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01.04-09/15/95-00170

Final

RCRA Facility Investigation
Naval Station Roosevelt Roads
Puerto Rico

Volume I of II

Prepared For:

Department of the Navy
Atlantic Division
Naval Facilities
Engineering Command
Norfolk, Virginia

Under the

LANTDIV CLEAN Program

Comprehensive Long-Term
Environmental Action Navy

FINAL

PROJECT MANAGEMENT PLAN

RCRA FACILITY INVESTIGATION

NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CONTRACT TASK ORDER 0223

SEPTEMBER 14, 1995

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

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1.0 INTRODUCTION

This Project Management Plan has been prepared by Baker Environmental, Inc. (Baker) for the Atlantic Division (LANTDIV) as Naval Facilities Engineering Command Contract Task Order (CTO) 0223 under the LANTDIV Comprehensive Long-Term Environmental Action Navy Program (Navy CLEAN), Contract Number N62470-89-D-4814.

In November, 1984, Congress passed the Hazardous and Solid Waste Amendments (HSWA) to the 1976 Resource Conservation and Recovery Act (RCRA). One provision of these amendments specifically addresses corrective action for continuing releases from hazardous waste treatment, storage or disposal facilities. Under this provision, any facility applying for a RCRA Part B permit will be subject to an assessment by the regulatory agency when the application is submitted. If any solid waste management unit (SWMU) or area of concern (AOC) is suspected to be the source of a contaminant release to the environment, the owner or operator of the facility may be required to perform a RCRA Facility Investigation (RFI) to define the nature and extent of the release. This information will be used to determine the need for corrective measures and to aid in their formulation and implementation (USEPA, 1986).

A Final RCRA Part B permit has been issued by USEPA Region II to Naval Station Roosevelt Roads (NSRR). This permit contains requirements for RFI activities at 24 SWMUs and 3 AOCs. These SWMUs and AOCs are presented in Table 1-1. RFI activities at these SWMUs/AOCs will include soil, groundwater, and surface water/sediment investigations as appropriate and as directed by the permit.

This Project Management Plan provides the technical approach and scope of the RFI for NSRR, the overall schedule of the identified tasks, and the project management team to be utilized in accomplishing the objectives of the RFI.

This Project Management Plan is one of five project plans associated with the RFI. Other RFI project plans include:

- Data Collection Quality Assurance Plan (DCQAP)
- Data Management Plan (DMP)

- Health and Safety Plan (HASP)
- Community Relations Plan (CRP)

The DCQAP contains the specific Scope of Work for RFI activities at each SWMU/AOC. The DMP describes reporting and documentation procedures for field measurement and analytical results. The HASP documents the health and safety protocols for the RFI activities. The CRP included in this package is an addendum to the existing NSRR CRP.

It is the intent that the Project Management Plan serves to document the overall management approach to the RFI. The Project Management Plan is comprised of the following sections:

1.0 Introduction
2.0 Technical Approach
3.0 Description of Current Conditions
4.0 Schedule
5.0 Project Management and Staffing

2.0 TECHNICAL APPROACH

2.1 RFI Activity

Investigation requirements (full RFI, first phase RFI, contingent, or no action by media) for each SWMU/AOC are presented in Table 1-1. SWMU/AOC descriptions and summaries of previous investigations are included in Section 3.0 (Description of Current Conditions). The RFI Scope of Work is presented in detail in the DCQAP. The RFI schedule (Section 4.0) follows the previously prepared NSRR Site Management Plan (included as Attachment A to this Project Management Plan).

There are a number of SWMUs and three AOCs at NSRR at which first phase RFIs have been designated due to the limited information presently available regarding possible releases at these sites. The purpose of the first phase RFI is to assess whether there have been releases from areas which, based on available information, may have been used routinely, systematically, or deliberately in the management of wastes. The first phase RFI differs from a full RFI in the extent and degree of investigations required. First phase RFIs are limited to sampling and analysis of certain environmental media. Pending the results of the first phase RFI, a full RFI may be required.

RFI activities at SWMU 19 (Building 121-Discarded Pesticide Storage Area) are contingent on the results from closure under an approved RCRA closure plan. Pending results of these ongoing actions, a full RFI may be required. If releases at these SWMUs/AOC are verified, reporting guidelines listed in Appendix C of the permit will be followed and appropriate Corrective Measures Study (CMS) activities will be initiated.

Interim Corrective Measures are completed at SWMUs 11/45 (IR Site 16) and SWMU 10 (IR Site 15). Results of the remediation efforts (e.g., confirmatory sample results) have been provided.

2.2 Investigation Media

Soil, groundwater, and surface water/sediment investigations will be conducted at various SWMUs. Table 1-1 lists the media subject to investigation at each SWMU. The general rationale for and approach to the RFIs at NSRR are described in the subsections below. Specific sampling rationale

for each SWMU/AOC is presented in Section 4.0 (Data Collection Strategy and Requirements) of the DCQAP.

2.2.1 Soil Investigations

Soil investigations will be conducted to assess whether releases of hazardous waste or hazardous constituents have occurred and, if so, to identify the source and extent of contaminants in the soil at the SWMUs/AOC. The potential for migration of contaminants in the soil or to other media (groundwater, surface water/sediment) will be evaluated. The investigations will involve collection of surface and subsurface soil samples and submission of the samples for laboratory analysis. Analytical parameters will be dependent on the operational history of each SWMU/AOC and other available information which may provide evidence regarding potential contaminants.

2.2.2 Groundwater Investigations

Groundwater investigations will be conducted as required to assess whether releases of hazardous waste or hazardous constituents to groundwater have occurred and, if so, to identify the source and extent of contaminants in the groundwater. These investigations will involve collection of groundwater samples from existing or newly-installed monitoring wells or Hydropunches™. Analytical parameters will be dependent on the operational history of each SWMU/AOC and other available information which may provide evidence regarding potential contaminants.

2.2.3 Surface Water/Sediment Investigations

Surface water/sediment investigations will be conducted to assess whether releases of hazardous water or hazardous constituents to surface water/sediments have occurred and, if so, to identify the source and extent of contaminants in the surface water/sediment at the SWMUs and AOC. The investigation will include collection of surface water and sediment samples. Analytical parameters will be dependent on the operational history of each SWMU/AOC and other available information which may provide evidence regarding potential contaminants.

3.0 DESCRIPTION OF CURRENT CONDITIONS

This section contains information regarding facility background, previous investigations, and the nature and extent of contamination of SWMUs/AOC. This information was originally submitted in the Pre-Investigation Corrective Measures Screening Evaluation Report (Baker, 1994). It is included in the Project Management Plan in order to fulfill the requirements listed in the Draft Corrective Action Permit, Section III, of Appendix A.

3.1 Facility Background

This facility background section includes a description of the NSRR facility, a summary of the general physical setting, and descriptions of the individual SWMUs/AOC included in this RFI.

3.1.1 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. Figure 3-1 is a facility map depicting SWMU/AOC locations. 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.

NSRR was commissioned in 1943 as a Naval Operating Base, and finally redesignated a naval station in 1957. The primary mission of NSRR today is provision of full support for Atlantic Fleet weapons training and development activities.

3.1.2 Physical Setting

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

3.1.2.1 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.

3.1.2.2 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.

3.1.2.3 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.

3.1.2.4 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.

3.1.2.5 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 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 3-1 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 El 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 1.3 mgd on average. Treatment consists of pre-chlorination, 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.

3.1.3 Summary of Previously Conducted Environmental Investigations

A number of environmental investigations have been conducted at NSRR. The results of these investigations provide information regarding the nature and extent of contamination at selected SWMUs/AOC. These investigations 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)
- Supplemental Investigation
- Summary and Technical Evaluation Review of Work Performed at SWMUs/AOC (RFA Reinspection)

Each of these investigations is discussed below.

3.1.3.1 Initial Assessment Study (IAS)

As part of a Navy-wide program to manage past disposal sites through the 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 16 sites that warranted further study under the NACIP Program.

3.1.3.2 Confirmation Study (CS)

In May 1986, the CS was performed by Environmental Science and Engineering (ESE) of Gainesville, Florida. Fifteen (15) of the 16 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 quality of data obtained during the CS is questionable and; therefore, no conclusions regarding conditions at any of the sites investigated can be drawn on the basis of this information.

3.1.3.3 RCRA Facility Assessment (RFA)

A RFA was conducted at NSRR in 1988 by A.T. Kearney, Inc. (Alexandria, Virginia) for the USEPA to identify SWMUs and AOC and assess the potential for release of hazardous wastes and hazardous constituents from these units to the environment. The description of SWMUs and AOC 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 AOC 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.

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

3.1.3.4 Remedial Investigation/Feasibility Study (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.

3.1.3.5 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. This RI/FS was performed according to criteria in the NCP and guidelines stipulated by the USEPA in RI/FS guidance documents.

3.1.3.6 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:

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

These sites correspond to the following SWMUs/AOC listed on the RCRA Corrective Action Permit for NSRR.

IR Site 5	-	SWMU 1
IR Site 6	-	SWMU 2
IR Site 7	-	SWMU 3
IR Site 10	-	SWMUs 31 and 32, AOC B
IR Site 12	-	SWMUs 7 and 8
IR Site 13	-	SWMU 9
IR Site 15	-	SWMU 10
IR Site 16	-	SWMUs 11 and 45
IR Site 17	-	SWMUs 12 and 14

IR Site 18 - SWMU 13

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; however, the sites are regulated under CERCLA and therefore are not included in the Draft RCRA Part B Permit, Corrective Action Module III. Therefore, no further discussion will be included on these sites.

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; Target Analyte List (TAL) - metals and cyanide. Quality control of analyses was specified at NEESA Level D, equivalent to CLP procedures at EPA Level 4.

3.1.3.7 Summary and Technical Review of Work Performed at SWMUs/AOC Report

TRC Environmental Corporation (TRC) prepared the Summary and Technical Review of Work Performed at SWMUs AOC Report for USEPA in 1993 to assess the investigation and/or remedial work done on the 51 SWMUs and AOC 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).

3.2 SWMU/AOC Descriptions

A general description and history of each SWMU/AOC is presented in the following subsections. Available information regarding the nature and extent of contamination at the SWMU/AOC is also presented. Figure 3-1 is a facility map depicting SWMU/AOC locations.

3.2.1 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). A site map of this SWMU is presented on Figure 3-2.

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, 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). The quality of the data obtained during the Confirmation Study is questionable and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

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.

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. The traverses followed access lanes cleared by heavy equipment along orientations selected following review of photo-interpretation and map analysis, 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 additionally provided more precise mapping of the disposal feature as well as the concentration of metallic objects along each traverse.

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. A summary of the analytical results is presented on Table 3-1.

3.2.2 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). A site map for this SWMU is presented on Figure 3-3.

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, generally 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, 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). The quality of the data obtained during the Confirmation Study is questionable and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

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).

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. A summary of the analytical results is presented on Table 3-2.

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

3.2.3 SWMU 3 - Base Landfill

The Base Landfill (IR Site 7) is located south of the Industrial Area Wastewater Plant (Building 1758) and has operated since the early 1960s. The landfill is still operating and accepting wastes in accordance with the Puerto Rico Environmental Quality Board (EQB) regulations.

The landfill covers 85 acres, and is separated into several different disposal areas (A.T. Kearney, Inc., 1988). A site map of this SWMU is presented on Figure 3-4.

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 probable disinfecting agent (NEESA, 1984).

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). The quality of the data obtained during the Confirmation Study is questionable and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

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

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

3.2.4 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 or chain link fencing. There is one entrance at ground level. A site map of this SWMU is presented on Figure 3-5.

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).

3.2.5 SWMU 7 - Tow Way Fuel Farm

SWMU 7 is the Tow Way Fuel Farm itself (Figure 3-6). Repeated episodic spills have resulted in groundwater and soil contamination. A free product recovery system is presently operating at the site. To date, this SWMU has been addressed under the UST regulations as administered by the Puerto Rican Environmental Quality Board (EQB).

SWMU 7 has been included in the corrective action requirements of the NSRR RCRA permit. The Navy is in the process of shifting responsibility for investigations at this SWMU from their UST contractor to the CLEAN contractor. An addendum to these workplans, for additional RFI investigations at SWMU 7, which will take into account all the previous work, will be submitted separately.

3.2.6 SWMU 8 - Two Way Fuel Farm Disposal Pits

Associated with the tanks of the Tow Way Fuel Farm are reported disposal pits where sludges resulting from tank cleaning were placed. Three locations are as shown on the drawing (Figure 3-6); other locations may also be present.

3.2.7 SWMU 9 - Tanks 212-217 Sludge Burial Pits

This SWMU consists of sludge burial pits associated with six fuel storage tanks. The six fuel storage tanks are still in place and operational. The tanks (and their associated burial pits) are located in three separate areas within this SWMU. These areas include:

- Area A - Tanks 212 and 213
- Area B - Tanks 214 and 215
- Area C - Tanks 216 and 217

Areas A and B (Figure 3-7) are located north of Forrestal Drive along Manila Bay Road. Area C (Figure 3-8) is located approximately 4,000 feet southeast of Areas A and B, north of Forrestal Drive. 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. Tanks 212-214 are still in operation. Tanks 216 and 217 are still in place but no longer in service. 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).

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 (ranging between 7.79 mg/kg and 400 mg/kg in Round One to 4.67 mg/kg and 189 mg/kg in Round Two), 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. The quality of the data obtained during the Confirmation Study is questionable and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

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 August 1995, a long-term employee at the Base was contacted. He led NSRR environmental to the locations of three disposal pits. The pit locations are shown on Figure 3-6 and 3-7. Additional pit locations may be present.

3.2.8 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 (Figure 3-9). The soils at this SWMU are being investigated and remediated under the IRP.

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 focused 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. Remediation of SWMU 10, using Alternative B, was initiated in December 1993 and completed in December 1994. A total of 4,169 tons of contaminated soil was removed. The project close-out report for this work has been submitted as appropriate.

3.2.9 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 1979, 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). A site map of this SWMU is presented on Figure 3-10.

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). The quality of the data obtained during the Confirmation Study is questionable and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

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).

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. Soils outside Building 38 have been remediated and a project close-out report has been submitted.

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.

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

3.2.10 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 Visual Site Inspection (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). A site map of this SWMU is presented on Figure 3-11.

3.2.11 SWMU 13 - Old Pest Control Shop/Building 258

This SWMU comprises IR Site 18. A site map of this SWMU is presented on Figure 3-12. 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 interviews, regarding the amounts or concentrations of the pesticides used (NEESA, 1984).

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. The quality of the data obtained during the Confirmation Study is questionable and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

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).

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

3.2.12 SWMU 14 - Fire Training Pit Area

This SWMU comprises IR Site 17. A site map of this SWMU is presented on Figure 3-11. 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.

- 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 bricks 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).

3.2.13 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 (SWOBs) [SWMU 22]. A site map of this SWMU is presented on Figure 3-13. 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).

3.2.14 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). A site map of this SWMU is presented on Figure 3-13. 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 Defense Reutilization and Marketing Office (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. However, minor staining around the edge of the separator was observed during the 1993 RFA reinspection (TRC, 1993).

3.2.15 SWMU 25 - DRMO Storage Yard

This SWMU is comprised of 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) within the larger DRMO Yard. A site map of SWMU 25 is presented on Figure 3-14. 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 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). However, during the 1993 RFA reinspection, the area could not be accurately located but may coincide with an area now used for storage of raw material (TRC, 1993). A color photograph of the site showing the stained area (from the original RFA) was used to locate the area to be subjected to sampling.

3.2.16 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; but the drums have been removed. Soil from the area where the drums were stored had been bulldozed approximately 20 feet and stockpiled. No evidence of stained soil was observed during the 1993 RFA reinspection (TRC, 1993). A site map of this SWMU is presented on Figure 3-15.

3.2.17 SWMU 30 - Former Incinerator

This SWMU is comprised of an incinerator formerly used to burn flammable wastes and an associated UST. The UST was removed under the UST regulations; however, some residual groundwater contamination appears to be present.

The SWMU is located along the landfill access road as shown on Figure 3-10.

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

This SWMU is part of IR Site 10. A site map of this SWMU is presented on Figure 3-16. According to the 1988 RFA, the Transportation Shop services Public Works Department (PWD) 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 valve is set into the curbing, and at the time of the 1988 VSI, was found to be broken 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).

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. The quality of the data obtained during the Confirmation Study is questionable and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

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. Table 3-3 presents a summary of the analytical results.

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

This SWMU is part of IR Site 10. A site map of this SWMU is also presented on Figure 3-16. 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.

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. The quality of the data obtained during the Confirmation Study is questionable and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

Eight soil samples were collected from IR Site 10 during the Supplemental Investigation (Baker, 1993). Organic contaminants were present in trace concentrations (see Table 3-3). 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.

3.2.20 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 Hangar 200. The drums were observed by the VSI team to contain waste gasoline and lubricating oil from Aircraft Intermediate Maintenance Department (AIMD) operations. A site map of this SWMU is presented on Figure 3-17.

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. Freshly exposed soil from the area yielded measurable organic vapors (TRC, 1993).

3.2.21 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. A site map of this SWMU is presented on Figure 3-18. This building stores waste batteries and battery acid that are 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. 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).

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

This SWMU, which is part of IR Site 16, consists of an area outside of Building 38, the Old Power Plant (SWMU 11) where transformer oils, containing PCBs, were routinely discarded directly onto the ground during transformer maintenance. A site map of this SWMU was presented on Figure 3-10.

3.2.23 SWMU 46 - Pole Storage Yard Covered Pad

According to the 1988 RFA report, this unit was cited in the Naval Assessment and Control of Installation Pollutants (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. A site map of this SWMU is presented on Figure 3-19. 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).

3.2.24 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. A site map of this SWMU is presented on Figure 3-20. 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).

3.2.25 Area of Concern (AOC) B - Building 25

This AOC is part of IR Site 10. A site map of this SWMU is presented on Figure 3-5. 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. 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). 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.

3.2.26 Area of Concern C - Transformer Storage Pad

A site map of this AOC is presented on Figure 3-19. 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).

3.2.27 Area of Concern D - Ensenada Honda Sediments

The Area of Concern D is comprised of the sediments of Ensenada Honda. Episodic spills of fuels and possible releases from SWMUs abutting the Honda (e.g., SWMUs 1, 2, 3 and 7) affecting the sediments is the concern related to this AOC. It is the intent of the RFI to address the sediments by sampling associated with each SWMU that contacts the Honda.

4.0 SCHEDULE

The purpose of this section is to present project schedules for the seven Operable Units at the Activity. These schedules will be adjusted annually as necessary.

Those SWMUs included in Operable Unit 1 are presented on Table 4-1. Operable Unit 2 includes SWMUs 7, 8, and 9. SWMUs 11 and 45 are included in Operable Unit 3. The Base Landfill comprises Operable Unit 4. Operable Unit 5 includes SWMUs 1 and 2. AOC B - Building 25 comprises Operable Unit 6 and Operable Unit 7 is comprised of AOC D Ensenada Honda sediments.

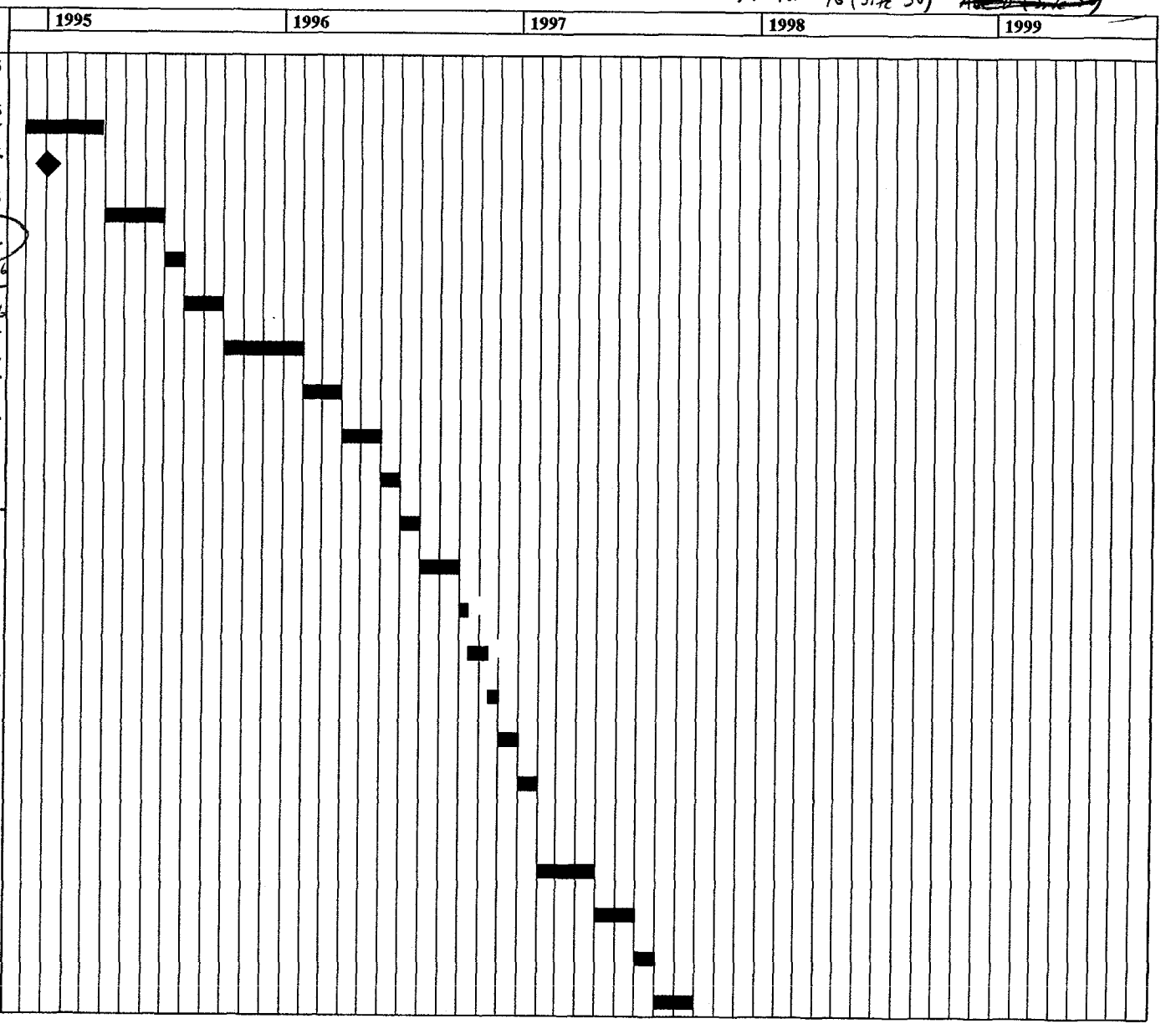
The project schedules are depicted on Figures 4-2 through 4-5.

