metals and basic organic constituents, such as amines, ethers, and anilines
- Basic solutions (sodium hydroxide) - removes certain metals (zinc, tin, and lead), phenols, complexing/chelating agents, and surfactants
- Surfactants (See Table 5-1 for partial list of surfactants) - removes hydrophobic organics

Several factors impact the effectiveness of this technology. The most important factors are (USEPA, 1986):

- Appropriateness of solution for specific waste
- Soil hydraulic conductivity
- Soil homogeneity
- Waste/solution contact
- Soil adsorption coefficient of the waste

The suitability of the site for flooding and well/drain installation, in terms of its hydraulic conductivity, homogeneity, topography, and depth to groundwater, must be assessed. These soil properties also impact the ability of the solution to contact the waste. The partitioning of the contaminants between the solvent and the solution must be acceptable, on the order of $K < 10^{-3}$, so that removal of contaminants can be accomplished (USEPA, 1990a).

Consideration must be given to interaction between the soil and the flushing solution as well as to the solute/solution interactions. Some flushing solutions are themselves capable of contaminating soils and groundwater; thus, provision must be made to remove these solutions following completion of treatment. Washing solutions may alter soil properties, including pH, compaction, and organic content, possibly even to the extent of reducing effectiveness of the treatment process. Conversely, soils may modify the flushing solution properties, including

inactivation and/or retention of active constituents. Therefore, it is advisable to conduct laboratory tests on site-specific soils with selected flushing solution(s) (USEPA, 1990a).

Provided appropriate washing solutions(s) can be utilized, soil washing/flushing may be used alone to remediate contaminated soils. Alternately, soil washing/flushing offers several options for use with other treatment technologies. For example, soil washing may be used after in situ chemical treatments, such as oxidation, to remove reaction products. On the other hand, an organic elutriate may be recycled back to the soil at low concentration and a controlled rate for subsequent treatment by biodegradation (USEPA, 1990a).

Relative cost of soil washing/flushing is moderate, depending strongly on price and availability of the flushing solution. Generally, flushing solutions are widely available and inexpensive; however, often such a large volume of the solution is required that overall expenditure may be considerable (USEPA, 1990a), particularly in light of the facility location on the island of Puerto Rico.

Soil washing/flushing is effective, implementable, and available at moderate costs, according to Table 5-1. However, the proper set of conditions must be in place. The appropriate reagent for the contaminants in the soil must be identified. Further, the partition coefficient between the reagent and the soil must favor contaminant migration with the reagent. Such information can be obtained as part of a treatability study for this technology.

For in situ operations, the washing/flushing agent must also be compatible with the in place soils. In situ soil washing/flushing requires site accessibility. The site must be accessible to subsurface drains or extraction wells. In addition, the site must be available for application, generally by spray techniques, of the flushing agent. Further, if the design includes a recycle step, sufficient area needs to be available for storage prior to recycle back to the site. For these reasons, sites which are obstructed partially or wholly by buildings or monolithic covers are not appropriate for in situ soil washing/flushing.

Soil washing has costs which are in the medium range of soil technologies when considered on a unit cost basis, depending on the selection of reagent. Overall costs may be high for this technology due to a typically large volume of reagents used, and potential limited availability of this material on the island of Puerto Rico.

Since soil washing/flushing is appropriate for management of contaminated soils, it will be retained for further evaluation.

5.2.1.7 Biotreatment

Biodegradation of contaminants is addressed in Section 5.2.2 - Groundwater. Much of the discussion included under Groundwater is applicable to soils. In addition to the factors presented in Section 5.2.2 which impact the ability to maintain biodegradation, two more factors are significant when considering in situ soils biotreatment: degree of water saturation and hydraulic conductivity of the soil. Degree of water saturation is important since moisture prevents desiccation of the biomass and allows transport of necessary nutrients in a bioavailable form. Hydraulic conductivity must be favorable to ensure that additives, such as oxygen, nutrients, and water, are available at the furthest edges of the site, i.e., that additives are not consumed prior to transport to all contaminated portions of the site (USEPA, 1985).

Further considerations with in situ biotreatment concern the precipitation of minerals, e.g. iron and manganese, onto the soil particles which could lead to clogging. Similarly, the growth of the biomass itself can cause soil plugging.

Land treatment as discussed in Section 5.2.2 is a particularly applicable means of biotreatment of soils. In addition, as discussed in Section 5.1.2.6 Soil Washing/Flushing, land treatment may be used as a method of disposing of the contaminated washing solution. Another technology option, slurry bioremediation, appears applicable for soils contamination. Slurry bioremediation involves combining soil, sediments, or sludge with water. The resulting slurry may be treated aerobically in a self-contained tank or a lined lagoon. The operation and considerations important to slurry biotreatment are similar to those of an activated sludge process. Potential pretreatment considerations for slurry bioremediation options include communition for oversized particles and pretreatment for metals removal, since they may inhibit biodegradation (USEPA, 1985).

Biotreatment is effective on degrading most organic contaminants and also halogenated organics, although the slower anaerobic organisms are needed to degrade the halogenated organics. Some contaminants are not readily degraded, and treatability studies are necessary. In addition, biotreatment is not effective on contaminated soils that have metals present as well as organics, since metals have been associated with poisoning of some treatment organisms.

Biotreatment can be fairly easily implemented if the appropriate organism can be identified. Also, for in-situ land application, the site must be accessible.

Costs associated with biotreatment are expected to be moderate. Variations, which might include energy-intensive operations such as supplying power to blowers, mixers, and pumps, may cause costs to become relatively high. This equipment may not be readily available on the island of Puerto Rico.

Based on these considerations, this technology will be retained for further study.

5.1.2.8 Solidification/Stabilization

Several processes are included within the category of solidification/stabilization. The purpose of this group of processes is one or more of the following (USEPA, 1990a):

- To improve handling and physical characteristics
- To reduce contaminant solubility
- To decrease exposed surface area

Solidification/stabilization may be employed alone to minimize potential impacts from soil contamination or it may be applied as part of a treatment train. Solidification/stabilization processes are commonly used to treat sludges resulting from groundwater/surface water remediation by such technologies as chemical precipitation.

Differences between solidification processes and stabilization processes are based on the fact that solidification processes effect a change in the physical properties of the soil matrix and stabilization processes effect a chemical change on certain constituents. While a chemical interaction may occur in solidification processes and a physical change may occur in stabilization processes, such modifications are not the primary remedial mechanisms (USEPA, 1990a).

Some of the soil property modifications possible when employing solidification processes include: eliminating free liquid; increasing bearing strength; decreasing surface area; and producing a monolithic solid product. Two main types of solidification occur; microencapsulation which involves the encapsulation of fine particles and

macroencapsulation which involves the encapsulation of large blocks of waste. Since the contaminants are mechanically bound within a solidified matrix, release of contaminants upon exposure is minimized. Stabilization processes, on the other hand, chemically convert contaminants to the least soluble or mobile form or to the least toxic form. Both types of treatment may increase the volume of soils due to reaction products and/or soil property changes (USEPA, 1990a).

Several agents or systems of agents may be used to effect solidification/stabilization changes, the more common ones are as follows (USEPA, 1990a):

- Pozzolan/portland cement system - produces "concrete" microencapsulation.

- Lime/fly ash pozzolan systems- produces low-strength "concrete" microencapsulation.

- Thermoplastic microencapsulation system - liquid and volatile materials vaporize, and microencapsulation of remaining solid materials occurs when heated thermoplast (e.g., melted asphalt) cools.

- Sorption system - soaks up free liquid (Some additives, such as zeolites and activated carbon, may adsorb certain constituents as well.).

- Organic binding system - adsorbs organic constituents by means of clay modified with quarternary ammonium ions.

For the thermoplastic microencapsulation system, the generation of gases may require their collection for further treatment.

Complete and uniform mixing of solidification/stabilization agents with soils to be remediated is critical for effective treatment. Mixing is especially important if one or more of the following conditions exist (USEPA, 1990a):

- Multiple constituents are present in the wastes
- Soils to be treated are multi-textured
- Multiple treatment agents will be used
- Wastes are involved in reactions

For in situ applications, a backhoe, clamshell, or dragline is commonly used to achieve mixing. This equipment may only be effective for shallow contamination depths.

Common methods of applying solidification/stabilization agents include (USEPA, 1990a):

- Injection. Injection is used for application of liquid or slurry. A porous tube is placed at the desired depth and the agents are injected into the soil. One variation calls for a hollow drill to rotate at low speed while applying the fluid to facilitate mixing.

- Surface Application. Solid or liquid is applied on the surface of the site, if contamination is shallow.

The long-term durability of treatment products is generally good. Future use of the site may be limited, since reduced permeability may be inappropriate for revegetating or construction. Furthermore, run off controls may be necessary to prevent erosion of neighboring areas (USEPA, 1990a).

Compatibility between wastes, soils and solidification/stabilization agents must be appropriate to ensure effectiveness. General guidelines for compatibility were available for several waste types with cement-based, pozzolan-based, and thermoplastic encapsulation systems. Metals are generally compatible with all three of these systems. Organics often experience vaporization when subjected to these three systems, and may impede setting in both the cement-based and pozzolan-based encapsulation systems (USEPA, 1990a).

Solidification/stabilization processes are effective at minimizing impacts on health and the environment and are implementable with moderate difficulty.

Implementability of solidification/stabilization processes is quite feasible when performed ex-situ following excavation. Cost savings can be realized when treatment is performed in-situ, although it is more complex to apply these technologies in-situ. Proper mixing of reagents and contaminated soils is essential, although difficult to achieve in-situ if depth of contamination is great. In addition to needing to know the extent of contamination, treatability of contaminated soils should be investigated through treatability studies with potential treatment system(s) prior to final selection. Accessibility of the soil site is necessary for in situ solidification/stabilization, since mixing is commonly practiced with conventional construction equipment, such as bulldozers.

Cost of applying solidification/stabilization techniques is typically in the medium range, although it is dependent on reagent cost. Reagents and other materials/equipment may not be readily available on the island of Puerto Rico.

Solidification/stabilization will not be considered any further at this time since implementation involves some difficulty, particularly with regard to in situ mixing. Consideration of solidification/stabilization may be resumed if other options become less attractive; for instance, if the reagent costs for in-situ soil washing of inorganic species are high and cause the overall cost of the soil washing option to become prohibitive, then solidification/stabilization may appear more feasible.

5.2.1.9 Vitrification

Vitrification is a type of solidification/stabilization process that uses electrical energy to convert contaminated soils into chemically inert and stable glass and crystalline materials. Soils to be treated must contain considerable amounts of silicate material. For in-situ vitrification, two electrodes are placed into the soil to be treated and graphite and glass frit are placed between them to begin the process since soils are not generally highly conductive. The electric current heats up the soil to as high as 3600°F. Most soils and solid waste melt at around 2000 to 2500°F. Generally, organics within the matrix pyrolyze and metals either fuse with the soils or vaporize. Hence, it may be necessary to collect gases and vapors (USEPA, 1990a).

The final volume may be considerably less than the initial volume. In addition, the material is impermeable, stable, and inert; thus, fill material must be used above an in situ treatment site in order to revegetate (USEPA, 1990a).

Vitrification is appropriate for numerous waste types: metals, PCBs, sludges, plating wastes, and nitrate and sulfate compounds. Anions, such as fluoride and chloride, are dissolved in the glass. However, contaminants may migrate with the advancing front of the soil melt instead of being contained within the glass matrix or migrating to the upper surface for collection. Contaminants which concentrate at the melt/soil interface may be leachable after the material has cooled (USEPA, 1990a).

Vitrification can treat 3 to 5 tons per hour of contaminated soils. The remediation achieved is permanent and exposure of workers or the general public is minimized. Additive requirements are small and the materials are relatively inexpensive. However, energy requirements may be very high and specialized equipment and highly trained personnel must be used. For example, the power supply for a typical full-scale, four electrode operation, may be handled by a 4160 V, 3000 kW multitype transformer (USEPA, 1990a). In addition, soils with high moisture contents may require greater energy input to vaporize the excess moisture (USEPA, 1990a).

Vitrification is effective at protecting health and the environment by minimizing potential for migration from the soils. In addition, vitrification may be implemented with a moderate amount of difficulty. However, high costs are attributed to this technology due to the high cost of operating such energy-intensive equipment. This equipment may not be readily available on the island of Puerto Rico.

Implementation of vitrification in situ involves placement of glass frit and graphite to initiate conduction of the electrical current. The electrodes themselves must be placed appropriately, which may preclude in situ application of this technology at soil sites where asphalt or concrete pads or buildings overly the site or are present nearby. In addition, due to the volume change, backfill of in situ treatment sites is necessary. While implementability of this technology ex situ is not subject to obstructions or backfill, it does involve handling of the molten soils prior to cooling.

Vitrification will not be considered any further at this time since implementation involves some difficulty, both in-situ and ex-situ, and since operating costs are high. Consideration of vitrification may be resumed if other options become less attractive; for instance, if off-site disposal costs are excessive or if appropriate facilities are not available, vitrification may appear more feasible.

5.2.1.10 Thermal Destruction

Thermal destruction is a treatment method which uses high temperature oxidation under controlled conditions to convert a waste into a less hazardous or non-hazardous form. Thermal incineration is an appropriate technology for destruction of organic wastes. The incineration process may be viewed as consisting of four parts:

- Preparation of the feed materials for placement in the incinerator

- Incineration or combustion of the material in a combustion chamber

- Cleaning of the resultant air stream by suitable air pollution control devices (e.g., wet scrubbers, electrostatic precipitators, fabric filters, and after-burners).

- Disposal of combustion by-products

Conventional thermal destruction technologies include: rotary kiln, multiple hearth furnace, fluidized bed combustor, and liquid injection furnace. In addition, several new technologies are emerging: plasma arc furnace, circulating fluidized bed combustor, wet air oxidation process, high temperature fluid wall process, molten salt reactor, and low-temperature thermal desorption. Off-gas heat recovery from boilers, heat exchangers, and turbine generators is possible.

Thermal processes are typically used for highly toxic waste or highly concentrated organics. Other toxic wastes and non-toxic wastes also may be burned. If the BTU content is high enough the waste may be used for fuel; if not, supplemental fuel can be added to ensure combustion.

Thermal destruction techniques may be employed alone to remediate soils or as part of a treatment train. A common option involves thermal destruction of concentrated VOCs following such processes as vapor extraction.

Contaminated soils can be transported off-site for incineration (although this may involve transport off the island of Puerto Rico), or a mobile incinerator may be used on-site. Off-site incinerators may limit wastes accepted for thermal destruction according to the following parameters (USEPA, 1985):

- BTU content - Permits often specify a minimum BTU content for acceptable wastes. Generally, a BTU content not less than 5000 BTU per lb is specified.

- Viscosity - Some incineration units cannot handle and combust highly viscous or solid waste materials.

- Halogen content - Permits often specify a maximum halogen content so as to achieve compliance with HCl emission limits. Typically, greater than 99 percent HCl removal is required.

- Ash content - Restrictions on ash content may be set to minimize slagging and also to achieve compliance with particulate emission limits. Less than 180 milligrams per cubic meter emitted is generally acceptable.

- Moisture content - High moisture contents may increase costs of thermal destruction and decrease efficiency. Excessive moisture must be vaporized requiring a portion of the energy intended for combustion. An incineration unit may need to be larger to accommodate the same quantity of solids (dry basis) if the moisture content is higher.

In addition, few facilities are permitted to incinerate PCBs and low level radioactive wastes, due to special permitting requirements (USEPA, 1985).

Pretreatment prior to incineration may be necessary. Liquid wastes, if compatible, may be "bulked" in tank cars prior to transport to the facility. Acid/base neutralization may be employed to prevent attack on incinerator equipment. Cyanides and sulfides may be oxidized by hypochlorite prior to combustion. Solid waste may be subjected to communition (USEPA, 1985).

Various potential methods to accomplish incineration are briefly described, including some that are applicable to concentrated organic liquids as opposed to soils. Since soils technologies such as vacuum extraction may result in such a stream, the liquid feed processes are discussed. Among the various processes, the following are most appropriate for soils:

- Rotary Kiln
- Multiple Hearth Furnace
- Fluidized Bed Combustor
- Circulating Fluidized Bed Combustor
- Plasma Arc Furnace

Rotary kilns are conventional, demonstrated technologies. A rotary kiln incinerator is essentially a long, inclined tube that is rotated slowly. Wastes and auxiliary fuels are introduced to the high end of the kiln and travel to the low end. The rotation constantly

agitates the solids material being burned. Agitation causes a great amount of solid mixing which allows for improved combustion. Rotary kilns are intended primarily for solids combustion, but liquids and gases may be co-incinerated with solids. As such, rotary kilns are preferred for treating mixed wastes. Exhaust gases from the kiln pass to a secondary chamber or after-burner for further combustion. Rotary kilns are typically large in size, thus, high capital costs are experienced.

Multiple-hearth furnaces are demonstrated, conventional technologies. A multiple-hearth incinerator consists of a refractory-lined metal shell with several hearths located in series in a vertical configuration. A central shaft with attached rabble teeth arms rotates which moves the solids from top to bottom of the furnace. Fuel, air and water may be entered at any hearth level for enhanced combustion control. It can treat the same wastes as a rotary kiln provided that pretreatment of the solids is performed. Reliability concerns include treatment of solid wastes with high ash content that slag the unit and control of air leakage.

Fluidized bed combustors are a relatively recent technology presently being applied for treating wastes. Fluidized beds use a very turbulent bed of inert granular material (usually sand) to improve the transfer of the heat to the waste streams being incinerated. In some cases, the waste itself may make up all or part of the bed. Air is blown through the granular bed until the particles are suspended and able to move and mix in a manner similar to a fluid. In this manner, the bed particles come in intimate contact with wastes being burned. Waste is fed into multiple injection ports. Fluidized beds achieve excellent heat transfer and a long solids retention time. Most typical applications include slurries and sludges. Reliability concerns include the ability to maintain a fluidized mass of solids and the removal of residuals.

An emerging technology applicable to soils is the circulating fluidized bed combustor. The circulating fluidized bed combustor is designed to be an improvement over conventional fluidized beds. The system operates at higher fluid velocities and finer sorbents than conventional fluidized beds. This permits use of a more compact unit with the potential of higher efficiency and less emissions. Potential destruction of PCBs, chlorinated hydrocarbons, and aromatics occur at 850°C. Acid gases are captured by the addition of limestone. Compounds containing high levels of phosphorus, sulfur, and cyanide can be processed with low emission levels of NOx, CO, and acid gases.

The plasma arc furnace is an emerging technology. Plasma arc technology may be used to destroy either liquid or solid wastes by pyrolyzing them into combustion gases. The wastes

contact a gas which has been energized into a plasma. The gas temperature is very high at 9000°F. The advantages are the lack of hazardous combustion products, high efficiency, and ability to be portable.

The liquid injection furnace is a conventional, demonstrated technology. The liquid injection system consists of a single or double refractory chamber with a series of atomizing nozzles. The most popular configurations are double-chambered, horizontally- or vertically-fired units. Liquid injection systems generally can be applied to any pumpable organic waste with high moisture content; however, wastes with high solids content may foul nozzles. In addition, wastes with high concentrations of inorganics are typically unsuitable for this furnace. Pretreatment with tanks for flow equalization may be required.

The high temperature fluid wall process is an emerging technology. The process is carried out in a patented reactor capable of emitting radiant energy supplied by electrodes in the jacket of the reactor. During the process an inert gas is injected to coat the wall of the reactor to prevent destruction from high temperatures. It has been used to treat PCB wastes.

The wet air oxidation process is another nonconventional technology. Wet air oxidation involves aqueous phase oxidation of wastes. The temperature is relatively low; however pressures of 300 to 3000 pounds per square inch are required to maintain reaction rates. Waste is pumped into the system by a high pressure pump and mixed with air by a compressor. The reaction products are further processed by separation into a liquid and gas stream. Wet air oxidation is used primarily to treat concentrated waste streams containing organic and inorganic wastes. It is generally selected for treating nonbiodegradable materials and when it is more cost effective than other incineration technologies. Waste streams for which wet air oxidation is particularly applicable include concentrated streams that contain pesticides, herbicides, or other complex organics which are not readily biodegradable.

Another emerging technology, the molten salt incinerator, can be used for the destruction of hazardous wastes. In this method wastes undergo catalytic destruction when they contact hot molten salt. Hot gases rise through the hot molten salt bath, pass through a secondary reaction zone, and through an off-gas clean-up system. The technology has been demonstrated to be highly effective for chlorinated hydrocarbons, including PCB, and chlorinated solvents.

Thermal destruction is effective and implementable, although high costs are associated with this option. The effectiveness of thermal destruction applies to organic contaminants; another

treatment may be needed to effectively minimize impacts from inorganic contaminants. Implementability assumes that an approved incineration facility is available at a reasonable transport distance from the site that can accept the contaminated soils. This is unlikely for the island of Puerto Rico. Waste characterization data may be required prior to acceptance by the incinerator. On-site incineration requires considerable permitting which has been increasingly more difficult and time-consuming to obtain due to public perception.

Since thermal destruction is appropriate for management of contaminated soils, it will be retained for further evaluation.

Low-Temperature Thermal Desorption

A related option to thermal destruction for soils is low-temperature thermal desorption. Under the name X*TRAX™, Chemical Waste Management markets the low-temperature thermal desorption process as an alternative to incineration. The process operates between 200 and 900°F. Organic contaminants are removed and condensed into a high BTU liquid. The liquid may then be disposed of in an incinerator or by another appropriate means (USEPA, 1990).

Low-temperature thermal desorption is accomplished via an externally-fired rotary dryer. The rotary dryer is used to volatilize water and organics. The vapor stream mixes with an inert gas stream, generally nitrogen, and is treated to separate organics, water, and dust. The solids are cooled with condensed water and are prepared for replacement into their original location. Removal of dust and 10 to 30 percent of the organics from the inert gas stream is accomplished in a high-energy scrubber. Heat exchangers are then used to cool the gas stream to below 40° F, thus condensing the water and organics. The majority of the cleaned inert gas is recycled; however, a slipstream of approximately 5 to 10 percent is passed through a filter and two carbon absorbers, then discharged (USEPA, 1990b).

Low-temperature thermal desorption is effective at removal of VOCs, SVOCs, and PCBs from a variety of soils. Reportedly, volatiles are reduced to below 1 ppm and semi-volatiles are reduced to below 10 ppm. PCB removal is greater than 98 percent (USEPA, 1990b).

Since the entire volume of contaminated soils does not require incineration or similar treatment with this separation technique, a savings may be realized over other thermal destruction options. This technology, while emerging, has been demonstrated through the SITE program (USEPA, 1990b).

Low temperature thermal desorption is effective at removing organic contaminants from soils; however, not enough process information is available to assess the implementability and cost of this technology. Predominantly, lack of information concerns the availability of equipment and trained personnel. Since this is a relatively new technology, uncertainties exist concerning equipment procurement, availability of knowledgeable personnel, and costs, which may be linked to personnel and equipment availability. The location of the facility on the island of Puerto Rico contributes to these uncertainties.

Although low temperature thermal desorption has uncertain implementability and cost, it will be retained for further consideration. However, prior to implementation of this technology, the availability of equipment and personnel and associated cost must be evaluated in greater detail.

5.2.1.11 Chemical Dechlorination

Dechlorination is an innovative technology used to remove halogens form chlorinated organics including PCBs, dioxins, furans, halogenated VOCs and SVOCs, and halogenated herbicides and pesticides.

A mobile process has been developed that uses sodium bicarbonate to dechlorinate soils, sediments, and liquids. contaminated soils and sediments are screened, processed in a pugmill and stockpiled. Sodium bicarbonate is mixed with the stockpiled material in an amount equal to 10 percent of the weight of the stockpile. The mixture is then placed in a rotary reactor and heated to 630°F for approximately one hour. Off-gases are treated and released; residuals from off-gas treatment are decomposed in a stirred tank slurry reactor. The resulting sludge can be disposed of in the same manner as municipal sewage sludge. Treated soils and sediments can be returned to the site and used as backfill material.

This technology can potentially meet remedial action objectives and reduce toxicity, and mobility and the volume of contaminants of concern. Also, it has a demonstrated effectiveness for PCBs and other chlorinated. Additionally, there is a potential for moderate to high exposure of workers during implementation.

Chemical dechlorination is a relatively new technology. Variations in dechlorination processes produces either aqueous/organic wastestreams that require further disposal or

sludge also requiring disposal. Chemical dechlorination processes require off-gas treatment prior to discharge to the atmosphere. Additionally, treatability testing may be required to determine operating and final design parameters.

Despite the high capital and O & M costs associated with this technology, it will be retained for further consideration.

5.2.2 Evaluation of Groundwater Corrective Measures Technologies

Several corrective measures technologies are potentially applicable to minimize health and environmental impacts due to contamination in the groundwater medium. Literature sources have been reviewed to identify and characterize potential corrective measures technologies. The following general technologies were examined for potential suitability to remediate groundwater at the Naval Station, Roosevelt Roads.

- No Action
- Institutional Controls
- Containment
- Collection/Discharge
- Phase Change Separation
- Chemical Processes
- Biotreatment
- Gravity Separation
- Filtration
- Membranes
- Activated Carbon Adsorption
- Ion Exchange

In this section, brief, general reviews of potentially applicable groundwater corrective measures technologies are presented, followed by site-specific evaluations based on currently available information.

5.2.2.1 No Action

The no action alternative involves minimal effort. Contaminated groundwater left over time will disperse and possibly biodegrade via natural mechanisms. To ensure that groundwater

does not migrate, off-site monitoring may be required. In many cases, this may not be an effective option due to immediate and potential health risks. It may not be readily implemented due to public perception and the desire to eliminate contamination. Theoretically, this option may be the lowest cost option.