OU 2 (SWMUs 7, 8 and 9) (Sites 12, 13)

OU 1 →
SWMU #6 (Site 11)
SWMU # 12/14 (Site 17)
SWMU # 13 (Site 18)
SWMU # 23 (Site 21)
SWMU # 24 (Site 22)
SWMU # 25 (Site 23)
SWMU # 26 (Site 24)
SWMU # 30 (Site 25)
SWMU # 31 (Site 26)
SWMU # 32 (Site 27)
SWMU # 37 (Site 28)
SWMU # 39 (Site 29)
SWMU # 46 (Site 30)
SWMU # 51 (Site 31)
SWMU # 55/AOC C (Site 32)
~~AOC D (Site 33)~~

Figure 4 - 2
Project Schedule
Operable Units 1 and 2 - NSRR

Task	Duration	Start	Finish
Work Plans	174d	11/30/94	8/1/95
Draft	118ed	11/30/94	3/28/95
Meeting with EPA	0ed	~~1/3/95~~ 1/13/95	~~1/3/95~~ 1/13/95
Review	91ed	4/1/95	7/1/95 9/12/95
Final	31ed	7/1/95 11/15/95	~~8/1/95~~ 1/15/96
Sub Procurement / Mobilization	61ed	~~8/1/95~~ 1/15/96	~~10/1/95~~ 4/15/96
Field Investigation	123ed	~~10/1/95~~ 4/15/96	~~2/1/96~~ 6/15/96
Laboratory Analysis	60ed	~~2/1/96~~ 6/15/96	~~4/1/96~~ 8/15/96
Validation	61ed	~~4/1/96~~ 8/15/96	~~6/1/96~~ 9/15/96
Data Summary & Recommendations	30ed	~~6/1/96~~ 9/15/96	~~7/1/96~~ 10/15/96
Work Plan Addendum	31ed	~~7/1/96~~ 10/15/96	~~8/1/96~~ 12/15/96
Review	61ed	~~8/1/96~~ 12/15/96	~~10/1/96~~ 12/30/96
Final	14ed	~~10/1/96~~ 12/30/96	~~10/15/96~~ 1/30/97
Mobilization	31ed	~~10/15/96~~ 1/30/97	~~11/15/96~~ 2/28/97
Field - SWMUS Upgraded to Full RF	16ed	~~11/15/96~~ 2/28/97	~~12/1/96~~ 3/28/97
Laboratory Analysis	31ed	~~12/1/96~~ 3/28/97	~~1/1/97~~ 4/28/97
Validation	31ed	~~1/1/97~~ 4/28/97	~~2/1/97~~ 4/28/98
RFI Report	260d	~~2/1/97~~ 4/28/97	~~2/1/98~~ 7/28/97
Preliminary Draft	89ed	~~2/1/97~~ 7/28/97	~~5/1/97~~ 9/28/97
Review	61ed	~~5/1/97~~ 9/28/97	~~7/1/97~~
Draft	31ed	~~7/1/97~~	~~8/1/97~~
Review	61ed	8/1/97	10/1/97

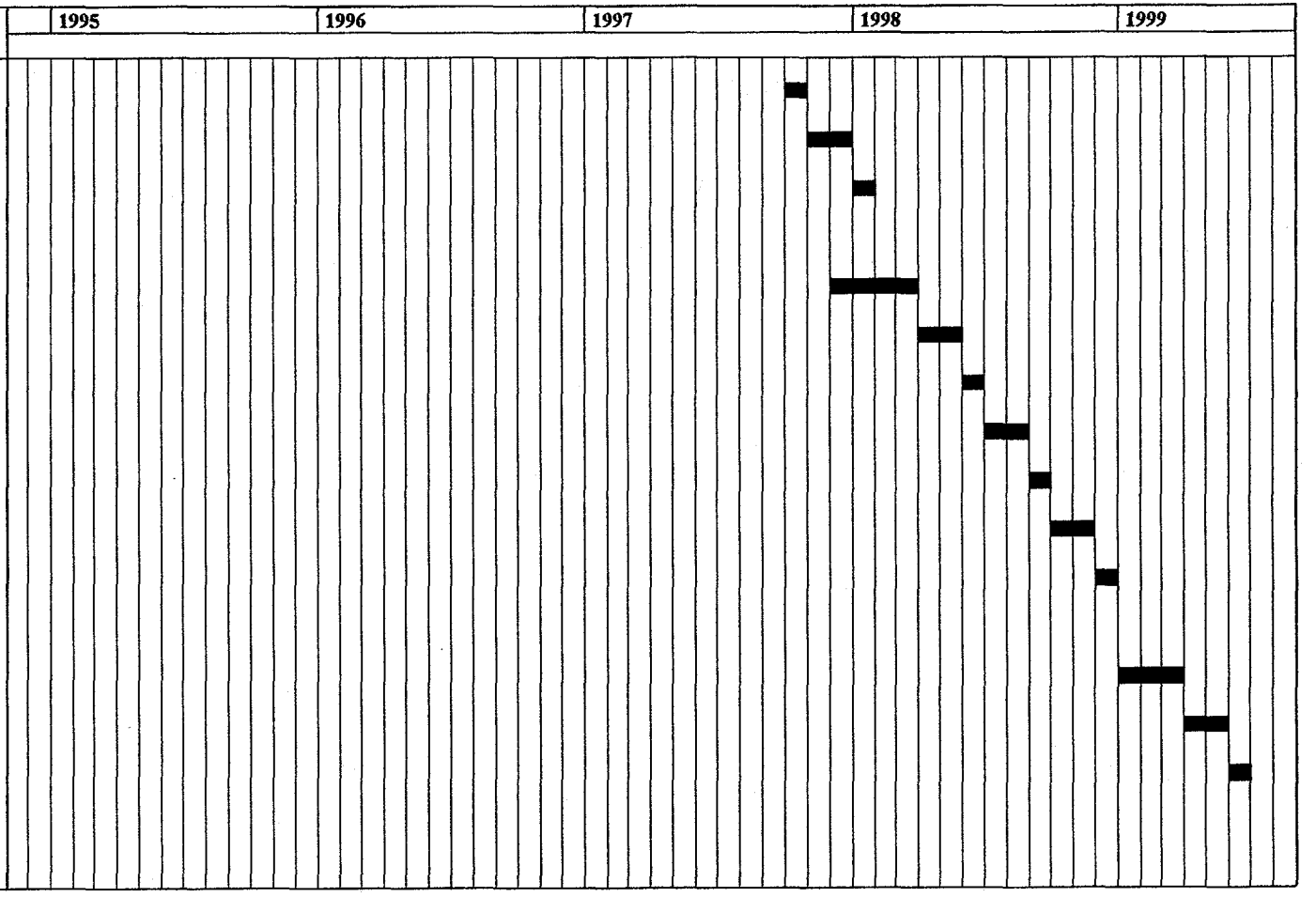


(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4 - 2

Project Schedule
Operable Units 1 and 2 - NSRR

Task	Duration	Start	Finish
Draft Final	31ed	10/1/97	11/1/97
Review	61ed	11/1/97	1/1/98
Final	31ed	1/1/98	2/1/98
CMS Report	284d	12/1/97	1/1/99
Preliminary Draft	121ed	12/1/97	4/1/98
Review	61ed	4/1/98	6/1/98
Draft	30ed	6/1/98	7/1/98
Review	62ed	7/1/98	9/1/98
Draft Final	30ed	9/1/98	10/1/98
Review	61ed	10/1/98	12/1/98
Final	31ed	12/1/98	1/1/99
CMI	129d	1/1/99	7/1/99
Design	90ed	1/1/99	4/1/99
Review	61ed	4/1/99	6/1/99
Final	30ed	6/1/99	7/1/99
Implementation (1)	0d	7/1/99	7/1/99
Petition (2)	0d	7/1/99	7/1/99

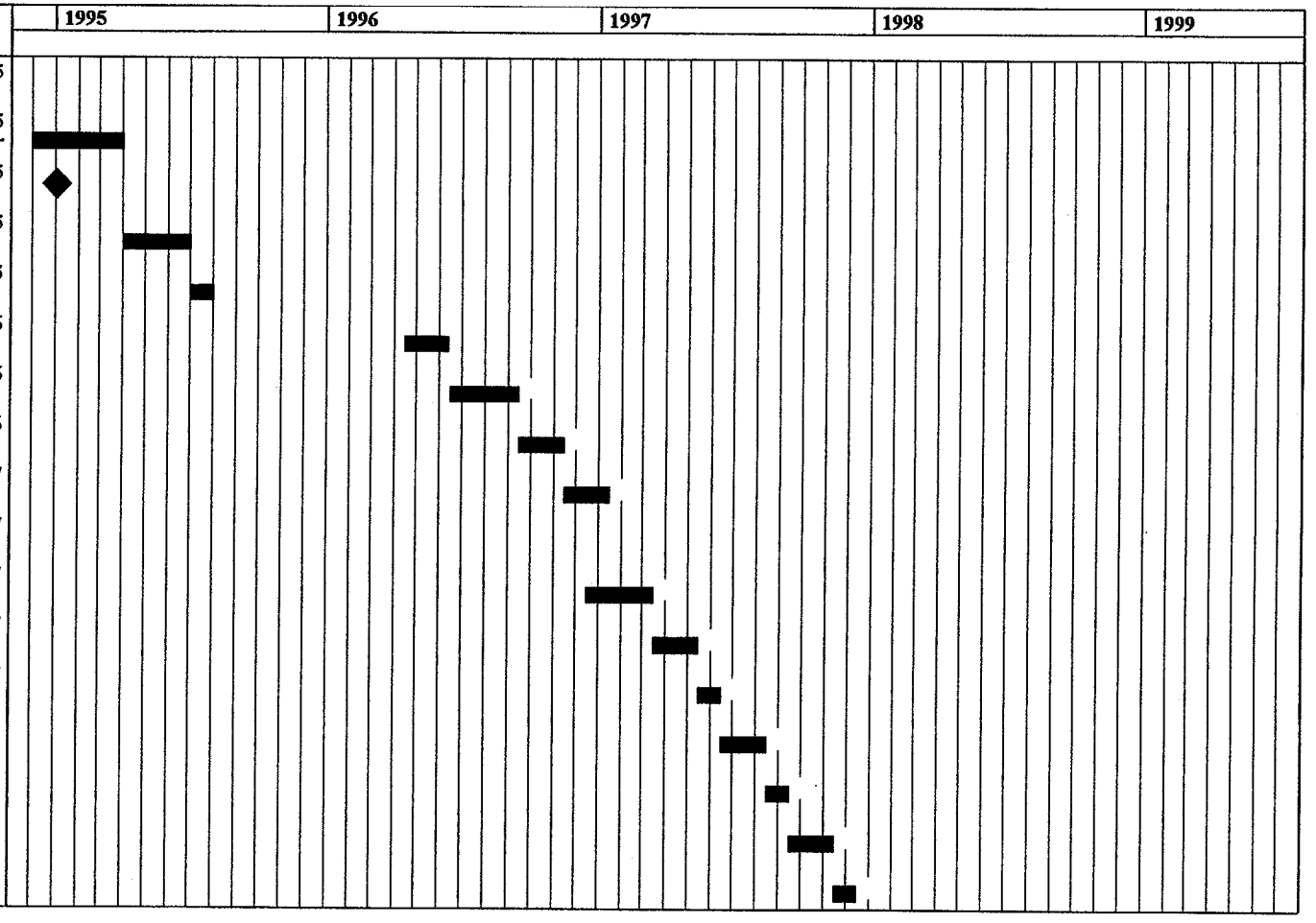


(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4 - 3

Project Schedule
Operable Units 3 and 5 - NSRR

Task	Duration	Start	Finish
Work Plans	174d	11/30/94	8/1/95
Draft	122ed	11/30/94	4/1/95
Meeting with EPA	0ed	1/13/95 ~~1/3/95~~	1/13/95 ~~1/3/95~~
Review	91ed	4/1/95	7/1/95
Final	31ed	7/1/95	8/1/95
Sub Procurement / Mobilization	59ed	4/15/96	6/13/96
Field Investigation	92ed	6/15/96	9/15/96
Laboratory Analysis	61ed	9/15/96	11/15/96
Validation	61ed	11/15/96	1/15/97
RFI Report	260d	12/15/96	12/15/97
Preliminary Draft	90ed	12/15/96	3/15/97
Review	61ed	3/15/97	5/15/97
Draft	31ed	5/15/97	6/15/97
Review	61ed	6/15/97	8/15/97
Draft Final	31ed	8/15/97	9/15/97
Review	61ed	9/15/97	11/15/97
Final	30ed	11/15/97	12/15/97



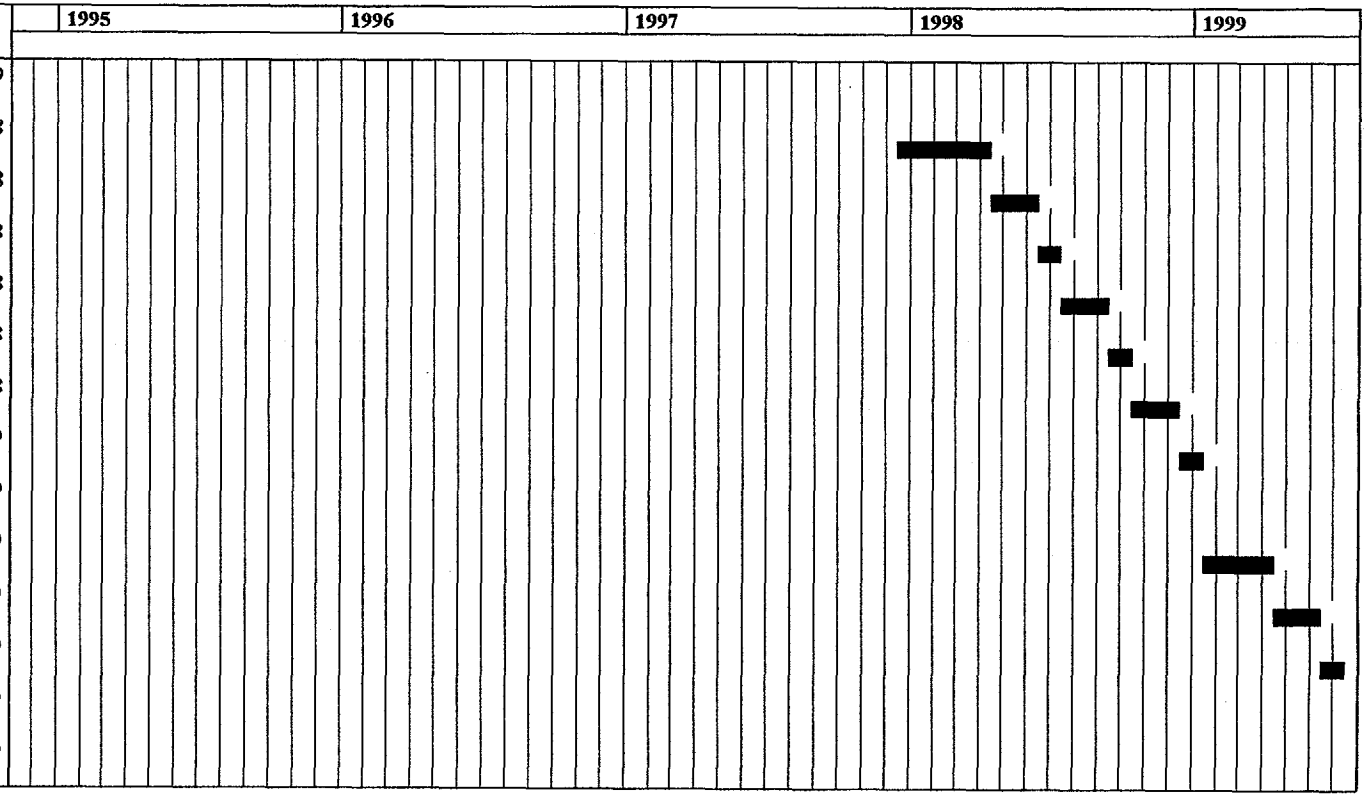
(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

OU 3 (SWMUS 11/45) (Site 16)
(Site 15)
OU 5 (SWMU 10) (Sites 5 and 6)
SWMUS 1 and 2

Figure 4 - 3

Project Schedule
Operable Units 3 and 5 - NSRR

Task	Duration	Start	Finish
CMS Report	284d	12/15/97	1/15/99
Preliminary Draft	121ed	12/15/97	4/15/98
Review	61ed	4/15/98	6/15/98
Draft	30ed	6/15/98	7/15/98
Review	62ed	7/15/98	9/15/98
Draft Final	30ed	9/15/98	10/15/98
Review	61ed	10/15/98	12/15/98
Final	31ed	12/15/98	1/15/99
CMI	129d	1/15/99	7/15/99
Design Draft	90ed	1/15/99	4/15/99
Review	61ed	4/15/99	6/15/99
Final Desgin	30ed	6/15/99	7/15/99
Implementation (1)	0d	7/15/99	7/15/99
Petition (2)	0d	7/15/99	7/15/99

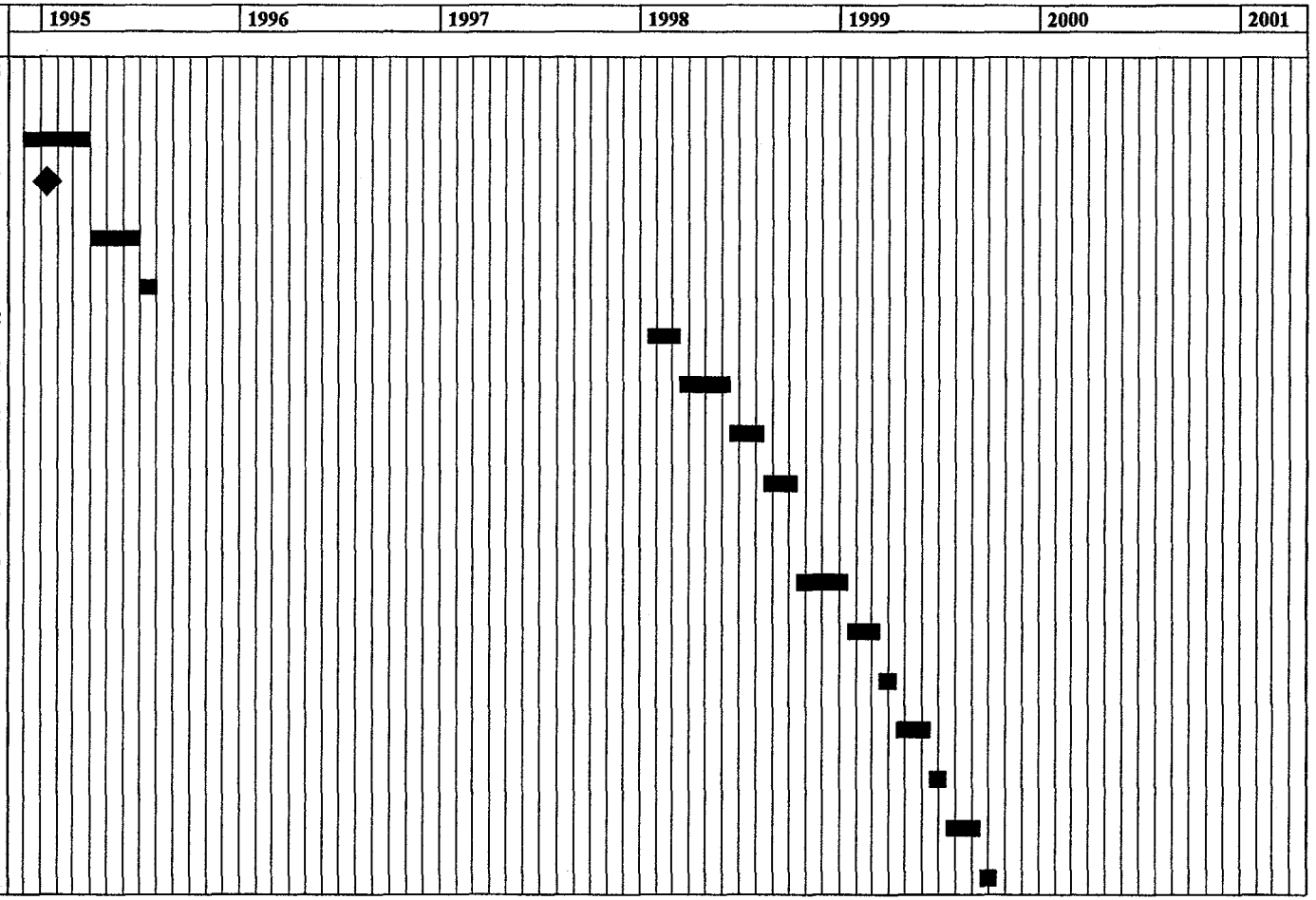


(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

OU 4 (SWMU 3) (Site 7)
OU 6 (AOC B) (Site 10)

Figure 4 - 4
Project Schedule
Operable Units 4 and 6 - NSRR

Task	Duration	Start	Finish
Work Plans	174d	11/30/94	8/1/95
Draft	120ed	11/30/94	3/30/95
Meeting with EPA	0ed	1/13/95	1/13/95
Review	91ed	4/1/95	7/1/95
Final	31ed	7/1/95	8/1/95
Sub Procurement / Mobilization	59ed	1/15/98	3/15/98
Field Investigation	92ed	3/15/98	6/15/98
Laboratory Analysis	61ed	6/15/98	8/15/98
Validation	61ed	8/15/98	10/15/98
RFI Report	261d	10/15/98	10/15/99
Preliminary Draft	92ed	10/15/98	1/15/99
Review	59ed	1/15/99	3/15/99
Draft	31ed	3/15/99	4/15/99
Review	61ed	4/15/99	6/15/99
Draft Final	30ed	6/15/99	7/15/99
Review	62ed	7/15/99	9/15/99
Final	30ed	9/15/99	10/15/99

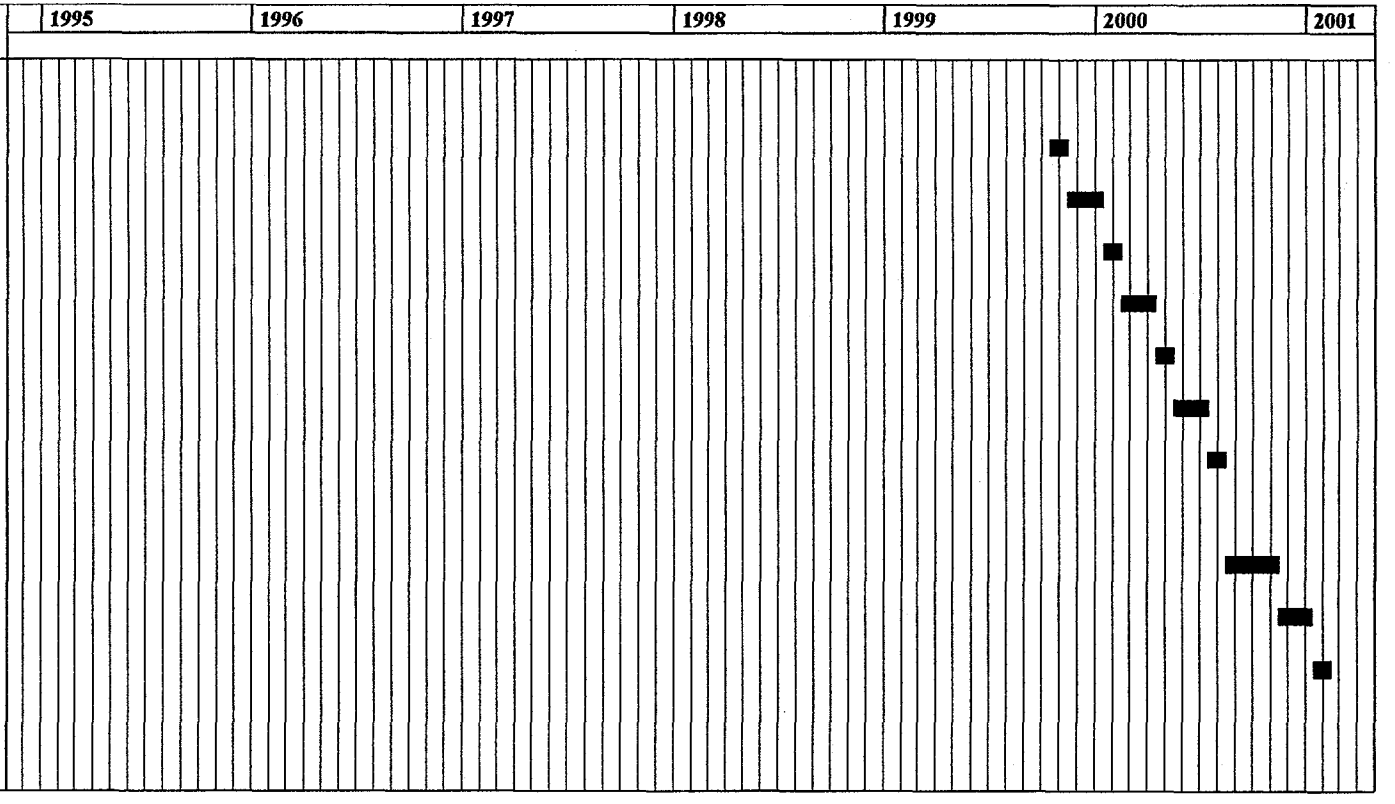


(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4 - 4

Project Schedule
Operable Units 4 and 6 - NSRR

Task	Duration	Start	Finish
CMS Report	217d	10/15/99	8/15/00
Preliminary Draft	31ed	10/15/99	11/15/99
Review	61ed	11/15/99	1/15/00
Draft	31ed	1/15/00	2/15/00
Review	60ed	2/15/00	4/15/00
Draft Final	30ed	4/15/00	5/15/00
Review	61ed	5/15/00	7/15/00
Final	31ed	7/15/00	8/15/00
CMI	132d	8/15/00	2/15/01
Draft Design	92ed	8/15/00	11/15/00
Review	59ed	11/15/00	1/13/01
Final Design	31ed	1/15/01	2/15/01
Implementation (1)	0d	2/15/01	2/15/01
Petition (2)	0d	2/15/01	2/15/01

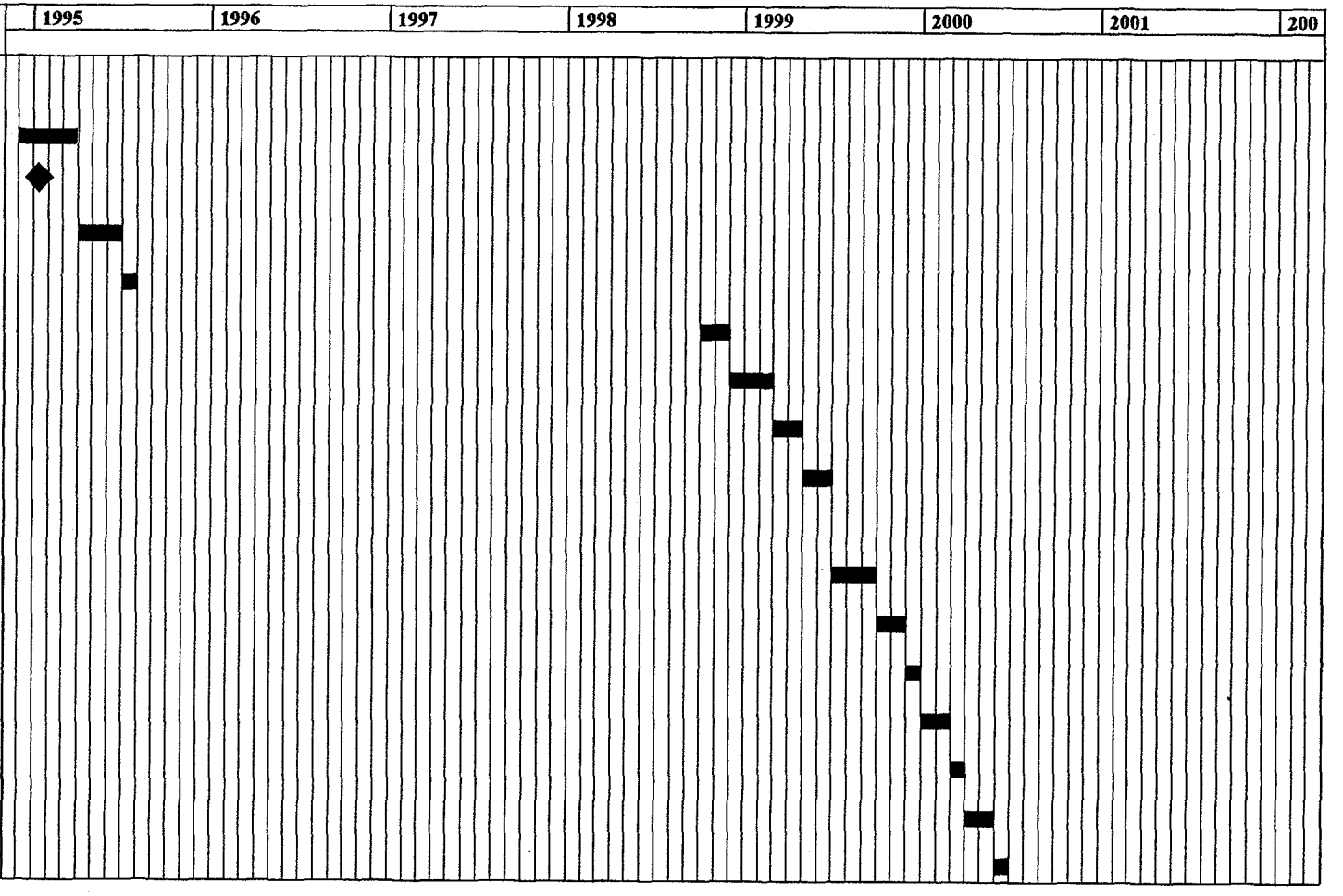


(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

OU 7 (~~Swsu~~ AOC D) (Site 33)

Figure 4 - 5
Project Schedule
Operable Units 7 - NSRR

Task	Duration	Start	Finish
Work Plans	174d	11/30/94	8/1/95
Draft	118ed	11/30/94	3/28/95
Meeting with EPA	0ed	1/13/95	1/13/95
Review	91ed	4/1/95	7/1/95
Final	31ed	7/1/95	8/1/95
Sub Procurement / Mobiliza	61ed	10/1/98	12/1/98
Field Investigation	90ed	12/1/98	3/1/99
Laboratory Analysis	61ed	3/1/99	5/1/99
Validation	61ed	5/1/99	7/1/99
RFI Report	240d	7/1/99	6/1/00
Preliminary Draft	92ed	7/1/99	10/1/99
Review	61ed	10/1/99	12/1/99
Draft	31ed	12/1/99	1/1/00
Review	60ed	1/1/00	3/1/00
Draft Final	31ed	3/1/00	4/1/00
Review	61ed	4/1/00	6/1/00
Final	30ed	6/1/00	7/1/00

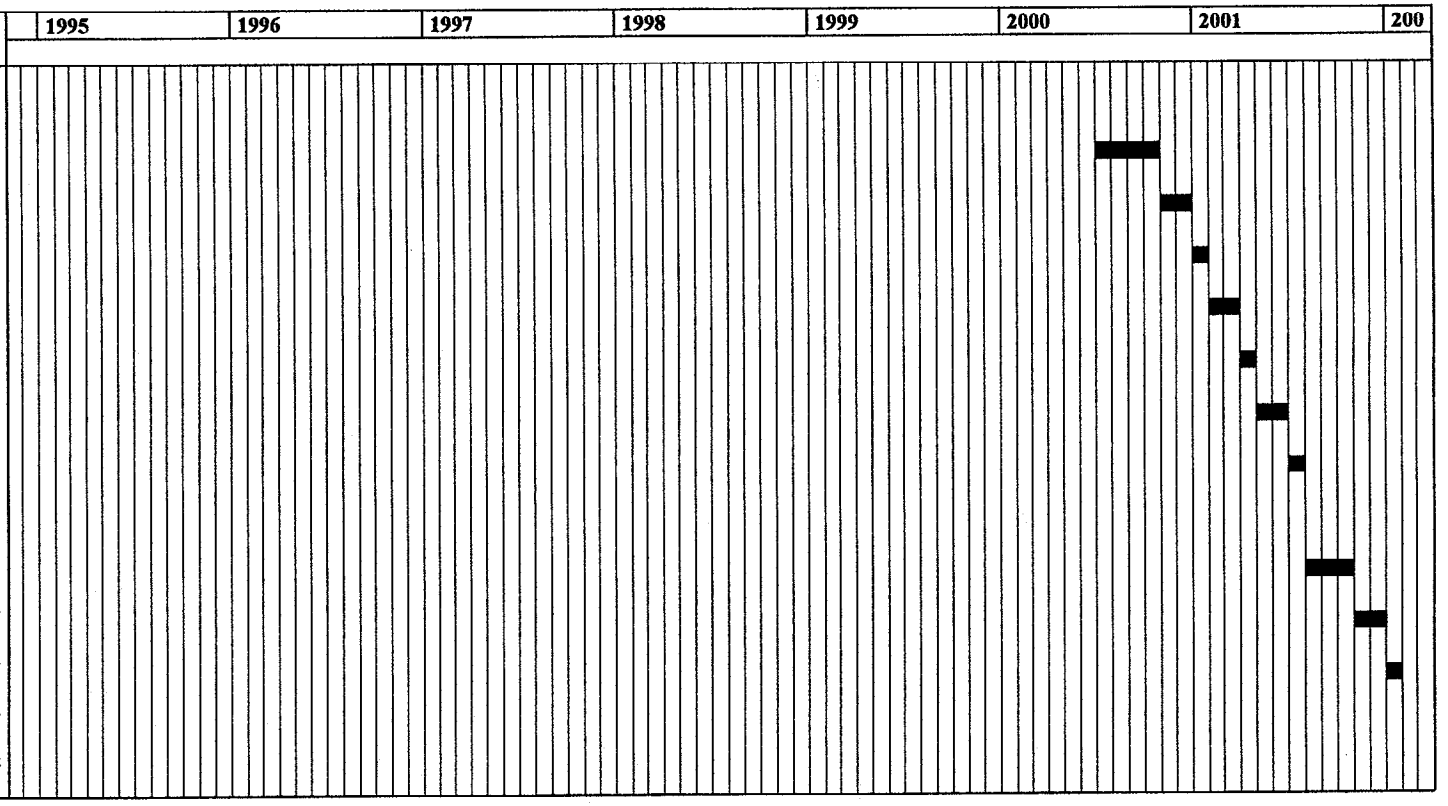


(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4 - 5

Project Schedule
Operable Units 7 - NSRR

Task	Duration	Start	Finish
CMS Report	282d	7/1/00	8/1/01
Preliminary Draft	123ed	7/1/00	11/1/00
Review	61ed	11/1/00	1/1/01
Draft	31ed	1/1/01	2/1/01
Review	59ed	2/1/01	4/1/01
Draft Final	30ed	4/1/01	5/1/01
Review	61ed	5/1/01	7/1/01
Final	30ed	7/2/01	8/1/01
CMI	0d	8/1/01	8/1/01
Draft Design	92ed	8/1/01	11/1/01
Review	61ed	11/1/01	1/1/02
Final	31ed	1/1/02	2/1/02
Implementation (1)	0d	2/1/02	2/1/02
Petition (2)	0d	2/1/02	2/1/02



(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

5.0 PROJECT MANAGEMENT AND STAFFING

The Baker Project Team will be managed by Mr. Christopher D. Boes, P.G. under the direction of Mr. Thomas C. Fuller, P.G., the Activity Coordinator for NSRR. Their primary responsibility will be to monitor the projects technical performance and cost and schedule and maintain close communication with the LANTDIV Engineer-in-Charge, Mr. Art Wells. As shown on Figure 5-1, Mr. Boes will report to Mr. Fuller and Program Management, Mr. John W. Mentz. Mr. Raymond P. Wattras will be responsible for overall Quality Assurance/Quality Control.

The Project Team will consist of the Activity Coordinator, Project Manager, Engineer, Geologist, Risk Assessment Specialist, Environmental Scientist, and technical support staff as shown on Figure 5-1. Resumes for key staff are included in Appendix A of the DCQAP.

TABLES

TABLE 1-1

SWMUs/AOC MEDIA SUBJECT TO CORRECTIVE 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[1]
#2 Langley Drive Disposal Site	Yes	Yes	Yes	Full
#3 Base Landfill	Yes	Yes	Yes	Full
#6 Building 145	No	Yes	No	First Phase[2]
#7 Tow Way Fuel Farm	Yes	Yes	No	Full
#8 Tow Way Fuel Farm - Disposal Pits	Yes	Yes	No	Full
#9 Tank 212-217 Sludge Burial Pits	Yes	Yes	Contingent[3]	Full
#10 Substation 2/Bldg. 90	Yes	Yes	No	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
#30 Former Incinerator	Yes	No	No	
#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
AOC #D/Ensenada Honda Sediments	No	No	Yes	First Phase

Notes: (1) Full RFIs are conducted where releases were established during previous investigations. The purpose of the full RFI is to determine the nature, rate, direction, and extent of hazardous waste or hazardous constituents.

(2) The purpose of the first phase RFI is to confirm any releases from these SWMUs and/or AOC.

(3) Contingent requirements are pending results of ongoing investigation or closure activities.

BLE 3-1

SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGATION
SWMU 1 - ARMY CREMATOR DISPOSAL SITE

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 3-1

SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGATION
SWMU 1 - ARMY CREMATOR DISPOSAL SITE

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 3-1

MMARY ANALYTICAL RESULTS FROM SUPPLEMENTA VESTIGATION

SWMU 1 - ARMY CREMATOR DISPOSAL SITE

SAMPLE ID	05 SS 138	05 SS 139	05 SS 142	05 SS 143	05 SS 140C	05 SS 140D	05 SS140E
					Background	Background	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 3-2

SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGATION
SWMU 2 - LANGLEY DISPOSAL AREA

SAMPLE ID	06 GW 101A	06 SS 141	06 SS 142	06 SS 143	06 SS 145	06 SS 146
UNITS	ug/L	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
VOLATILES						
Acetone	10 U	16 UJ	R	180 J	370 J	39 J
Benzene	5 U	8 U	18 U	10 U	7 U	7 U
Butanone,2-	10 U	16 UJ	410 J	19 UJ	14 UJ	15 UJ
Carbon disulfide	5 U	17 U	110 U	10 U	7 U	7 U
Ethylbenzene	5 U	8 U	18 UJ	10 U	7 U	7 U
Methylene chloride	5 U	24	590	9 J	65	11
Toluene	5 U	8 U	14 J	10 U	7	7 U
Xylene, o-	NA	8 U	18 UJ	10 U	7 U	7 U
Xylenes, m-, p-	NA	8 U	18 UJ	10 U	7 U	7 U
PESTICIDES/PCBs						
Aldrin	0.05 U	2.5 U	4.2 U	2.2 U	2.3 U	0.35 J
BHC,alpha-	0.05 U	0.085 NJ	4.2 U	2.2 U	2.3 UJ	2.7 U
BHC,beta-	0.05 U	0.8 NJ	1.1 J	2.2 U	2.3 U	2.7 U
BHC,delta-	0.05 U	0.39 NJ	0.86 J	2.2 U	2.3 U	2.7 U
BHC,gamma-	0.05 U	2.5 U	0.13 NJ	2.2 U	1.2 NJ	2.7 U
Chlordane,alpha-	0.05 U	2.5 UJ	4.2 UJ	2.2 U	2.3 U	2.7 U
DDD,4,4-	0.1 U	5.1	8.2 U	0.75 NJ	4.5 UJ	5.2 U
DDE,4,4-	0.1 U	3 NJ	8.2 U	4.3 U	5.3 J	5.2 U
DDT,4,4-	0.1 U	1 NJ	8.2 U	4.3 U	1.1 J	5.2 U
Dieldrin	0.1 UJ	4.9 U	4.2 UJ	2 J	4.5 UJ	5.2 U
Endosulfan I	0.05 U	2.5 U	1.5 NJ	2.8 NJ	2.3 UJ	2.7 U
Endosulfan II	0.1 U	4.9 U	8.2 UJ	4.3 U	0.15 NJ	5.2 U
Endosulfan sulfate	0.1 U	1 NJ	8.2 UJ	4.3 U	4.5 U	5.2 U
Endrin	0.1 U	4.9 UJ	8.2 UJ	4.3 U	0.15 NJ	5.2 U
Endrin aldehyde	0.1 U	4.9 U	8.2 U	4.3 U	0.71 J	5.2 U
Endrin ketone	0.1 U	4.9 UJ	8.2 U	4.3 U	0.25 NJ	5.2 U
Heptachlor	0.0017 NJ	0.36 J	0.42 J	2.2 U	0.17 J	2.7 U
Heptachlor epoxide	0.05 U	2.5 UJ	4.2 UJ	0.46 NJ	2.3 UJ	2.7 U
Methoxychlor	0.05 UJ	25 U	1.5 J	22 UJ	24 UJ	27 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

TABLE 3-2
SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGATION
SWMU 2 - LANGLEY DISPOSAL AREA

SAMPLE ID	06 GW 101A	06 SS 141	06 SS 142	06 SS 143	06 SS 145	06 SS 146
UNITS	ug/L	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
SEMIVOLATILES						
Anthracene	21 U	2000 U	4400 U	2500 U	1900 U	110 J
Benzo(a)anthracene	21 U	2000 U	4400 U	2500 U	1900 U	1000 J
Benzo(a)pyrene	21 U	2000 U	4400 U	2500 U	180 J	270 J
Benzo(b)fluoranthene	21 U	2000 U	4400 U	2500 U	180 J	1300 J
Benzo(g,h,i)perylene	21 U	2000 U	4400 U	2500 U	1900 U	350 J
Benzo(k)fluoranthene	21 U	2000 U	4400 U	2500 U	260 J	2000
Bis(2-ethylhexyl)phthalate	2 J	2000 U	15000	2500 U	1900 U	1700 U
Carbazole	21 U	2000 U	4400 U	2500 U	1900 U	92 J
Chrysene	21 U	2000 U	4400 U	2500 U	150 J	1400 J
Di-n-butylphthalate	21 U	2000 U	4400 U	2500 U	1900 U	94 J
Dibenzo(a,h)anthracene	21 U	2000 U	4400 U	2500 U	1900 U	450 J
Fluoranthene	21 U	2000 U	4400 U	2500 U	1900 U	3200
Indeno(1,2,3-cd)pyrene	21 U	2000 U	4400 U	2500 U	1900 U	700 J
Phenanthrene	21 U	2000 U	4400 U	2500 U	1900 U	1900
Pyrene	21 U	2000 U	4400 U	2500 U	1900 U	2100

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 3-2

SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGATION
SWMU 2 - LANGLEY DISPOSAL AREA

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

TABLE 3-2
SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGATION
SWMU 2 - LANGLEY DISPOSAL AREA

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 3-2

SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGATION
SWMU 2 - LANGLEY DISPOSAL AREA

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
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

TABLE 3-2

SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGATION
SWMU 2 - LANGLEY DISPOSAL AREA

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
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

TAI 3-3

SUMMARY ANALYTICAL RESULTS FROM SUPPLEMENTAL INVESTIGTATION
SWMU 31 - BUILDINGS 31 AND 2022

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

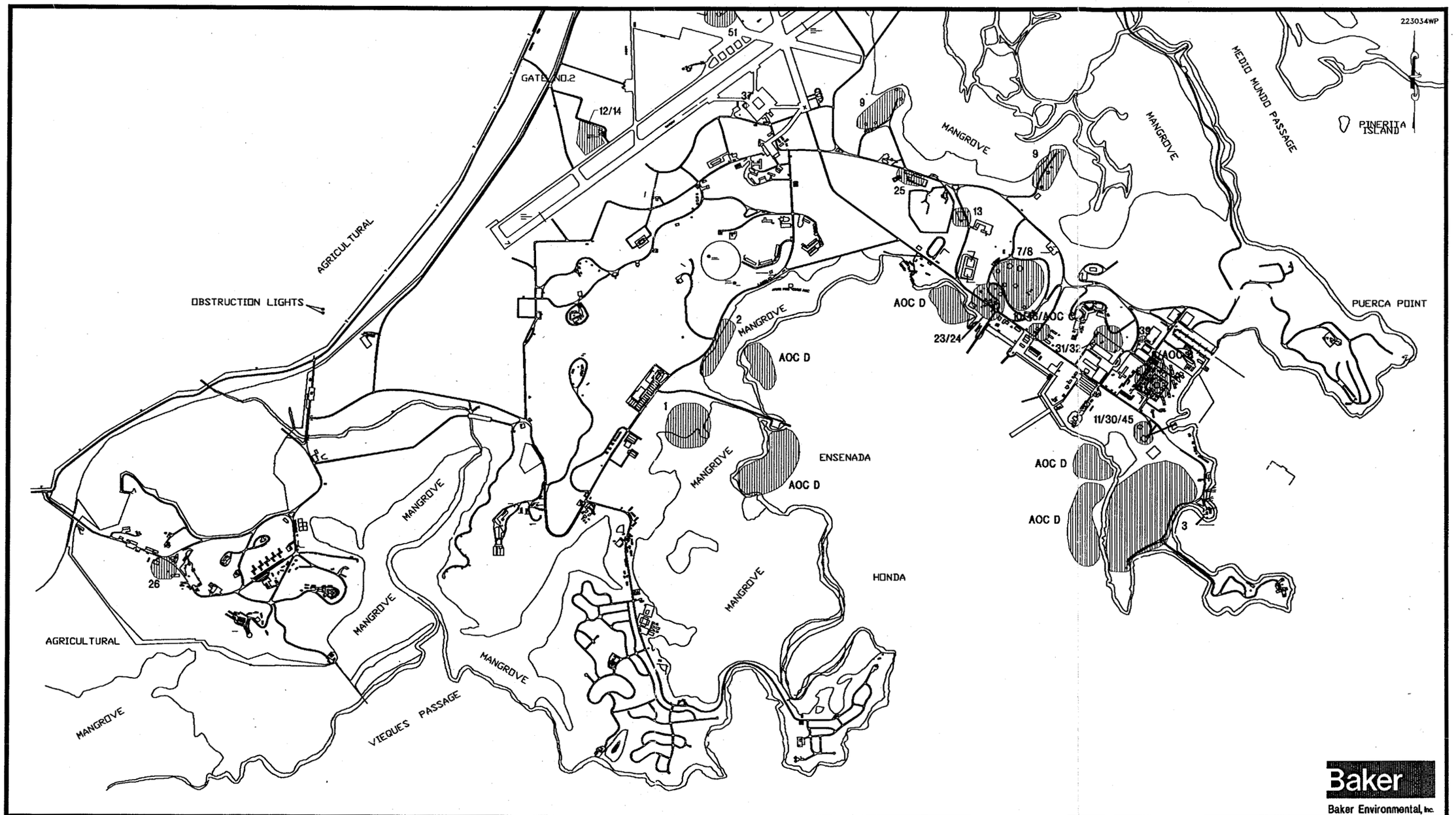
TABLE 4-1

SWMUs COMPRISING OPERABLE UNIT 1

SWMU	Name
~~3~~	~~Base Landfill~~
6	Building 145
10	Substation 2/Building 90
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
30	Former Incinerator Area
31	Waste Oil Collection Area/Buildings 31 and 2022
32	PWD Storage Yard/Battery Collection Area/ Building 31
37	Waste Oil Storage Area/Building 200
39	Building 3158 - Former Battery Drain Area
46	Pole Storage Yard Covered Pad
51	New AIMD Storage Pad/Building 379
55	Area of Concern C

This is OU4

FIGURES



LEGEND

1 SWMU AND/OR AOC

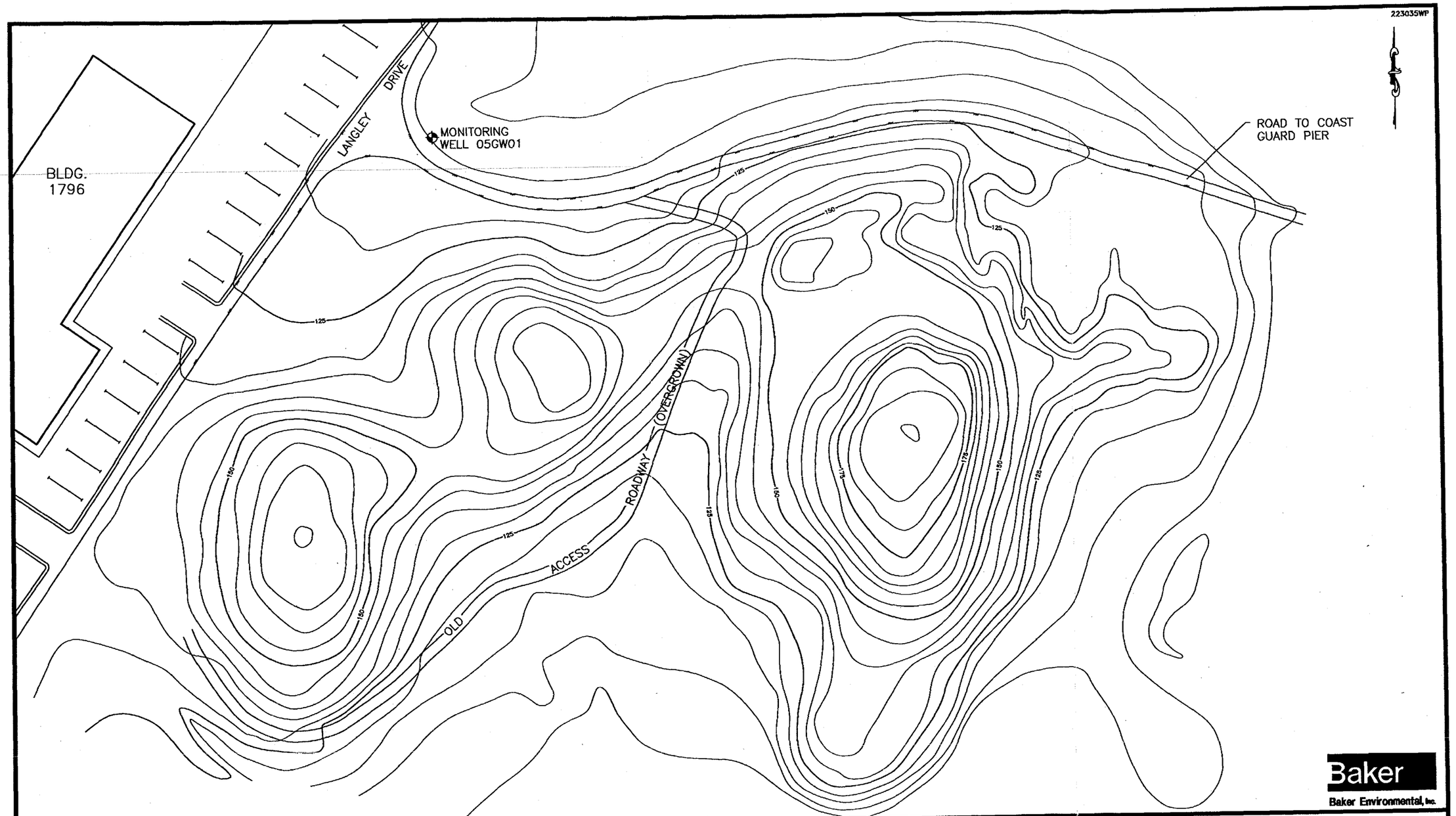
SOURCE: LANTDIV, FEB. 1992

2500 0 1250 2500 5000

1 inch = 2500ft.