5.2.2.2 Institutional Controls

Institutional actions include imposing access restrictions on-site and monitoring of the contaminants at the site. Access restrictions encompass actions such as fencing off the site or developing deed restrictions. Monitoring includes sampling and analysis of surface water and groundwater and, if necessary, expansion of the monitoring system to track contaminant movement. Development of an alternate water supply system and relocation of residents are also institutional actions.

Institutional controls may be applicable as a conditional remedy. A conditional remedy is one that appears adequate to protect human health and the environment under the present site conditions; however, provisions must be made to allow remediation at some time in the future, such as shut-down of a SWMU/AOC or sale of property.

Alternate Water Supply

Provision for an alternate water supply is necessary when central water supplies become contaminated at the source or in transmission. An alternate water source may be supplied on a temporary or permanent basis. Replacement of water supplies may involve the following:

- Purchase of water from another supply
- Provision of a new surface water intake(s)
- Provision of a new groundwater well(s)
- Connection to or extension of a new distribution line or system
- Purchase of bottled and bulk water
- Installation of point-of-use wells
- Collection of rainwater

Alternate water supplies are currently being used for replacement of contaminated drinking water supplies. If the plume widens, additional supplies could be required. Implementability of this option depends on a variety of site specific constraints. These may include:

development of water supply distribution system and treatment requirements for the alternate water supply. In addition, if the groundwater is contained there may be the possibility of eliminating dependence on alternate drinking water supplies. The detailed costs and options will be evaluated during the corrective measures study. No field investigative data gaps are associated with provision of an alternate water supply, nor is alternate water supply envisioned as ever being required at NSRR since all water comes from a remote site off-base.

Relocation

Relocation, as a general response action, is necessary when a site poses an immediate risk to human health. Residents are moved from their homes either temporarily or permanently.

There might be the potential of purchasing public land and relocating receptors in contact with contaminated groundwater supplies. However, due to public reaction, this is not recommended as an implementable option at this time. In addition, relocation does not provide a means of controlling migration and limiting long-term human and environmental health threats.

5.2.2.3 Containment

Containment involves leaving the groundwater in place and applying technologies for minimizing the migration of contaminants. For additional information, see Section 5.2.1, Soils.

Surface Capping

Surface capping has been effectively utilized in industry and in the management of hazardous waste sites to control the contaminant migration mechanisms of infiltration and run-off.

Available materials for surface capping includes geomembranes, low permeability soil (clays, silty clays, clayey silts, and selected silts), local or on-site soil materials, asphalt materials, chemical stabilizers, or multimedia caps constructed of geomembrane and low permeability soil layers. These materials may not be readily available on the island of Puerto Rico.

Surface capping may be an effective option for preventing migration of the contaminants from soil into the groundwater. A full discussion is provided in Section 5.2.1.

Impermeable Barriers

Impermeable barriers can be used to divert groundwater flow around a waste disposal area or to contain contaminated groundwater. Such barriers can be placed upgradient of a site, downgradient of a site, or completely surrounding a site. Various methods and types of vertical and horizontal impermeable barriers include:

Vertical Barriers

- Slurry walls
  - soil/bentonite
  - cement/bentonite
- Sheet piling
- Grout curtain
- Vibrating beam

Horizontal Barriers

- Grout injection
- Block displacement

Impermeable barriers constitute a method of reducing transport of wastes into the groundwater. It may be combined with capping to increase its effectiveness. Because this technology is effective in combination with capping, it will be retained for further evaluation.

5.2.2.4 Collection/Discharge

The collection systems are the devices or combination of devices installed at the interception locations to extract groundwater from the saturated flow zone. While there are many variations, the main distinctions are between active and passive devices, and between point and line (or area) devices. Addressing a particular site, variations can include implementation of one or more devices in a combined, reinforced, or supplemental role.

Trenches

Extraction trenches, whether in the interior, intermediate or perimeter position, form a line which captures, either actively or passively, the contaminated groundwater flow. Trenches offer advantages of a wide area of coverage with maximization of the cross-section through the

saturated zone. The major disadvantages are the large volumes of water extracted and the magnitude of the construction effort involved in installation.

Trenches may have the potential of being readily implemented at Roosevelt Roads. Extraction wells may be used to supplement the application of trenches for source remediation at selected site locations. Trenches are preferred to extraction wells in shallow depth applications. Trenches easily eliminate migration outside of property boundaries, whereas extraction wells must be carefully designed and placed to eliminate off-site migration. Because of the relatively shallow depth to groundwater at the facility, this technology will be for further evaluation.

Extraction Wells

Extraction wells are individual point collection devices which intercept a horizontally limited area. They may be employed individually or as a field of wells. Extraction wells may be used as secondary and supplemental devices. The major advantages of extraction wells are relative simplicity of installation, ability to influence an area of contamination and the ability to address locations of particular significance to the remedial action. The major disadvantages are that they are poor barriers allowing the escape of some contaminated groundwater.

- Active System

  An installation of active extraction devices enhances a gradient on the existing groundwater system by withdrawing groundwater and inducing an increased flow toward the collection location. While the groundwater flow rate can be increased along the paths of static flow, the usual effect includes diversion of flow toward the device.

- Passive System

  A passive collection system takes advantage of static conditions to collect contaminants, relying on the natural groundwater flow to carry the contaminants to the collection location and removing a fraction of the flow without extracting the bulk of the flow. Energy requirements for operation are low, but the system is applicable primarily in cases where floating contaminants are encountered, since collection efficiency is low.

The active/passive and point/line systems can be variously combined to achieve particular results or to suit peculiar site circumstances.

In many cases, extraction wells may be employed at locations where depth to groundwater is significant. They may aid collection of groundwater by trenches and provide extraction at points where trenches cannot be easily installed. As such, application of wells for extracting groundwater will be considered in more detail.

Gallery

A groundwater gallery is a system that provides the advantage of a trench in extracting groundwater, intercepting a line rather than a point (although the vertical interception can be incomplete where a large saturated thickness is encountered). However, the construction effort can be considerably more complex than for a trench.

The particular circumstance favoring installation of a gallery is when restriction of access to the target zone from the land surface is encountered.

Use of galleries is not recommend at this time since trenches will potentially be more cost effective than galleries, due to the extra construction effort. However, if it is determined that site specific constraints prevent installation of a trench, this option may be further considered.

Wick Drains

Wick drains can be buried horizontally or vertically to provide preferential paths for movement of subsurface fluids to another collection device. They have the disadvantage of slow operation and incomplete effect.

Drains could be installed to provide preferential paths of the groundwater flow. This is an unlikely candidate at the activity due to the relatively high conductivity of the soil in the horizontal direction. Increasing the flow in the vertical direction is not desired since this may conduct the contamination to underlying aquifers.

5.2.2.5 Treatment Technologies

A variety of technologies exist for treating contaminated groundwater. These technologies include: phase change separation, chemical processes, biotreatment, gravity separation, filtration, membrane separation, activated carbon adsorption, and ion exchange. There are several variations of these main classes of technologies. Predominantly, the technologies are "pump and treat" (i.e., they are performed ex situ), unless otherwise indicated. A general description of these technologies and evaluation of their potential application to the SWMUs and AOCs at NSRR, is given below.

Phase Change Separation

Phase change involves processes that transfer contaminants from the groundwater to other media phases. The transferred contaminant can then be treated in the new phase. Air stripping or steam stripping, evaporation, distillation, and freeze crystallization are all examples of phase change technologies.

Evaporation can be performed in closed ponds with solar energy or in closed vessels with steam as a heating medium. There are many varieties of commercial systems available. Evaporation is usually applied to solvents that are nonvolatile. Distillation is evaporation followed by condensation of the volatile materials for concentration and potential recovery and recycle. Both halogenated and nonhalogenated solvents can be recovered by distillation. Distillation may be carried out in batch or continuous systems. Continuous systems typically are towers with several trays. Continuous systems are not always suited for liquids with high viscosity, metals, and solids due to operational problems with plugging.

Direct treatment of the groundwater by evaporation and distillation may not be effective due to the low concentration of contaminants. However, this technology could be used as a post treatment for concentrated waste from another process such as membrane treatment. This technology will not be considered by itself, but may be potentially evaluated as a post treatment technology.

Air stripping and steam stripping are conventional technologies used for treating groundwater contaminated with VOCs and semi-volatiles. Air stripping is a simple operation which involves pumping contaminated groundwater into a column for contact with air. In practice, the contaminants are transferred from the liquid to the air phase. Steam stripping

provides additional capabilities of removing semi-volatiles; however, additional considerations are required for generation of the steam. Off-gases from the air stripper may be treated by a variety of air pollution technologies including vapor phase adsorption, fume incineration, and catalytical oxidation. Air strippers are not effective for removing metals and plugging may occur due to the oxidation of species such as iron. In these cases, a number of pretreatment steps or operating procedures may be implemented to overcome the iron plugging problem. Pretreatment schemes may include: aeration or pH adjustment or addition of a reducing agent. Plugged air stripper packing may be removed and/or treated with acid for extended operational times as an alternative to pretreatment and the generation of organic sludges.

Air stripping is an effective proven technology for removal of VOCs. It can be readily implemented at Roosevelt Roads. Pre-treatment for removal of fouling agents such as iron and manganese will be considered. Post-treatment options for control of VOC emissions will be considered. In addition, this technology may require combination with other unit processes for removals of metals and non-strippable organics found on-site.

Freeze crystallization is a process based on the principal that when ice crystals are formed by freezing, they contain only pure water. A typical system involves flow of a liquid as a falling film down heat exchange tubes. A slurry of ice crystals is further processed by separation in a tank followed by washing in a gravity tank where the ice rises to the top and is removed. The ice crystals are then recycled to the heat exchanger for make up cooling fluid. This technology can be applied to wastes containing metals, organic compounds and waste containing pesticides. Freeze crystallization technology is being developed under the SITE program.

The potential for application of freeze crystallization for treating groundwater at Roosevelt Roads is likely minimal considering the climate. In addition, the limited experience with this technology makes the potential effectiveness uncertain. The costs of treatment may also be high due to the low concentrations of contaminants. Further consideration of this technology is not recommended at this time.

In situ sparging is a technology that is used below the saturated zone. It is a recent innovation. In this process, air is injected under pressure below the water table. The air bubbles which have formed, traverse horizontally and vertically through the soil column creating transient air filled regions in the saturated zone. Volatile compounds are vented and carried by air movement into the vadose zone, where they can be captured by a vent system.

The strippability of VOC contaminants by the air sparger system is roughly indicated by the Henry's Law constant. This process may be operated in conjunction with a soil vacuum extraction system for removal of VOCs.

Based on its potential effectiveness, relatively easy implementability, and anticipated moderate cost, this technology will be retained for further evaluation.

Chemical Processes

In these processes, a chemical is applied to the waste to convert it to a nonhazardous or less hazardous form. The chemical treatment process may utilize phase change separations to remove specific species from the hazardous waste. A wide range of chemical processes are used for treating wastes. Main processes include pH adjustment, chemical precipitation, oxidation, reduction, chlorination, and hydrolysis. Chemical treatment processes rely on intimate mixing of reagents with the waste. Chemical processes are very specific to the wastes that they treat.

pH adjustment is a relatively simple process for neutralizing acid or base wastes to reduce the reactivity or corrosiveness. Neutralization, by itself, is a process used to adjust the pH of a waste stream for discharge, usually between 6 to 9 standard units. Neutralization may also be used for pre and post-treatment of other processes.

Neutralization systems consist of a chemical storage tank and feeding mechanism, neutralization tank, pH meters, and automatic metering devices to maintain the effluent pH at a fixed level.

Typical neutralization agents include; sulfuric acid, hydrochloric acid, nitric acid, lime, ammonia, calcium carbonate, calcium hydroxide, carbon dioxide, sodium carbonate, sodium hydroxide, and sodium sulfide. Factors to consider in selecting a suitable reagent for wastewater neutralization processes include: speed of reaction, buffering qualities, product solubility, reagent cost and availability, ease of handling, and cost.

pH adjustment is a standard technology that is effective for treating groundwater. This technology may be used as a pre-treatment and post-treatment for chemical precipitation of metals at Roosevelt Roads. For example, the pH of the groundwater may be raised to reduce the solubility of metal species such as copper and nickel. After precipitation, the pH may be

adjusted back to meet discharge limits. Other applications include pH adjustment before air stripping of VOCs.

Precipitation is a widely-used process in which the chemical equilibrium of a waste is changed to reduced the solubility of undesired components. Precipitation is applicable to the removal of most metals from wastewater including zinc, cadmium, chromium, copper, fluoride, lead, manganese, and mercury. Certain anionic species such as phosphate, sulfate, and fluoride may also be removed.

These components precipitate out of the solution, as a solid phase, often in the form of small or even colloidal particles and are removed by several different techniques. Solid separation is effected by coagulation/flocculation. Typical chemical additives are: sodium hydroxide, sodium sulfide, lime, iron salts, iron sulfide, ferric sulfate, phosphate salts, and alum. Conventional precipitation processes are performed in the following steps:

- Rapid mixing of chemicals and wastewater
- Slow mixing to allow flocculation
- Separation of solids by sedimentation or flotation.
- Use dewatering techniques to concentrate the solids
- Polish the liquid effluent for further clarity

The hydroxide precipitation process for removing heavy metals from wastewater consists essentially of raising the pH of the normally acid or neutral wastewater to a predetermined value that is within the range of 8 to 11 pH. A hydroxide reagent is added, and the resultant precipitate, containing the bulk of the heavy metals is separated. It will not remove chromium in the form of chromates or dichromates and metals complexed with cyanide. Sulfide precipitation is applicable when treatment of solutions to achieve low concentrations of metals is required. The solubilities of metal sulfide complexes are typically lower than metal hydroxide complexes.

Flocculation is the process by which small, unsettleable particles suspended in a liquid media are made to agglomerate into more settleable particles. It occurs by reducing particle surface forces and providing chemical bridges to allow the nonrepelling particles to stick together. The inorganic flocculants such as alum, lime, or iron salts, make use of precipitation reactions. Upon mixing, the slightly higher pH of the water causes the chemicals to hydrolize and form fluffy, gelatinous precipitates of hydroxides. Once suspended particles have been flocculated

into larger particles, they can be usually be removed form the liquid by sedimentation, provided that a sufficient density difference exists between the suspended matter and the liquid. Organic chemicals are commonly referred to as polyelectrolytes. These materials generally consist of long-chain water soluble polymers such as polyacrylamides. A polyelectrolyte may be termed cationic or ampholytic depending on the type of ionizable group.

This is an effective method for removing metals such as chromium, copper and nickel from groundwater. However, the technology can only reduce metal concentrations to a lower limit due to solubility restrictions. In addition, the conditions of the groundwater (e.g., presence of competing contaminants) will determine this lower limit. Chemical precipitation is preliminarily selected for further consideration.

Chlorination of alkaline cyanide-containing groundwater removes cyanide by oxidation in stages to the less toxic cyanate ion and then to non-toxic bicarbonates and nitrogen. Caustic and chlorine are added to the water in a reactor in batch or flow through configuration. Cyanide destruction is used not only to reduce the hazard of cyanide gas generation under acidic conditions, but also as a pretreatment for some heavy metal treatments, such as precipitation, where cyanide complexes interfere with metal removal. Chlorination is broadly applied to cyanide containing wastes of highly varying composition. Concentrations may be reduced to less than one part per million. Common chlorination sources are chlorine gas and sodium hypochlorite.

It is not anticipated that it will be required to remove cyanide from groundwater. As such, this technology will not be retained for further consideration. If the PHERE requires the removal of cyanide this technology will be considered in detail during the CMS.

The function of a chemical reduction process is to convert inorganics to less toxic and/or more easily treated form. It also serves as a pretreatment step for inorganics in which chemical precipitation is used to remove the metal hydroxide from solution. Reduction processes have been applied to hexavalent chromium waste, mercury wastes, hexavalent selenium, organic lead compounds, and chelated metal bearing wastes. The reaction products are usually inorganic salts. Careful design is required since violent reactions are possible, air emissions and odors can be produced, and slurries, tars, or sludges are difficult to treat.

Toxic hexavalent chromium can be reduced to the less toxic and soluble trivalent chromium ion (Cr III). The reduction process is followed by Cr III removal through the precipitation

process as an insoluble hydroxide. Chromium reduction is carried out by adding a reducing agent under highly acidic conditions(of pH 2 to 3). Sulfuric acid is most commonly used to acidify the solution. Reducing agents include sulfur dioxide gas, sodium bisulfide, sodium metabisulfite, sodium hydrosulfite, and the base metals.

Chemical reduction is an effective technology for treating hexalavent chromium. The technology is commercially applied and readily available. Since chromium is present in the groundwater at some of the SWMUs, this technology will be considered further. Depending on the media protection standards, a treatability test may be required for determining optimal operating and design conditions.

Oxidation processes involve destruction of organics or conversion to more desirable forms. Inorganics may also be converted to more desirable forms. Typical oxidants include: air, oxygen, hydrogen peroxide, ozone, chlorine, chlorine dioxide, and potassium permanganate. Oxidation processes are applicable for highly reactive contaminants such as phenols, amines, ammonia, cyanide, iron, and manganese. These processes may depend on pH adjustment to increase reaction rate. The oxidant may be added with the contaminant to a stirred tank to enhance reaction rate. Removal of oxidant gases and by-product gases may be required. Removal of residual salts may also be required.

Oxidation is an effective technology for treating several inorganic compounds such as iron and manganese. There are several different commercial processes that are readily available and implementable. It may be necessary to use this process as a pre-treatment step in a complete treatment train. For example, if air stripping is selected, pre-treatment of the groundwater may be required to prevent fouling of the air stripping equipment. This technology will be considered in further detail during the CMS.

Recent requirements to treat low levels of toxic organic compounds in water and wastewaters have initiated reevaluation of chemical oxidation processes employing oxidants such as, hydrogen peroxide (H_2O_2) and ozone (O_3). Most promising processes are variations which include ultraviolet (UV) light catalysis (e.g., UV/ozone, UV/hydrogen peroxide, UV/ozone-hydrogen peroxide). UV radiation is known to be capable of causing certain organic compounds to decompose. This facet further enhances the oxidation process.

In advanced oxidation processes, contaminants in the wastewater are exposed to UV radiation and oxidizing agent(s) in a reaction chamber. The UV radiation photolyzes both oxidant and

contaminant to produce reactive free radical species, which participate in a series of oxidation reactions that lead to final products. Ultrox International, Inc. has demonstrated these technologies through the SITE program. Reaction rates and reactor performance depend on several factors. These factors include: concentration, type of contaminant, oxidant concentration, reactor residence time, contact efficiency, and background species. A major concern is potential by-products produced by reactions. As the concentration of the contaminant decreases, a potential decrease in reaction rate or reactor efficiency is possible.

Advanced oxidation has been shown to be effective in treating dilute concentrations of contaminants such as aromatic and chlorinated hydrocarbons. Equipment used in the advanced oxidation process are available from several vendors. Additionally, treatment costs are comparable to that of activated carbon treatment. As such, this technology will be retained for further consideration.

Hydrolysis is the process of breaking a bond in a molecule so that it will go into ionic solution with water. Hydrolysis may be achieved by addition of acid, irradiation, or by biological activity. Hydrolysis is suitable for pretreating difficult to treat wastes such as phenols or chlorinated hydrocarbons with reactive chlorine.

This technology has limited applications. It may be used to enhance treatment of immiscible organics in a waste. It may be used to dissolve refractory organics allowing treatment in the aqueous phase. The application of this technology at Roosevelt Roads is not anticipated, since immiscible contaminants have not been identified.

In-situ chemical processes use the same principles as employed for above-ground treatment processes. This option reduces the risk of pumping hazardous waste aboveground for treatment.

In situ chemical treatment involves adding chemicals to the groundwater to enhance degradation mechanisms. Reaction of the chemicals with the soil is possible. The effectiveness and implementability of the technology is unproven. This technology will not be retained for further consideration.

Biotreatment

Biological activity can be classified into three main categories: aerobic respiration, in which oxygen is utilized; anaerobic respiration, in which sulfate or nitrate serves as a reactant; and fermentation, in which the microorganism rids itself of excess matter by exuding reduced organic compounds. The process may completely destroy organics, convert organics to smaller constituents or dehalogenate organic compounds. Some compounds, called refractiles, are persistent or not readily biodegradable. Also, it is difficult to apply biodegradation to wastes of very high and low concentrations.

Aerobic and anaerobic are two commonly employed applications of biodegradation. Aerobic processes are oxidative processes which depend on a constant supply of oxygen and nutrients. Engineered aerobic processes include suspended growth systems, fixed-film systems, hybrid reactors, and in-situ applications. Anaerobic digestion is the microbial degradation of organic compounds in the absence of air. Anaerobic systems are capable of degrading halogenated organics that are not degraded under aerobic conditions.

Several environmental factors effect the ability to maintain biodegradation for aerobic systems. These factors include: pH, temperature, oxygen, nutrients, and toxicity.

- pH

  Typically, the biological waste stream operates best when the pH is near 7. However, systems may be applied in a pH range of 4 to 10. The exceptions are aerobic systems in which ammonia is oxidized to NO_x as well as anaerobic methane fermentation systems. For these systems the pH should range between 6 and 8.

- Temperature

  Biological growth is very sensitive to temperature. Specific organisms function best under controlled regions. Small increases in temperature may yield large changes in bioactivity. Extreme cold and heat may destroy the function of organisms.

- Oxygen

  To enhance biogrowth residual dissolved oxygen should be maintained at 2 milligrams per liter or greater. Methods of providing oxygen will be discussed in the section on technology variations.

- Nutrients

  Major nutrients include: carbon, hydrogen, oxygen, nitrogen, and phosphorus. Minor nutrients include: sodium, potassium, ammonium, calcium, magnesium, iron, chloride, and sulfur (1-100 milligrams per liter). Trace nutrients include: manganese, cobalt, nickel, vanadium, boron, copper, zinc, molybdenum, and various organics (1 milligrams per liter). Optimal nutrient ratios are determined by treatability studies of the specific waste.

- Toxicity

  Toxicity depends on concentration. Most chemicals become toxic at high concentrations. Toxicity may be minimized by waste dilution and by microbe acclimation.

Activated sludge treatment is conventional and well-demonstrated. Existing plants have been used to treat leachate from hazardous waste sites. Effectiveness depends on the type of organics present, type of aeration, and retention time. Extended aeration may be applied in lagoons. Reliable operation is accomplished by using an equalization tank and pH adjustment for waste pretreatment. Activated sludge systems are most effective for wastes with a high organic load. Disposal of the biomass may be direct or the biomass may be concentrated by filtration methods. Activated sludge systems may have difficulty in removing highly chlorinated organic compounds.

This technology is an effective technology for removing easily biodegradable organic compounds. However, it may not be effective for removing chlorinated hydrocarbons and metals. In addition, due to the low concentration of organics in groundwater biomass growth may be limited. At this time it is not recommended to evaluate this form of biotreatment.

Surface impoundments are systems in which the process of microbial oxidation, photosynthesis, and sometimes anaerobic digestion combine to breakdown hazardous organic compounds. They are similar to activated sludge units without sludge recycle. Aeration may be supplied passively by wind and algae or, in aerated surface impoundments, by mechanical aerators. Clarification may occur in the lagoon or in a separate clarifier. The technology is conventional and has been well demonstrated.

Surface impoundments can normally handle BOD levels of 200-500 milligrams per liter; anaerobic systems can tolerate somewhat higher levels. Most often, impoundments are used to polish low BOD content from activated sludge or trickling filters prior to discharge. High performance has been demonstrated for cyanides and alcohols, while poor performance has been observed for halocarbons, metals, pesticides, and PCBs.

Temperature, shock loading, suspended solids, gas generation, and sludge removal must be considered to maintain reliable operation. Pre-treatment may be required to reduce excess suspended solids or shock loadings of waste. Provisions must be made for sludge removal and considerations for handling offensive off-gas odors.

The application of this technology at Roosevelt Roads seems limited. Installation of a surface impoundment may be expensive with potentially limited success. The types of contaminants found in the groundwater may not be readily biodegradable by aerobic processes. As such, this technology will not be retained for further consideration.

Fixed-film reactors rely on maintaining the biomass on some media and passing the contaminated organic matter over the media to promote activity. Trickling filters, rotating biological reactors, and packed media reactors are variations. Fixed-film reactors are applicable to influents containing lower concentrations of organics or for maintaining a specialized, slow-growing biomass such as would be required to degrade complex organic wastes. Sloughing (i.e., release from the fixed-film) of biomass may require additional equipment to recover and separate this biomass.

A rotating biological disc process is a fixed-film biological method of treating effluent containing organic waste. A series of discs or drums rotate through troughs containing the waste fluid. Forty to fifty percent of the disc is immersed in the fluid. The shearing motion of the disc through the effluent keeps the floc from becoming too dense. The technology is conventional but undemonstrated for groundwater treatment.

A trickling filter is a form of a biological treatment in which a liquid waste of less than 1 percent suspended solids is trickled over a bed of rocks or synthetic media on which microbial organisms are grown. The technology is conventional, but demonstration has not been widely documented for the application of groundwater treatment.

The effectiveness of fixed-film reactors on the type of contaminants found at Roosevelt Roads has not been demonstrated. As such, this technology will not be retained for further evaluation.

In submerged biological rectors, the fixed film is submerged and the reactor contents are continuously stirred. Recycling of the effluent reduces shock loads. These systems are more compact due to the enhanced surface area provided by the support media. Set-up and operation of these reactors tends to be somewhat more technically demanding than more conventional biological systems.

Of the bio-treatment technologies examined, submerged biological reactors may have the potential of being the most effective. There is the possibility of operating in the anaerobic mode for removal of chlorinated hydrocarbons. Pre-treatment for removal of metals may be required to prevent the toxic effect of the metals on the organisms. In addition, this process may be used as a polish for aerobic treatment of compounds such as acetone. Selection of the biogrowth media may also provide the opportunity for additional effectiveness. However, there are concerns about toxic intermediate by-products and the lack of documented effectiveness of this technology since it is relatively new. This technology is potentially applicable, depending on the media protection standards.

Because biological activity is frequently occurring in the natural environment, the key to in-situ treatment is to supplement or enhance these mechanisms. In-situ treatment is site-specific, but in general may require the injection of nutrients, oxygen, and microbial populations to degrade the organic material present. The most developed in-situ treatment systems are aerobic; however anaerobic systems are being investigated. Site specific factors that influence effectiveness include: nutrient level, oxygen content, redox potential, pH, degree of water saturation, hydraulic conductivity of the soil, degree of water saturation, osmotic pressure, temperature, toxins, growth inhibitors, predators, type of contaminant, and concentration of contaminant. It can be generalized that for degradation of petroleum hydrocarbons, aromatics, halogenated aromatics, polyaromatic hydrocarbons, phenols,

halophenols, biphenyls, organophosphates, and most pesticides and herbicides aerobic conditions are favored over anaerobic conditions. Anaerobic conditions have been investigated for degradation of halogenated lower molecular weight hydrocarbons; however, these studies have not been commercially demonstrated.

Various processing conditions and equipment are used in in-situ treatment. Oxygen can be added by air, pure oxygen, hydrogen peroxide and ozone. The type of nutrients required may be determined by laboratory batch tests. Consideration of groundwater quality is required to ensure that nutrients will remained dissolved and not interact with background species. Most of the systems that have been used for bioreclamation involved the use of subsurface drains, injection wells and extraction wells. Additional wells may be required to deliver the oxygen and nutrients. Nutrients, oxygen, and recycled groundwater may be premixed in a tank before injection into the groundwater plume. Nutrients and oxygen may also be injected at various locations throughout the plume. The required equipment and materials may not be readily available on the island of Puerto Rico.

Implementation of in-situ treatment is similar to other conventional pump and treatment methods. Implementation of a remediation involving in-situ bioremediation may be more cost effective than conventional pump and treat especially when simultaneous bioremediation of the soil occurs.

In situ biotreatment technology involves the injection of air and nutrients for aerobic growth. Sparging is being considered for concurrent and enhanced removal of VOCs. In-situ biotreatment could be potentially applicable if sparging is used for corrective action. Addition of nutrients with the air might be considered for enhanced removal of compounds such as acetone. Another potential consideration is anaerobic degradation of the chlorinated hydrocarbons in the groundwater. However, there is insufficient demonstration of effectiveness to make an assessment, since this technology is just emerging. This technology may be considered, but at present it is not recommended to evaluate it in detail.

Land treatment is the intimate mixing or dispersion of wastes into the upper zone of the soil-plant system. There are four main categories of land treatment. Irrigation is spraying wastes to sustain growth of plants. Grass filtration is spraying of wastes onto a gently sloping, relatively impervious soil planted with vegetation. Infiltration-Percolation allows large volumes of waste to infiltrate the surface and percolate through the soil.

It is unlikely that land treatment will be an effective treatment technology for groundwater, due to cost and the type of contaminants found at Roosevelt Roads. It is not recommended to consider this technology at this time.

Density Separation

Density separation is a purely physical phenomenon in which the contaminant is allowed to separate from the carrying phase. Variations include: sedimentation, centrifugation, oil/water separation, dissolved air flotation, and heavy media separation. Several processes are well-established and commercially available.

Oil/water separation is a purely physical phenomenon in which the contaminant is allowed to separate from the carrying phase. A typical application would be separation of the gasoline or free oil from a fuel contaminated aquifer. Gravity operation has also been used to separate PCB oils from contaminated groundwater. Emulsion between water and oil is common, and an emulsion breaking chemical must frequently be added to the waste for efficient treatment. A variety of configurations are available for operation. Consideration is required for disposal of the extracted waste.

Oil/water separation is a standard technology for separating compounds based on density differences. If free floating oils with PCBs are encountered, this technology may have some potential. In addition, if two phases of chlorinated hydrocarbons are found, this may be applied. Oil/water separation is a potentially applicable technology depending on the media protection standards.

Sedimentation is a gravity settling process which allows heavier solids to collect at the bottom of a containment vessel resulting in its separation from the suspending fluid. There are several physical configurations in which the process may be applied. Efficiency of sedimentation depends on tank depth, holding time, solid particle size, fluid flow rate, and solution particle properties. Its use is restricted to solids that are more dense than water.

Sedimentation is an effective method for removing suspended solids. It may be applied as a post-treatment in the chemical precipitation process. However, direct treatment of groundwater to remove suspended solids is unlikely due to the quality (i.e., low suspended solids) of groundwater. This technology will be considered under chemical precipitation, as appropriate.

Centrifugation is a physical separation process in which the components of a fluid mixture are separated, based on their relative density, by rapidly rotating the fluid mixture within a rigid vessel. This treatment is limited to dewatering sludges, separating oils, and clarification of various emulsions.

Centrifugation is potentially applicable for dewatering sludges from a precipitation process and removing oil from groundwater. However, the application is most appropriate for specific contaminants and it is not anticipated that there will be the need to use this technology at Roosevelt Roads.

Dissolved air flotation is a physical process whereby suspended particles, emulsified oil, or mixed liquid can be removed from an aqueous waste stream. The mixture to be separated is saturated with air and typically the pressure is reduced above the treatment tank. As the air comes out of the solution, the microbubbles which form can be readily absorbed onto suspended solids or oils, enhancing their floating characteristics. In the flotation chamber, separated oil or other floats are skimmed off the top while the aqueous liquids flow off the bottom. This technology is only applicable for waste having densities close to that of water. Air emission controls may be necessary if hazardous volatile organics are present in the waste.

Dissolved air flotation is applied for separation of solids and for streams that are difficult to treat by other separation methods. It is not anticipated that there will be the need to use this technology at Roosevelt Roads.

Heavy media separation is a process for separating the solid materials which have significantly different densities. The mixed solids to be separated are placed into a fluid whose specific gravity is chosen so that the light solid floats while the heavier sinks. This type of separation is readily used for separating two insoluble solids having different densities.

Due to the anticipated low suspended solids of groundwater, this technology is not applicable.

Filtration

Filtration is a physical means of separating solids from liquids by forcing the fluid through a porous media. Filtration is also applied to aqueous liquids containing droplets of another immiscible liquid phase such as oil-contaminated water. Variations of filtration include:

granular media, powdered media, rotary vacuum drums, press filters and cartridge filters. In most cases filtration is conventional and well-demonstrated.

The filter media for granular filtration consists of a bed of particles such as sand or anthracite coal. The particles are contained within a packed bed. As water passes downflow through the system particles become trapped at the top and a layer builds up. In addition particles may be trapped throughout the bed in deep filters. As treatment proceeds pressure drop increases to a point where the bed is backwashed to remove trapped particles. This backwashed fluid is then further treated to remove the highly concentrated particles. Methods of backwashing include: water backwashing, surface washing, and air scouring. Backwash water is approximately 1 to 5 percent of total flow. Automation of the backwash cycle improves the reliability of operation.

Granular filters are used in treating wastes with suspended particles at less than 100 to 200 mg/l concentrations. Granular filters are only marginally effective in treating colloidal materials. In many cases, filters are used as pre-treatment steps to reduce downstream plugging of equipment or for final effluent polishing. Filtration is readily implemented with on-site mobile treatment systems.

Granular filtration is an effective method of removing suspended solids from solution. This may be used as a pre-treatment step for protecting equipment. Although it is anticipated that the suspended solids of groundwater will be low, these solids will build up over time in equipment during a pump and treat operation. This option will be retained for further consideration.

A variety of filters are available for dewatering sludges. These filters could possibly be applied directly to groundwater for removing metals. Some common configurations are vacuum, pressure, and belt filters. Another application of these filters is for removal of sludges from various groundwater treatment options involving removal of metals or suspended matter.

Dewatering filtration is a proven and effective technology for reducing the sludge volume from a precipitation process. Various configurations are available and they will be retained for further consideration.

Membranes

Membrane separation processes are conventional processes for purifying water and treating wastewater discharges. The main variations of membranes for treating liquids are reverse osmosis, ultrafiltration, and electrodialysis. Emerging technologies include the liquid emulsion membrane and combined air stripping membrane process.

In general, these processes involve contacting a waste stream with a surface. This surface is selectively penetrated by species in the waste stream. Transport mechanisms through this surface vary with the membrane design. In general the transported species is concentrated and collected in a reduced volume stream called the permeate. The purified waste stream is discharged, recycled, or further processed. Membrane configurations vary with each application. They may be arranged in series or parallel. Membranes may be combined to form complete treatment trains. A common combination is the triple membrane. The triple membrane is used for producing ultrapure water. The system is composed of a ultrafiltration membrane, followed by an electrodialysis unit with a final reverse osmosis unit for polish.

Osmosis is the spontaneous flow of pure solvent through a semipermeable membrane into a solution. Reverse osmosis (RO) is the application of sufficient pressure to the solution to overcome the osmostic pressure and force the net flow through the membrane toward the pure solvent. Small molecules and ions in water can be separated by this technique. The basic components of a reverse osmosis unit are the membrane, a membrane support structure, a containing vessel, a high pressure pump and pretreatment systems for removing oil, grease, suspended solids, oxidizers, and pH adjustment, and associate membrane cleaning equipment.

Membrane systems are varied and have evolved throughout the years. The original form was a membrane supported in a tubular shell. Various polymer materials are used to produce membranes with a variety of properties. To improve performance, higher surface area membranes were fabricated. These are basically the spiral wound and hollow fiber membrane. Various types of membranes exist for a variety of applications. Production of new membranes is ongoing with the goal of producing membranes that can withstand wide operating conditions such as low or high pH, high chlorine content, and wide temperature ranges. Production of systems that minimize fouling is also a high priority.

RO units may be used to remove metals, alcohols, ketones, amines and aldehydes. Units come in modular form and are readily installed by vendors. Concerns include high capital and operating costs and maintenance of the membrane structure.

Use of reverse osmosis for producing drinking water is a common application. Recently, new membranes are being produced to enhance the application of membranes for removal of trace organics from water. However, these applications are limited in scope and require further demonstration. This technology is potentially applicable, but it may be necessary to conduct feasibility and pilot tests for demonstration.

The ultrafiltration process is operationally similar to RO. Ultrafiltration is distinguished from reverse osmosis by the relatively larger size of the pores on the membrane surface, relatively lower operating pressure, and the possibility of the feed solutions involving macromolecular solutes, colloidal particles, and suspended solids.

Ultrafiltration membranes are more applicable to removing large molecule chains. This may improve the color of the discharged water. They also may be used as a method to filter metals. Typically the metals are converted to precipates or colloidal forms and then pumped into a ultrafiltration membrane for removal.

Ultrafiltration is typically applied for removing metals from solution. A claimed advantage over standard precipitation is reduction of metals to lower levels. In addition, a system is being tested in the Superfund Innovative Technology Program. This is a potentially applicable technology if the media protection standards require removal of metals to a low level. Extensive treatability studies would be required to demonstrate the effectiveness of the technology.

These systems are used for concentrating metal wastes. Electrodialysis is an electrochemical separations process in which ions are transferred from a less concentrated solution to a more concentrated solution as a result of the flow of direct electric current.

Electrodialysis is applicable to removal of metal ions from solution. There is limited experience with this technology for applications similar to Roosevelt Roads SWMUs and AOCs. This technology will not be considered further at this time.

Liquid emulsion membranes are new and innovative. They involve wetting the membrane to enhance the transport of a specific species. They have been investigated for the removal of chromium from a liquid.

Liquid emulsion membranes have limited commercial applications. The effectiveness and implementability are uncertain since the technology is unproven. This technology will not be considered further at this time.

Activated Carbon Adsorption

Activated carbon adsorption is widely used in groundwater treatment. This technology is driven by the capacity of carbon to adsorb molecules to its surface. This adsorption process is influenced by the following factors:

- Carbon Characteristics
  - Particle size
  - Pore structure and size distribution
  - Particle shape
  - Surface Characteristics

- Adsorbent Characteristics
  - Solubility
  - Molecular size and weight
  - Ionization
  - Polarity

- Aqueous System Characteristics
  - Temperature
  - pH
  - Competing solutes
  - Dissolved solids

In general, the cost effectiveness of activated carbon increases as the concentration of the contaminant decreases. Activated carbon is more efficient for removal of poorly soluble organics and higher molecular weight compounds. Activated carbon has also been used for removal of specific metals. The performance of activated carbon for metals removal depends

on the form of the metal species and pH of solution. Activated carbon has been used to remove trace levels of metals, such as chromium and mercury; however, activated carbon is more proven for removal of organics.

Carbon adsorption treatment can be implemented in a number of process configurations (e.g., batch or continuous flow slurry reactor or adsorption column). Continuous flow systems have been the flow configuration of choice. Slurry operations with powdered carbon are widely used in water treatment; however, in small applications such as those at sites with contaminated groundwater, column type operations are the norm. Irrespective of process configuration, carbon adsorption has been proven effective.

The performance of column type carbon adsorption systems can be affected by inorganic and physical constituents in the water to be treated (e.g., suspended solids, iron, manganese, and oil and grease). Calgon Carbon, Inc. recommends that the influent stream to carbon columns contain less than 5 milligrams per liter oil and grease and 10 milligrams per liter suspended solids. In situations with high iron and manganese concentrations, deposition on the carbon particles could present operation/maintenance problems. In formulating treatment systems involving carbon adsorption, this factor must be considered because of the impact on performance and system cost.

Additionally, with small treatment systems disposal of spent carbon generally must be considered; in large systems the carbon may be regenerated on site depending on adsorbed materials and the availability of utilities (e.g., steam).

Activated carbon adsorption is a standard technology for treating groundwater. The cost effectiveness varies with the quality of groundwater. Costs involved with shipment of the carbon to the island of Puerto Rico and for disposal of spent carbon may be significant. It is usually more effective for trace organic contaminants that have low solubilities. In addition, activated carbon has shown potential for removing trace levels of metals. However, combining activated carbon with other metal removal processes such as precipitation is also a possibility. This technology can be used as a post treatment step for a process such as air stripping or used to directly treat the groundwater. Pre-treatment of the groundwater may be required to protect the system. Treatability studies are required for defining the cost effectiveness. This technology will be retained for further consideration.

Ion Exchange

Ion exchange is a process whereby the toxic ions are removed from the aqueous material by being exchanged with relatively harmless ions held by the ion exchange material. Modern ion exchanges resins are primarily synthetic organic material, containing ionic functional groups to which exchangeable ions are attached. After a critical relative concentration of ion to exchanged ions in solution is exceeded, the exchange resin is said to be spent. This spent resin is regenerated with a concentrated solution of the original ion in the resin. The process is commonly used to remove toxic ions from solution in order to recover concentrated metal solutions for recycling.

Ion exchange may be applied for removal of trace metals in groundwater. It is a standard and commercial technology. The cost effectiveness is determined by treatability studies. If the media protection standards require removal of trace metals, this technology may be appropriate. A major consideration is determining whether the exhausted resin should be regenerate on or off-site. This technology will be retained for further consideration.

Deep Well Injection

Underground injection entails drilling a well to the depth required to intersect an approximate geological formation (known as an injection zone). Liquid wastes are pumped with sufficient pressure to displace the native fluids, without causing fracture or excessive migration of wastes. Formations suitable for waste injection must satisfy the following conditions:

- Cannot be used for drinking water, geothermal energy recovery, or hydrocarbon recovery
- Sealed from above and below to prevent migration of waste
- Locked in an area of little seismic activity

Injection wells are capable of accepting a wide range of liquid wastes. Limits include: high viscosity, high suspended solids, and chemical incompatibility with injection well zone formation. The class of the well depends on whether injection is below, into, or above a drinking water source. The effectiveness of the well depends on whether leakage of the waste

through continuing geological formation occurs. Injection into wells below drinking water sources is safer.

The effectiveness and implementability of deep well injection at Roosevelt Roads is rather low. Extensive efforts are required to show that the deep well will contain the wastes. This technology will not be considered further.

5.2.3 Evaluation of Surface Water Corrective Measures Technologies

Surface water controls are required in instances where run-off from a site requiring remedial actions may transport contaminants to different locations. Pollutants can either be dissolved or suspended in water and carried to groundwater, other surface waters or off-site land surfaces. Surface water controls are designed to prevent surface waters from becoming contaminated through contact with waste and preventing contaminated surface water from migrating off-site. There are several different methods for control of run-on and run-off.

Once controlled, contained and collected, the surface water can be treated by a variety of technologies. These technologies are similar to those for treating groundwater and are described in Section 5.2.2, Groundwater. The difference is how the technologies are applied. The site specific characteristics of the surface water are used to assess technologies and to determine the types of technologies preliminarily selected. Applicable surface water technologies may differ from applicable groundwater technologies, due to differences in collection techniques, flow rates, contaminants, treatment objectives, and background water quality.

5.2.3.1 No Action

No action will be effective at reducing contamination to background levels if the on-site sources of surface water contamination, including sediments and groundwater, are remediated. Monitoring may be required to ensure that remediation of associated media results in mitigating impacts on surface waters. This alternative has been preliminarily selected as acceptable assuming other media impacting the surface waters are remediated.

5.2.3.2 Institutional Controls

Institutional controls may involve limiting access to the surface waters or providing alternate drinking water sources, as applicable, due to off-site migration. Effectiveness may be limited since restricted access is more difficult to implement at off-site locations. Furthermore, the natural environment within the surface waters will not be restored. Institutional controls may be potentially applicable as a conditional remedy until remediation of on-site sources is complete.

5.2.3.3 Diversion of Surface Water

Water diversion methods prevent run-on from off-site contamination sources and prevent infiltration through the site surface sediments potentially contaminating groundwater. Water diversion techniques may also be used to prevent surface water contact with contaminated on-site soils. On a temporary basis, surface water diversion may allow additional remediation alternatives to be applied to in-stream sediments (i.e., soil wash or stabilization, etc.) Run-on includes stormwater, and floodwater. Diverting this water from the site reduces water flow and potential for infiltration. If run-on is successfully diverted, precipitation and groundwater discharge become the only manner in which surface water becomes recharged. Water diversion methods included barriers and landscaping techniques. Technologies include dikes, berms, channels, floodwalls, terraces, grading, revegetation, seals, and capping. Temporary water diversion techniques may be employed to facilitate remediation of sediments (refer to Section 5.2.4). Diversion techniques generally are not used to permanently alter surface water courses, particularly when wetlands would be affected, for corrective action.

Dikes and Berms

Dikes are compacted earthen ridges designed to divert or retain surface water flow. They can control floodwater and run-off. A dike is constructed by the addition of several lifts of soil, each being adequately compacted. The structures are constructed around the contaminated area to prevent surface water contact. Benefits include low construction costs and ease of construction. Effectiveness may be limited if used greater than a year and not properly maintained. Potential infiltration of the groundwater exists. They are limited to small sites.

Channels and Waterways

Channels are excavated ditches used to intercept run-off. Channels stabilized with vegetation or stone riprap are used to divert and collect water. Channels are readily available and easy to construct. They are more appropriate for collecting water than dikes. They are also more permanent than dikes. Maintenance is required. Channels may be used to surround contaminated soil sites to prevent run-on from contacting soils. Alternately, channels may be constructed near property borders to collect and divert run-on from off-site sources; however, considerations must be made for ultimate disposition of collected run-on, if its quality does not permit direct discharge.

Chutes and Downpipes

Chutes are open channels lined with non-erodible material. Downpipes are drainage pipes constructed of rigid piping or flexible tubing. Chutes and downpipes are useful in transferring concentrated flows of surface run-off from one level of a site to a lower level without erosion damage.

Grading

Grading facilitates the management of surface water runon or runoff while controlling erosion. Grading consists of altering the terrain surrounding a contaminated area to redirect surface water flow away from the perimeter of the area. This technology is often performed in conjunction with surface sealing practices and revegetation as part o fan integrated landfill closure plan.

Grading is an effective means for reducing infiltration, runon, and diverting surface water runoff. However, there is a potential for worker exposure during grading activities. Additionally, performance of this technology depends on effective revegetation.

This technology is easily obtainable. Factors limiting the use of this technology include: the contours of the existing terrain, availability of cover soils to modify existing slopes, and the amount of maintenance involved with regrading slopes which have settled or eroded.

Low capital and low O & M costs are associated with the technology. Because of this technology's low cost, as well as its effectiveness and implementability, it will be retained for further consideration.

Capping

A detailed discussion of capping is presented in Section 5.2.1, Soils. Capping may be used to prevent infiltration of surface water into contaminated soil. It may provide a more cost effective solution than other treatment technologies. As discussed in Section 5.2.1, however, capping materials may not be readily available on the island of Puerto Rico.

Vegetation

Vegetation may reduce run-off and erosion. Grasses, legumes, shrubs, and trees may be used. Grasses provide quick and lasting dense growth. They may be suitable in wet areas, but require mowing. Legumes are suitable for steep slopes and are low maintenance. Shrubs provide a dense covering and are tolerant to acidic soils.

Terraces

Terraces are embankments or combinations of embankments and channels constructed across a slope. They may divert surface flow away from a site and control erosion by reducing slope length.

5.2.3.4 Collection/Discharge

Water collection methods are used to prevent off-site contamination. Water may be diverted to water courses or holding ponds, storage areas, treatments plants, or recycled to the contaminated area. Diversion techniques include waterways, chutes, and downpipes. Collection technologies include ditches, sedimentation basins, and storage ponds. Once the water is collected a variety of treatment technologies may be used to treat the water prior to discharge. These technologies are identical to technologies used for groundwater. The application of the technologies may differ since the quality of the surface water may vary, treatment objectives may be different, and collection procedures are different.

Seepage Basins and Ditches

These systems allow collected water to discharge by allowing it to seep through the ground. They have a finite life and may become clogged with solids and biological growth. Their lifetime depends on soil permeability, hydraulic gradient, and loading pattern.

Sedimentation Basins/Ponds

Basins are created by excavating or using natural depressions. Dams control the flow of water from leaving the basin. They are especially useful in reducing silt or sand sediments from a high run off surface water. Efficiency of solids removal depends on flow rate, pond size, and type of particles being removed. However, collected sediments may be contaminated and need waste management.

5.2.3.5 Treatment Technologies

Treatment technologies used for surface water are essentially the same as groundwater technologies. A detailed discussion of treatment technologies is given in Section 5.2.2, Groundwater. Brief, general technology descriptions are provided in this section, since all treatment technologies are assessed as potentially applicable. Greater considerations of site specified conditions will be given at a later time if treatment technologies are evaluated further.

Phase Change Separation

Phase change separation results from processes that transfer contaminants from surface water to other media phases. Processes include: air/steam stripping, evaporation/distillation, and freeze crystallation. Surface water flow rate, suspended solids, type of contaminants, and treatment objectives are considerations in evaluating the technology. Section 5.2.2 provides more process information.

Chemical Processes

Chemical processes include technologies that convert contaminants to a non-hazardous or less hazardous form via chemical reaction. Thorough mixing of reagents with waste streams is essential for the effectiveness of this technology. Chemical processes include: pH adjustment,

chemical precipitation, chlorination, chemical reduction, chemical oxidation, advanced oxidation, and hydrolysis. Surface water flow rate, suspended solids, type of contaminants, and treatment objectives are considerations in evaluating this technology. Section 5.2.2 provides additional background information.

Biotreatment

Biotreatment is accomplished by use of microorganisms which degrade organic compounds into nonhazardous or less hazardous materials. Both aerobic and anaerobic treatment processes are available, although anaerobic processes are more appropriate for halogenated hydrocarbons. Application of biotreatment may include: activated sludge, surface impoundments, fixed film reactors, submerged biological reactors, and land treatment. The type and concentration of contaminants are the most significant factors impacting this technology. Section 5.2.2 presents greater detail concerning biotreatment.

Density Separation

Density separation is achieved by physical processes which take advantage of density differences between contaminants and surface water. Processes include: oil/water separation, sedimentation, centrifugation, dissolved air flotation, and heavy media separation. Surface water flow rate, suspended solids, type of contaminants, and treatment objectives are considerations in evaluating this technology. Section 5.2.2 provides more process information.

Filtration

Filtration separates solids from liquids by passing the fluid through a porous medium. Granular filtration and dewatering filtration are typical options. Surface water flow rate, type of contaminants, and treatment objectives are considerations in evaluating this technology. Section 5.2.2 details technology options.

Membranes

Membrane separation processes purify water streams by selectively allowing penetration by contaminants during contact. Technology variations include: reverse osmosis, ultrafiltration, electrodialysis, and liquid emulsion membranes. Surface water flow rate, type of

contaminants, and treatment objectives are considerations in evaluating this technology. Section 5.2.2 provides additional background information.

Carbon Adsorption

Activated carbon has the ability to attract, or absorb, contaminants to its surface. When the surface becomes saturated, the carbon is spent and may be regenerated with heat or disposed. Surface water flow rate, suspended solids, type of contaminants, and treatment objectives are considerations in evaluating this technology. Section 5.2.2 presents greater detail concerning carbon absorption.

Ion Exchange

Ion exchange removes toxic ions from surface water by exchanging them with non-toxic ions absorbed on the surface of the exchange resins. When a critical concentration of toxic ions is absorbed, the resin is spent and may be regenerated with a concentrated solution of the original ions. Surface water flow rate, suspended solids, type of contaminants and treatment objectives are considerations in evaluating this technology. Section 5.2.2 provides more process information.