FIGURE 3-1
SWMU/AOC LOCATION MAP
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

00170BB12



LEGEND

EXISTING MONITORING WELL LOCATION

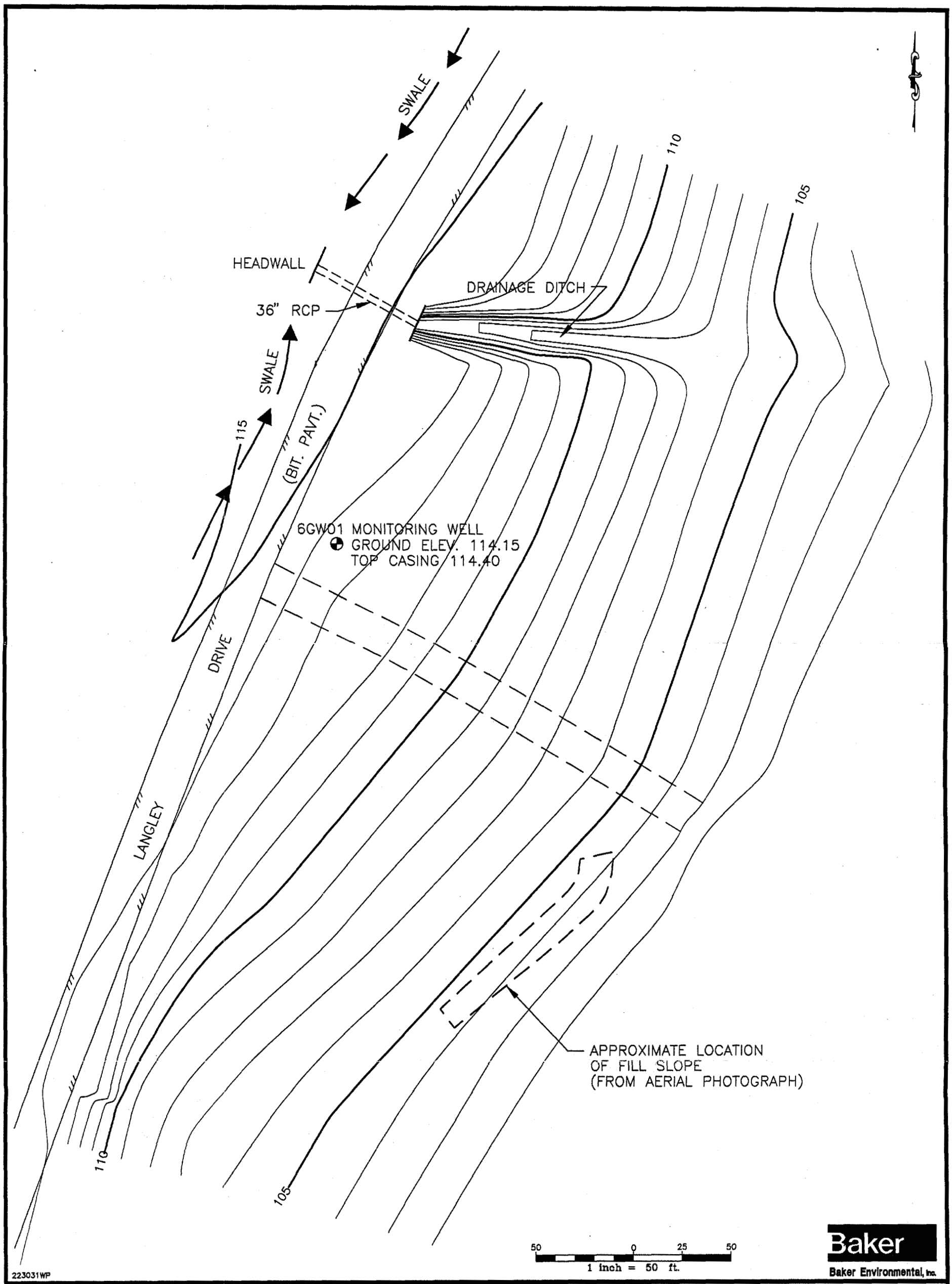
SURFACE ELEVATION CONTOUR

160 0 80 160 320

1 inch = 160 ft.

FIGURE 3-2
CURRENT CONDITIONS
RFI – SWMU 1
ARMY CREMATOR DISPOSAL SITE

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

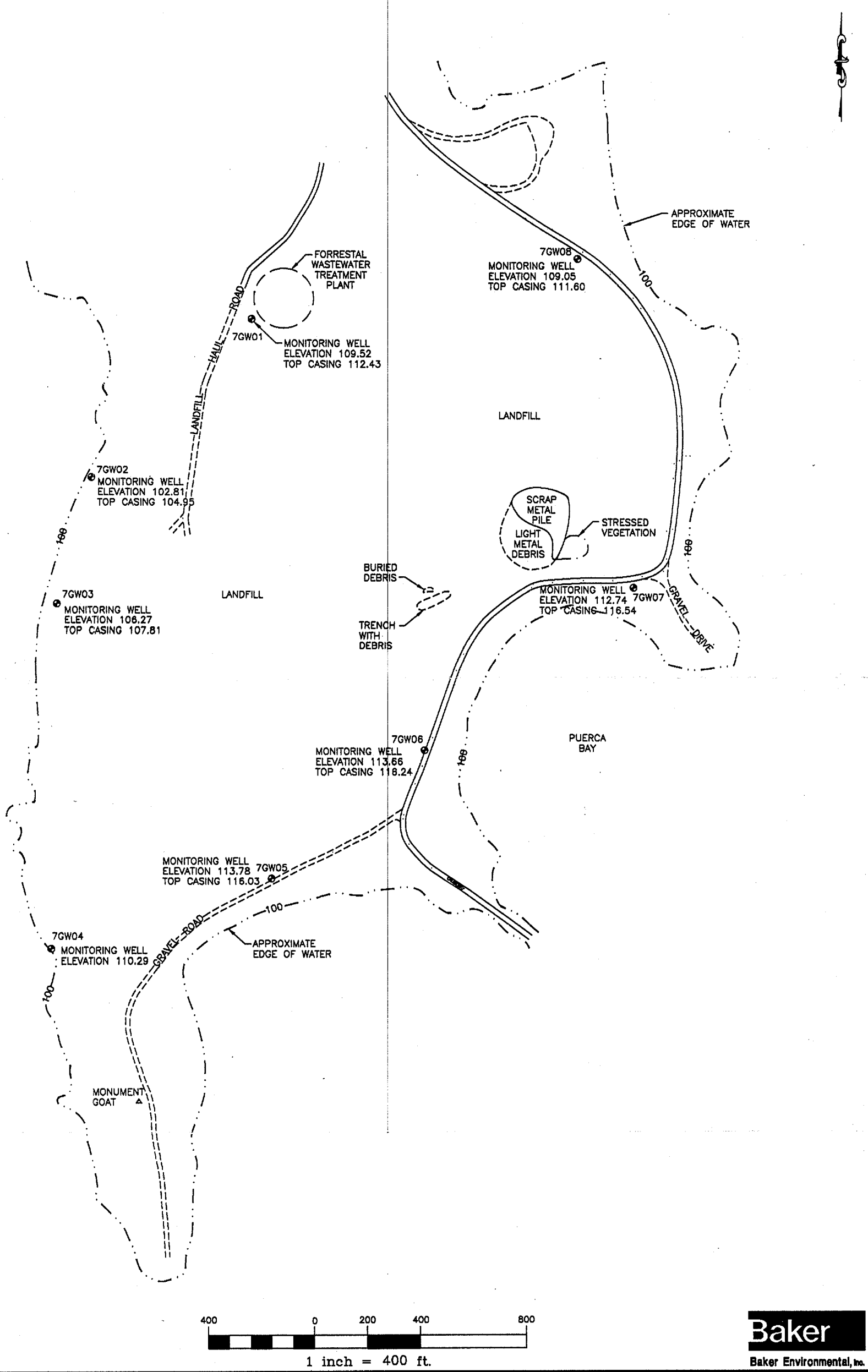
6GW01 EXISTING MONITORING WELL LOCATION

110 SURFACE ELEVATION CONTOUR

SURFACE WATER DRAINAGE DIRECTION

FIGURE 3-3
CURRENT CONDITIONS
RFI - SWMU 2
LANGLEY DRIVE DISPOSAL SITE

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

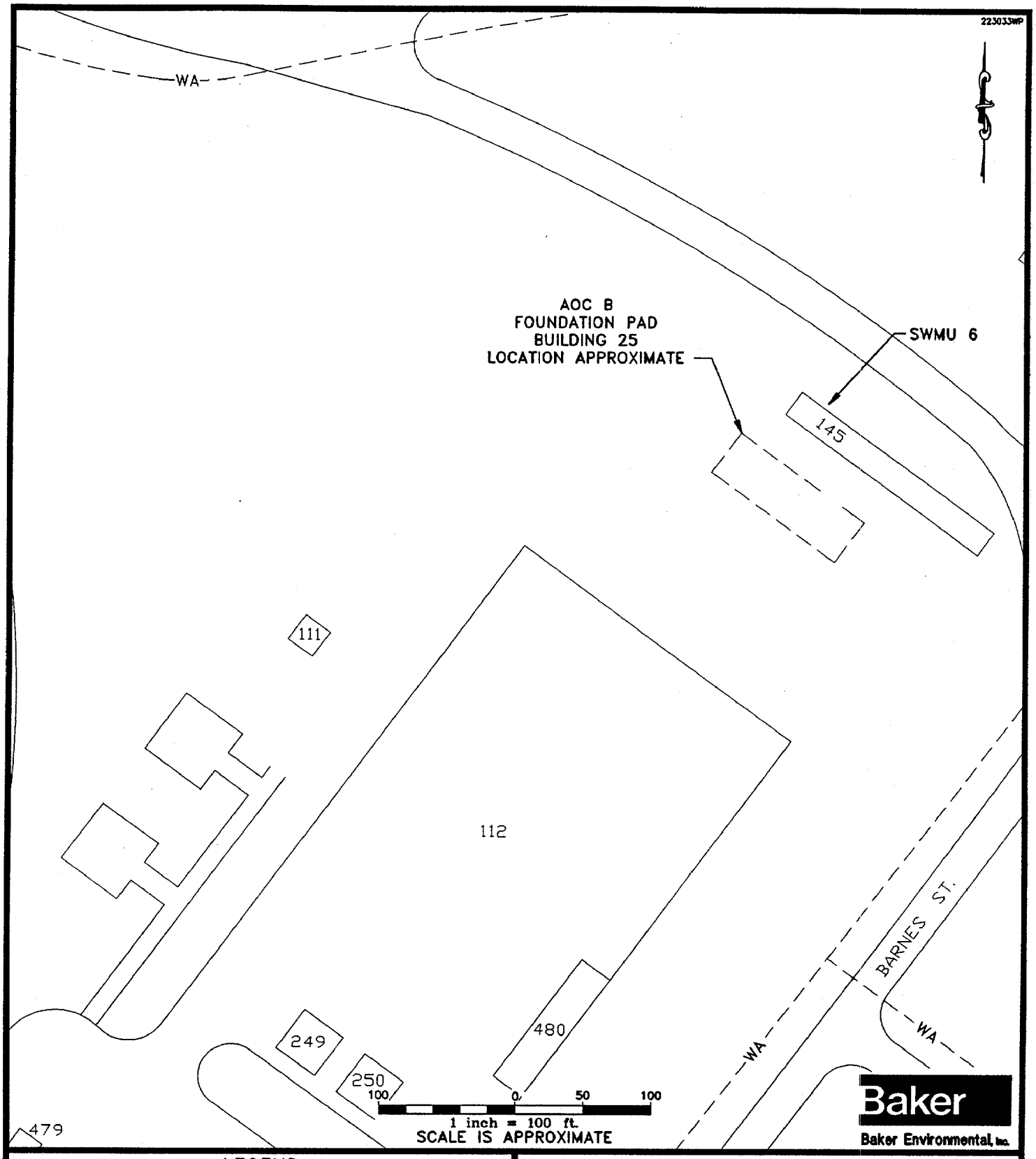


LEGEND

7GW01 EXISTING MONITORING WELL LOCATION

FIGURE 3-4
CURRENT CONDITIONS
RFI SWMU 3
BASE LANDFILL

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

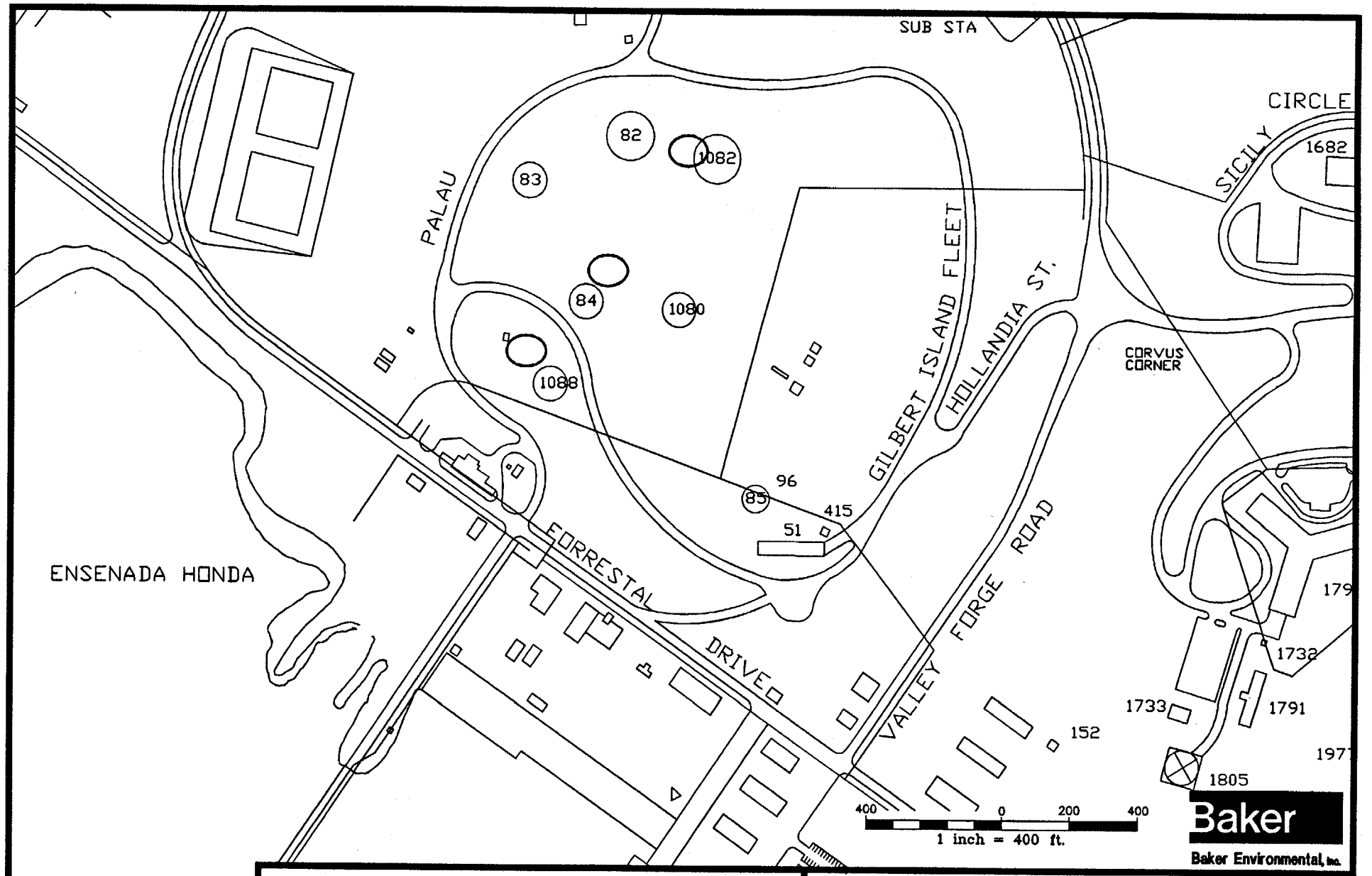
249 STATION STRUCTURE

– –WA– – WATERLINE

SOURCE: STATION PUBLIC WORKS BASE MAP, FEB. 1992
SOURCE: BAKER ENVIRONMENTAL GPS SURVEY, NOV. 1992

FIGURE 3–5
CURRENT CONDITIONS
RFI – AOC B AND SWMU 6
BUILDING 25 STORAGE AREA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



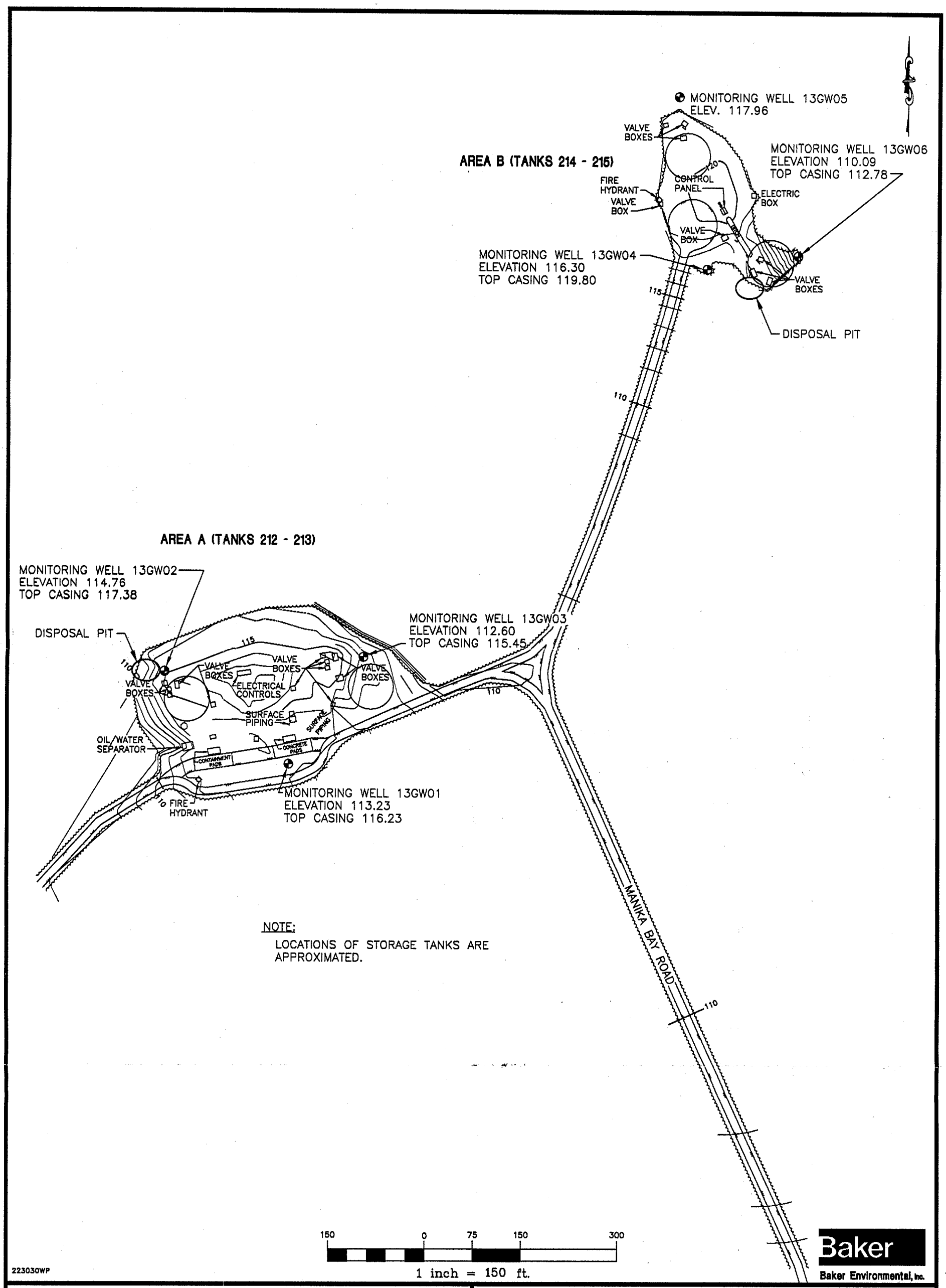
LEGEND

◯ – APPROXIMATE LOCATION OF KNOWN DISPOSAL PIT

SOURCE: LANTDIV, FEB. 1992

223028WP

FIGURE 3-6
CURRENT CONDITIONS
SWMUs 7 AND 8 TOW WAY FUEL FARM
AOC D
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:

LOCATIONS OF STORAGE TANKS ARE APPROXIMATED.

LEGEND

13GW01 EXISTING MONITORING WELL LOCATION

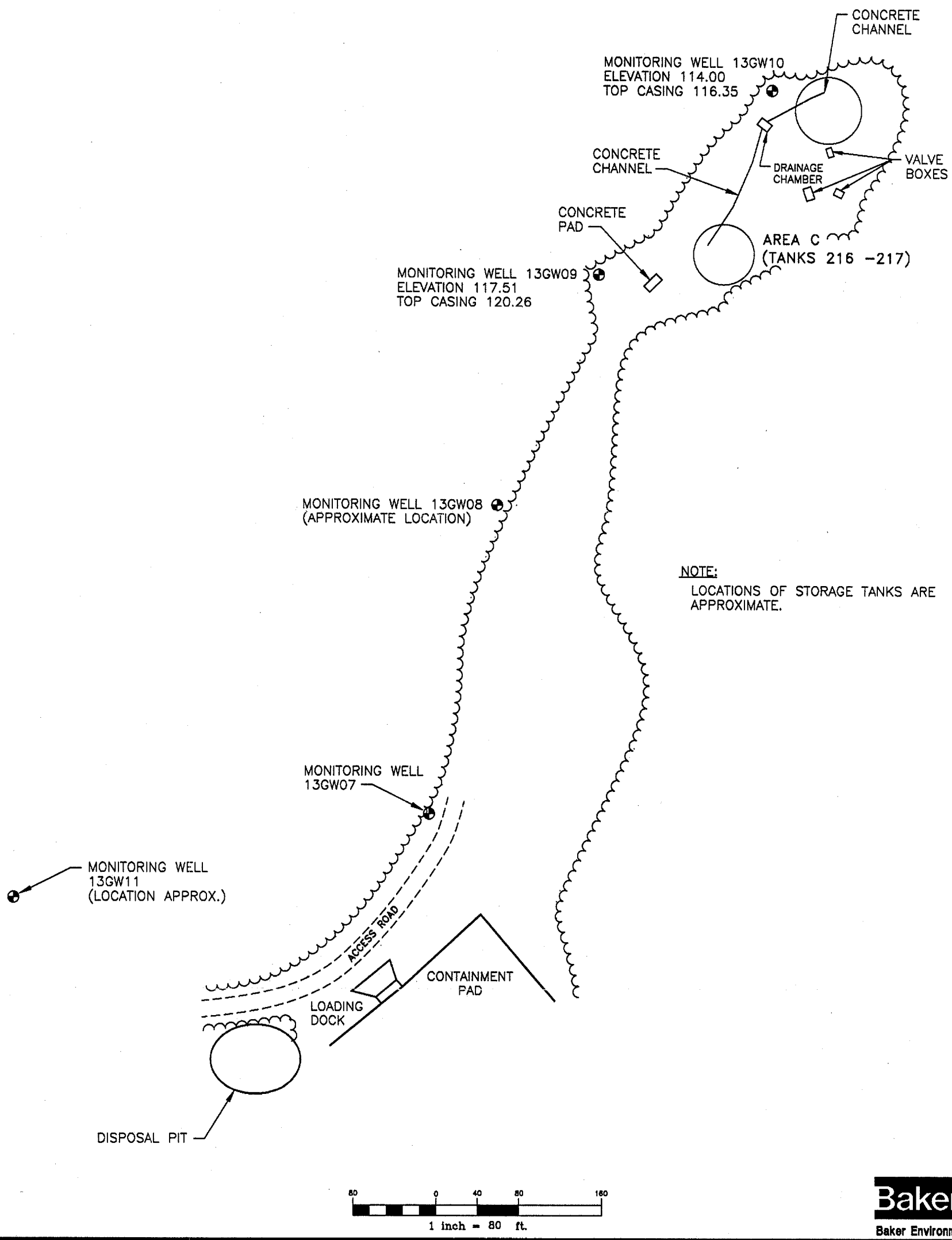
115 SURFACE ELEVATION CONTOUR

APPROXIMATE LOCATION OF DISPOSAL PIT

FIGURE 3-7
CURRENT CONDITIONS
RFI - SWMU 9, AREAS A AND B
TANKS 212 - 215

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

00170BB2Z



LEGEND

13GW07 EXISTING MONITORING WELL LOCATION

APPROXIMATE LOCATION OF DISPOSAL PIT

SOURCE: BAKER ENVIRONMENTAL, INC., MAY 1994

FIGURE 3-8
CURRENT CONDITIONS
RFI - SWMU 9, AREA C
TANKS 216 - 217

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

223024WP

FORRESTAL DRIVE

BUS STOP

115

120

125

SLOPE

125

120

115

120

115

TRANSFORMER PAD

ELECTRIC SUBSTATION NO. 2 WITH GRAVEL BASE

BLDG. NO. 90

113

110

VALLEY FORGE ROAD

Baker

Baker Environmental, Inc.

LEGEND

120 – CONTOUR LINE WITH ELEVATION

– BUILDING OR STRUCTURE

FIGURE 3–9
CURRENT CONDITIONS
RFI–SWMU 10 SUBSTATION 2/BUILDING 90

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

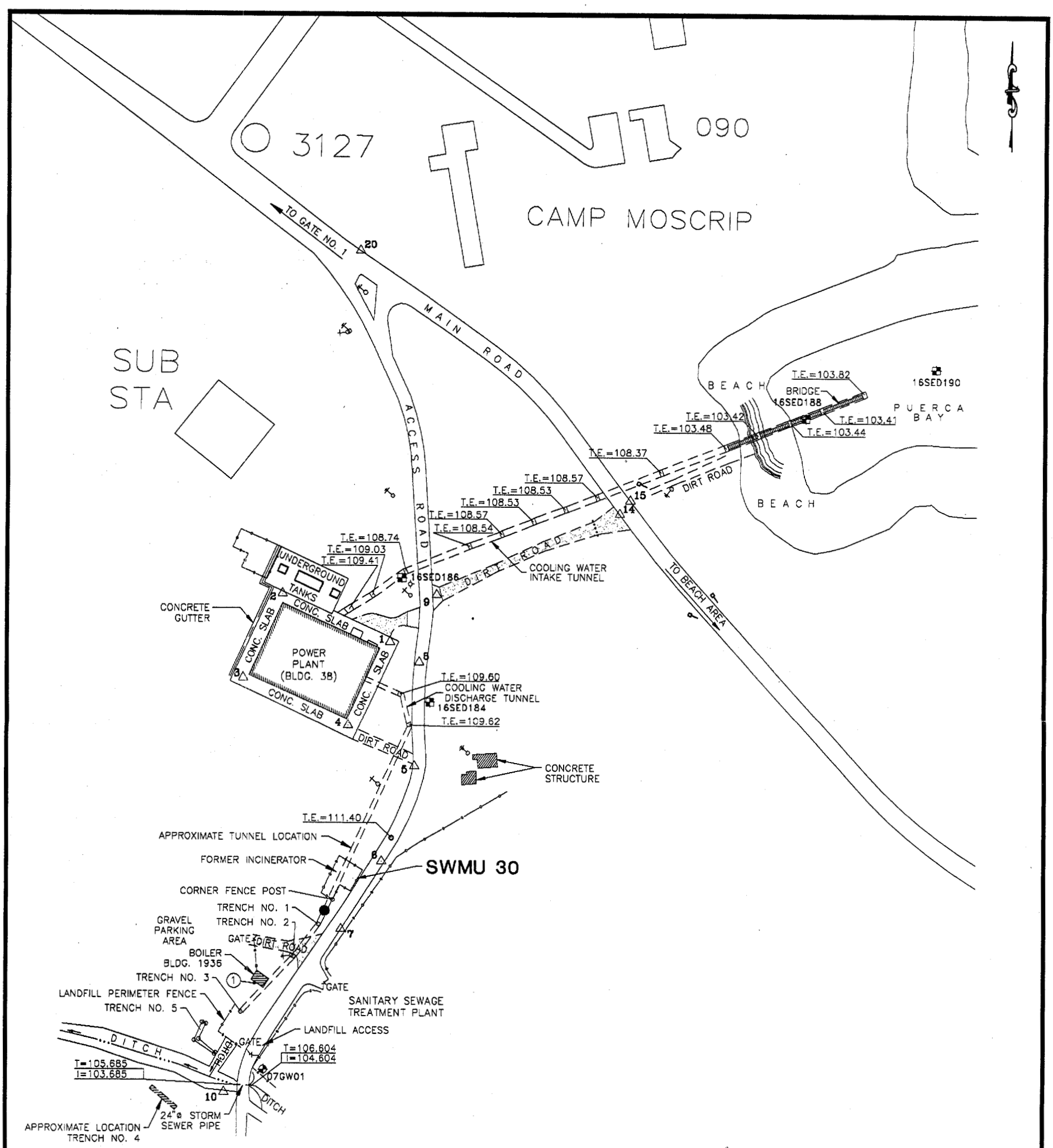
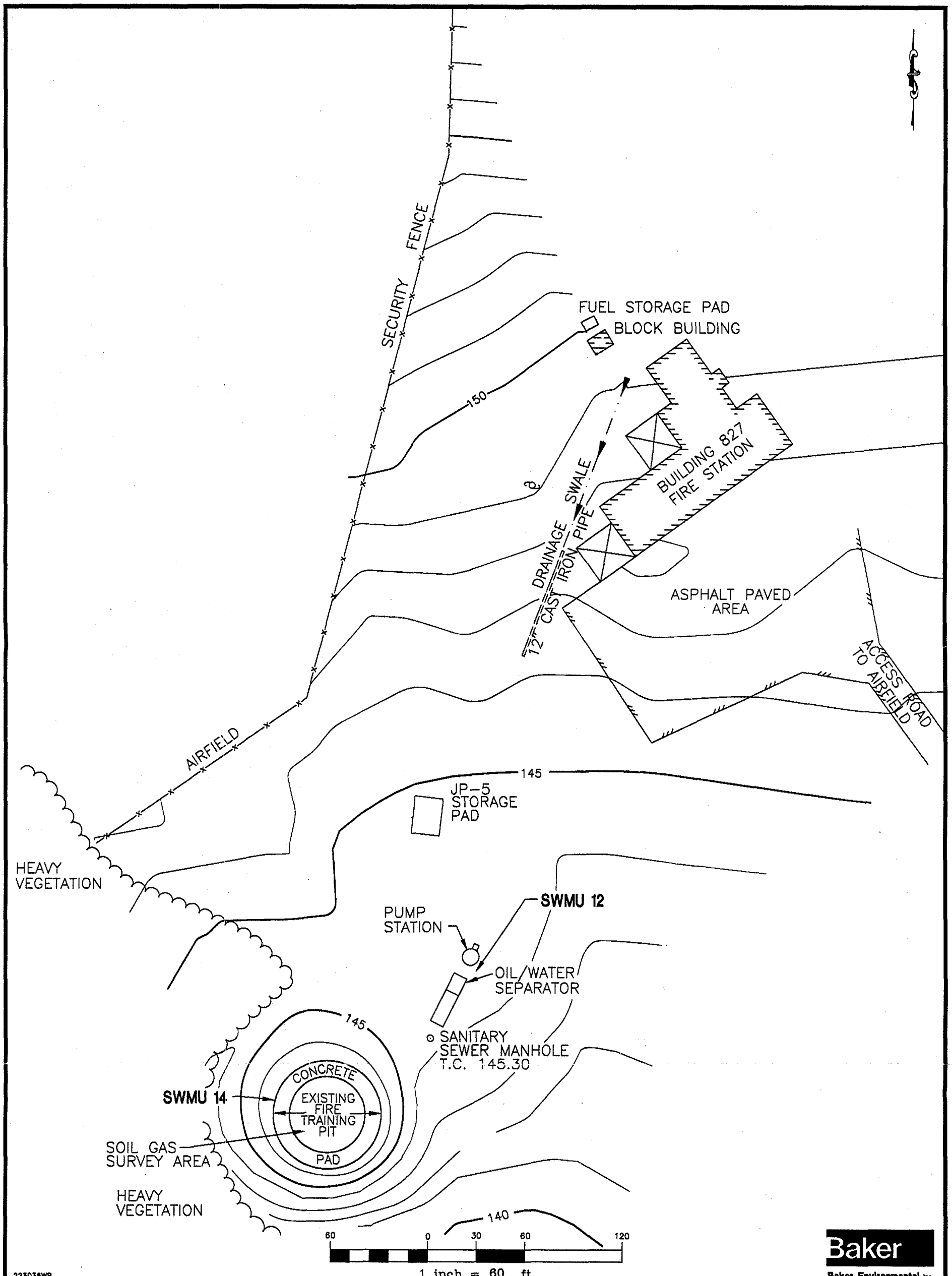


FIGURE 3-10
CURRENT CONDITIONS
RFI-SWMU 30, 11/45

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



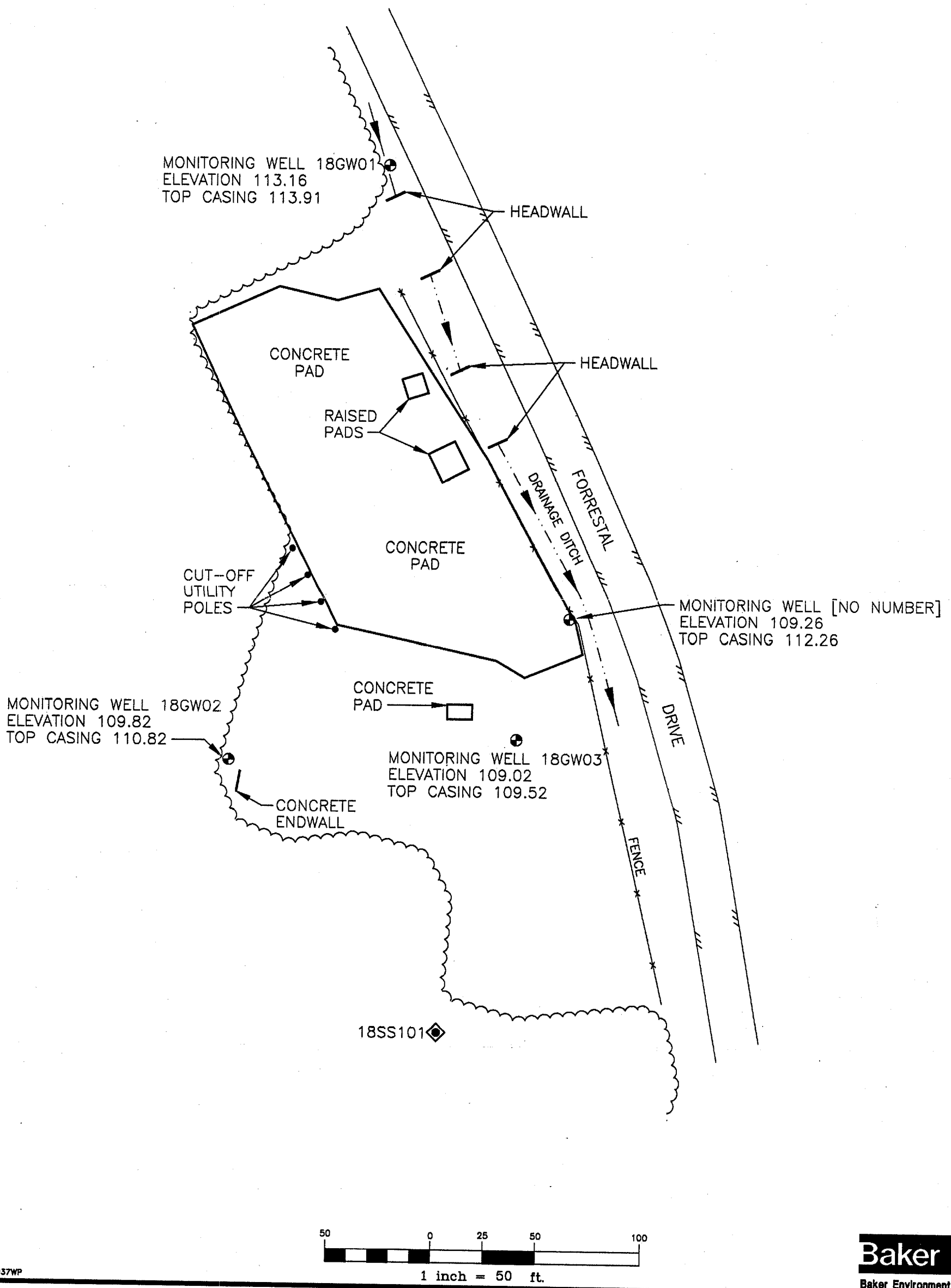
LEGEND

145 SURFACE ELEVATION CONTOUR

SURFACE WATER DRAINAGE DIRECTION

FIGURE 3-11
CURRENT CONDITIONS
RFI - SWMU 12-FIRE TRAINING PIT OIL/WATER SEPARATOR AND SWMU 14-FIRE TRAINING PIT AREA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



223037WP

Baker
Baker Environmental, Inc.

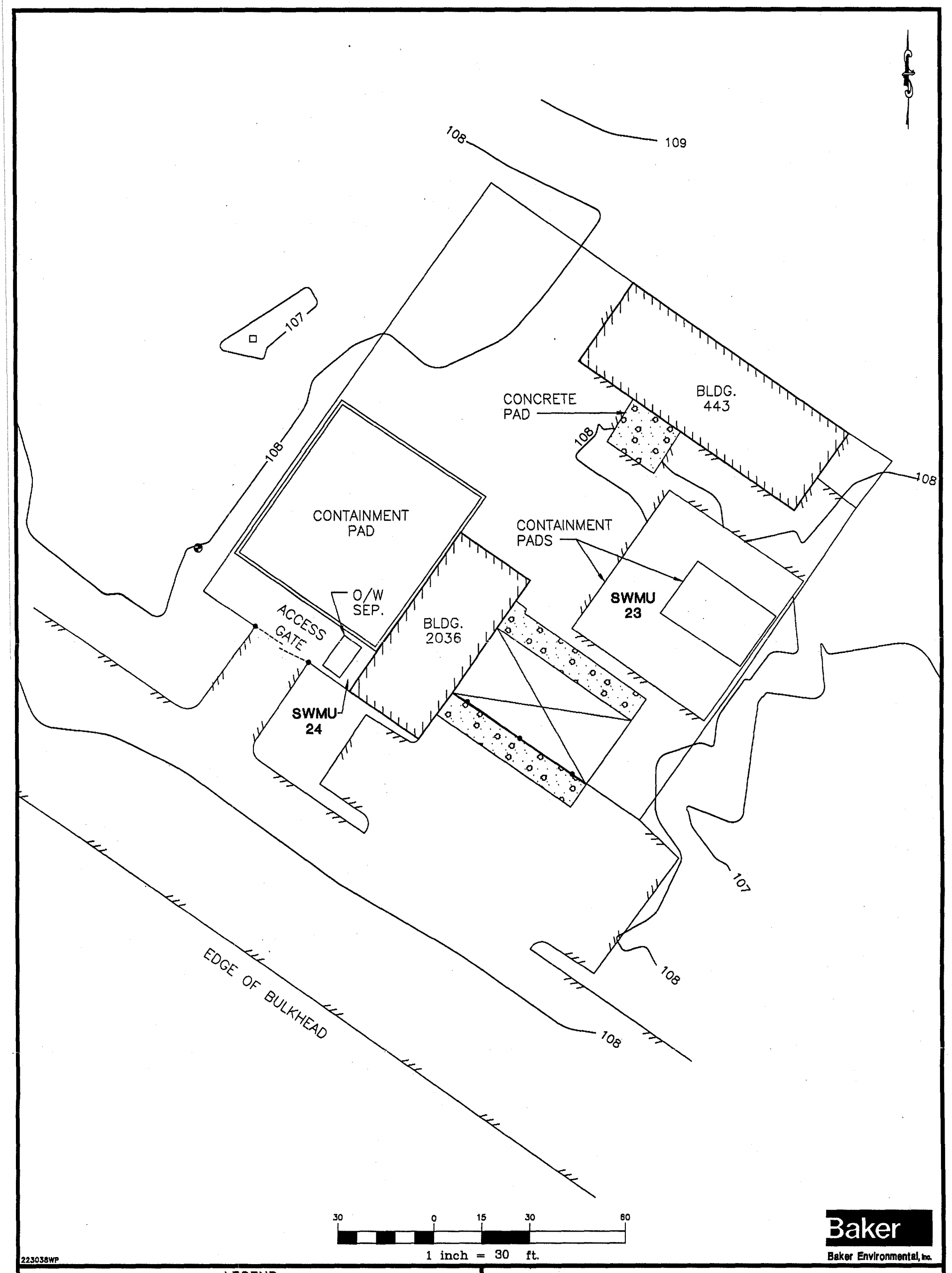
LEGEND

18GW03 EXISTING MONITORING WELL LOCATION

DRAINAGE DITCH/SURFACE DRAINAGE FLOW DIRECTION

FIGURE 3-12
CURRENT CONDITIONS
RFI - SWMU 13
PEST CONTROL SHOP AND SURROUNDING AREAS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- EXISTING MONITORING WELL LOCATION
- 108 SURFACE ELEVATION CONTOUR

FIGURE 3-13
CURRENT CONDITIONS
RFI - SWMU 23-OIL SPILL SEPARATOR TANKS
SWMU 24-OIL SPILL OIL/WATER SEPARATOR
AND ADJOINING PAD
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

223039WP

HEAVY
VEGETATION

FORRESTAL DRIVE

18" RCP

PAVED CHANNEL

PARKING AREA

120

125

130

135

FENCE

BUILDING 1973

125

OPEN STORAGE YARD

CONCRETE CHANNEL

INLET

DRUM STORAGE AREA

MANHOLE

LOADING RAMP

SWMU 25

MATERIAL STORAGE RACKS

18" RCP

BLDG. 2009

BUILDING 2010

FENCE

140

HEADWALL

130

135

140

Baker

Baker Environmental, Inc.

LEGEND

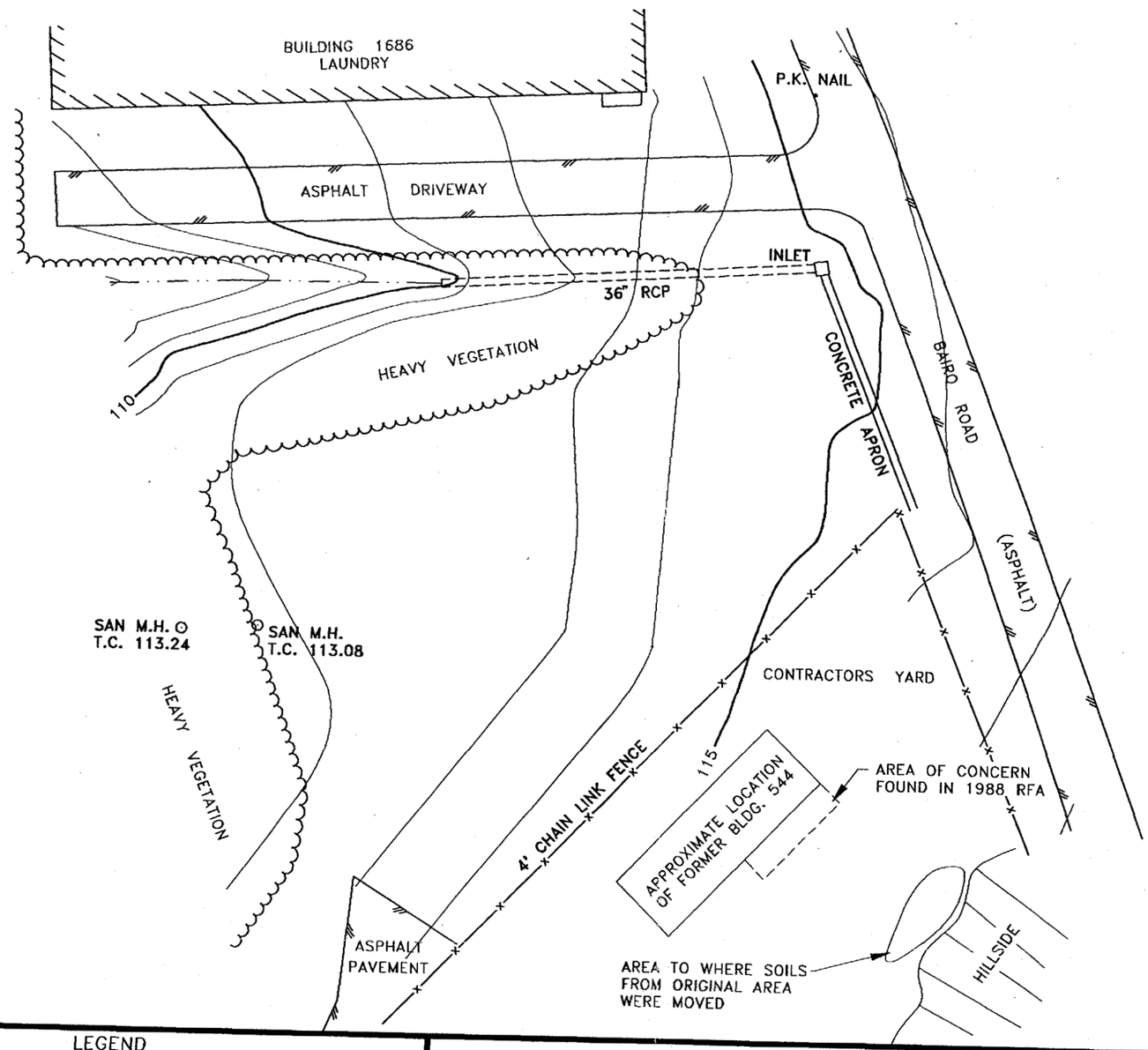
130 SURFACE ELEVATION CONTOUR

60 0 30 60 120

1 inch = 60 ft.

FIGURE 3-14
CURRENT CONDITIONS
RFI - SWMU 25
DRMO STORAGE AREA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



Baker
Baker Environmental, Inc.

LEGEND

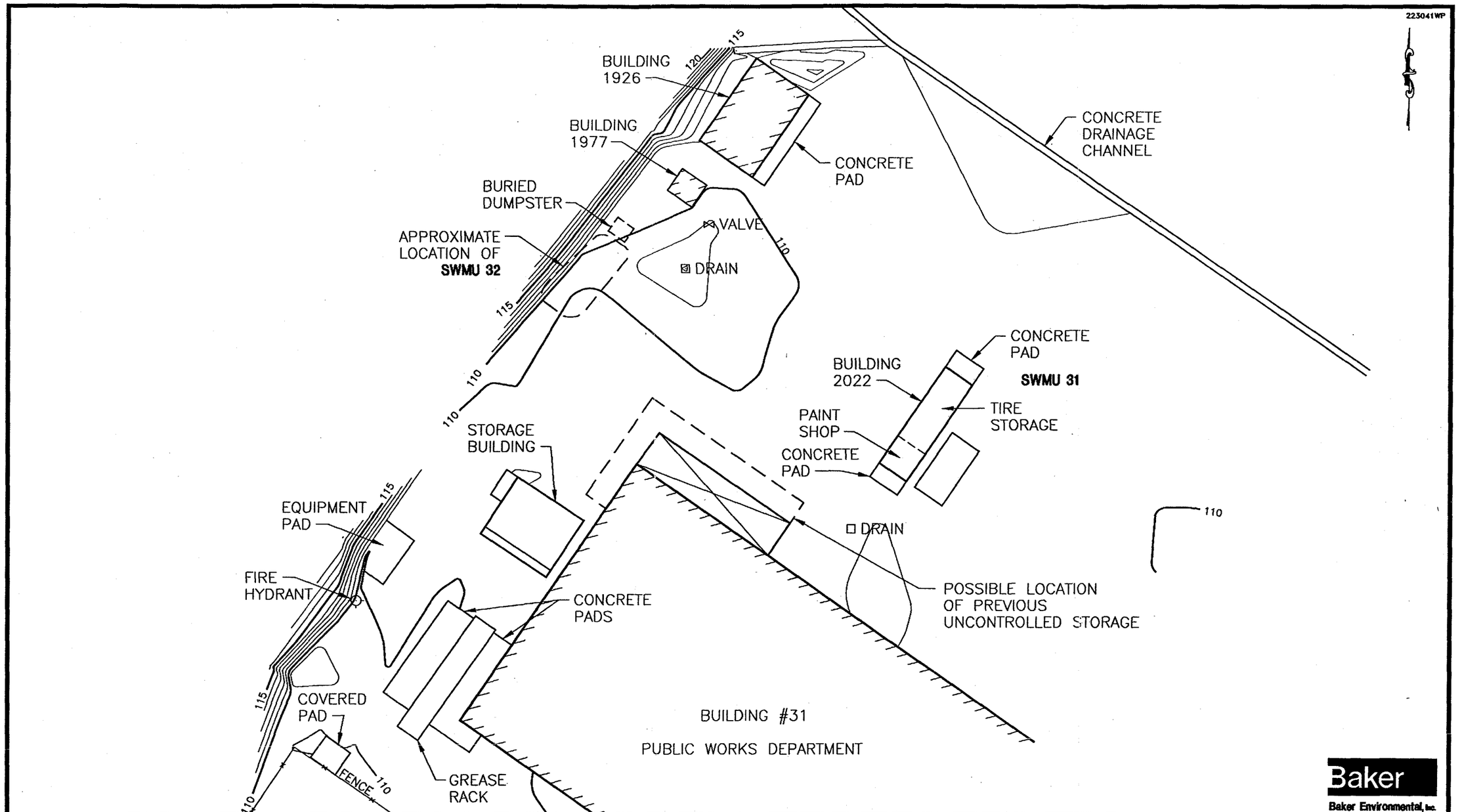
110 SURFACE ELEVATION CONTOURS

50 0 25 50 100

1 inch = 50 ft.