5.2.4 Evaluation of Sediments Corrective Measures Technologies

Several corrective measures technologies are potentially applicable to remediation of contamination in sediments associated with surface waters on site. Literature sources were reviewed to identify and characterize potential corrective measure technologies. The following general technologies were examined for potential suitability to remediate sediments at Roosevelt Roads:

- No Action
- Institutional Controls
- Containment
- Excavation and Disposal
- Sediment Washing/Flushing
- Biotreatment
- Solidification/Stabilization
- Thermal Destruction

In this section, brief, general reviews of potentially applicable sediments corrective measures technologies are presented, followed by site-specific evaluations based on currently available information.

5.2.4.1 No Action

No action is a treatment technology that allows the contaminated sediments to continue to exist as they are currently. The potential for contact between fresh water vegetation, benthic animals, or other receptors and the contaminated sediments will not be mitigated by this option. In addition, it is possible that contaminants within the sediments will migrate through surface waters upon disturbance or as a result of climatological cycles or through the air upon volatilization of volatile contaminants if the no action alternative is used. However, migration may not occur if one or more of the following conditions exists:

- Climatological variations affect the associated surface waters such that the sediment layer is not involved and that the contaminant-specific partition between water and sediment does not change significantly to favor water over sediment.

- Topography limits disturbance potential.

No action may be appropriate if the potential for direct receptor contact is low, such as in cases where sediment contamination occurs remote from benthic populations and sensitive vegetation, and where the potential for contaminant migration is low as well.

Implementation of no action is feasible site-wide. Similarly, no cost is associated with this option.

The No Action technology is expected to be ineffective at limiting impacts on health and the environment from the contaminated sediments on site. However, climatological and topographic factors that might indicate limited potential for migration are present at some SWMUs.

5.2.4.2 Institutional Controls

Sediment corrective measures known as institutional controls are generally administrative actions designed to limit receptor contact. Such actions include water use restrictions, dredging restrictions, deed restrictions, fencing, and access restrictions. Use of institutional controls allows contamination to exist, as does using no action, although institutional controls attempt to limit direct receptor contact. The potential for contaminant migration due to outside disturbance may also be reduced, although the same considerations regarding climatological effects on migration as were discussed under Section 5.2.4.1, No Action, may still apply. Thus, institutional actions are more appropriate when site conditions minimize the potential for contaminant migration.

Generally, this technology involves minimal effort and cost to implement. On-site controls require least effort due to property ownership and the presence of activity security through which restrictions may be mandated. Off-site controls may require acquisition of contaminated areas and/or legal or political assistance.

Implementation of institutional controls may be feasible in certain cases as a conditional remedy. A conditional remedy is one which may be adequate to protect human health and the environment under the present site conditions; however, provision must be made to allow remediation at some time in the future, such as at shut-down of a SWMU/AOC or sale of property.

Institutional controls are assessed as being ineffective at limiting migration from contaminated sediments on site. However, because site conditions at some SWMUs and AOCs limit potential receptor contact with sediment, institutional controls are warranted in some cases. As such, this technology will be retained for further consideration.

The physical constraints of certain SWMUs and AOCs would limit receptor contact under the No Action scenario. Thus, considering its low cost and ease of implementability, the technology will be retained for further consideration.

5.2.4.3 Containment

In situ containment of sediments may be accomplished by covering, sealing, or grouting to isolate the sediments. Containment of sediments is generally used alone, rather than within a

treatment train. Covering involves placement of a cover of inert or contaminant-specific active material. Sealing is accomplished by mixing in or applying to the surface an agent that will set up and seal the surface. Grouting involves injecting a grout that will set up and include the contaminated sedimentation within the solidified mass (USEPA, 1985).

Inert materials used to cover sediments include riprap, sand, clay, and silt and are primarily used to isolate contaminated sediments from contact with potential receptors and to limit potential for migration. Active materials perform the same functions as inert materials do and also provide treatment to reduce toxicity. Some active materials and their treatment potential are (USEPA, 1985):

- Limestone - neutralization of acidic sediments
- Oyster shells - binding of metals
- Ferric sulfate - neutralization of basic sediments and chemical precipitation
- Alum - neutralization of basic sediments

Inert covers are placed to minimize erosion of cover materials by surface water action. In addition, a sufficiently thick continuous layer of cover materials should be placed so that leaching of contaminants through the cover is limited. One final consideration for inert cover materials is whether benthic organisms may recolonize the covered site and what effect their actions (e.g. burrowing) may have on containment (USEPA, 1985).

With active materials used to construct the cover, the same considerations may apply in some cases. However, for active covers, the primary objective is to design the cover so that the active material remains in place at least long enough to treat the contaminated sediments. Erosion, dissolution, and physical disturbance can impact the durability of covers. In addition, sufficient material must be placed to adequately treat the contaminated sediment volume. Treatability studies could be designed to include identification of required volume of active materials, effect depth of treatments, and necessary retention time.

Cover material placement may be accomplished a number of ways. The three most popular are (USEPA, 1985) given below.

- Dumping - Dumping generally occurs from transportation vehicles. Accurate placement of the cover materials may be difficult to achieve. Dumping may cause considerable turbidity in the associated water both from the cover material itself as it

falls through the water and from the disturbance of sediments upon impact (USEPA, 1985). Variations of dumping are equipment-assisted placement (e.g., backhoe) or hand placement.

- Pump Down - Cover materials are released near the bottom of the body of water from a pipe or hose. Relatively calm and deep waters are required for accurate placement. Turbidity due to turbulence from the pump down placement method is less than that of dumping methods (USEPA, 1985).

- Submerged Diffuser - Submerged diffuser is similar to the pump down method, except that the diffuser head allows greater control for placement of cover materials. Less turbulence is associated with this method as well (USEPA, 1985).

Sealants, such as cement and quicklime, may be applied on the surface of or mixed within the contaminated sediments. Application of sealants may be accomplished with or without stream diversion. When stream diversion is practiced, shotcrete or grout may be applied pneumatically on the surface of the contaminated sediments. Alternatively, concrete, quicklime, or grout may be mixed into the sediments with rotor or trencher mixing equipment. Without stream diversion, grout or concrete may be pumped to the bottom of the body of surface water, placed on top of the contaminated sediments, and allowed to harden. Consideration on the impact of the water quality is required. Another option is to place aggregate on top of the sediments, using one of the techniques for placing covers, then pumping a cement-based grout over the aggregate to fill the voids. Typically, stream diversion techniques are used in shallow waters and methods employed without stream diversion are reserved for deep, open bodies of surface waters (USEPA, 1985).

In situ grouting is used to solidify the mass of sediments. Injection pipes with bladed ends are commonly used to apply and mix grout at various depths throughout the sediment strata. Resuspension of contaminated sediments may be a problem with this technology. Information on the extent of contamination areally and vertically and the typical bottom current patterns are needed in order to assess the feasibility of this technology. Although it varies with the grouting materials selected, in situ grouting of sediments is generally less costly than dredging (USEPA, 1985).

Durability of sealants and grouting is not well-documented at this time. Materials such as cement and quicklime generally require sufficient curing time under appropriate conditions

to harden. Treatability studies may be used to design an appropriate sealant mixture to achieve desired strength.

Containment of contaminated sediments with covers, sealants, or grouting cannot prevent accumulation of additional contaminated sediments from alternate sources. Assuming remediation of soils and groundwater occurs concurrently, potential sources of additional contaminated sediments beyond background are not expected. Further, contamination of uncontained sediments from new on-site sources is not anticipated once remediation of soils and groundwater is complete.

In-situ containment may not be appropriate for wetland areas due to the potential impacts on vegetative growth. At minimum, application of covers, sealants, or grouting will require special state and federal permits.

In-situ containment on a permanent basis is not widely practiced. Long-term reliability of this technology is unknown (USEPA, 1985).

Use of inert covers as containment for sediments is well-demonstrated relative to the use of dumped or grouted riprap for erosion control. However, since placement of inert covers for containment of contaminated sediments is not widely practiced, treatability studies may be conducted with the goal of providing additional information on effectiveness and durability.

Implementability of inert covers is assessed as implementable to moderately difficult depending on the cover material. Generally, for on-site sediments at the Roosevelt Roads SWMUs and AOCs, landbased placement equipment is necessary. Most potential equipment is readily available, although some equipment options may be more limited. Additional permits may be required for wetlands.

Inert covers are available at low cost, although some cost variation with placement technique and materials selection will occur. Required materials may not be readily available on the island of Puerto Rico.

Inert covers appear appropriate for at least some of the contaminated sediments being considered. As such, this technology will be retained for further evaluation.

Active Covers

Limited demonstration of active covers in controlling contaminated sediments does not permit an assessment of effectiveness. Treatability studies may need to be conducted during the CMS to facilitate assessment of effectiveness and durability.

Considerations for implementation of inert covers are applicable to active covers. In addition, compatibility between active materials and both the contaminated sediments and the planned equipment should be assessed.

As for inert covers, materials and placement impact costs. Since active materials such as limestone often command a higher price than inert materials such as rock or sand, overall costs for active covers are expected to be in the medium range of costs for sediment technologies. Required materials may not be readily available on the island of Puerto Rico.

Active covers appear appropriate for at least some of the contaminated sediments being considered. As such, they will be retained for further consideration.

Sealant

Sealants are not well-demonstrated and, therefore, an assessment of effectiveness cannot be made. Treatability studies can be performed to indicate effectiveness.

Sealants are moderately implementable since, in one method, techniques must be used to divert surface waters prior to sealant application, and in the other method, sealants must be applied through standing water. Remaining considerations for implementability of sealants are the same as those for inert covers.

Since materials used for sealants, such as cement, may be more costly than inert materials, cost of this technology is in the medium range of costs for sediment technologies.

Sealants will not be considered further at this time, due to the additional difficulty associated with implementation of sealants as opposed to inert or active covers. Sealants may be considered further if additional information indicating effectiveness is available or if other technologies indicate consideration of sealants is warranted.

Grouting

Effectiveness of grouting is not well demonstrated except relative to grouted riprap. An assessment of effectiveness indicates insufficient information is available to make a determination. Treatability studies may be performed to ascertain effectiveness. Implementability of grouting is moderate, involving injection and mixing in-situ.

Cost of grouting is in the medium range among sediment technologies primarily due to the cost of application.

Grouting will not be considered further at this time, due to its moderate implementability and the uncertainty about its effectiveness. Consideration may be given to grouting at a later time, depending on performance of other technologies and information concerning the effectiveness of grouting.

5.2.4.4 Excavation and Disposal

Excavation and disposal permanently remove the potentials for receptor contact on-site with contaminated sediments and for contaminant migration. Excavation of sediments is typically referred to as dredging to distinguish from on-land excavation of soils. Dredging may also be used to recover contaminated sediments for treatment by other technologies rather than disposal. Caution must be used during dredging operations to minimize resuspension of contaminants. Resuspension may cause considerable amounts of sediments to be transported downstream from the dredging site. In addition, since resuspension increases the solid-liquid contact between the sediments and the associated surface water, increased leaching of contaminants into the water may occur (USEPA, 1985).

Dredging may be accomplished mechanically, hydraulically, or by a related mechanism. Mechanical dredging is the most common method used. Mechanical dredging, however, has a high incidence of resuspension. A low production rate is generally associated with mechanical dredging as well, although the material collected is very close to its in-place moisture content. Mechanical dredging is appropriate for sediments found in wetlands, shallow rivers and streams, and those that are in surface waters with low flow velocities. Equipment used for mechanical dredging includes (USEPA, 1985):

- Backhoe - limited reach
- Draglines - may be either vessel-mounted or land-based
- Clamshells - may be either vessel-mounted or land-based
- Bucket ladder dredges - limited availability

Among these, the clamshell is the most commonly used dredging equipment. Clamshells used for mechanical dredging are crane-operated and typically barge-mounted, although they may be land-based. Clamshells may dredge up to 100 feet in depth and a typical bucket capacity is 1 to 12 cubic yards (USEPA, 1985).

Hydraulic dredging is another option for removal of contaminated sediments. When sediments are collected hydraulically, they are pumped to the surface as a slurry, which may then be transferred on to treatment or disposal. Since collection occurs in slurry form, a significant amount of dewatering may be necessary (USEPA, 1985).

Hydraulic dredges typically employ centrifugal pumps, and most are mounted on barges. Generally, hydraulic collection requires relatively free-flowing sediments, although variations are available which make excavation of more consolidated material possible. Hydraulic dredges have relatively high production rates, although significant resuspension of sediments may still occur (USEPA, 1985).

The suction end of a hydraulic dredge is mounted on a movable ladder that is raised and lowered in the sediments to the depth desired. Hydraulic dredges are designed to use plain suction, a rotary cutterhead to assist in removing solidified sediments, a dust pan head which uses high pressure water jets to dislodge solidified sediments, and/or a self-propelled storage vessel. The availability of most types of hydraulic dredges is relatively low (USEPA, 1985).

Two other types of sediment removal are available which are similar to hydraulic dredging in nature. The Mud Cat and the Vaughn Lagoon Pumper are small-sized dredges designed to be applicable for shallow water dredge sites. These dredges have low production rates and low resuspension as well (USEPA, 1985).

Hand-held dredges are also available which operate similarly to hydraulic dredges. Vacuum is supplied by truck and the individual dredges are held by wading operators. Particular attention must be given to the health and safety of workers when using this technology option (USEPA, 1985).

Pneumatic dredging is very similar to hydraulic dredging, although the vacuum is supplied by compressed air-operated pump. This option has very limited availability in this country (USEPA, 1985).

Pre-dredging operations may be performed as necessary to facilitate dredging operations. These include (USEPA, 1985):

- Stream diversion
- Erection of cofferdams
- Snagging (removal of stumps, logs, rocks, or debris)
- Removal of vegetative stands

Stream diversion techniques are temporary methods to change the stream flow. Such techniques include erection of cofferdams made from sheet piling, soil, or sandbags to redirect a portion of the flow. Alternately, streams may be diverted by means of dikes and berms to dam flow and allow for water retention and additional solids settling. Typical configurations limit access of surface waters to certain areas, for example, a semi-circle dam may be placed against a stream bank, a cofferdam may be constructed parallel to the stream bank to prevent contact of contaminated sediments by the bulk of the stream. Stream diversion techniques are rarely used as permanent means to limit stream flow. Dredging of contaminated sediments in wetland areas involves additional permitting over dredging in streams or lagoons. Provisions to restore wetlands following corrective action are generally required.

On-site disposal of dredged material is typically not permitted due to RCRA land disposal restrictions. The same off-site disposal options that are applicable to soils are also applicable to sediments, although some dewatering, stabilization, or treatment may be required for off-site land disposal. Section 5.2.1, Soils, discusses the viable options for off-site disposal. As discussed in Section 5.2.1, there are currently no landfills on the island of Puerto Rico permitted to accept hazardous waste.

Dewatering options include screens, filter presses, drum vacuum filters, belt vacuum filters, and disc filters.

Dredging

Dredging of contaminated sediments is assessed as effective and implementable with a moderate amount of difficulty. Maneuverability of dredging equipment near surface waters may be limited. Land-based equipment is necessary for the streams on site.

Medium costs are associated with dredging on a unit cost basis. Volume of contaminated sediments must be known to assess overall costs.

Dredging is appropriate for many of the contaminated sediments being considered. As such, this technology will be retained for further consideration.

Off-Site Disposal

Off-site disposal of dredged material is both effective and implementable. Potential liability associated with practices at off-site facilities necessitates careful selection of appropriate off-site waste management. As discussed in Section 5.2.1, there are currently no landfills on the island of Puerto Rico permitted to accept hazardous waste. The cost of utilizing this technology may be high, depending on whether treatment of wastes prior to disposal is necessary. Implementability of offsite disposal depends, in part, on the proximity of a permitted facility with sufficient capacity capable of managing the contaminated sediments. Identification of such a facility and the required treatment are necessary in order to fully evaluate this technology. In addition, considerations of liability are required since the waste is only being relocated.

Since off-site disposal is appropriate for management of dredged contaminated sediments, it will be retained for further consideration.

5.2.4.5 Sediment Washing/Flushing

Treatment of contaminated sediments by washing/flushing takes advantage of elutriation to remove contaminants. Extraction and dissolution also utilize elutriation, thus, all these processes are addressed in this section as one technology. Sediments are not appropriate for in situ sediment washing due to standing water. Ex-situ sediment washing involves thorough mixing of solvent and sediments in a self-contained tank.

Discussion presented in Section 5.2.1 (Soils) on soil washing/flushing applied ex-situ is largely applicable to sediments as well. Depending on the dredging technique and the flushing solution, dewatering of sediments prior to treatment may be necessary.

Factors impacting effectiveness of this process presented in Section 5.2.1 included soil hydraulic conductivity. The hydraulic conductivity of the sediments will have little impact on sediment flushing since it must be performed ex-situ.

Sediment washing/flushing is effective, implementable, and available at moderate costs. However, the proper set of conditions must be in place. The appropriate reagent for the contaminants in the sediment must be identified. Further, the partition coefficient between the reagent and the sediment must favor contaminant elutriation with the reagent. Such information can be obtained through the execution of treatability studies.

Sediment washing has costs which are in the medium range of sediment technologies being considered, depending on the selection of reagent. Overall costs may be higher for this technology since a large volume of reagents is sometimes used.

Since sediment washing/flushing is appropriate for management of contaminated sediments, it will be retained for further consideration.

5.2.4.6 Biotreatment

Biodegradation of contaminants is addressed in Section 5.2.2, Groundwater. Much of the discussion included under Groundwater is applicable to sediments. Another technology option, slurry bioremediation, also appears applicable for dredged sediment remediation. Slurry bioremediation was discussed in Section 5.2.1 for soils and the information presented is equally applicable to sediments. In fact, slurry biotreatment may be especially suitable for treatment of sediments which are dredged as a slurry.

Biotreatment is effective on degrading most organic contaminants and also halogenated organics, although the slower anaerobic organisms are needed to degrade the halogenated organics. Some organic compounds are not readily degraded, and treatability studies are necessary. In addition, biotreatment is not effective on contaminated sediments that have metals present as well as organics, since metals have been associated with poisoning of some

treatment organisms. A treatment train may be utilized to pretreat for removal of metals. In addition, the concentration of the contaminants impacts the effectiveness of the technology.

Biotreatment can be fairly easily implemented if the appropriate organism can be identified from treatability studies. For land application, the treatment site also must be accessible.

Costs associated with biotreatment are expected to be moderate. Variations, which might include energy-intensive operations such as supplying power to blowers, mixers, and pumps, may cause costs to become relatively high. This equipment may not be readily available on the island of Puerto Rico.

Biotreatment, although potentially applicable, will not be considered further due to the following:

- Anaerobic processes traditionally are extremely slow
- Intermediate degradation products of chlorinated organics are likely to be more toxic than the original contaminants

Consideration of biotreatment may be resumed if it is demonstrated to be capable of effectively and safely reducing contaminant concentration within a reasonable time frame.

5.2.4.7 Solidification/Stabilization

Solidification and/or stabilization of sediments may be performed in-situ or ex-situ, although ex-situ is more common. In-situ stabilization includes grouting techniques which are discussed in Section 5.2.4.3, Containment, due to the similarity to covering and sealing techniques in application and materials. Once sediments have been dredged, they are suitable for treatment by any of the ex-situ solidification/stabilization processes, including vitrification, discussed in Section 5.2.1 for soils. Partial dewatering of dredged material may be beneficial prior to solidification/stabilization, depending on the relative cost and availability of dewatering processes and solidification/stabilization agents. This material may not be readily available on the island of Puerto Rico.

Solidification/Stabilization

Solidification/stabilization processes are implementable and effective at minimizing impacts on health and the environment.

Implementability of solidification/stabilization processes is feasible following dredging. A form of in-situ stabilization may be performed on sediments, although it was discussed previously under containment as grouting, due to similarity between its application and that of the other containment technologies.

Cost of applying solidification/stabilization techniques is typically in the medium range, although it is dependent on reagent cost.

Solidification/stabilization is appropriate for many of the contaminated sediments being considered.

Vitrification

Vitrification is effective at protecting health and the environment by minimizing potential for contaminant migration from the sediments. In addition, vitrification may be implemented with a moderate amount of difficulty. Implementability of this technology involves handling of the molten sediments prior to cooling. Treatment of organics that volatize may also be required. However, high costs are attributed to this technology due to the high cost of operating such energy-intensive equipment.

Vitrification will not be considered any further at this time since implementation involves some difficulty and since operating costs are high. Consideration of vitrification may be resumed if other options become less attractive; for instance, if off-site disposal costs are excessive or if appropriate facilities are not available, vitrification may appear more feasible.

5.2.4.8 Thermal Destruction

Thermal destruction (on-site and off-site) is a remediation technique that involves combustion of contaminated sediments to convert contaminants into non-hazardous by-products. This technology is discussed completely under Section 5.2.1 (Soils). Much of the discussion included under soils also is applicable for sediments. Dewatering of dredged sediments prior to thermal

treatment may be beneficial since excess moisture renders the process inefficient and greatly increases costs. The related technology of low-temperature thermal desorption also appears applicable for dewatered dredged contaminated sediments.

Thermal Destruction

Thermal destruction is effective and implementable, although high costs are associated with this option. The effectiveness of thermal destruction applies to organic contaminants; another treatment may be needed to effectively minimize impacts from inorganic contaminants. Implementability assumes that an approved incineration facility is available at a reasonable transport distance from the site that can accept the contaminated sediments. Waste characterization data may be required prior to acceptance by the incinerator. On-site incineration requires considerable permitting which has been increasingly more difficult and time-consuming to obtain due to public perception.

Since thermal destruction is appropriate for management of contaminated sediments, it will be considered further. There are no significant field investigation data gaps associated with this alternative beyond extent of contamination.

Low Temperature Thermal Desorption

Low temperature thermal desorption is effective at removing organic contaminants from sediments; however, not enough information is available to assess the implementability and cost of this technology. Predominantly, lack of information concerns the availability of equipment. Since this is a relatively new technology, implementation is uncertain due to equipment procurement, and cost may be linked to availability if the equipment is limited in supply.

Although low temperature thermal desorption has uncertain implementability and cost, it will be retained for further consideration. However, prior to any implementation of this technology, the availability of equipment and personnel and associated costs must be evaluated in groundwater data.

5.3 Preliminary Selected Corrective Measure Technologies

5.3.1 Introduction

Corrective measure technologies that are potentially applicable to the contaminated media at NSRR have been identified. A summary of the preliminarily selected corrective measure technologies is presented in Table 5-1. Additional technologies may be potentially applicable; however, the listed technologies represent those which appear most promising for application at NSRR given the information currently available. The technologies shown in Table 5-1 will be evaluated further as additional information is gathered. With availability of additional information, such as results of a full or first Phase RFI, additional potentially applicable technologies may be included.

The preliminary selection of potentially suitable technologies is one of the objectives of this screening. Identification of field investigative data gaps to be addressed by a full or first Phase RFI is another function of this screening. Data necessary to fully evaluate the corrective measures technologies is given by SWMU in Section 6.0.

5.3.2 SWMU 1 - Army Cremator Disposal Site (IR Site 5)

For SWMU 1, the amount of waste present at the site and the lack of clearly identified "hot spots" precluded the implementation of excavation and thus the related treatment and disposal technologies for soil. As such, only the following corrective measures for soil technologies were selected for this SWMU: no action; institutional controls; and containment (capping and barrier trenches).

For groundwater, the extent of contamination at SWMU 1 has not been fully characterized. It is assumed that the waste disposed at the SWMU is above the groundwater table, and thus the potential for groundwater contamination is somewhat reduced. Based on this assumption, a pump and treat scenario is not warranted. To prevent percolation through the waste material, the containment technologies that were selected for soil also were selected for groundwater.

The sediment and surface water technology options were selected in order to support the containment technologies for soil and groundwater. Specifically, this includes grading to control surface water runoff and thus prevent erosion and subsequent sediment formation.

5.3.3 SWMU 2 - Langley Drive Disposal Site

In Baker's Supplemental Investigation, arsenic is the primary contaminant of concern for exposure pathways associated with soil. Additionally, lead was encountered in soil in concentrations greater than 500 mg/kg. Based on this, these two contaminants were used in order to perform the preliminary screening of soil corrective action technologies for this SWMU. Additionally, because groundwater has not been adequately characterized at the site, arsenic and lead were also assumed to be the primary contaminants of concern for groundwater as well.

The following technologies were considered to be appropriate for soil at SWMU 2: no action; institutional controls; containment; excavation and disposal; and treatment. The following technologies were eliminated from further consideration because they are not appropriate for metal and metalloid contamination: vacuum extraction; biotreatment; thermal destruction; and low temperature thermal desorption. Additionally, vitrification was eliminated from consideration because of the high costs associated with this technology.

For groundwater, the following corrective action technology categories were identified as being potentially applicable for this SWMU: no action; containment/collection; and treatment. For treatment technologies, only ones capable of metals removal were identified as being applicable. These include: pH adjustment; precipitation, chemical oxidation, and filtration. Additionally, although the technologies of membranes and ion exchange are applicable to metals removal, they were not selected because of their relatively higher costs and lower reliabilities.

No action, institutional controls, ditches, basins, and filtration were the technologies preliminarily identified as being applicable to surface water contamination at this SWMU. Other treatment technologies, including phase change separation, chemical processes, biotreatment, density separation, and carbon absorption were eliminated because they are not applicable to the metals contamination at the SWMU. Also, as described in the paragraph above, ion exchange and membrane technologies were eliminated because of their relatively higher costs and lower reliabilities.

For sediment, no action, institutional actions, and various excavation and disposal technologies were retained for further consideration for this SWMU. The containment technologies presented in Table 5-1 were not retained for further evaluation because they are

inapplicable given the physical constraints of the site. The technologies of biotreatment, thermal destruction, and low temperature thermal desorption were eliminated because they are ineffective in the treatment of metals. Vitrification is not identified as potentially applicable because of the high costs associated with this technology.

For sediments, only the corrective measures technologies of no action and institutional controls were identified as potentially applicable to the conditions at SWMU 3. This is our only possible remedation.