FIGURE 3-15
CURRENT CONDITIONS
RFI - SWMU 26
BUILDING 544 AREA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



Baker
Baker Environmental, Inc.

LEGEND

110 SURFACE ELEVATION CONTOUR

60 0 30 60 120

1 inch = 60 ft.

FIGURE 3-16
CURRENT CONDITIONS
RFI – SWMU 31–WASTE OIL COLLECTION AREA/ BLDGS. 31 & 2022 AND SWMU 32–PWD STORAGE YARD/BATTERY COLLECTION AREA/BLDG. 31
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

223042WP

COVERED STORAGE
STORAGE CONTAINERS
ABOVE GROUND PIPING
115
SWMU 37
BITUMINOUS PAVEMENT
CONCRETE PAVEMENT
COVERED STORAGE
115
115
115
BUILDING 200
115
TRANSFORMER
GRASS AREA
TRAILER
115
CONCRETE CHANNEL
CONTAINMENT AREA
FUEL STORAGE
CONCRETE CHANNEL

Baker
Baker Environmental, Inc.

LEGEND

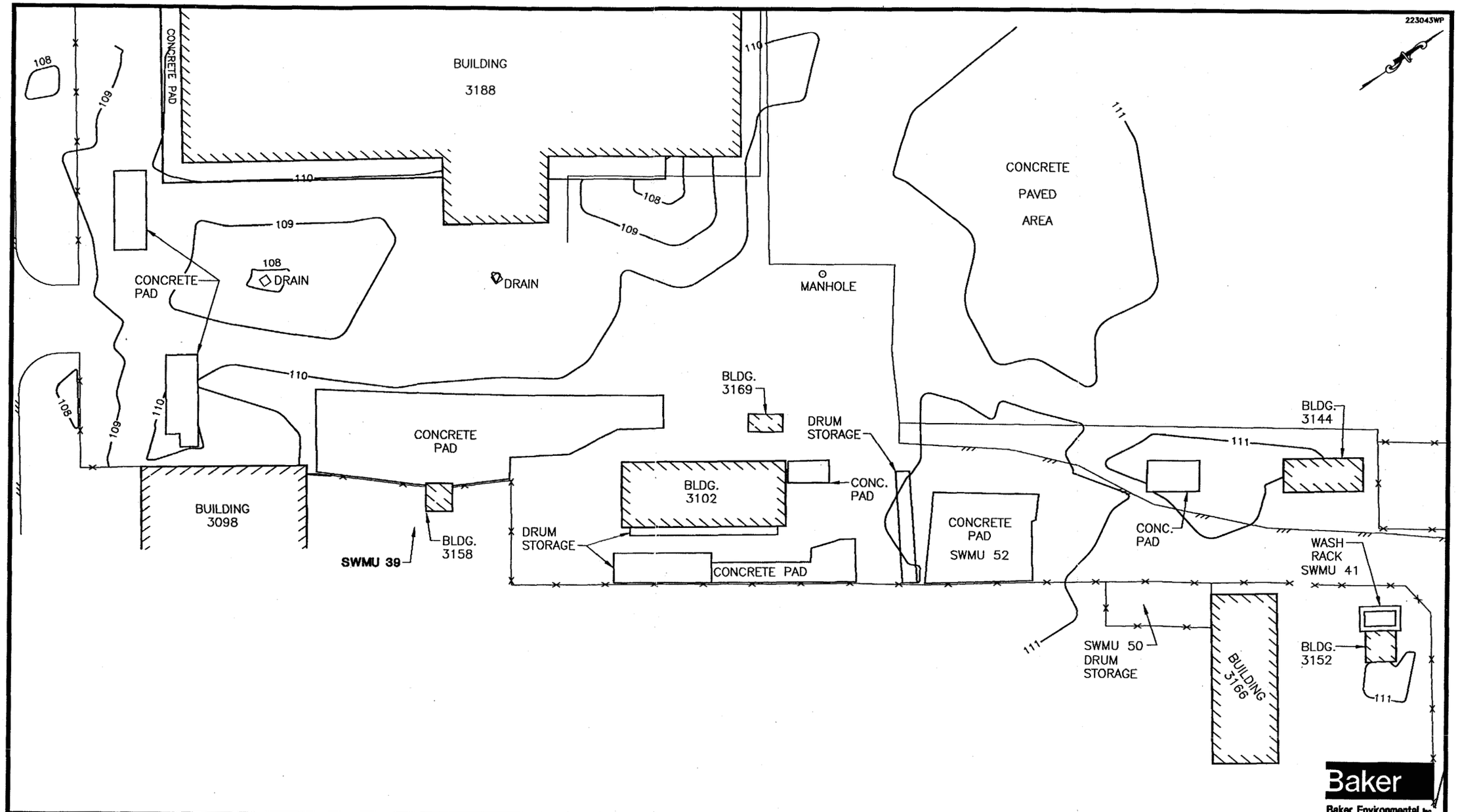
115 SURFACE ELEVATION CONTOUR

100 0 50 100 200

1 inch = 100 ft.

FIGURE 3-17
CURRENT CONDITIONS
RFI - SWMU 37
WASTE OIL STORAGE AREA/BLDG. 200

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

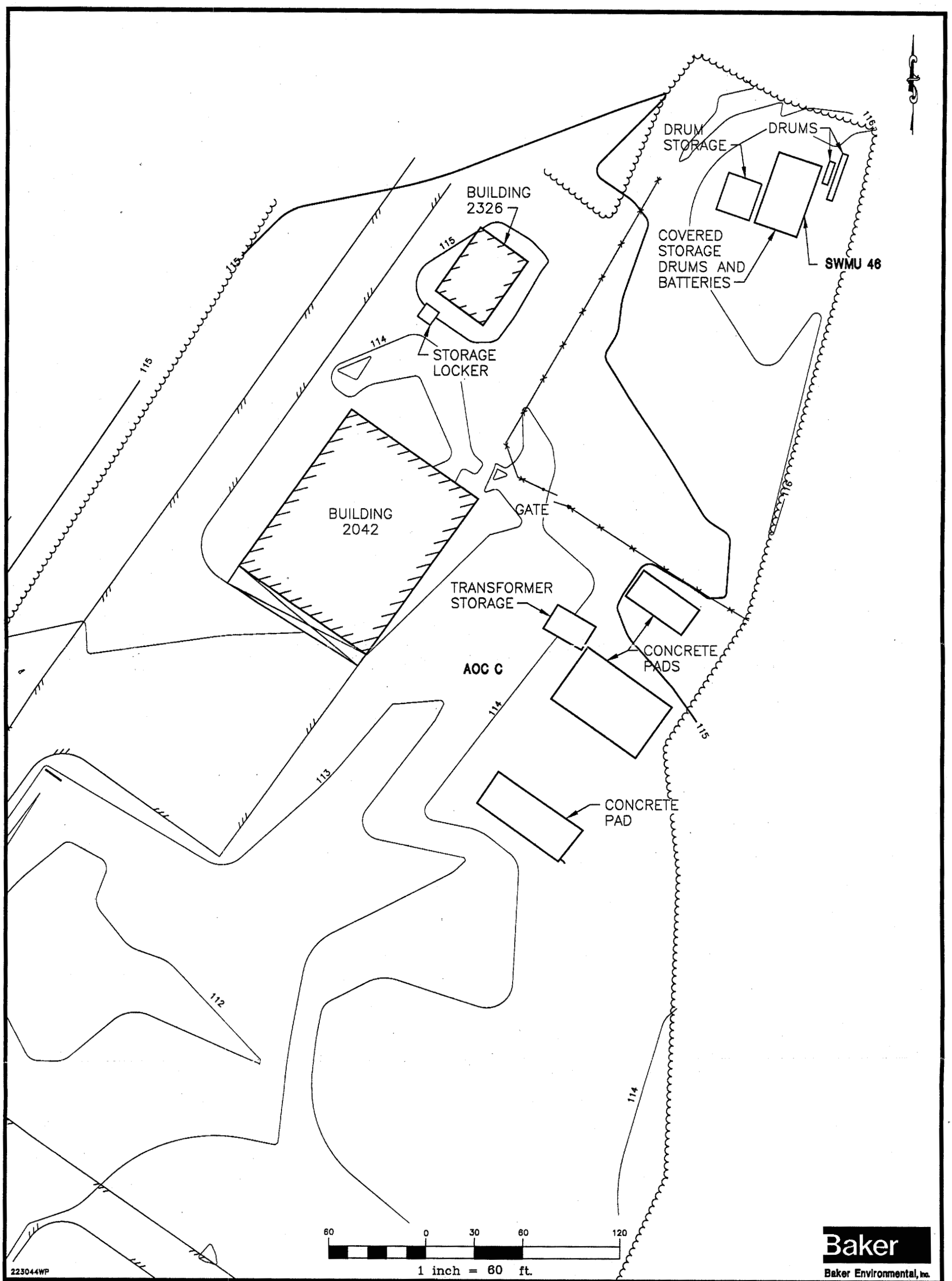
111 SURFACE ELEVATION CONTOUR

60 0 30 60 120

1 inch = 60 ft.

FIGURE 3–18
CURRENT CONDITIONS
RFI – SWMU 39
FORMER BATTERY DRAIN AREA/BLDG. 3158

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

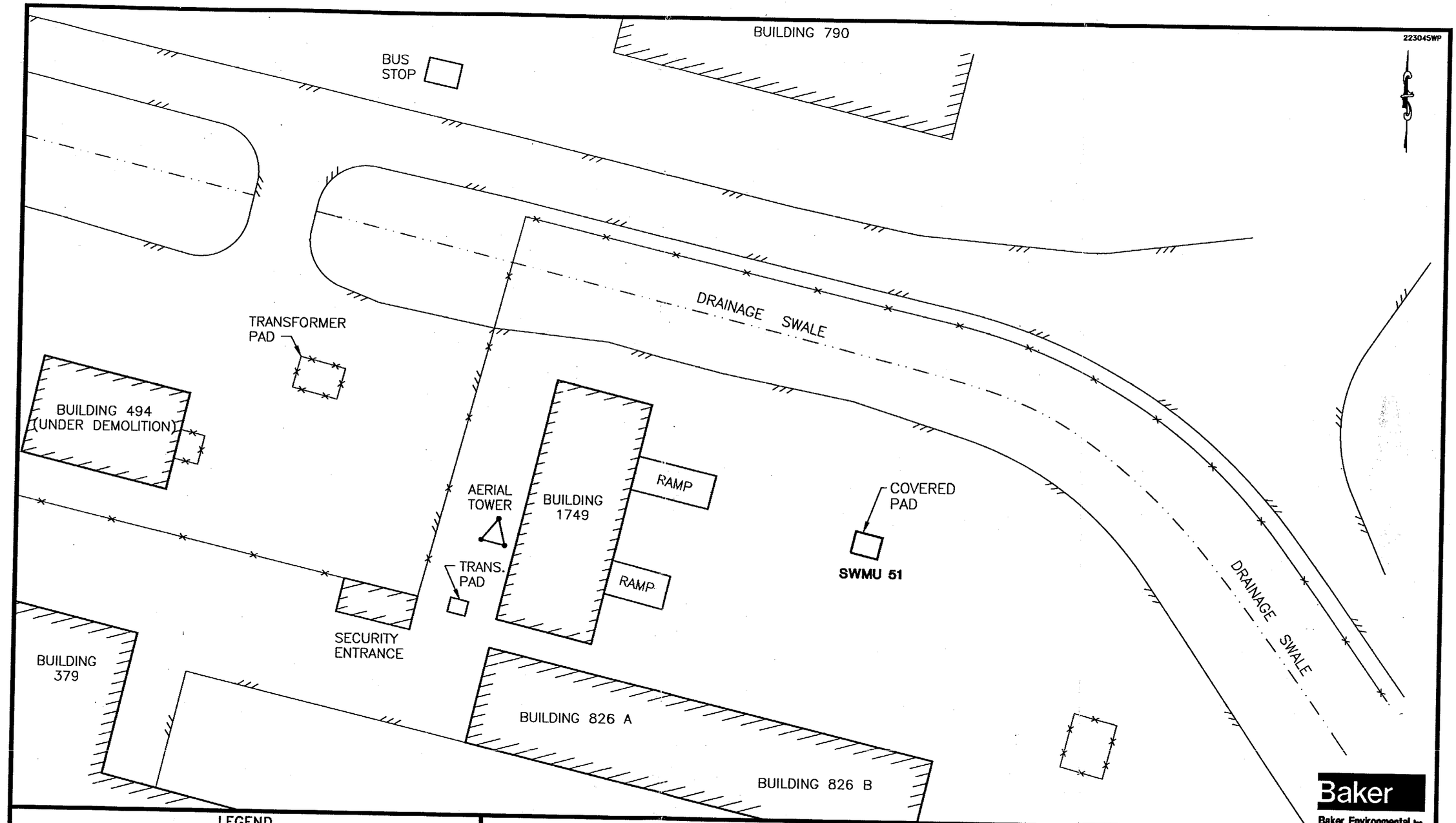


LEGEND

—115— SURFACE ELEVATION CONTOUR

FIGURE 3-19
CURRENT CONDITIONS
RFI - SWMU 46-POLE STORAGE YARD COVERED PAD AND AOC C-TRANSFORMER STORAGE PAD

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

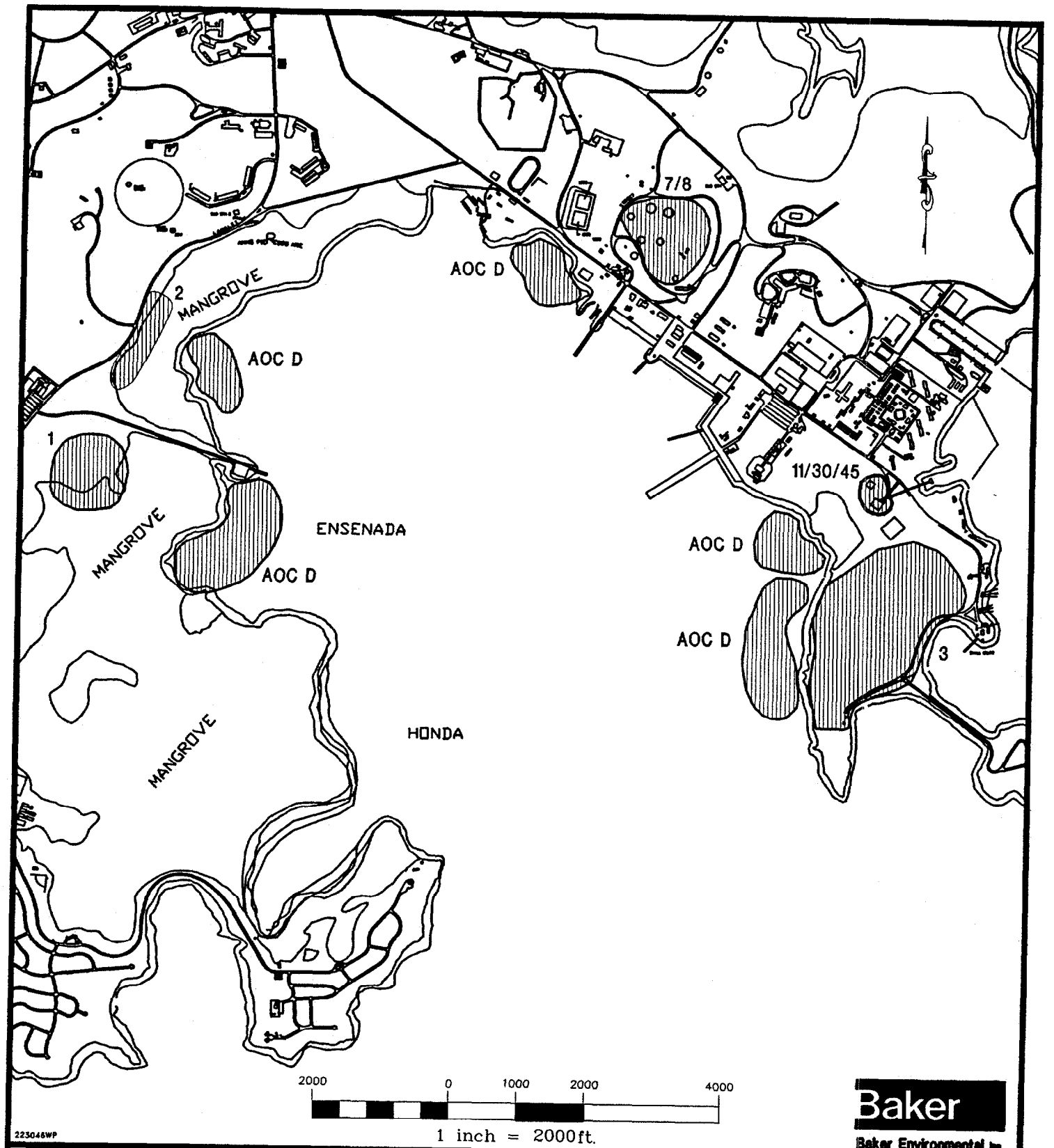
— · · — DRAINAGE SWALE

40 0 20 40 80

1 inch = 40 ft.

FIGURE 3–20
CURRENT CONDITIONS
RFI – SWMU 51

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

– SMWU/AOC

SOURCE: LANTDIV, FEB. 1992

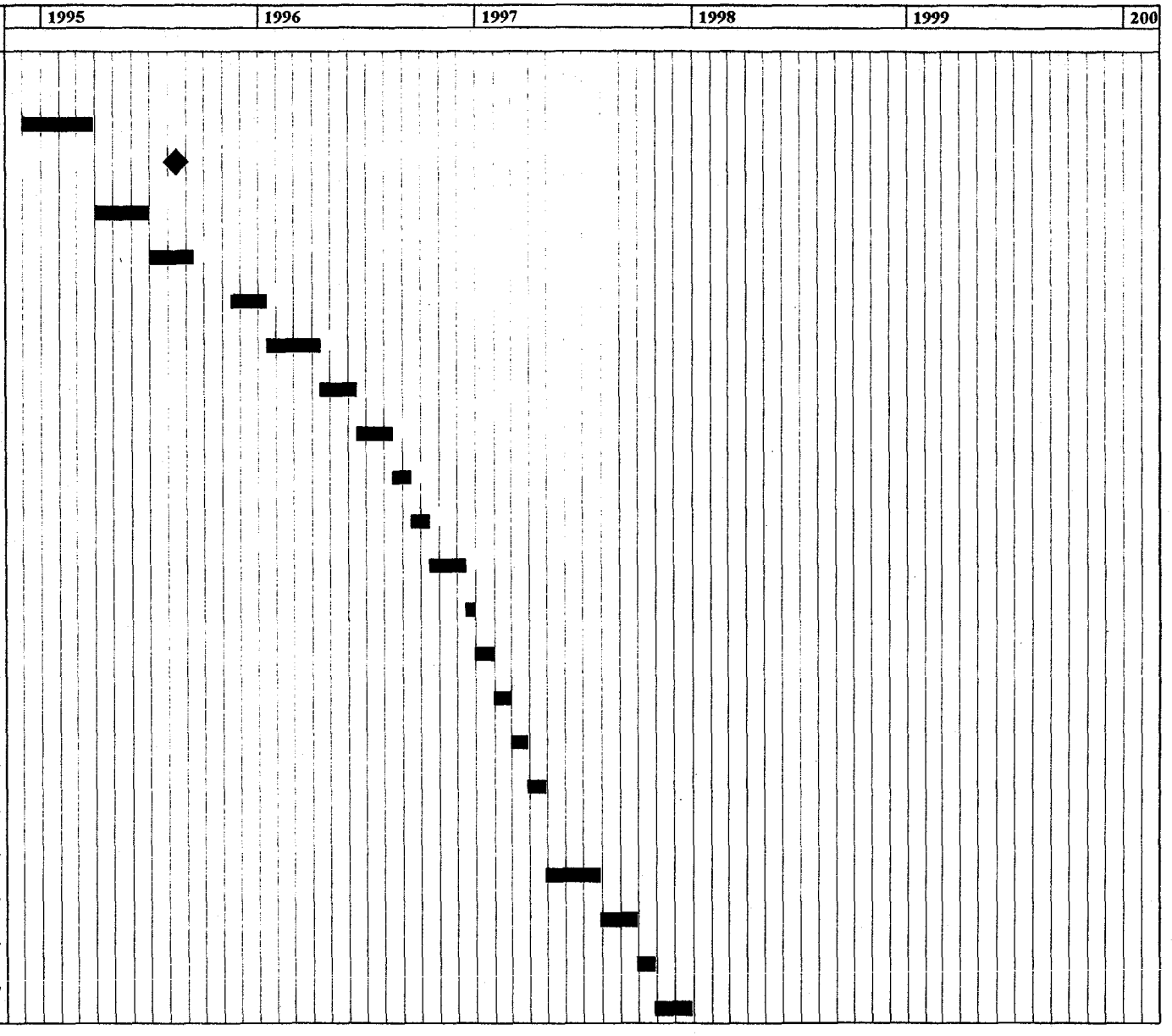
FIGURE 3–21
CURRENT CONDITIONS
AOC D ENSENADA HONDA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Figure 4-1

Project Schedule
Operable Units 1 and 2 - NSRR

Task	Duration	Start	Finish
Work Plans	204d	11/30/94	9/12/95
Draft	118ed	11/30/94	3/28/95
Meeting with EPA	0ed	8/15/95	8/15/95
Review	91ed	4/1/95	7/1/95
Final	73ed	7/1/95	9/12/95
Sub Procurement / Mobilization	61ed	11/15/95	1/15/96
Field Investigation	91ed	1/15/96	4/15/96
Laboratory Analysis	61ed	4/15/96	6/15/96
Validation	61ed	6/15/96	8/15/96
Data Summary & Recommendations	31ed	8/15/96	9/15/96
Work Plan Addendum	30ed	9/15/96	10/15/96
Review	61ed	10/15/96	12/15/96
Final	15ed	12/15/96	12/30/96
Mobilization	31ed	12/30/96	1/30/97
Field - SWMUS Upgraded to Full RFI	29ed	1/30/97	2/28/97
Laboratory Analysis	28ed	2/28/97	3/28/97
Validation	31ed	3/28/97	4/28/97
RFI Report	261d	4/28/97	4/28/98
Preliminary Draft	91ed	4/28/97	7/28/97
Review	62ed	7/28/97	9/28/97
Draft	30ed	9/28/97	10/28/97
Review	61ed	10/28/97	12/28/97