5.3.4 SWMU 9 - Tank 212 - 217 Sludge Burial Pits

The technologies for SWMU 9 were selected based on several assumptions regarding contamination at the SWMU:

- Soil - It was assumed that the soil is contaminated with constituents from fuel sludge, including petroleum hydrocarbons with high molecular weights and heavy metals such as nickel and vanadium

- Groundwater - It was assumed that the groundwater may be affected by aromatic hydrocarbons (such as benzene), heavy metals from the fuel, and free petroleum hydrocarbon product.

- Surface Water - It was assumed that the surface water contained petroleum hydrocarbons and required some pretreatment for suspended solids.

- Sediment - It was assumed that the sediment contamination was similar to that of soil.

For soil as well as sediment, the technologies of solidification/stabilization and vitrification were eliminated for this SWMU because of the high treatment costs associated with this technology. Also, the technologies of membrane separation and ion exchange were dropped from consideration for groundwater and surface water because of the moderate to high costs and relatively low reliability of these technologies.

5.3.5 SWMU 11 - Old Power Plant/Building 38 (IR Site 16)

As footnoted in Table 5-1, no potentially corrective measures technologies are identified for soil and groundwater for SWMU 11. Remediation of PCB-contaminated soil in the vicinity of Building 38 is currently being performed. Additionally, groundwater remediation will be initiated shortly at the SWMU. Because corrective measures have been initiated at this SWMU for soil and groundwater, no additional corrective measures are being identified at this time.

For surface water, only no action, institutional controls, and grading were identified as potentially applicable to the SWMU. Grading as included as a technology for surface water in order to limit future migration of contaminants from the soil to the surface water at the SWMU.

For sediment, four corrective measures scenarios were identified as applicable to SWMU 11: no action; institutional actions; excavation/disposal; and excavation/treatment/disposal. Containment technologies for sediment were not considered because of concerns about implementability under conditions of tidal action. For the treatment technologies, low-temperature desorption was dropped from consideration because this technology is not applicable to essentially non-volatile PCBs.

In addition to the media subject to corrective action requirements under the permit, corrective measure technologies for Building 38 and the cooling tunnels also have been identified. These include:

- Absorption
- Demolition
- Dismantling
- Dusting/Vacuuming/Wiping
- Encapsulation/Enclosure
- Gritblasting
- Hydroblasting/Waterblasting
- Fixative/stabilizer coatings
- Scarification
- Solvent Washing
- Steam Cleaning

- Vapor-Phase Solvent Extraction
- Drilling and Spalling
- K-20 Sealant

These technologies will be evaluated in greater detail as additional data from the RFI becomes available.

5.3.6 AOC B - Former Site of Building 25 (IR Site 10)

Based on available records for this AOC, it was assumed that the soil at AOC B is potentially contaminated with the following constituents: lead and other metals; BTEX compounds (benzene, toluene, ethylbenzene, and xylene); petroleum hydrocarbons; PAHs ; and PCBs. As such, all of the potentially applicable corrective measures technologies listed in Table 5-1, except solidification/stabilization and vitrification, were identified as applicable to AOC B. These two technologies were not considered as applicable because of the high costs associated with them.

It also was assumed that the following metals are present in the groundwater at the site: copper, silver, selenium, cadmium, and zinc. On this basis, metals removal technologies including pH adjustment, precipitation, filtration, and ion exchange were identified as potentially applicable to AOC B.

Surface water and sediment are not subject to corrective action requirements under the permit. This is indicated by shading in Table 5-1. As such, no technologies are identified for these media for AOC B.

5.3.7 First-Phase RFI Sites

The technologies identified in Section 5.2 are also applicable to conditions at SWMUs that are now undergoing first-phase RFIs. These site conditions include:

- PCB contamination resulting form the handling of transformers

- Lead contamination from the handling of batteries

- Spills of solvents and petroleum hydrocarbons, including those that involve free product in groundwater

- Disposal areas of petroleum hydrocarbon sludge

- Disposal areas, such as landfills, with large volume of solids waste mixed with some solid waste

- Spills of other organic compounds, such as pesticides

These SWMUs could be tentatively assigned corrective measures technologies; however, this evaluation would be based on incomplete information and would need to be performed again once the data from the first-phase RFI is available. For this reason, the detailed technology assessment is being delayed until the first-phase RFIs are completed. Additional technologies may be identified as generally applicable to NSRR at that time.

6.0 RCRA FACILITY INVESTIGATION - ADDITIONAL DATA REQUIREMENTS

6.1 Introduction

The purpose of this section is to provide an outline of the investigatory approach and scope of work for each SWMU requiring a full or Phase I RFI. Details of techniques to be employed during the investigations are not discussed (this will be included in the RFI Field Sampling Plan); however, the level of effort for each site is addressed in terms of numbers of sampling points for each environmental media of concern. In addition, all the miscellaneous investigations required to provide data for corrective measure evaluation are described.

It is the intent that this section provide the framework for all RFI activities at the NSRR. Developing the general approach and level of effort for investigations at this point in the work plan process allows the early definition of media of concern and the work elements required to address concerns. Establishment of scope at this time should allow the review and approval of subsequent work plans to be easier which will lead to accelerated investigations and movement to any required corrective actions more rapid.

6.2 SWMU 1 - Army Cremator Disposal Site (IR Site 5)

6.2.1 RFI Scope of Work

The only environmental media that remains inadequately characterized at this site is groundwater (see Section 4.0 for the rationale which supports this statement). A groundwater investigation is proposed encompassing the elements discussed below.

A total of up to four new monitoring wells will be installed with the actual number to be determined based on field conditions. One well will be placed along the Coast Guard pier road to monitor groundwater which may be flowing under the site exiting to Ensenada Honda north of the road (see Figure 6-1). Three wells were installed in a radial pattern along the eastern and southern boundaries of the site during a previous investigation. Most recently, these wells were not able to be located during a fieldwork program. The placement of these wells is appropriate; therefore, any existing well that cannot be located will be replaced. With the continued use of 5GW01 as a background well, the monitoring system will be comprised of five wells.

LEGEND

⊕ PROPOSED MONITORING WELL LOCATION

MONITORING WELL LOCATION

DATE	4-29-94
SCALE	1" = 50'
DRAWN	
REVIEWED	
S.O.#	62470-223
CADD#	001-50

NORTH

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BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

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FIGURE 6-1
PROPOSED SAMPLING LOCATIONS
RFI - SWMU 1
ARMY CREMATOR DISPOSAL SITE

SCALE 1" = 50'

DATE 4-29-94

FIGURE NO.
6-1

K:\SRN\19223\001-50.DWG (04/29/94 17:28:29) (PRFS:\PAPER\001-50.PRF) (PLOTTED BY: •NO I ... USER•) (S.O. NUMBER: •NO INSTRUCTION•)

All newly installed wells will be screened such that the top of the groundwater surface is monitored (e.g., the screened interval will extend across the water table). Following installation, new wells will be developed and slug tested to assess local horizontal hydraulic conductivity. Existing wells will be redeveloped and upgraded at the surface as necessary (e.g., new standpipes, new guard posts). These wells will also be slug tested.

A single sampling event will be undertaken after the wells have reached equilibrium. The samples will be analyzed for:

- Volatile organics
- Semivolatile organics
- RCRA metals (both dissolved and total)
- Pesticides/PCBs
- Selenium
- Sodium
- Thallium
- Arsenic
- Field parameters (pH, specific conductance and temperature)

Analytical methods employed will be those contained in the most recent edition of SW-846. Data packages will be required that correspond to NEESA Level D only for SW-846 methods. All data will be subjected to third party data validation.

6.2.2 Corrective Measures Data

As stated in Section 6.2.1, groundwater is the only media that remains inadequately characterized at the site. Generally, factors that need to be determined prior to final selection of a groundwater corrective measure include groundwater quality, types of contaminants, depth of groundwater contamination, groundwater of contaminants, depth to groundwater table, and plume definition. All of these factors would impact the selection and implementation of containment technologies. For certain types and concentrations of contaminants, a no action scenario may be warranted.

6.3 SWMU 2 - Langley Drive Disposal Site (IR Site 6)

6.3.1 RFI Scope of Work

This site has recently undergone additional site characterization by photographic analysis of historical waste deposition and through direct sampling of the soils and sediments. Surface water should not be affected by the site given the twice daily flux of waters related to tidal action. The results of these investigations indicated the site posed no significantly risk related to these environmental media. This leaves groundwater as the only medium not adequately characterized at this time. [See Section 4.0 for information supporting these statements.]

One well (06GW01) is in place at the site in an assumed upgradient location. This well will remain in the monitoring system. Three additional, new wells are proposed to complete the system. The proposed locations for these wells is shown on Figure 6-2. One well is intended for the center of the waste disposal area while the other two will be placed at the downgradient margin of the site. It should be noted that the southernmost well will be placed, as much as possible, directly downgradient of the "fill slope" identified from historical aerial photographs. This array of monitoring wells is designed to provide samples for adequate chemical characterization of the groundwater passing beneath the site and groundwater elevation information which should be capable of yielding flow directions and hydraulic gradient.

Newly installed wells will be screened so as to monitor the top of groundwater. Development procedures will be undertaken at all wells (including the existing one which will also receive surface installation repair/upgrading as necessary). Slug tests will be performed on all wells to assess local horizontal hydraulic conductivity.

A single sampling event will take place after the wells have equilibrated. The samples will be analyzed for:

- Volatile organics
- Semivolatile organics
- Pesticides/PCBs
- RCRA metals (both dissolved and total)
- Sodium
- Selenium
- Field parameters

Analytical methods employed will be those contained in the most recent edition of SW-846. Data packages will be required that correspond to NEESA Level D only for SW-846 methods. All data will be subjected to third party data validation.

6.3.2 Corrective Measures Data

Groundwater is the only medium that has not been adequately characterized at this SWMU. The following factors that need to be determined in order to more fully evaluate the selected remedial technologies: groundwater quality; types of contaminants; depth of groundwater contamination; groundwater flow direction; depth to groundwater table; and plume definition. For the "pump and treat" corrective measure that may be applicable to this SWMU, definition of the plume and determination of the groundwater flow direction are the more critical factors.

6.4 SWMU 3 - Base Landfill

6.4.1 RFI Scope of Work

The requirements for the RFI at this site include provisions for investigations of soils, sediments, surface water and groundwater. The Base Landfill is presently operating in accordance with its permit the provisions of which include a groundwater monitoring program. For this reason, the Navy feels that the requirement for a groundwater RFI is redundant. While this is the case, data from the sampling events which have taken place since 1987 will be presented and discussed in the RFI report.

The need for a soils investigation does not appear warranted at the landfill. Long-term use of the area as a landfill has limited the soils present to those known to be in contact with waste material or those used as cover. Since this is known, it would appear unnecessary to verify it through sampling. In addition, the media most likely to show impact from landfilling is the groundwater since it may be in contact with waste in some areas and receives recharge from downward percolating leachate. This media is (and has been for some time) being actively monitored.

Surface water, which surrounds the site on three sides, is exchanged twice a day by tidal action. Therefore, it is extremely unlikely that any surface water sample would show any

effect from landfilling. Based upon this, there does not appear to be any need for a surface water sampling program.

Sediments directly offshore from the landfill could be affected by migrating leachate or contaminated runoff from the landfill. In order to address this concern, a sediment sampling program is proposed. Figure 6-3 indicates the sampling points to be employed during the program. A total of 17 sampling locations spaced at approximately 500 foot intervals around the three sides of the landfill in contact with water.

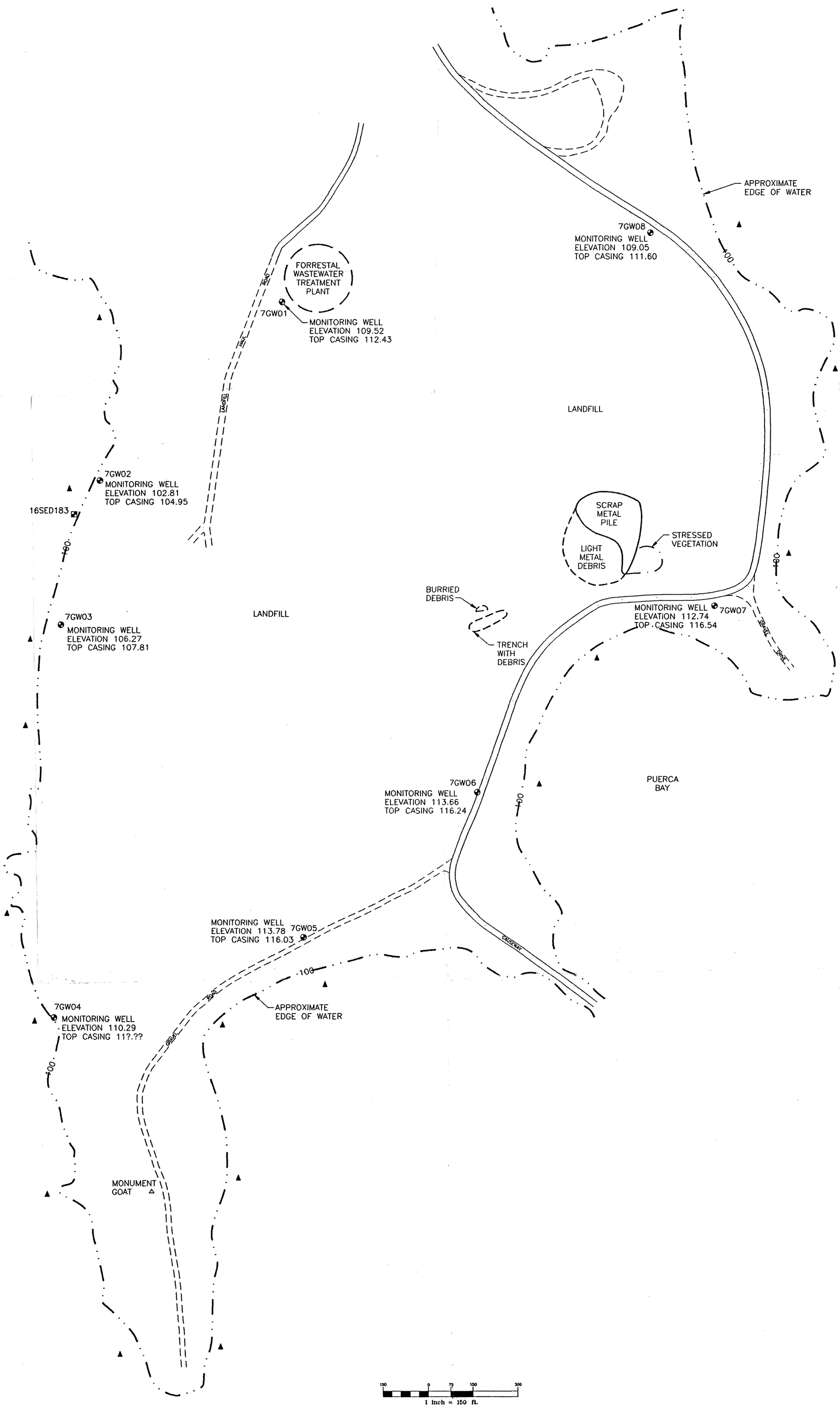
The 17 sediment sample locations will be sampled once. Analyses will be performed on the samples as follows:

- Volatile organics
- Semivolatile organics
- Pesticide/PCBs
- RCRA metals
- Arsenic
- Selenium

Analytical methods will be those provided in the most recent edition of SW-846. All data packages will comply with NEESA Level D requirements as they can be applied to SW-846 methods. Third party data validation will be performed on all sampling results.

6.4.2 Corrective Measures Data

As explained in Section 6.4.1, sediment is the only media at SWMU 3 that requires additional characterization. Generally, properties of sediment that need to be ascertained prior to sediment corrective measure include: grain size; cation exchange capacity; carbon content; surface water quality; redox potential; acidity; and types of contaminants. In order to evaluate the three corrective measures technologies (no action, institutional controls, and grading) potentially applicable to this SWMU, the types of contaminants need to be determined at a minimum. Additional characterization, such as testing for carbon content in the sediment, may be needed if additional technologies are considered.



LEGEND						
16SED183 SURFACE WATER/SEDIMENT SAMPLE LOCATION PROPOSED SURFACE WATER/SEDIMENT SAMPLE LOCATION 7GW01 MONITORING WELL LOCATION	DATE 4-29-94 SCALE 1" = 150' DRAWN REVIEWED S.O.# 62470-223 CADD# 003-50	NORTH		NAVAL STATION ROOSEVELT ROADS PUERTO RICO BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	FIGURE 6-3 PROPOSED SAMPLING LOCATIONS RFI SWMU 3 STATION LANDFILL SCALE 1" = 150' DATE 4-29-94	FIGURE NO. 6-3

6.5 SWMU 9 - Disposal Pits Associated with Tanks 212-217

6.5.1 RFI Scope of Work

The disposal pits existed in multiple areas and at various locations within the areas with apparently new pits created for each cleaning episode. There is no evidence of the pits at this time. Since the pits are relatively small, spaced part yet contained within general areas and 15 to 50 years old, there does not appear to be a need for locating individual pits. It is quite likely that over the course of years, any contamination related to the pits has merged with that from other pits and now presents a general pattern rather than a "hot spot" type profile. An RFI has been designed based on these site conditions.

There are actually three areas within this SWMU:

- Area A comprised of tanks 212 and 213
- Area B comprised of tanks 214 and 215
- Area C comprised of tanks 216 and 217

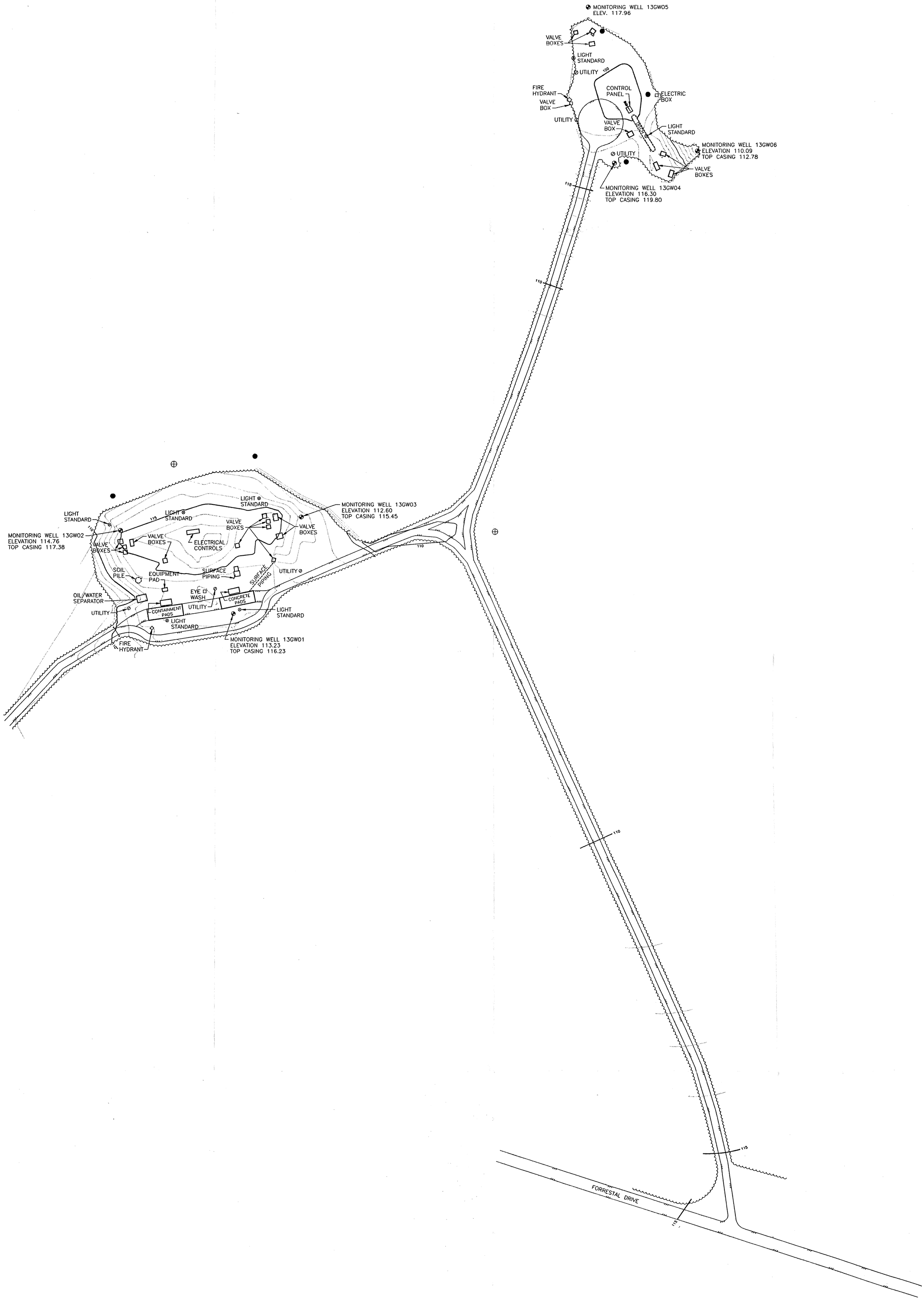
Since each of these ares is remote from one another, they will be discussed separately.

Area A Investigations

An investigatory program consisting of three soil borings and two monitoring well installations as well as use of existing monitoring points is proposed. The proposed array of wells and borings is shown on Figure 6-4A.

The intent of the soil borings is to provide an avenue for obtaining a subsurface profile of any contamination present. It is expected that pits would have been installed to the north and east and possibly west of the tanks to avoid the access road. Migration of contaminants is expected to have mirrored topography and groundwater flow which means the greatest percentage of movement would be to the north with some lesser component to the east. For this reason, soil borings have been placed as shown on the figure.

Indications of groundwater contamination are present from earlier investigations; therefore, the two wells shown are designed to monitor the two possible groundwater flow paths at a



LEGEND	
●	PROPOSED SOIL BORING LOCATION
7GW01 ◐	MONITORING WELL LOCATION
⊕	PROPOSED MONITORING WELL LOCATION

DATE	4-29-94
SCALE	1" = 80'
DRAWN	
REVIEWED	
S.O.#	62470-223
CADD#	09W-50

NORTH

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FIGURE 6-4A
PROPOSED SAMPLING LOCATIONS
RFI - SWMU 9, AREAS A AND B
TANKS 210 - 212

SCALE 1" = 80' DATE 4-29-94

FIGURE NO.
6-4A

point somewhat remote from the tanks. It is also planned to employ existing wells 13GW01, 13GW02 and 13GW03 in the RFI for additional data.

Area B Investigations

Area B sits on a peninsula of land jutting out into mangrove swamps. The site already is ringed by three wells (which are proposed for reuse in the RFI) and does not require further groundwater monitoring.

Four soil borings, the locations of which are shown on Figure 6-4A, are designed to have the capability of providing soil samples which can adequately characterize the nature of any subsurface contamination.

Area C Investigations

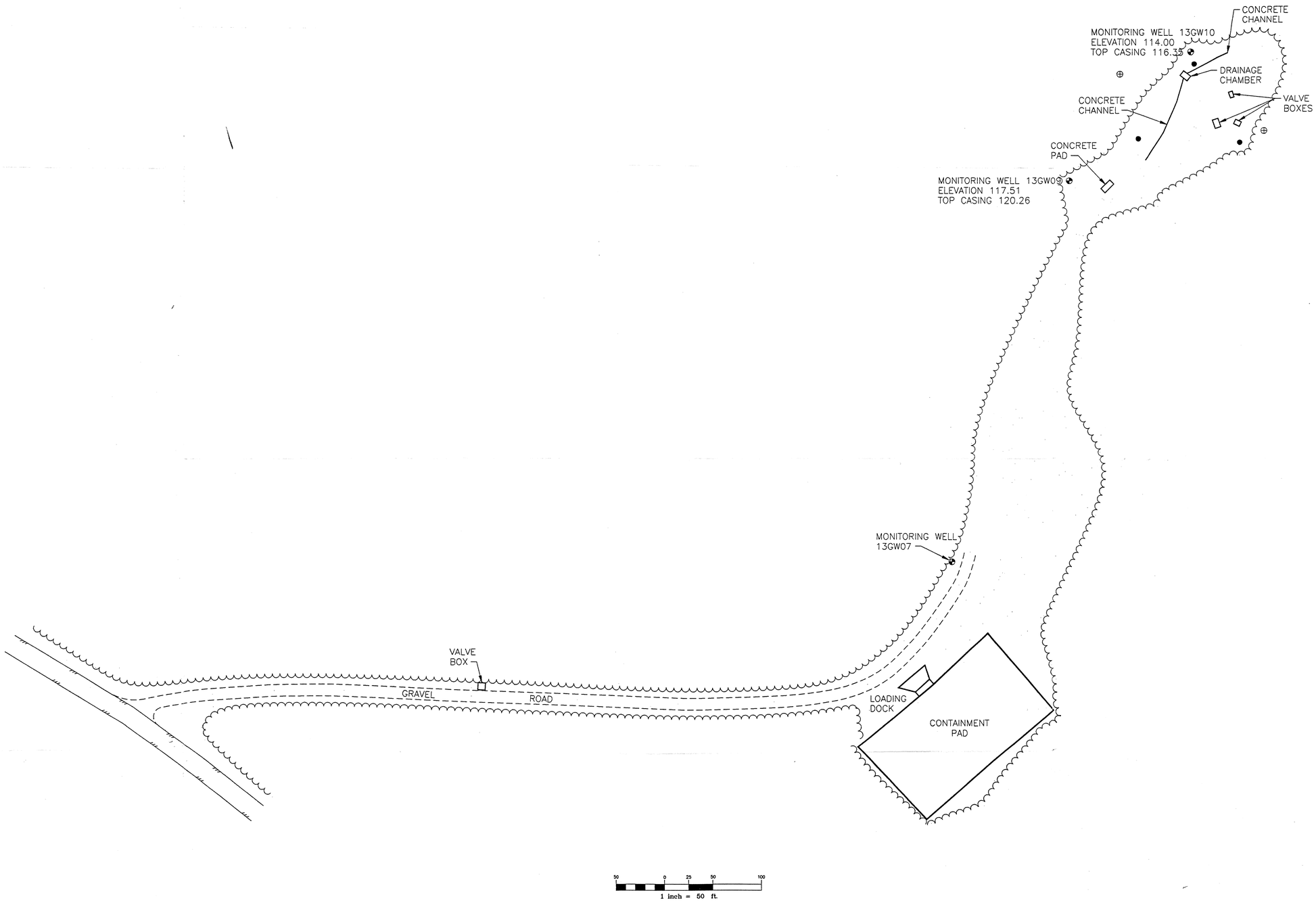
Area C, like Area A, has two primary directions for contaminant movement, to the west and to the northeast. Based on this, three soil borings and two new monitoring wells are proposed the locations of which are shown on Figure 6-4B.