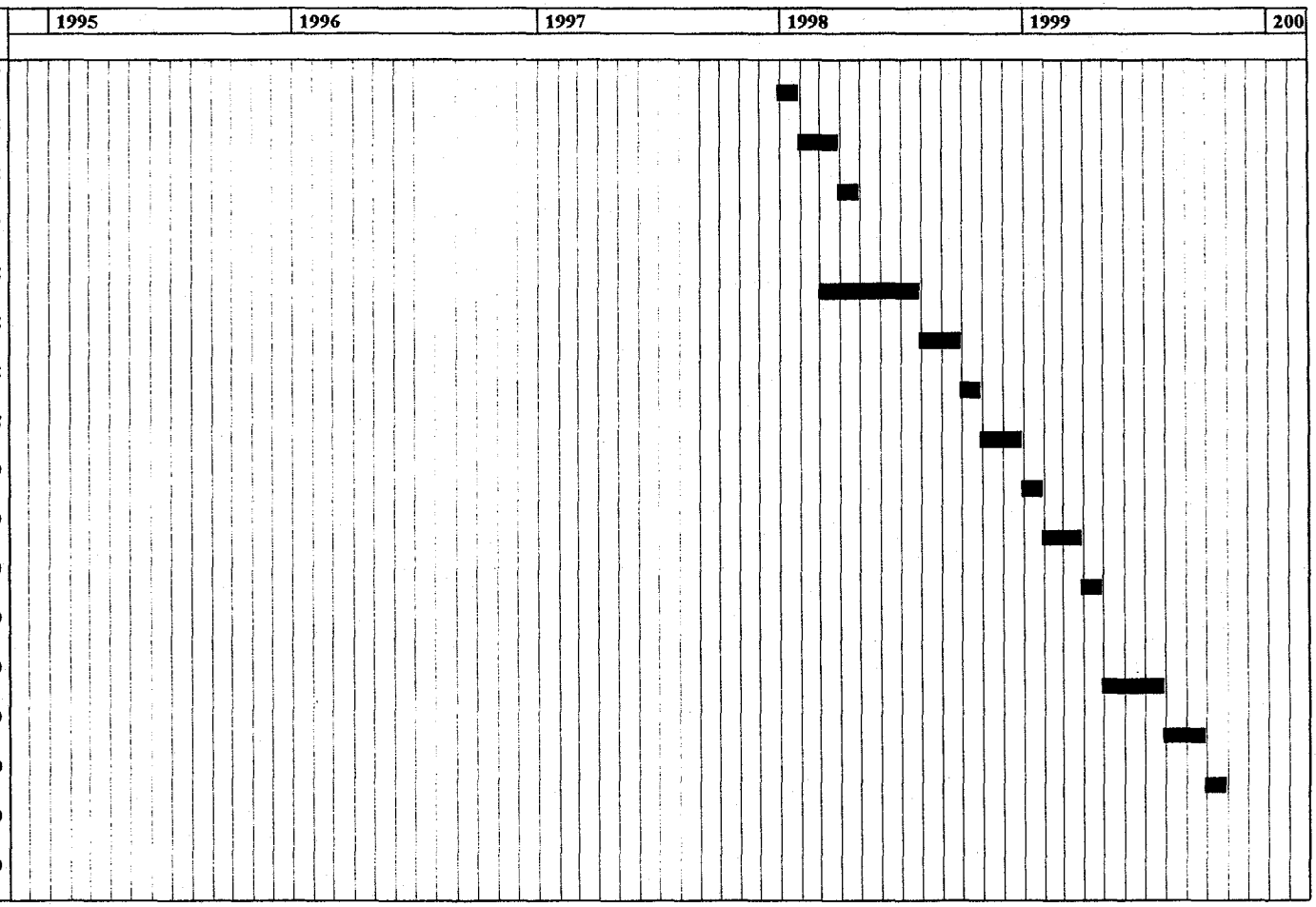


(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4-1

Project Schedule
Operable Units 1 and 2 - NSRR

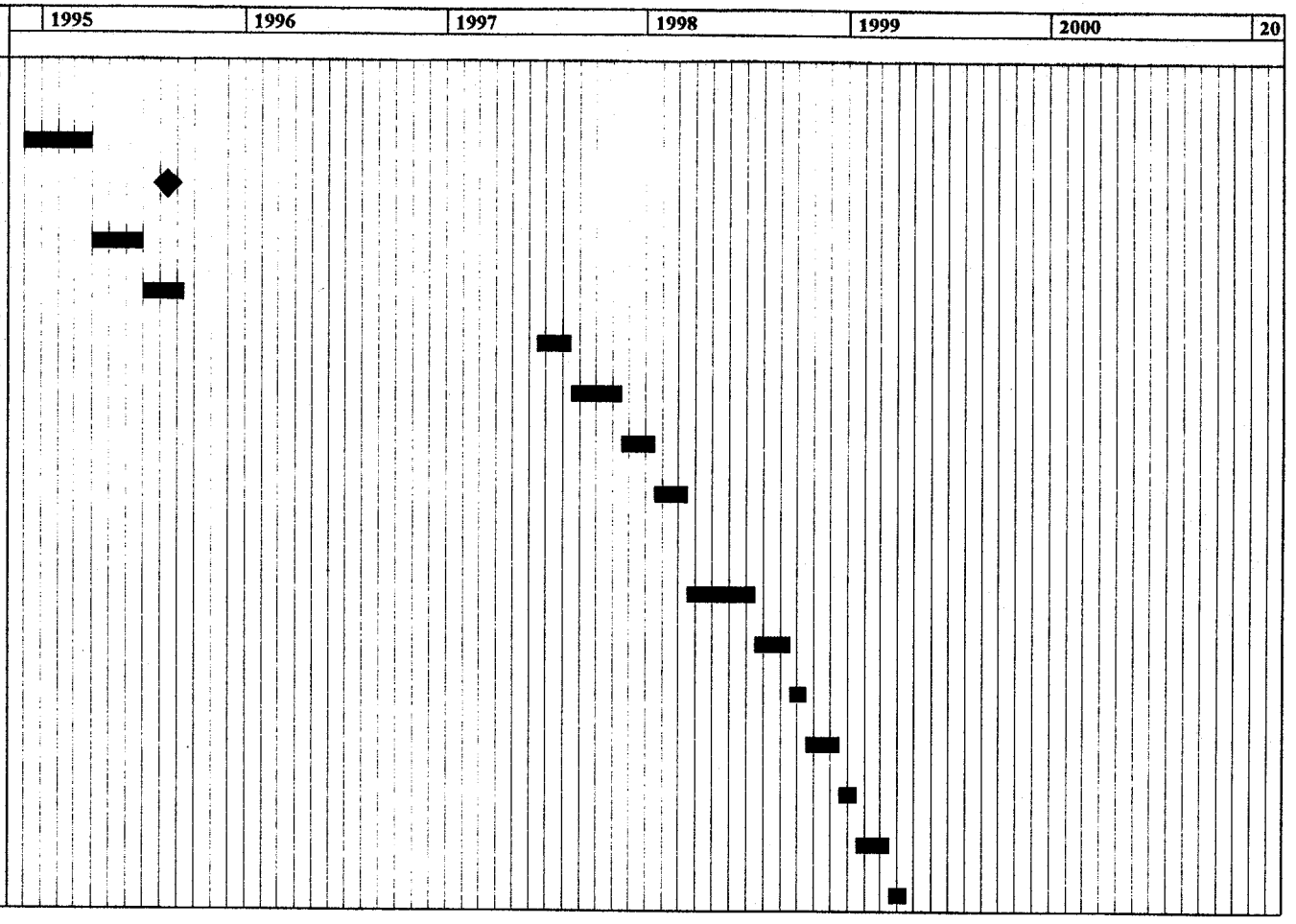
Task	Duration	Start	Finish
Draft Final	31ed	12/28/97	1/28/98
Review	59ed	1/28/98	3/28/98
Final	31ed	3/28/98	4/28/98
CMS Report	302d	2/28/98	4/28/99
Preliminary Draft	150ed	2/28/98	7/28/98
Review	62ed	7/28/98	9/28/98
Draft	30ed	9/28/98	10/28/98
Review	61ed	10/28/98	12/28/98
Draft Final	31ed	12/28/98	1/28/99
Review	59ed	1/28/99	3/28/99
Final	31ed	3/28/99	4/28/99
CMI	131d	4/28/99	10/28/99
Design	91ed	4/28/99	7/28/99
Review	62ed	7/28/99	9/28/99
Final	30ed	9/28/99	10/28/99
Implementation (1)	0d	10/28/99	10/28/99
Petition (2)	0d	10/28/99	10/28/99



(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4-2
Project Schedule
Operable Units 3 and 5 - NSRR

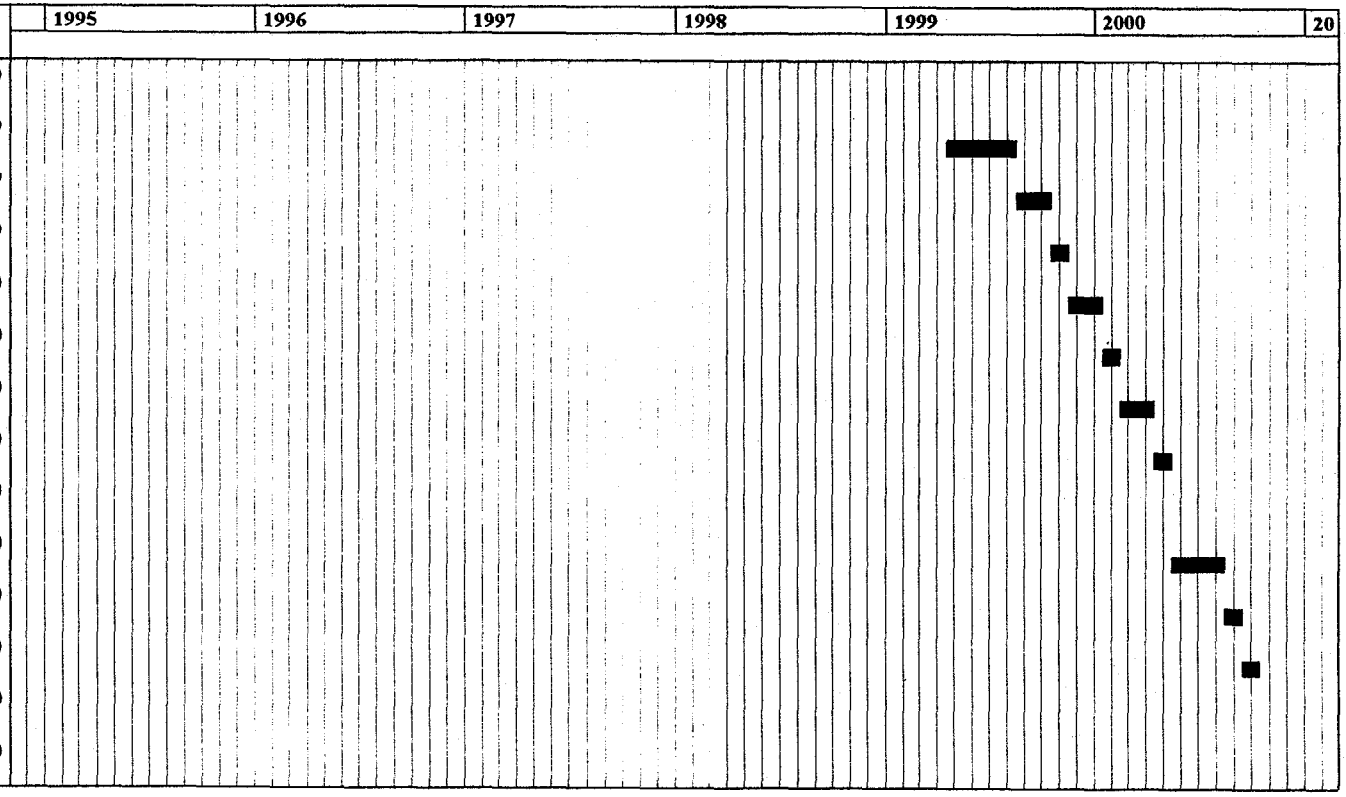
Task	Duration	Start	Finish
Work Plans	204d	11/30/94	9/12/95
Draft	122ed	11/30/94	4/1/95
Meeting with EPA	0ed	8/15/95	8/15/95
Review	91ed	4/1/95	7/1/95
Final	73ed	7/1/95	9/12/95
Sub Procurement / Mobilization	61ed	6/15/97	8/15/97
Field Investigation	92ed	8/17/97	11/17/97
Laboratory Analysis	61ed	11/17/97	1/17/98
Validation	59ed	1/17/98	3/17/98
RFI Report	284d	3/17/98	4/17/99
Preliminary Draft	122ed	3/17/98	7/17/98
Review	62ed	7/17/98	9/17/98
Draft	30ed	9/17/98	10/17/98
Review	61ed	10/17/98	12/17/98
Draft Final	31ed	12/17/98	1/17/99
Review	59ed	1/17/99	3/17/99
Final	31ed	3/17/99	4/17/99



(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4-2
Project Schedule
Operable Units 3 and 5 - NSRR

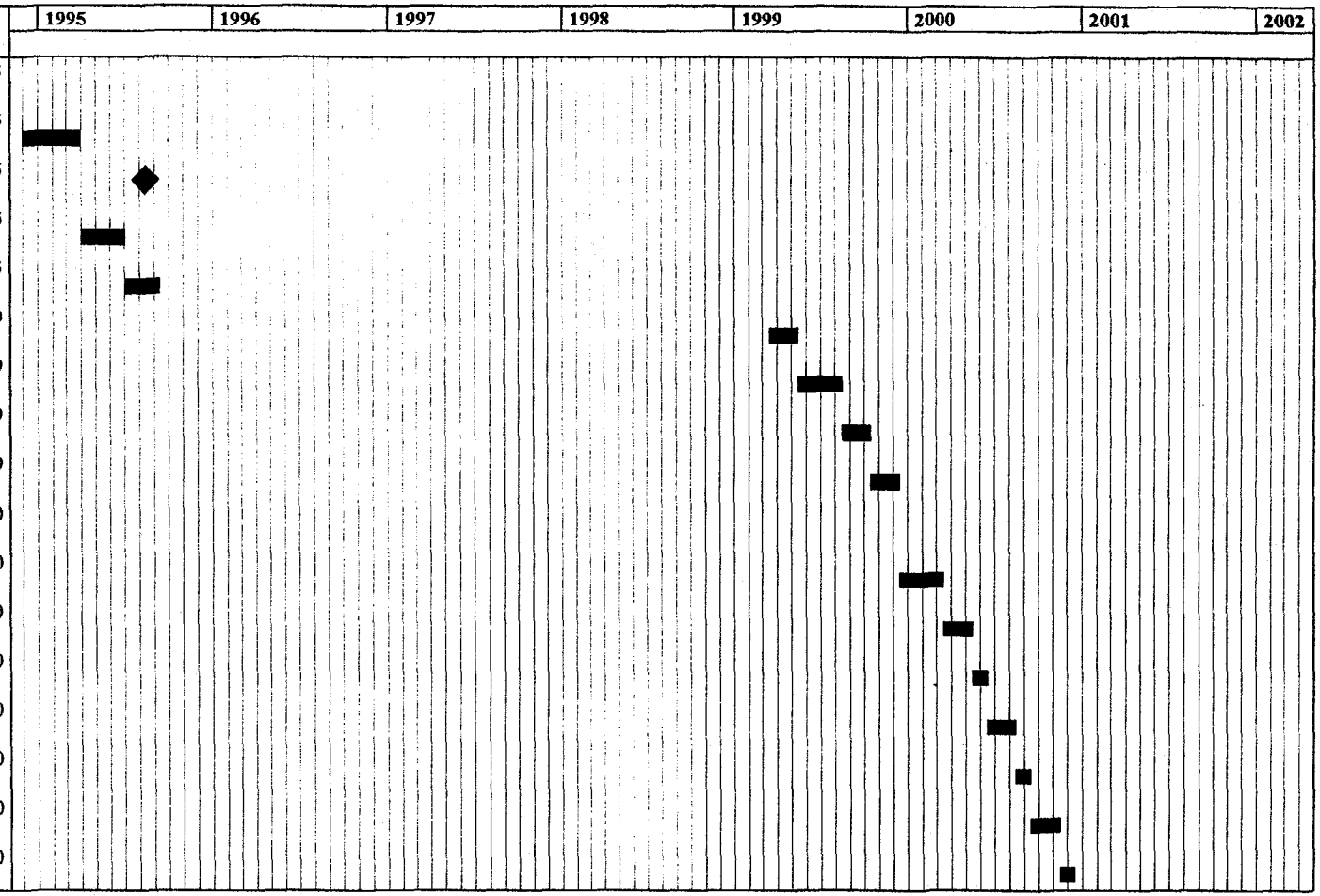
Task	Duration	Start	Finish
CMS Report	280d	4/17/99	5/15/00
Preliminary Draft	122ed	4/17/99	8/17/99
Review	61ed	8/17/99	10/17/99
Draft	31ed	10/17/99	11/17/99
Review	59ed	11/17/99	1/15/00
Draft Final	31ed	1/15/00	2/15/00
Review	60ed	2/15/00	4/15/00
Final	30ed	4/15/00	5/15/00
CMI	110d	5/15/00	10/15/00
Design Draft	92ed	5/15/00	8/15/00
Review	31ed	8/15/00	9/15/00
Final Desgin	30ed	9/15/00	10/15/00
Implementation (1)	0d	10/15/00	10/15/00
Petition (2)	0d	10/15/00	10/15/00



(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4-3
Project Schedule
Operable Units 4 and 6 - NSRR

Task	Duration	Start	Finish
Work Plans	204d	11/30/94	9/12/95
Draft	120ed	11/30/94	3/30/95
Meeting with EPA	0ed	8/15/95	8/15/95
Review	91ed	4/1/95	7/1/95
Final	73ed	7/1/95	9/12/95
Sub Procurement / Mobilization	61ed	3/15/99	5/15/99
Field Investigation	92ed	5/15/99	8/15/99
Laboratory Analysis	61ed	8/15/99	10/15/99
Validation	61ed	10/15/99	12/15/99
RFI Report	262d	12/15/99	12/15/00
Preliminary Draft	91ed	12/15/99	3/15/00
Review	61ed	3/15/00	5/15/00
Draft	31ed	5/15/00	6/15/00
Review	61ed	6/15/00	8/15/00
Draft Final	31ed	8/15/00	9/15/00
Review	61ed	9/15/00	11/15/00
Final	30ed	11/15/00	12/15/00

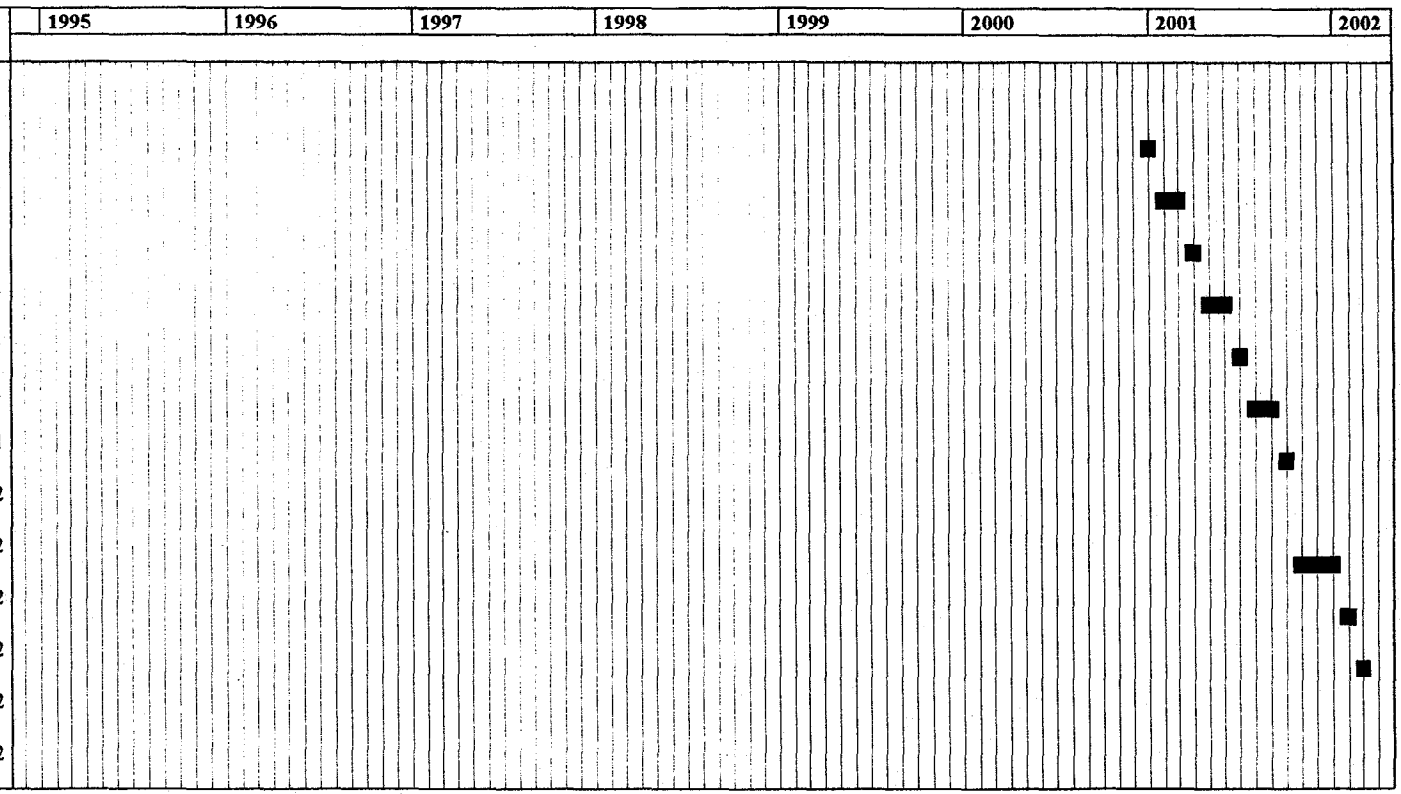


(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4-3

Project Schedule
Operable Units 4 and 6 - NSRR

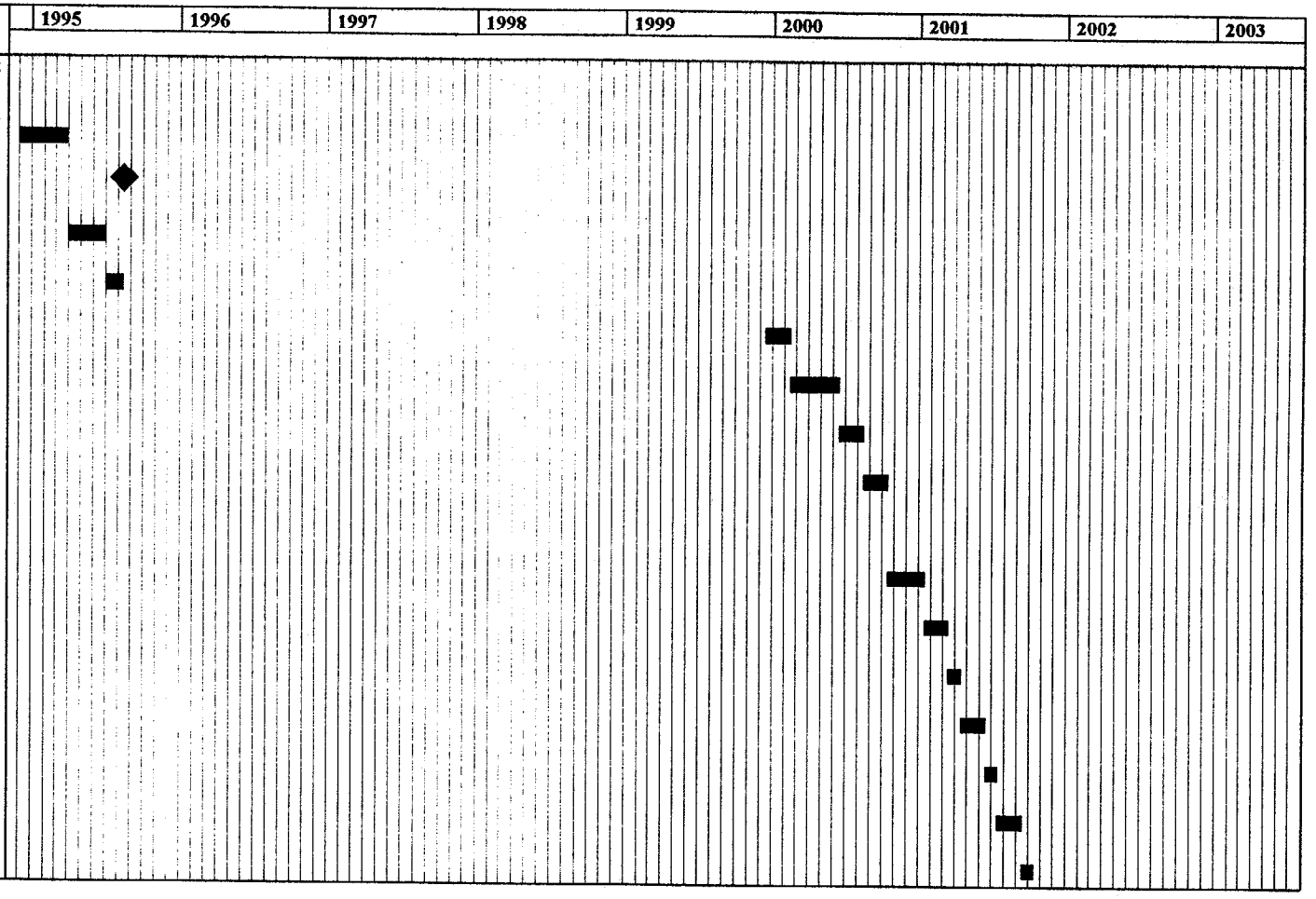
Task	Duration	Start	Finish
CMS Report	216d	12/15/00	10/15/01
Preliminary Draft	31ed	12/15/00	1/15/01
Review	59ed	1/15/01	3/15/01
Draft	31ed	3/15/01	4/15/01
Review	61ed	4/15/01	6/15/01
Draft Final	30ed	6/15/01	7/15/01
Review	62ed	7/15/01	9/15/01
Final	30ed	9/15/01	10/15/01
CMI	109d	10/15/01	3/15/02
Draft Design	92ed	10/15/01	1/15/02
Review	31ed	1/15/02	2/15/02
Final Design	28ed	2/15/02	3/15/02
Implementation (1)	0d	3/15/02	3/15/02
Petition (2)	0d	3/15/02	3/15/02



(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4-4
Project Schedule
Operable Units 7 - NSRR