The borings are designed to provide information regarding the vertical distribution of any contaminants within the area of reported disposal pit placement. Where possible and technically appropriate, borings have been located adjacent to existing monitoring wells to provide both soils and groundwater data for the same location.

Two new wells are proposed. These wells are located some distance from the site of reported sludge disposal to assess the extent of any contamination in the groundwater. In addition to the new wells, existing wells 13GW08, 09 and 10 will be utilized as continuing monitoring points.

Investigative Elements Common to the Three Areas

Soil borings will be advanced using hollow stemmed augers and will be continuously sampled for stratigraphic information. This includes both soil borings made for soil sampling and those for monitoring well installation. All borings will extend to confirmed groundwater occurrence with those for monitoring wells extending a minimum of 15 feet into the water table or to bedrock. Every third soil sample, starting with the one from 4 to 6 feet, will be sent to the



REMARKS
● PROPOSED SOIL BORING LOCATION
⊕ PROPOSED MONITORING WELL LOCATION
◐ EXISTING MONITORING WELL LOCATION

DATE	4-29-94
SCALE	1" = 50'
DRAWN	
REVIEWED	
S.O.#	62470-223
CADD#	09E-50

NORTH

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FIGURE 6-4B
PROPOSED SAMPLING LOCATIONS
RFI SWMU 9 AREA C

SCALE 1" = 50'
DATE 4-29-94

FIGURE NO.
6-4B

(04/29/94 18:42:06) (PRF: S:\PAPER\09E-50.PRF)
K:\SRN\19223\09E-50.DWG

laboratory for analysis. The interval producing a sample from immediately above the water table will also be sent if it does not coincide with a scheduled sample. All soil samples will be collected using split-spoon sampling methods.

Groundwater monitoring wells will be screened across the top of the water surface to allow for sampling of the uppermost groundwater. All wells, including both the existing an new wells, will be developed and slug tested. Following a period of time to allow the wells to reach equilibrium with the groundwater level, a single sampling event will be undertaken.

All samples will be analyzed for the following:

- Volatile organics
- Semivolatile organics
- RCRA metals (both total and dissolved for water)
- Total Petroleum Hydrocarbons

Analytical methods will be those contained within the most recent edition of SW-846. All data packages will comply with NEESA Level D as it applies to SW-846 methods. Third party data validation will be performed on all sampling results.

6.5.2 Corrective Measures Data

Of the considerations listed for groundwater in Section 6.2.2 and for soil in Section 6.5.2, the following would be most essential under a containment corrective measures scenario:

- Soil
  - Type of contamination
  - Amount of contamination
  - Depth to groundwater

- Groundwater
  - Type of contamination
  - Depth of groundwater contamination
  - Depth to groundwater
  - Plume definition

This information should be available after execution of the sampling program discussed in Section 6.6.1.

If contamination is encountered in the soil, the following information will be needed to be developed for surface water and sediments in order to evaluate corrective measures:

- Surface Water
  - Surface water quality
  - Type of contamination
  - Site hydrology
  - Climatological data
  - Sediment quality

- Sediment
  - Sediment quality
  - In situ water quality (i.e., pore water)
  - Grain size
  - Redox potential
  - Organic content
  - Acidity

The necessity of additional data for surface water and sediment can be evaluated based on the results of the soil and groundwater sampling program.

6.6 SWMU 11 - Old Power Plant, Building 38 (IR Site 16)

6.6.1 RFI Elements Discussion

There are actually five separate areas and/or environmental media discussed in the permit regarding this site. These are:

- The building interior
- The cooling tunnels
- The groundwater under the site
- The surface water/sediments at the intake and outfall of the cooling tunnels
- The soils surrounding the 50,000 gallon tanks

The proposed approach for each of these is discussed in the following paragraphs.

The Building Interior

Evidence of spills is present within the building. PCBs have been stored and/or managed within this location and, in fact, have been released. This condition warrants an RFI of the building interior.

The Cooling Tunnels

Extensive investigative work has been performed on the cooling tunnels with the results indicating a potential problem with contamination of the tunnel sediments. Based on this, further investigations of this feature appear warranted.

Groundwater

The need for groundwater investigations should be made contingent on the findings of the ongoing PCB contaminated soil remediation.

Cleanup of the presently PCB-contaminated soil in the vicinity of Building 38 will proceed until the levels in the approved workplace are reached. It is expected, based on the levels seen in the soils and the relative immobility of PCBs in soil, that the cleanup goals will be reached at a soil depth above the water table. Since the cleanup goals are based on, among other considerations, the leachability of PCBs, if cleanup goals are met prior to encountering groundwater then a groundwater monitoring program is not necessary. Should PCB contamination be found to extend to the uppermost groundwater, the Navy would agree that groundwater monitoring would be appropriate.

The presence of PCBs in the cooling tunnels also does not warrant groundwater investigations. There is no expectation that the integrity of the concrete structures comprising the cooling tunnels has been comprised. Therefore, no leakage of potentially contaminated sediment or water should have occurred. Should the results of the sampling program indicate a problem with the tunnel's integrity, the need for groundwater investigations can be revisited.

Surface Water/Sediments

Given the documented presence of PCBs in the cooling tunnels, a limited sediment sampling activity would be prudent. This will be undertaken at the intake (if located) in Ensenada Honda.

Previous investigations have provided sediment sampling results for the outfall (see Section 4.0) that indicate there is no significant risk posed by the sediments.

The surface waters in question are those of Puerca Bay and Ensenada Honda which are both arms of oceanic waters. As such, they are subject to daily fluxing through tidal action. This, coupled with current flow, means the surface waters are constantly changing and being diluted. Since there is no active discharge from the cooling tunnels, there is little likelihood that surface waters will provide any indication of contamination. Therefore, the Navy sees no strong technical basis for including surface water investigations in the RFI.

Soils Associated with Underground Storage Tanks

The 50,000 gallon tanks at the site have not been the site of documented, routine, systematic or deliberate releases nor have the tanks been used to store or otherwise manage wastes. The tanks have not been investigated to date, and will be included in the RFI.

6.6.2 RFI Scope of Work

There are three areas, which are separate, requiring RFIs. Each of these is discussed below.

6.6.2.1 Building 38 Interior

The contaminant of concern for the Building 38 interior is PCBs. In consideration of this, wipe sampling of the building's floor and bottom portion of the wall is proposed. This will only be done in the front (northeastern) portion of the building since no waste management activities have taken place in the rear portion.

A 20-foot grid will be established across the floor of the building. At each intersecting grid point a wipe sample for PCB will be obtained. In addition, at the point where the grid line

encounters a wall, a wipe sample of the wall will be obtained from a point approximately two feet off the floor. It is expected that this program will result in approximately 80 samples.

6.6.2.2 Cooling Tunnels

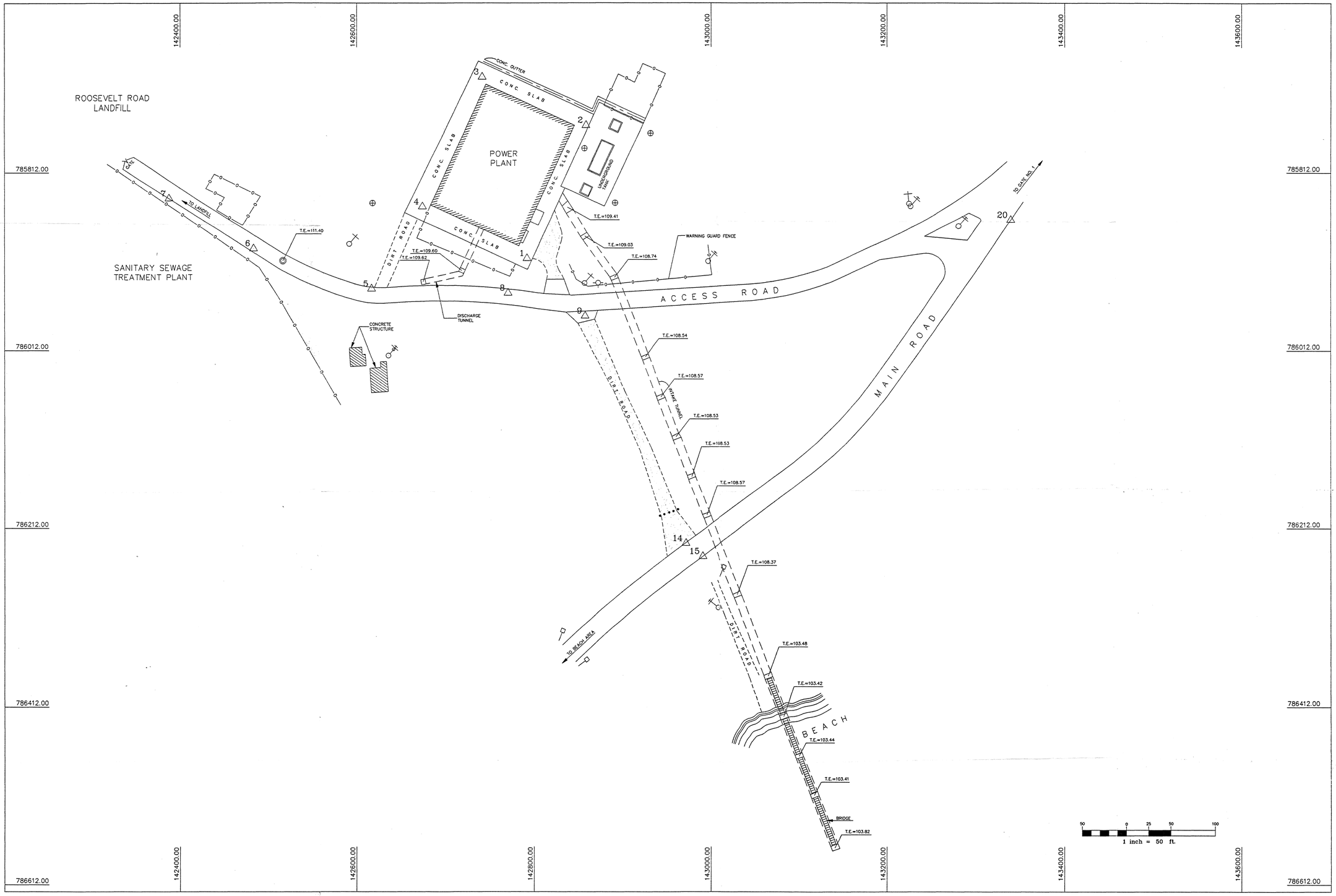
There are two portions to the cooling tunnel system; the intake tunnel from Puerea Bay; and, the outfall tunnel to Ensenada Honda (Figure 6-5). [Note: This is the usual understanding of the system; however, some drawings show the intake and outfall reverse from this.] Each requires a separate discussion since both will require different levels of effort.

The intake (east) tunnel has been the subject of numerous investigations the most recent which included sediment sampling at some access points and in Purea Bay somewhat away from the intake structure. Since that time, additional access points have been located.

It is proposed that all the access points not sampled during the Supplemental Site investigation be included in the RFI. Information from these points will provide good baseline set of data and allow profiling of any contamination found along the full length of the tunnel.

The outfall (west) tunnel presents a much greater problem in that, beyond one access way approximately 100 feet from the old powerhouse, the tunnel cannot be located. This remains true despite significant efforts made during the SSI and recent attempts using sophisticated geophysical techniques (the report of which will be appended to the RFI workplan). A review of the station's records indicate that there is no record of the tunnel being completed and, in fact, the outfall tunnel fails to appear on some base drawings.

Considering the efforts expended to date, there appears to be only one technique available to trace the tunnel - direct observation through test pitting or traveling. It is proposed to follow the tunnel using a backhoe. This type of direct method will positively prove the tunnel was never completed, has been destroyed through subsequent construction activities or will provide a route that the tunnel follows. Trenching or pitting along the tunnels route will continue until either the tunnel ends or trenching becomes impossible due to the depth. During the course of this examination, the sediment in all access ways to the tunnel will be sampled. Should the terminus of the tunnel in Ensenada Honda be located, sediment sample will be obtained near the outfall itself.



LEGEND			
⊕ PROPOSED MONITORING WELL LOCATION	DATE	4-29-94	NORTH
T.E.=108.54 ACCESS TO TUNNEL LOCATION (WITH ELEVATION)	SCALE	1" = 50'	
	DRAWN		
	REVIEWED		
	S.O.#	62470-223	
	CADD#	011-50	

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FIGURE 6-5
PROPOSED SAMPLING LOCATIONS
RFI SWMUS 11 AND 45

SCALE 1" = 50'
DATE 4-29-94

FIGURE NO.
6-5

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6.6.2.3 Underground Storge Tanks

Analyses for all sediments sampled will include:

- Volatile organics
- Semivolatile organics
- Pesticides/PCBs
- RCRA metals

Analytical methods will be those contained within the most recent edition of SW-846. All data packages will conform to NEESA Level D protocols as they can be applied to SW-846 methods. Sampling results will be subjected to third party data validation.

One soil boring will be advanced and each side of each underground storage tank. These will be advanced to below the bottom of the tanks. Soil samples will be collected and analyzed for:

- Volatile organics
- Semivolatile organics
- Pesticides/PCBs
- TPH

Analytical methods will be those contained within the most recent edition of SW-846. All data packages will conform to NEESA Level D protocols as they can be applied to SW-846 methods. Sampling results will be subjected to third party data validation.

6.6.3 Corrective Measures Data

As discussed in Sections 6.7.1 and 6.7.2, no further characterization of soil, groundwater, and surface water is warranted for this SWMU.

For the interior of Building 38, the following information needs to be gathered in order to evaluate the corrective measures technologies: contaminant locations; contaminant distribution; visibly contaminated areas; and the physical integrity of the building. The location and distribution of the contamination will be determined through the sampling scheme described in Section 6.7.2.1. The locations of physically contaminated areas and the

physical condition of the building will be ascertained through the field observations of the field samples.

For the cooling tunnels, the existence and location of the outfall (west) tunnel must be established so that costs associated with the applicable corrective measures technologies can be accurately evaluated. The physical integrity of the tunnels also must be determined sot that the appropriate technology is selected. For the sediment contained within the tunnels, its volume and related contaminant concentrations must be determined for the evaluation of corrective measures.

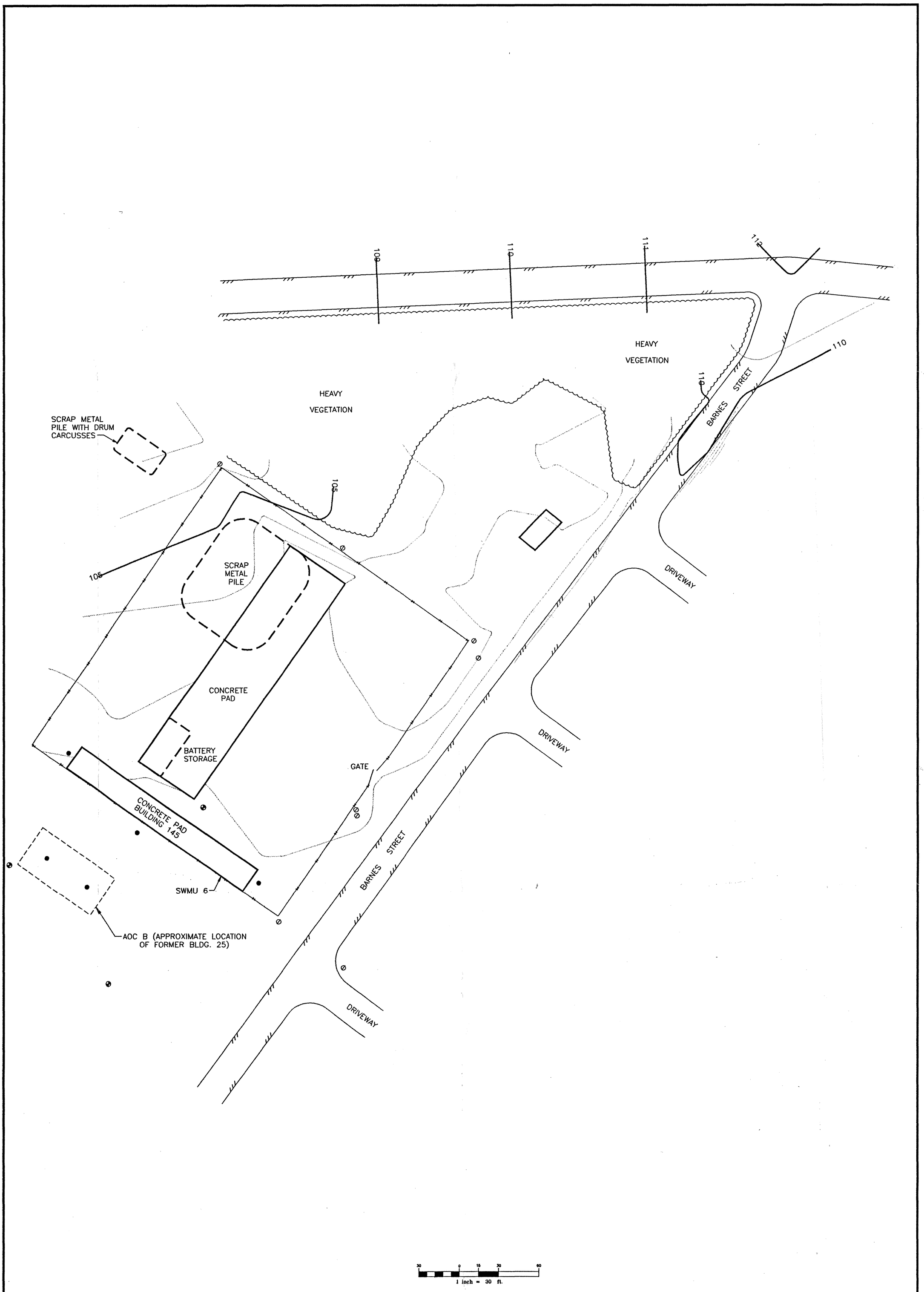
For sediment a number of specific factors used to evaluate corrective measures technologies are listed in Section 6.6.2. For the sediments in Puerca Bay and Ensenda Honda, the most probable contaminants of concern are PCBs. In general, PCBs are highly insoluble in water, and have a great affinity for organic matter such that is found in soil and sediment. As such, in addition to determining the location and concentration of PCBs in thee sediments, the sediment sample should be analyzed for total organic carbon content prior to election of a final corrective measure.

6.7 Area of Concern B - Former Site of Building 25

6.7.1 RFI Scope of Work

A series of surface soil samples were taken in this area during the SSI. While these provide some insight to conditions, no sampling was performed at depth or in the area under the former building. There are no nearby groundwater monitoring wells although, since this area has historically been included in IR Site 10 and groundwater associated with that groundwater management unit has been found to contain evidence of contamination, there is the possibility that AOC"B" may be effecting groundwater. For these reasons, an RFI consisting of soil sampling and groundwater monitoring is proposed.

Two soil borings (Figure 6-6) will be placed through the former building pad using hollow stem augers. The holes will be advanced to the top of groundwater. Continuous sampling will be performed using split-spoon sampling techniques to provide information on subsurface stratigraphy. Samples for laboratory analysis will be collected from the first sample (immediately below the bricks) and every other sample after that. The sample from immediately above the water table will also be submitted.



LEGEND						
● PROPOSED SOIL BORING LOCATION ● PROPOSED MONITORING WELL LOCATION	DATE 4-29-94 SCALE 1" = 30' DRAWN REVIEWED B.O.# 82470-223 CADD# C25-30	NORTH		NAVAL STATION ROOSEVELT ROADS PUERTO RICO BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	FIGURE 6-6 PROPOSED SAMPLING LOCATIONS RFI - AOC B AND SWMU 6 SCALE 1" = 30' DATE 4-29-94	FIGURE NO. 6-6

It should be noted that additional soil sampling information is available from the SSI and will be available from soil sampling efforts undertaken in conjunction with the RFI efforts at the adjacent Building 145. Taken together, and in combination with sampling for monitoring well installation, a coherent picture of subsurface conditions will emerge.

Three monitoring wells will be installed as a part of the RFI. The locations of these wells (shown on Figure 6-6) have been selected to provide representative chemical characterization of the groundwater and to allow a flow direction and possibly a hydraulic gradient to be assessed. Soil samples for laboratory analysis will be collected from 0-2 feet, 4-6 feet at the top of groundwater. In addition, one sample per hole will be selected that represents the "most contaminated" based on visual air monitoring instrument observations.

All wells will be screened across the water table to allow sampling of the uppermost occurring groundwater. Each well will be developed and subjected to slug testing to assess local horizontal hydraulic conductivity. After allowing some period of time for the well level to equilibrate with the ambient groundwater, the three wells will be sampled once.

The following analyses will be performed on all samples (both soil and groundwater):

- Volatile organics
- Semivolatile organics
- Pesticides/PCBs
- RCRA metals (both dissolved and total for water)
- Arsenic

Analytical methods will be those contained in the most recent edition of SW-846. Data packages will conform to NEESA Level D requirements as they are appropriate to SW-846 methods. All sampling data will be subjected to third party data validation.

6.7.2 Corrective Measures Data

Because of the general absence of information regarding soil and groundwater conditions at the site, the following information must be collected prior to final selection of a corrective measure for AOC B:

- Soil
  - Type of contamination
  - Amount of contamination
  - Cation exchange capacity
  - Grain size
  - Depth to groundwater
  - Organic matter

- Groundwater
  - Groundwater quality
  - Types of contaminants
  - Depth to groundwater contamination
  - Groundwater flow direction
  - Depth to groundwater table
  - Plume definition

The sampling program described in 6.8.1 will provide some data regarding contaminant concentration and distribution in soil and groundwater. The need for additional information will be determined after this data has been evaluated.

6.8 First Phase RFIs

6.8.1 Introduction

This section addresses those SWMUs requiring a First Phase RFI. Investigations, for the appropriate media of concern, have been designed to identify whether there are contaminants present at the individual sites. If contaminants are detected above risk-based action levels, the site will be further investigated and/or remediated. Should no contamination be detected (or if it is but is present below action levels and presents no risks), the RFI requirements for the site will be fulfilled and the site will be removed from further consideration.

One additional subset of sites may exist. A number of the sites are suspect because of evidence, or supposition based on site use, that minor releases to soil may have occurred. Should sites like this be discovered to have some contamination, the Navy may, at its discretion and with the approval of the USEPA, choose to forego further investigation at the site and move directly to remediation. An example of a site like this would be a storage pad

with minor surficial spills. It may be the best course of action to move directly to soil excavation in the spill area and, when clean-up is confirmed, remove the site from the permit.

6.8.2 SWMU 6 - Building 145

Building 145 is a partially underground concrete structure formerly used for the storage of surplus and discarded paints. It is presently empty although there is standing water in the lowest portion of the interior. Based on the former use of the facility, a first phase RFI has been mandated.

Figure 6-6 shows the planned RFI approach for this SWMU. Three soil borings will be made to the top of groundwater. One boring will be placed at both ends (access points) and the third will be located southwest of the structure at a point coinciding with the lowest elevation of the building. It should be noted that investigations scheduled for the Building 25 site include a boring to the northeast of this unit. This will serve to provide data for Building 145 as well.

Up to three samples per boring will be submitted to the laboratory for analysis. The samples will be selected as follows:

- The initial sample below the root zone (approximately 0.5 to 2.0 feet);
- The sample from immediately above the water table; and
- The sample from within the soil that shows the most significant evidence of contamination (if any) based on visual, and factory or instrumental information.

Sampling will be conducted continuously using split-spoon sampling methods to obtain stratigraphic information. All borings will be backfilled with drill cuttings mixed with powdered bentonite.

In addition to the soil sampling, a single sample of the standing water within the structure will be obtained. This will provide information to characterize the interior as the water enters by precipitation for condensation and flows along the floor to its point of collection.

Laboratory analyses to be performed on all the samples will be:

- Volatile organics
- Semi-volatile organics
- RCRA metals

All analyses will be done in accordance with SW-846 methodology and will follow the QH/QC procedures for deliverables detailed earlier. All data will be third party validated.

6.8.3 SWMU 12 - Fire Training Pit Oil/Water Separator

Early inspections of this unit provided evidence of spills based on stains and dead/stressed vegetation. Most recently, no evidence of release was visible. Based on the early findings, a first phase RFI is required.

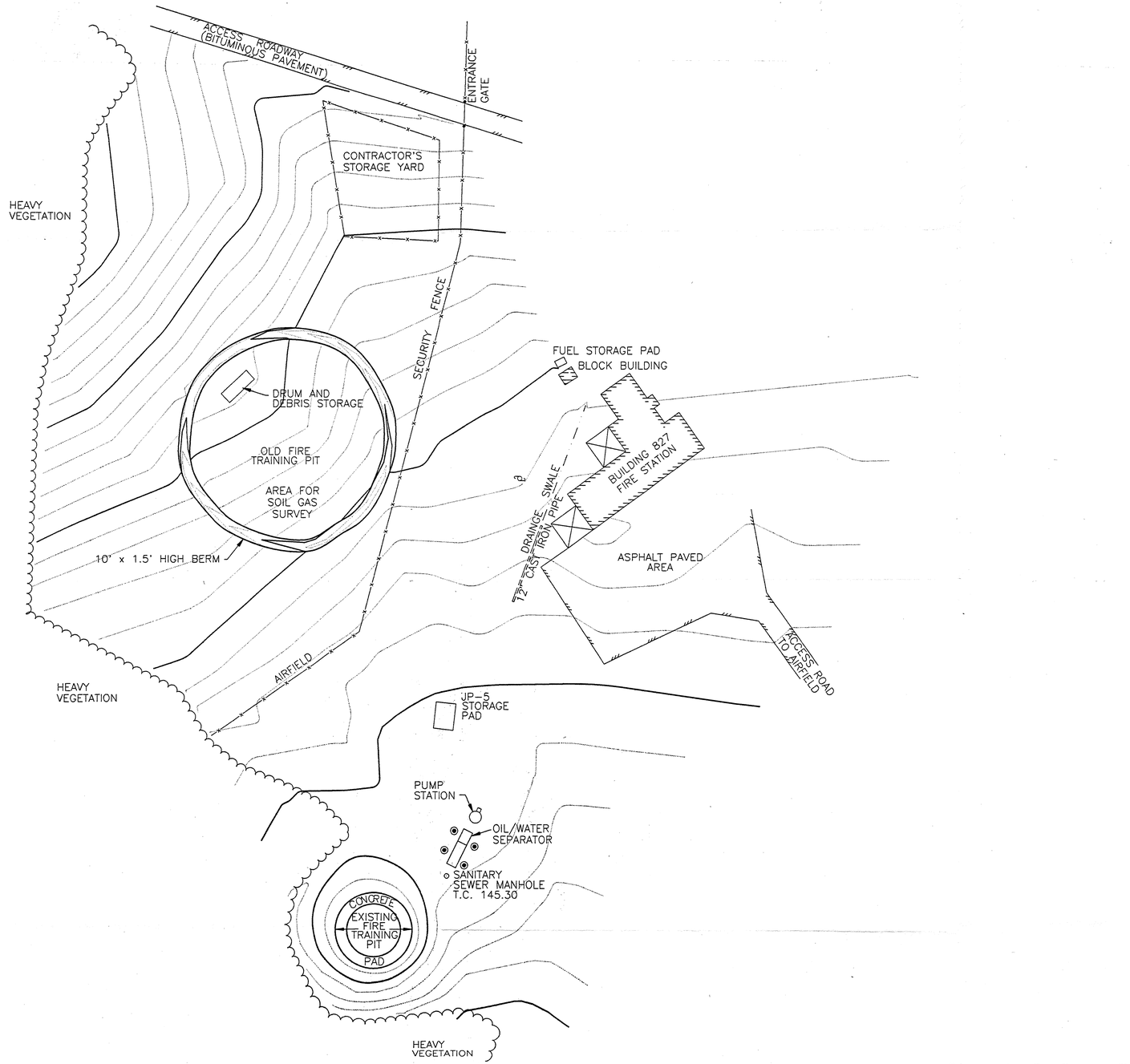
Four soil sampling locations are shown on Figure 6-7. Hand sampling of the zone directly below the root zone will be performed. Laboratory analysis will be limited to volatile and semi-volatile organics, PCBs, and oil and grease due to the nature of the possible releases. All analyses will be performed in accordance with SW-846 methods, will require QA/QC data packages that comply with CLP Level D and will be subjected to third party data validation.

6.8.4 SWMU 14 - Former Fire Training Pit Area

Prior to the installation of the new Fire Training Pit in 1983, two adjacent areas were used for fire training. Only possible evidence of one site now exists in the area shown on Figure 6-8. The area has most recently been apparently used as a contractor material laydown area.

The initial step in the first phase RFI will be to conduct a limited qualitative soil gas survey using slam-bar techniques and PID/FID measurements. In this type program, a hole is made by driving a bar into the ground one to one and one half feet. The bar is removed and the resulting hole is covered. After some period of time to allow soil gas to enter the hole, the cover will be removed and the air monitoring probe inserted for a total volatile organic measurement. A twenty foot grid will be established by tape in the general area shown on Figure 6-7. The area will extend at least one grid node beyond the limits of any evidence of fire training pit area. Measurements will be taken, recorded, and analyzed in the field.

Based on the results of the soil gas work, soil sampling locations will be selected with the intent of sampling areas showing the greatest evidence of contamination. A minimum of five



LEGEND

⊙ PROPOSED SOIL SAMPLING LOCATION

DATE	4-29-94
SCALE	1" = 50'
DRAWN	
REVIEWED	
S.O.#	62470-223
CADD#	012-50

NORTH

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

FIGURE 6-7
PROPOSED SAMPLING LOCATIONS
RFI SWMUS 12 AND 14

SCALE 1" = 50'

DATE 4-29-94

FIGURE NO.
6-7

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samples will be collected with one of them taken from the center of the suspect area regardless of soil gas results. More samples, as appropriate in the light of soil gas results, may be taken. All samples will be taken from holes/pits excavated by hand. Samples will be collected from the zone 0.5-1.0 feet.

At the most effected site, or at the center of the area site, a boring will be made extending to the top of groundwater, up to two samples will be obtained with one from the zone immediately above the water table and one from the most contaminated zone (if one is obvious).

Analytics to be performed will be:

- Volatile organics;
- Semi-volatile organics;
- PCBs; and
- Oil and grease.

All analyses will be conducted in accordance with SW-846 methods with data packages provided similar to those required for CLP Level D. Data will be subjected to third party data validation.

6.8.5 SWMU 13 - Pest Control Shop Area (Building 258)

This includes the new demolished Pest Control Shop and surrounding area (including drainage features). Sampling performed prior to 1992 indicated pesticides exceeding proposed subparts Action Levels were present in the drainage ditch. On this basis, provisions for a first phase RFI were included in the draft permit.

Investigations conducted in 1992 as a part of the SSI (Appendix A) included sampling efforts which adequately characterized the media prescribed for sampling in the permit (as shown on Figure 6-8). The results of this sampling effort, detailed in Section 4.0, showed there was no significant risk posed to human health or the environment associated with this site.

6.8.6 SWMU 23 - Oil Water Separator Tanks (Fuel Pier)

SWMU 23 consists of three rectangular steel oil/water separator tanks surrounded on three sides by a curbed concrete pad. A curb separates the eastern portion of the tanks from the

grassed area. Visual inspections of the area have indicated that some spills have occurred on the concrete pad and possibly on the grassy area along one side of the unit.

The concrete pad was seen to be in good condition, with no cracking or breakage visible, albeit stained. Since it is the purpose to manage oily materials, staining in the working area is not surprising nor does it constitute a release since it is contained. Based on this, no sampling of the concrete is proposed.

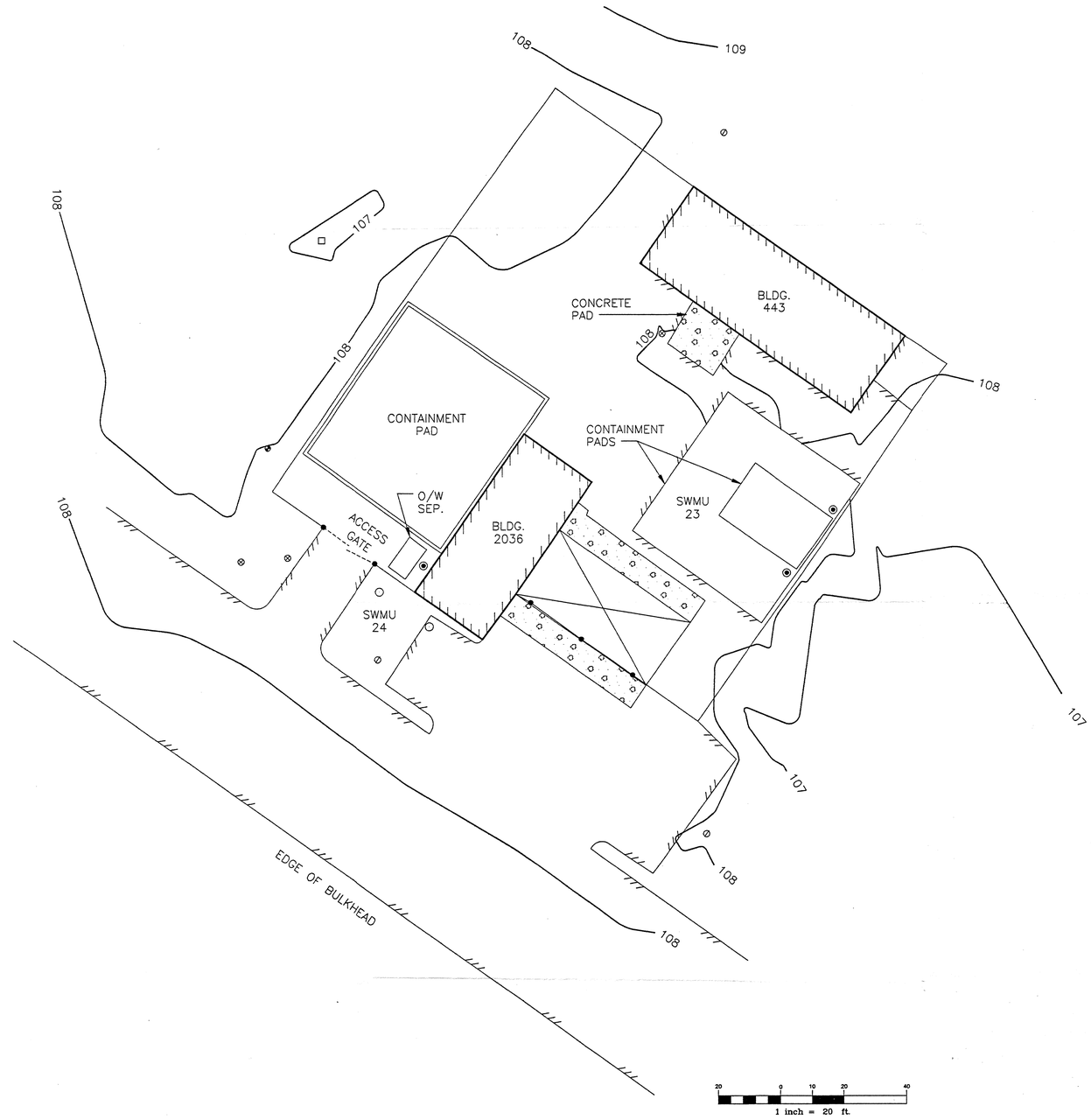
Although no evidence now exists regarding releases to the soil, previous inspections have apparently indicated releases were occurring or had occurred. To assess the impact of these releases (if any) a limited soils investigation is proposed. This will be comprised of two sampling locations as shown on Figure 6-9. The locations for these samples will be field selected based on either a regular spacing of on visual evidence of release. Samples will be taken from hand excavated pits generally from 0-6 inches in depth. If visual evidence exists, a surficial sample will be collected.

The two soil samples will be submitted to the laboratory and analyzed for volatile organics, semi-volatile organics and Total Petroleum Hydrocarbons (TPH) as these are the potential containments of concern related to the management of oily wastes not associated with electrical use. Analyses will be done in accordance with SW-846 methods with the data package complying with CLP Level D deliverables as appropriate. The data packages will be subjected to third party data validation.

6.8.7 SWMU 24 - Oil Water Separator (Fuel Pier)

This oil/water separator relate to oil spill clean-up activities is located immediately adjacent to Building 2036. Staining on the asphalt around this unit on three sides indicates the potential for release to the soils which abut the unit on the remaining side (although no visual evidence was seen during the most recent inspection). To address the possibility of release, a single soil sample will be obtained from the soil area in approximately the location shown on Figure 6-9. No samples are planned for the asphalt covered areas as possible releases are contained on the asphalt which is maintained and separating spilled oily material from asphalt constituents is different at best.

The single sample will be collected and analyzed following the same criteria and protocols as those defined for SWMU 23.



LEGEND

◉ PROPOSED SOIL SAMPLING LOCATION

DATE	4-29-94
SCALE	1" = 20'
DRAWN	
REVIEWED	
S.O.#	62470-223
CADD#	023-50

NORTH

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

BAKER ENVIRONMENTAL,Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

FIGURE 6-9
PROPOSED SAMPLING LOCATIONS
RFI SWMUS 23 AND 24

SCALE 1" = 20'

DATE 4-29-94

FIGURE NO.
6-9

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6.8.8 SWMU 25 - DRMO Storage Yard

The area identified in the 1988 RFA could not be located during the 1993 inspection. According to the recollections of site personnel and the general layout of the site, the area in question is now likely occupied by Building 2009 (see Figure 6-10) which replaced the open storage area for flammable materials. Based on this information and the lack of any evidence of release noted during the 1993 inspection, a limited soil sampling program is proposed.

Four sampling locations are proposed that will yield one sample each. The approximate locations for sampling are shown on Figure 6-10; however, the actual locations will be field selected based on site conditions. It is intended that one sample from each side be obtained where storage could have occurred; i.e., somewhat away from the fence. The remaining two samples will be obtained from along the fence line at the maximum extent of the pad (one on either side of Building 2009) to assess whether contaminants may have exited the site to the drainage ditch behind the fence.

Each sample will be collected from a hand dug pit and will be comprised of soil/fill from 0-6 inches. Areas of obvious staining, if present, will be sought as sampling sites. The four samples will be subjected to analysis for:

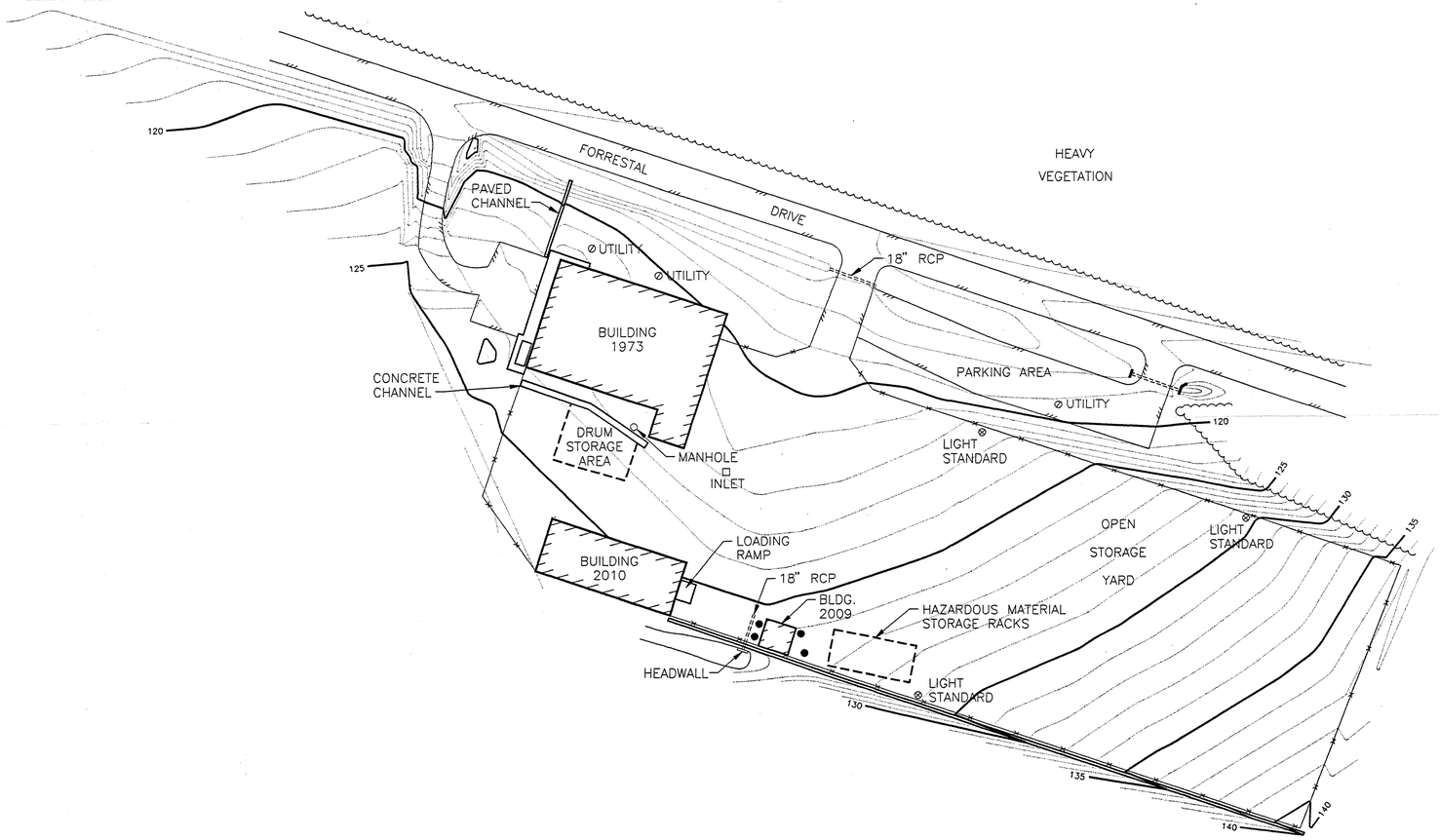
- Volatile organics
- Semi-volatile organics
- TPH

This analytical suite has been selected based on the apparent nature of the materials formerly stored in the area.

All samples will be analyzed using SW-846 methods with data packages complying with CLP Level D deliverables as appropriate. The resulting data will be subjected to third party validation.

6.8.9 SWMU 26 - Storage Area Behind Building 544

Building 544 was demolished sometime after the 1988 RFA and the base personnel accompanying the 1993 inspection team were unsure of its former location and, therefore, it is



50 0 25 50 100

1 inch = 50 ft.

LEGEND
● PROPOSED SOIL SAMPLING LOCATION

DATE	4-29-94
SCALE	1" = 50'
DRAWN	
REVIEWED	
S.O.#	62470-223
CADD#	025-50

NORTH

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

BAKER ENVIRONMENTAL,Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

FIGURE 6-10
PROPOSED SAMPLING LOCATIONS
FIRST PHASE RFI
SWMU 25

SCALE 1" = 50' DATE 4-29-94

FIGURE NO.
6-10

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thought that the wrong site was inspected. While this is the case, it does not negate the findings of the initial RFA regarding the drains seen behind the building. Based on this information, a three task approach has been developed for the RFI at this site.

The first task will be to accurately locate the site where Building 544 was formerly located. This will be accomplished through the use of existing Station mapping and contact with long term Station employees. Once the building location is established, the area behind the building will be examined to visually assess the size of the site requiring investigation. As necessary based on the level of vegetative overgrowth, the site will be cleared.

The second task will be to establish an appropriate sized grid across the site for the conduct of soil gas surveys. Presently, a twenty foot grid is envisioned; however, field conditions relating to the size of the site will dictate actual grid dimensions. At each grid node, a slam-bar soil gas survey will be performed using the methodology described earlier. The data resulting from the soil gas survey will be plotted and reviewed in the field and will serve as the basis for determining soil sampling quantities and locations.

Soil samples will be taken in sufficient numbers to adequately assess whether contamination is present at the site during task 3. The sampling strategy to be employed will generally follow that contained in SW-846 referred to as "Simple Random Sampling." Use of this strategy will ensure an adequate number of samples required by the strategy, a maximum of three additional samples will be collected from possible "hot spots" identified during the soil gas investigation.

All samples will be collected from soils between 0 and 6 inches in depth and taken from hand excavated pits. Samples from the Building 544 area will be subjected to the following laboratory analyses:

- Volatile organics
- Semi-volatile organics
- Pesticide/PCBs
- TPH

Based on the drummed (i.e., liquid) nature of the materials containing the potential contaminants, this suite of analytics is considered sufficient.

All analyses will be conducted in accordance with SW-846 methods with data packages complying to CLP Level D as appropriate. Sampling results will be subjected to validation by a third party.

6.8.10 SWMU 31 - Waste Oil Collection Area

This SWMU is composed of two separate areas. The first area is the waste Oil Collection Area associated with Building 2022. The second area is "...storing containers of unidentified wastes outside the building [31} and spills of these wastes onto the soil." as found during the IAS and quoted from the permit. It is presently unknown where the second area is located; it may well be the same area as that near 2022. In order to provide for an adequate level of effort for the RFI, the second area, for the time being, is assumed to be immediately adjacent to Building 31 as shown on Figure 6-11.

A soils and groundwater investigation program is proposed for the area adjacent to Building 2022. Five soil borings are proposed in the general configuration shown on Figure 6-11. Five soil borings are proposed in the general configuration shown on Figure 6-11. The four locations designated as soil borings will be advanced through the asphalt to a depth of three feet or until visible contamination is absent. These borings will be terminated at the groundwater surface should contamination be seen throughout the soil column. Samples will be taken based on the following:

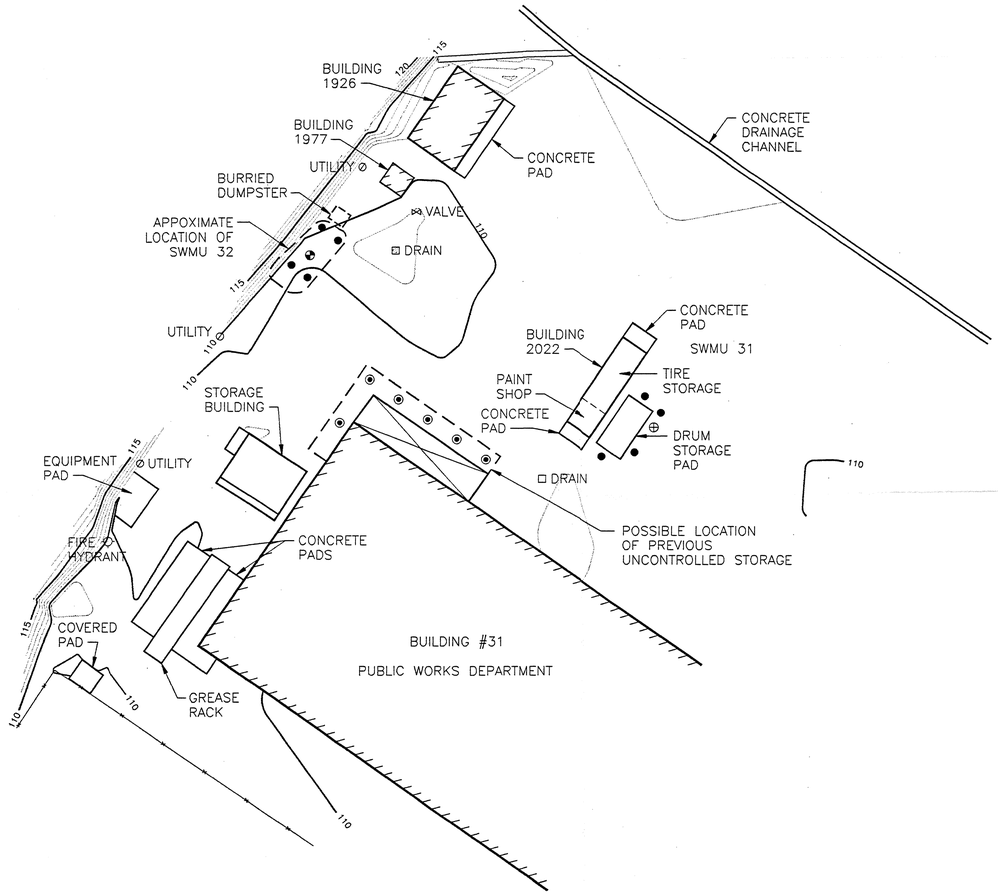
- An initial sample from each hole will be obtained from the six inch zone immediately below the subbase of the asphalt (likely to be the 0.5-1 foot zone)

- The second sample will be obtained from the zone between 2-3 feet

- For those borings extending beyond 3 feet, samples will be obtained of visibly contaminated material from the 5-7, 9-11, 13-15, etc. zones as appropriate

- If contamination is found to extend to groundwater, the sample from immediately above the water table will be collected

The boring designated for the installation of a monitoring well (Figure 6-11) will extend a minimum of 10 feet into the water table (or to bedrock). Sampling will be conducted



50 0 25 50 100
1 inch = 50 ft.

LEGEND

- ● PROPOSED SOIL BORING LOCATION
- ◉ POTENTIAL SOIL SAMPLING LOCATION
- ◐ PROPOSED MONITORING WELL LOCATION

DATE	4-29-94
SCALE	1" = 50'
DRAWN	
REVIEWED	
S.O.#	62470-223
CADD#	031-50

NORTH

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

BAKER ENVIRONMENTAL,Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

FIGURE 6-11
PROPOSED SAMPLING LOCATIONS
RFI SWMUS 31 AND 32

SCALE 1" = 50' DATE 4-29-94

FIGURE NO.
6-11

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continuously to assess stratigraphy with samples for laboratory analysis taken in accordance with the criteria listed above.

All borings (with the exception of the monitoring well boring) will be backfilled with a sand/bentonite mix to avoid the return of potentially contaminated soils to the hole and extend contamination to "depth below that which is now present. An asphalt patch will be placed at the surface to restore the working surface and to minimize the potential for surface water entry.

The monitoring well will be installed with the screened interval straddling the water table to ensure that the uppermost occurring water can be sampled. Following development, the well will be subjected to slug testing to assess local horizontal hydraulic conductivity.

Soil samples will be analyzed for the following:

- Volatile organics
- Semi-volatile organics
- PCBs
- Arsenic
- Chromium
- Lead
- Selenium
- TPH (for remedial option information)

Groundwater will be sampled once from the newly installed well and those existing IR Site 10 wells near the Building 31 area. Analyses of groundwater will include all those parameters listed for soils with the addition of oil and grease which is needed to assess the applicability of certain remedial alternatives.

All analyses will be conducted using SW-846 methods with data packages complying with CLP Level D requirements as appropriate. Sampling results received from the laboratory will be subjected to data validation by a third party.

The location of the other area associated with Building 31, which was identified in the RFA, is presently unknown. Initial efforts will be made to locate the area using old reports, drawings and long-term employee recollections. If the area is found and reasonably delineated, a soil

sampling program will be undertaken utilizing soil borings. The techniques and sampling strategy employed will parallel those used at Building 2022 with the exception that no monitoring well is necessary.

6.8.11 SWMU 32 - Battery Collection Area (Building 31)

The battery collection area location is only generally known; since, after the RFA was performed, battery management procedures and area were changed. The drums which were noted during the 1993 inspection were only stored in the area temporarily; however, the area is identifiable and roughly corresponds to that at the battery collection area and will be investigated. The general area, encompassing both, is shown on Figure 6-11.

A total of up to five soil borings will be made in the area with one hole to be used for the installation of a monitoring well. To establish the locations for borings, a slam-bar soil gas survey will be conducted using an appropriately dimensional gird. Based on the findings, soil boring locations will be selected with the areas indicating contamination given priority as sampling sites. The pattern shown on Figure 6-11 is only an example; the actual boring array may be quite different. While this is the case, it is intended that the monitoring well will be installed approximately in the center of the area to ensure that water underneath the unit is being sampled.

The borings will be advanced and samples using the same criteria as that employed at SWMU 31. In like manner, the monitoring well will be installed and sampled as indicated for SWMU 31.

All analytical suites and methods will also parallel those employed at SWMU 31. This congruence of approach is deliberate. The SWMUs in question are close and similar sub-surface conditions are expected to prevail. Also, given the closeness of the sites and their all being included in IR Site 10, the groundwater results will have to be interpreted together to be properly understood.

6.8.12 SWMU 37 - Waste Oil Storage Area - Building 200

The temporary waste storage area is bounded on the northeast and northwest sides by soil and by tarmac elsewhere. Staining inside the area is minor and the area is maintained indicating the lack of need for investigations within the unit. No visible staining or evidence of release

was present on the tarmac. In the light of these conditions, it appears that only the soil immediately adjacent to the two northern walls warrants a first phase RFI.

A slam-bar soil gas survey will be conducted along the walls (Figure 6-12). The first ring of measurement points will be within 6 inches of the wall on 30 inch centers. A second ring of soil gas points will be 10 feet from the wall at 5 foot centers. Should any significant levels of soil gas be encountered in the second ring, a third, and final will be established at 25 feet from the unit margin at 10 foot centers. Should a trend appear in the data that appears to indicate a soil plume, this feature will be tracked with soil-gas points as deemed appropriate in the field.

Soil, taken from hand dug pits, will be collected at or near the ground surface from the three sites exhibiting the highest concentrations. If no area is obvious, a single sample will be obtained from representative soils along each of the two walls. In addition, a single sample will be obtained from the area of stressed vegetation if that area remains detectable at the time of investigation.

Up to two samples each will be obtained from the second and third soil-gas rings. These samples will be taken from sites exhibiting the highest concentration of soil gases. No samples will be obtained unless a need is indicated by the soil gas results.

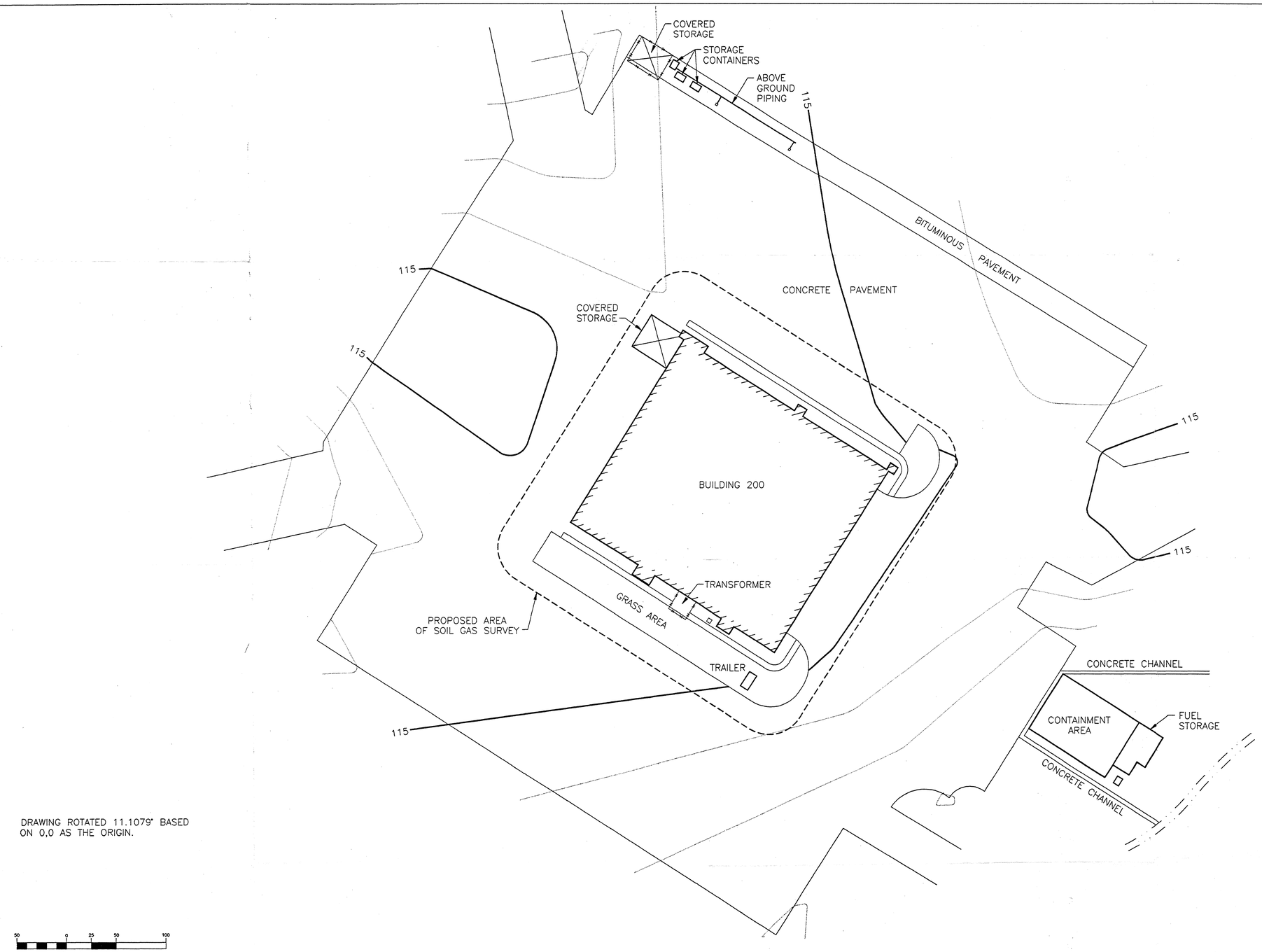
Analyses on these samples will be conducted for:

- Volatile organics
- Semi-volatile organics
- PCBs
- TPH (for remedial alternative selection purposes)

All analyses will be performed in accordance with SW-846 methods and data packages will comply with CLP Level D as appropriate. Data will be subjected to validation using a third party validator.

6.8.13 SWMU 39 - Former Battery Drain Area Building 3158

The actual SWMu at this site is the area on the right-hand side of the building that originally was an opensided concrete pad with a roof. This was the area observed during the RFA where



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50 0 25 50 100
1 inch = 50 ft.

LEGEND		NORTH		NAVAL STATION ROOSEVELT ROADS PUERTO RICO	Baker Baker Environmental, Inc.	FIGURE 6-12 PROPOSED SAMPLING LOCATIONS RFI SWMU 37	FIGURE NO. 6-12
	DATE 4-29-94 SCALE 1" = 50' DRAWN REVIEWED S.O.# 62470-223 CADD# 037-50			BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania		SCALE 1" = 50' DATE 4-29-94	

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batteries were cracked and the contents dumped or saved for recycling (plates). Presently, the area is grassed with the deteriorated pad having been removed.

A limited soil sampling program is proposed for this area comprised of three samples. Two samples will be taken from just below the root zone to approximately six inches within the area (Figure 6-13). Locations will be selected based on observation; or, if no evidence of vegetative stress is visible, random selection. In addition, a third sample will be taken from a nearby area that is similar in nature (i.e., grassed). This sample will serve as background for comparison to in unit samples.

The soil samples will be analyzed for RCRA metals since these represent the containments of concern at this site. There is no evidence that suggests any solvents, fuels or oils were ever used/managed in the area. Analyses will conform with SW-846 methods. Laboratory data packages will comply with CLP Level D requirements. All data will be subjected to third party data validation.

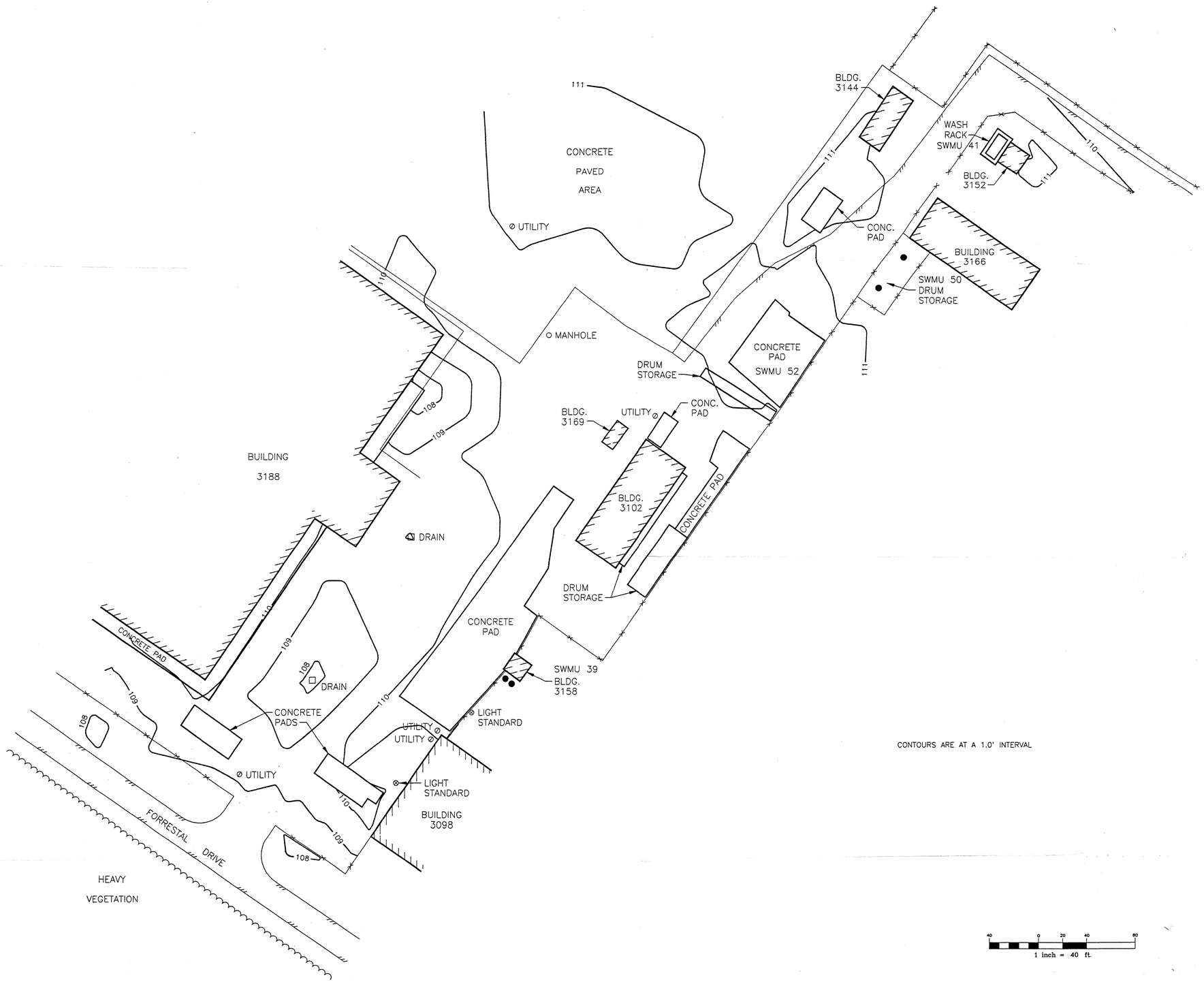
6.8.14 SWMU 46 - Pole Storage Yard - Covered Pad

This unit is presently being used for under 90 day accumulation of wastes related to maintenance activities at this station. Formerly the site was used for the storage of transformers and other electrical equipment. Based on these uses of the site, a limited surface soil investigation of the area immediately adjacent to the pad appears warranted.

A total of six soil sampling locations is proposed as shown in Figure 6-14. These are situated such that one at each end of the pad and two evenly spaced samples from each longer side will be obtained. Samples will be taken of soils immediately below the root zone within 18 inches of the concrete pad using hand dug excavations.

The soil samples will be analyzed, using SW-846 methods, for the following:

- Volatile organics
- Semi-volatiles
- PCBs
- TPH



LEGEND					
● PROPOSED SOIL SAMPLING LOCATION	DATE 4-29-94 SCALE 1" = 50' DRAWN REVIEWED S.O.# 62470-223 CADD# 039-50	NORTH	NAVAL STATION ROOSEVELT ROADS PUERTO RICO BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	FIGURE 6-13 PROPOSED SAMPLING LOCATIONS RFI SWMUS 39, 41, 50 AND 52 SCALE 1" = 50' DATE 4-29-94

FIGURE NO.
6-13

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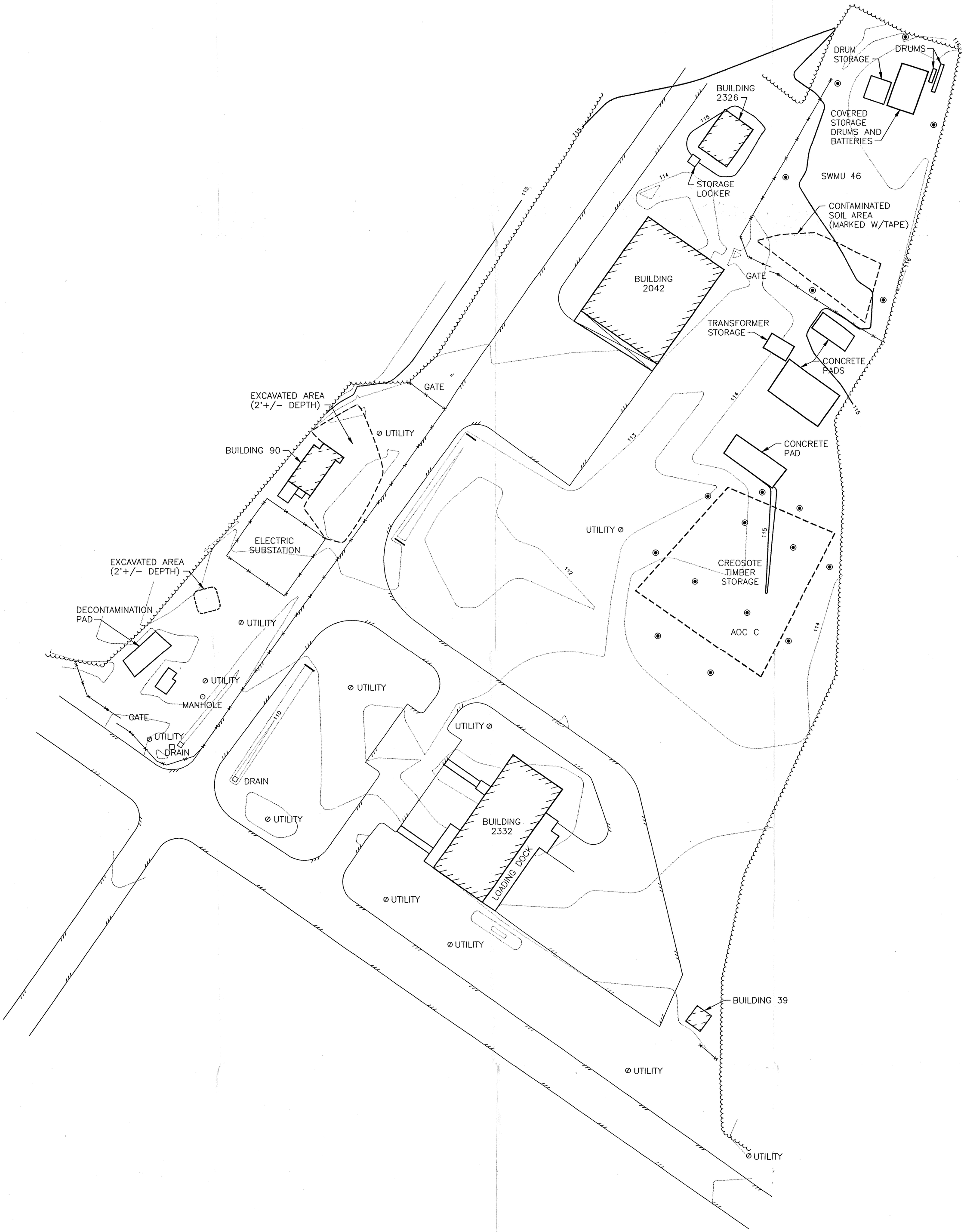


LEGEND						
◉ PROPOSED SOIL SAMPLING LOCATION	DATE 4-29-94 SCALE 1" = 40' DRAWN REVIEWED S.O.# 62470-223 CADD# 010-50	NORTH		NAVAL STATION ROOSEVELT ROADS PUERTO RICO BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	FIGURE 6-14 PROPOSED SAMPLING LOCATIONS RFI - SWMU 46 AND AOC C STATION LANDFILL SCALE 1" = 40' DATE 4-29-94	FIGURE NO. 6-14

Data packages will comply with CLP Level D requirements as appropriate. All data will be subjected to third party data validation.

Since PCB containing materials (e.g., transformers) were once stored at the site, a limited sampling program of the pad will be included in the first phase RFI. A total of four wipe samples for PCBs will be taken. Where appropriate, wipe samples will be obtained from stained areas. If stained areas are not present, four sampling areas will be selected at random to provide representative samples of the pad surface.

6.8.15 SWMU 50 - Storage Area Behind Building 3166

During the 1993 inspection, this area was only used to store raw materials which were in the process of being used for their various applications. Since this time, new tenants have occupied the building and the area is now being used as a temporary waste accumulation area. Given the former and present uses of this site, a very limited soils investigation is proposed for the area within the fenced area (Figure 6-13).

It should be noted that the transformers seen during the 1993 investigation are new or reconditioned and were spare parts, not waste. These have since been moved and there is no evidence suggesting any release. Further, the area where they were stored was remote from the fenced area (approximately 50 feet) along the back wall of the building. Based on these considerations, no investigations appear warranted for this sub-area.

The soils program for the fenced area will consist of two soil samples. These will be obtained at equal spacing within the unit or at areas where staining is visible. The zone 0-6 inches will be sampled using hand excavated pits. Analytical parameters for the soil samples will be:

- Volatile organics
- Semi-volatile organics
- Pesticides/PCBs (because of the known malathion use)

All analyses will be performed in accordance with SW-846 methods and data packages will comply with CLP Level D criteria, as appropriate. The data will be subjected to third party validation.

6.8.16 SWMU 51 - New AIMD Storage Pad Building 379

Drainage features exist to the north and east of the unit at a distance of approximately 100 feet. The area is flat and sleet drainage only occurs during periods of heavy precipitation. Normally, most precipitation evaporates as it commonly occurs as brief showers. However, a limited soil sampling program is proposed for immediately off the asphalt.

The five proposed soil sampling locations are shown on Figure 6-15. The spacing for these samples is intended to be regular; however, areas indicating staining or stressed vegetation will be sampled where appropriate. Soils from just below the root zone will be taken from hand excavations. All samples will be analyzed, using SW846 methods, for:

- Volatile organics
- Semi-volatile organics
- TPH

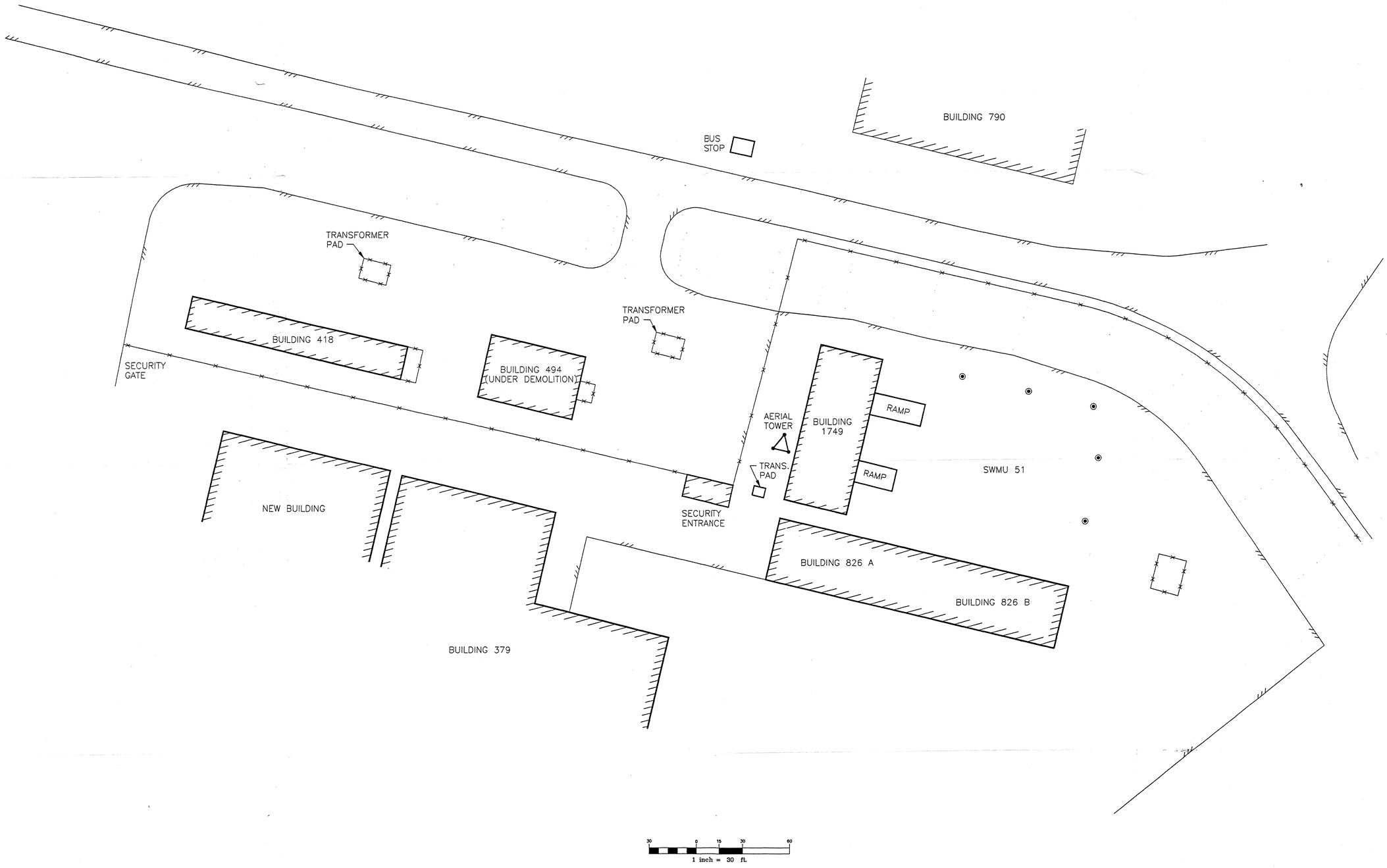
Data packages will comply with CLP Level D criteria, as appropriate, and will be subjected to third party data validation.

6.8.17 Area of Concern (AOC) C - Transformer Storage Pads

Based on the use of this site to manage surplus transformers and other miscellaneous electrical equipment prior to off-site disposal, a limited first phase RFI appears warranted. The analytical contaminants of concern here are PCBs and TPH since there is no evidence of any other potential contaminants ever having been present.

A total of 14 soil samples are proposed approximately in the locations shown on Figure 6-14. The rationale for this sampling is to provide for two samples between each pad, two samples along the long edge of the outermost pads and one sample at each end of each pad. In addition to these samples, the area surrounding the pads for a distance of 50 feet will be thoroughly scrutinized for any evidence of spills or stressed vegetation (this will encompass the area where the 3 transformers off the pad were noted during the 1993 inspection). Up to six additional samples will be taken from any areas identified during this visual investigation.

All samples will be obtained from immediately below the root zone and those associated with the pads will be taken from within 18 inches of the concrete. Hand excavations will be used to



LEGEND			
◉ PROPOSED SOIL SAMPLING LOCATION	DATE 4-29-94	NORTH	
	SCALE 1" = 30'		
	DRAWN		
	REVIEWED		
	S.O.# 62470-223		
	CADD# 033-50		

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

FIGURE 6-15
PROPOSED SAMPLING LOCATIONS
SWMU 51

SCALE 1" = 30'
DATE 4-29-94

FIGURE NO.
6-15

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obtain samples. Each sample will be analyzed for PCBs and TPH, as indicated above, using SW-846 methods. Data packages will comply with CLP Level D requirements as appropriate and will be subjected to third party data validation.

7.0 REFERENCES

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