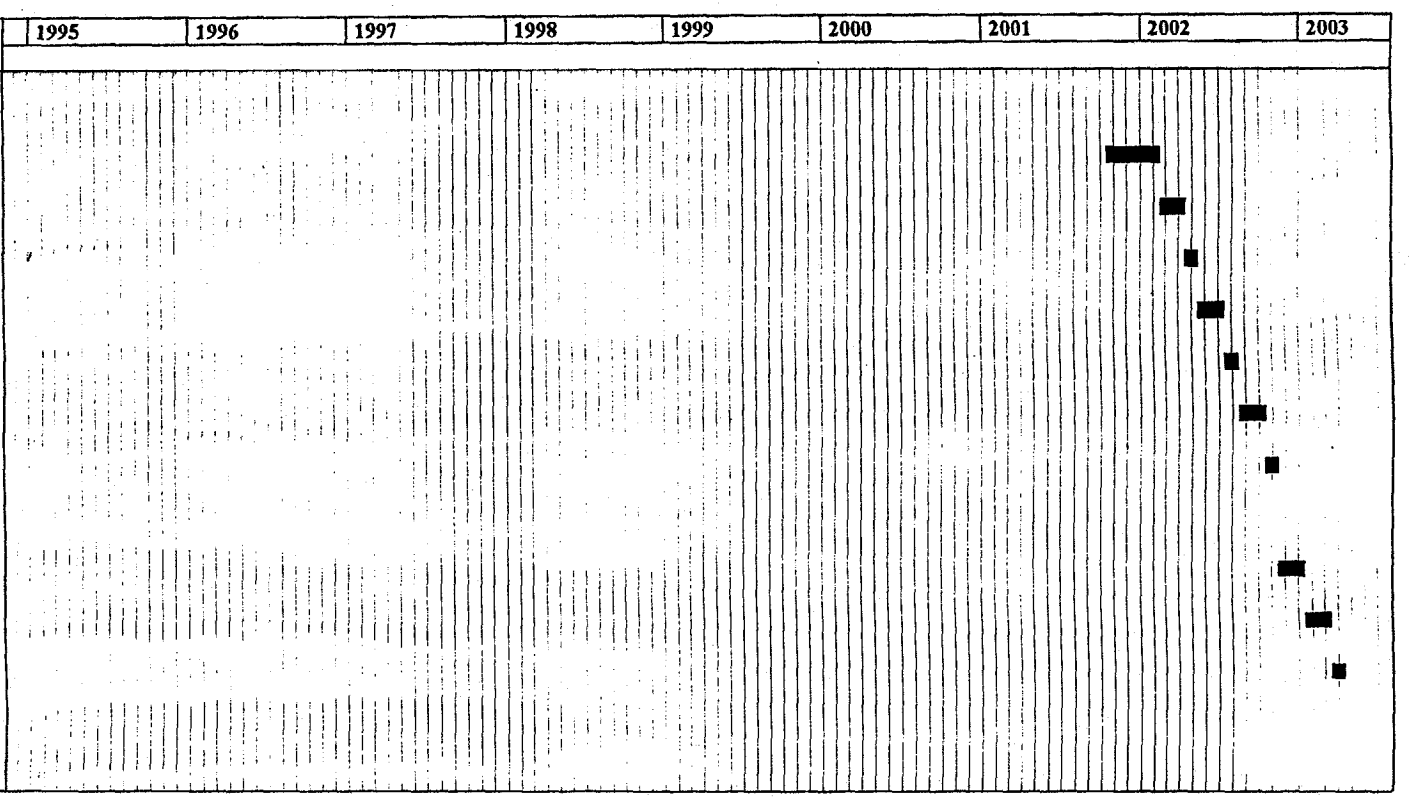
Task	Duration	Start	Finish
Work Plans	184d	11/30/94	8/15/95
Draft	118ed	11/30/94	3/28/95
Meeting with EPA	0ed	8/15/95	8/15/95
Review	91ed	4/1/95	7/1/95
Final	42ed	7/1/95	8/12/95
Sub Procurement / Mobilization	62ed	12/15/99	2/15/00
Field Investigation	121ed	2/15/00	6/15/00
Laboratory Analysis	61ed	6/15/00	8/15/00
Validation	61ed	8/15/00	10/15/00
RFI Report	260d	10/15/00	10/15/01
Preliminary Draft	92ed	10/15/00	1/15/01
Review	59ed	1/15/01	3/15/01
Draft	31ed	3/15/01	4/15/01
Review	61ed	4/15/01	6/15/01
Draft Final	30ed	6/15/01	7/15/01
Review	62ed	7/15/01	9/15/01
Final	30ed	9/15/01	10/15/01



(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

Figure 4-4
Project Schedule
Operable Units 7 - NSRR

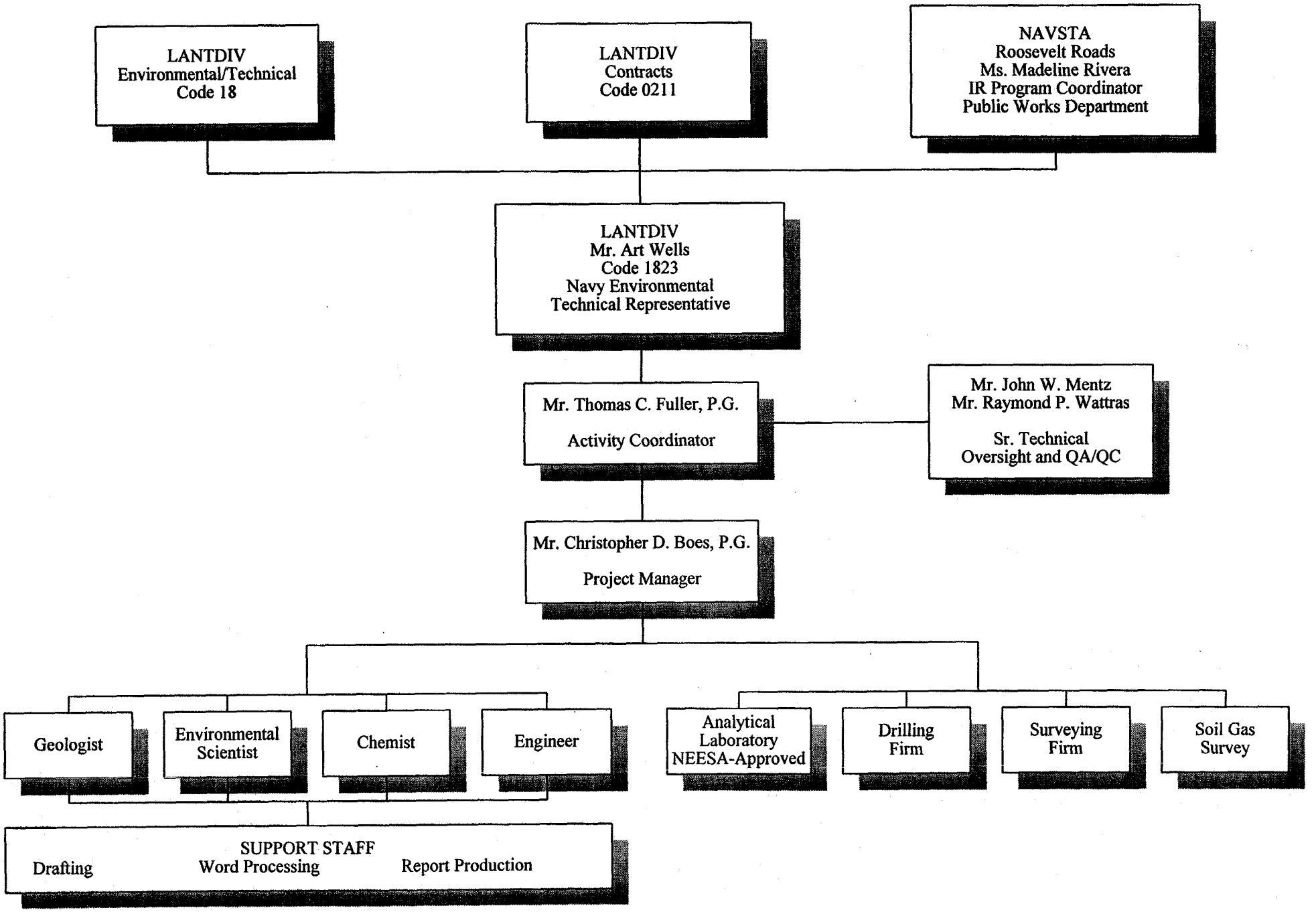
Task	Duration	Start	Finish
CMS Report	284d	10/15/01	11/15/02
Preliminary Draft	123ed	10/15/01	2/15/02
Review	59ed	2/15/02	4/15/02
Draft	30ed	4/15/02	5/15/02
Review	61ed	5/15/02	7/15/02
Draft Final	31ed	7/15/02	8/15/02
Review	61ed	8/15/02	10/15/02
Final	31ed	10/15/02	11/15/02
CMI	107d	11/15/02	4/15/03
Draft Design	61ed	11/15/02	1/15/03
Review	59ed	1/15/03	3/15/03
Final	31ed	3/15/03	4/15/03
Implementation (1)	0d	4/15/03	4/15/03
Petition (2)	0d	4/15/03	4/15/03



(1) Determined by Scope of Remedial Measures (2) To be started at end of Remediation

FIGURE 5-1

PROJECT ORGANIZATION



FINAL

DATA COLLECTION QUALITY ASSURANCE PLAN

RCRA FACILITY INVESTIGATION
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

CONTRACT TASK ORDER 0223

SEPTEMBER 14, 1995

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

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Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

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6-1 Project Organization

1.0 INTRODUCTION

This document presents the Data Collection Quality Assurance Plan (DCQAP) 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 RCRA Corrective Action Permit. A complete list of these SWMUs/AOCs is presented in Table 1-1.

This DCQAP has been prepared by Baker Environmental, Inc. (Baker) under the Naval Facilities Engineering Command (NAVFACENGCOM), Atlantic Division (LANTDIV) Contract Number 62470-89-4814, Contract Task Order 0223 (CTO-0223).

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. A Resource Conservation and Recovery Act (RCRA) Part B permit has been issued for the Defense Reutilization and Marketing Office (DRMO) at NSRR which included provisions for corrective action under the Hazardous and Solid Waste Amendments (HSWA) provisions of RCRA. Environmental Activities at NSRR, exclusive of underground storage tanks, are now being conducted under RCRA guidelines based on this permit.

This DCQAP is one of five project plans associated with the RFI. Other RFI project plans include:

- Project Management Plan
- Data Management Plan
- Health and Safety Plan
- Community Relations Plan

This DCQAP addresses the quality assurance and quality control steps that will be administered for the sample collection and analysis during the RFI. Detailed information regarding sample handling and analytical methods are provided in Sections 7.0 and 9.0, respectively.

This DCQAP addresses the sample collection and analyses which are to be a part of the RFI at NSRR. The DCQAP has been developed for the Navy in accordance with the following guidance documents:

- "Interim Final RCRA Corrective Action Plan," USEPA, EPA/530-SW-88-028, June 1988

- "Interim Final RCRA Facility Investigation Guidance - Volume I," USEPA, EPA/530/SW-89-031, May 1989

In order to provide adequate QA/QC for samples which are collected and analyzed, this investigation will require:

1. Use of a NEESA-certified analytical laboratory.

2. Use of accepted analytical methods for the samples collected. Where possible, analysis of samples will be performed using "Test Methods for Evaluating Solid Waste" USEPA, SW-846, November 1986.

3. Field audit(s) during the initial sampling activities to verify that sampling is being performed according to the DCQAP.

The structure of this DCQAP and the QA elements addressed are:

- Title page
- Table of Contents
- Introduction
- Permit Requirements for DCQAP
- SWMU/AOC Status
- Data Collection Strategy and Requirements
- Field Investigation
- Project Organization

- Sample and Document Custody
- Calibration Procedures and Frequency
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal QC Checks
- Performance and System Audits
- Preventative Maintenance
- Data Measurement Assessment Procedure
- Corrective Action
- Quality Assurance Reporting Procedures

2.0 PERMIT REQUIREMENTS FOR DATA COLLECTION QUALITY ASSURANCE PLAN

The RCRA Corrective Action Permit (Module III, Appendix A, Section V) specifies the items to be included in the DCQAP. The DCQAP has been designed to satisfy these requirements; however, the order in which this DCQAP presents this material differs somewhat from the order in which this material is presented in the RCRA Corrective Action Permit (Module III, Appendix A, Section V). These differ due to the following:

- This DCQAP covers RFI activities at a number of SWMUs/AOCs. The text of this DCQAP presents the required material on a site-by-site basis.

- The field investigation and sampling procedures included in this DCQAP are presented in a Standard Operating Procedure (SOP) format. SOPs are referenced in the text of this plan, but are presented separately in Appendix B.

Table 2-1 serves as a cross-reference between the material presented in this DCQAP and the material required by the Corrective Action Permit (Module III, Appendix A, Section V). Table 2-1 is designed to allow the reader of this DCQAP to quickly retrieve selected information from the text.

3.0 SWMU/AOC STATUS

This section presents a summary of SWMU/AOC status with respect to existing information. A detailed description of the previous investigations which generated this information is presented in Section 3.0 of the Project Management Plan. It also includes a discussion of media requiring corrective measures (if any) at each SWMU/AOC.

3.1 First Phase RFI SWMUs/AOCs

There are a number of SWMUs/AOCs at NSRR that, according to the RCRA Corrective Action Permit, will require a first phase RFI. These SWMUs/AOCs are listed on Table 3-1. 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 3-1.

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

3.2.1 Site Status

The RCRA 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. The sample analytical results indicate the following:

Groundwater

Volatile organic compounds (VOCs) were not detected. Semivolatile organic compounds (SVOCs) data do not indicate significantly high concentrations. Pesticides were found as a trace concentration of heptachlor. Inorganic compounds of the Target Analyte List (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

VOCs 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 do not indicate significantly high concentrations. Pesticides 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.

3.2.2 Media Potentially Requiring Corrective Measures

In accordance with the RCRA 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:

- A total of twenty-one soil samples were collected at this SWMU. Laboratory analytical results indicate that there is no risk to human health or the environment associated with this media. While this is the case, additional soil samples are required to provide information over a broader area and at depth.

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

- 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. Samples will be obtained of the near shore sediments to verify the results of previous investigations. Additionally, surface waters will be sampled from the Disposal Site if found during the field investigations.

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

3.3.1 Site Status

The RCRA 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. The sample analytical results indicate the following:

Groundwater

VOCs were not detected. SVOC data do not indicate significantly high concentrations. Pesticides/PCBs 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

VOCs 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 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 material in a coastal margin developed from a ferromanganous, igneous rock.

3.3.2 Media Potentially Requiring Corrective Measures

In accordance with the RCRA 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:

- A total of sixteen soil samples were collected at SWMU 2. Laboratory analytical results indicate that there is no unacceptable risk to human health or the environment associated with this media. While this is the case, additional samples will be obtained to further characterize the subsurface soils and provide broader site coverage.

- 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.

- Two sediment samples were collected along the Ensenada Honda Shoreline (IR Site 14) during the Supplemental Investigation. Laboratory analytical results indicate that there is no risk to human health or the environment associated with this media. Additional sediment samples will be obtained to confirm these findings. In addition, surface waters on the Disposal Site will be sampled if noted during the field investigation.

3.4 SWMU 3 - Base Landfill (IR Site 7)

3.4.1 Site Status

The RCRA 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.

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.

3.4.2 Media Potentially Requiring Corrective Measures

In accordance with the RCRA 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 will be sampled using the existing well network.

- 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 methoxychlor (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 off-shore surface water sample analysis will provide usable data representative of SWMU conditions. Any surface water/sediments associated with on-site drainage features found during the field investigation will be sampled.

- Surface soils will be assessed as part of the RFI.

- Subsurface materials will be assessed during the investigation.

3.5 SWMU 6 - Building 145

3.5.1 Site Status

The permit has identified this SWMU as requiring an RFI for surface and subsurface soil.

3.5.2 Media Potentially Requiring Corrective Measures

Previous site visits have identified the storage of 55-gallon drums, 5-gallon paint cans, and a number of other small containers. Conditions of these containers ranged from intact and neatly stacked to randomly placed and leaking.

3.6 SWMU 7 - Tow Way Fuel Farm

3.6.1 Site Status

The permit has identified this SWMU as requiring an RFI for soil and groundwater and, contingent upon the results, investigations may also be necessary for surface water and sediments. This SWMU addresses the overall fuel farm area - disposal pits associated with individual tanks comprise SWMU 8.

3.6.2 Media Potentially Requiring Corrective Measures

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

- Soils at this SWMU have been subjected to intensive and repeated sampling efforts; however, additional samples are required to adequately characterize the soils.

- Groundwater has been investigated using numerous monitoring wells. Presently groundwater is undergoing a remedial program. The need for additional wells is under review[1].

- Sediments off-shore of the unit will be sampled as part of the investigatory program for AOC D.

3.7 SWMU 8 - Tow Way Fuel Farm Disposal Pits

3.7.1 Site Status

The need for an RFI addressing soils and groundwater has been included in the permit. SWMU - 8 only encompasses the disposal pits associated with cleaning operations for the individual tanks. To date, repeated attempts to locate the pits have failed.

3.7.2 Medial Potentially Requiring Corrective Measures

No investigations have been conducted specifically for the disposal pits although extensive investigations have been performed in the Tow Way area. Therefore, the following work will be undertaken during the RFI:

- Geophysical investigations to potentially locate the disposal pit sites,

- Test pitting with sampling and laboratory analysis

- Groundwater has been investigated through previous (and ongoing) monitoring programs conducted under the purview of the Puerto Rican EQB UST regulations. Additional wells may be required. The need for more wells will be assessed in the workplan addendum for SWMUs 7 and 8.

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[1]Note: A proposal for investigation of this SWMU will be provided separately as an addendum to this workplan.

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

3.8.1 Site Status

The RCRA 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). Some disposal pits have been located through contact with a long-term employee. Other pits may exist and will be the focus of this investigation.

3.8.2 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. Soil samples will be obtained in known pit locations. A geophysical investigation will be required in an effort to determine the location of additional 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. Groundwater samples will be collected.

3.9 SWMU 10 - Building 90 (IR Site 15)

3.9.1 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 Corrective Action Permit (Module III, Section E.4, page 35) RFI requirements (soil, surface water/sediment) are contingent on the results of the Interim Remedial Action.

The objective of the Interim Remediation Action is to remove all soils which exceed the established cleanup level of 10 ppm PCBs. The DoN has forwarded to US EPA Region II 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 project closeout report was provided in May 1995. The above referenced documents satisfy the RCRA Corrective Action Permit, Module III, Section B.6, page 26.

3.9.2 Media Potentially Requiring Corrective Measures

A series of HydroPunch™ boring will be advanced in order to collect groundwater samples. Analyses to determine if PCB or other constituents have migrated into the water table.

3.10 SWMU 11 - Building 38 (IR Site 16)

3.10.1 Site Status

A RI/FS has been conducted at this site (Versar, 1992). An Interim Remedial Action under the DoN IR Program has been completed for the soils at this SWMU. The Project Close-out Report was provided to the EPA in May 1995. In accordance with the RCRA 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 RCRA 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.

The west tunnel had not been located over its full length in the field despite a geophysical investigation being conducted at this SWMU (Baker, 1993) and additional intrusive investigations in 1995. However, the contractor performing a UST investigation at the former incinerator, located the tunnel on the west side (towards the landfill) of the fence surrounding the former incinerator. The geophysical report is included in Appendix C of this DCQAP.

An Interim Remedial Action (IRA) under the DoN IR Program is currently underway at this SWMU. The objective of the Interim Remedial Action 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, the project QA/QC plan dated 27 December 1993 and the Project Close-out Report in May 1995. The above referenced documents satisfy the RCRA Corrective Action Permit, Module III, Section B.6, page 26.

3.10.2 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 media 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.

- Soil in the vicinity of the USTs has not been adequately characterized. Soil borings will be advanced in this area.

- Groundwater monitoring wells will be installed in the vicinity of the UST.

- Hydropunch samples will be obtained from the site perimeter.

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

- The Versar 1992 report also included the collection of wipe and concrete ship samples from the concrete surfaces of Building 38. A total of 33 wipe samples and six concrete chip samples were collected (see Figure 3-1). Based on the analytical results, approximately half of the wipe samples did not detect PCBs and only two samples exceed the 1,00 $\mu g/m^2$ ARAR for outdoor high contact surfaces under TSCA for industrial areas and nonrestricted access areas. These locations included W-12 (1,300 $\mu g/m^2$) and W-21 (1,300 $\mu g/m^2$). Analytical results for the wipe and concrete chip samples are presented on Table 3-2.

3.11 SWMU 12 - Fire Training Pit Oil/Water Separator

3.11.1 Site Status

The permit has identified this SWMU as requiring an RFI to include surface soils surrounding the separator. Visual observations indicated no structural problems, however, dead grass and oil stains were observed adjacent to the unit. Soil, surface water, sediments and groundwater samples were analyzed during the confirmation study. The sample results indicate the following:

3.11.2 Media Potentially Requiring Corrective Measures

Soil samples will be collected.

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

3.12.1 Site Status

The RCRA 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. The sample analytical results indicate the following:

Groundwater

VOCs were present as trace concentrations of acetone, carbon disulfide and tetrachloroethene. SVOC data do not indicate significantly high concentrations. Pesticides/PCBs were not detected. 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

VOCs 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 do not indicate significantly high concentrations. Pesticides 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.

Only the VOC acetone in low concentration was detected. SVOC data do not indicate significantly high concentrations. Pesticides 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. VOCs were present as moderate to high concentrations of acetone and 2-butanone, and a moderate concentration of toluene. SVOC data do not indicate significantly high concentrations. Pesticides are present in trace to high concentrations, the highest being of 4,4'-DDD.

3.12.2 Media Potentially Requiring Corrective Measures

In accordance with the RCRA 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 sampling results indicate that there is no threat to human health or the environment with these media; however, confirmatory samples will be obtained and a series of samples will be obtained to investigate an area of anomalously high arsenic concentration.

3.13 SWMU 14 - Fire Training Pit Area

3.13.1 Site Status

The RCRA Corrective Action Permit has indicated that this SWMU will require a first phase RFI. This SWMU comprises IR Site 17. Previous visual site inspections indicated staining of the metal structure, rocks, and concrete curbing.

3.13.2 Media Potentially Requiring Corrective Measures

- A limited soil gas survey and surface soil sampling program will be conducted to address the SWMU.

3.14 SWMU 23 - Oil Spill Separator Tanks (Oil Spill Control Area)

3.14.1 Site Status

The RCRA Corrective Action Permit has identified this SWMU as requiring a first phase RFI. The VSI team noted black staining on the concrete pad, curbing, and asphalt surrounding the SWMU.

3.14.2 Media Potentially Requiring Corrective Measures

Surface Soil samples will be collected to address conditions at this SWMU.

3.15 SWMU 24 - Oil Water Separator (Oil Spill Control Area)

3.15.1 Site Status

This SWMU, adjacent to SWMU 23, also has been identified as requiring a first phase RFI. The VSI team did not observe any signs of release, however, minor staining was noted around the edge of the separator.

3.15.2 Media Potentially Requiring Corrective Measures

A single surface soil sample is to be collected at this SWMU.

3.16 SWMU 25 - DRMO Storage Yard (Building 2009)

3.16.1 Site Status

This unit is situated adjacent to the Ignitable Storage Facility (SWMU 18) and was reported to store hazardous materials. Evidence of past releases and soil staining were observed during the VIS.

3.16.2 Media Potentially Requiring Corrective Measures

A series of surface soil samples will be collected at this SWMU.

3.17 SWMU 26 - Building 544 Area

3.17.1 Site Status

This unit comprises a number of 30-gallon drums stored behind Building 544 and has been identified as requiring a first phase RFI. Past inspections did not observe signs of a release.

3.17.2 Media Potentially Requiring Corrective Measures

A limited soil gas survey and boring program will conduced in order to address this SWMU.

3.18 SWMU 30 - Former Incinerator Area

3.18.1 Site Status

This unit is located adjacent to SWMU 11 (Building 45) and shall receive a first phase RFI. The unit includes the incinerator and recently removed USTs. Results of previous investigations indicate the following:

- Total petroleum hydrocarbons (TPH) were detected in soils and groundwater. An associated risk assessment indicated a very low risk.

3.18.2 Media Potentially Requiring Corrective Measures

- Soil and groundwater have not been adequately characterized. Previous investigations assessed the unit for petroleum products. This RFI will conduct a soils and groundwater investigation and analyze for full scan.

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

3.19.1 Site Status

This SWMU is part of IR Site 10 and has been identified as requiring a first phase RFI. Previous investigations indicate the following:

Groundwater

Samples detected low levels of organic compounds and inorganics above primary drinking water standards.

Soil

Samples detected trace amounts of VOCs. An associated risk assessment indicated no threat to human health and the environment.

3.19.2 Media Potentially Requiring Corrective Measures

- Soil has not been adequately characterized. Additional surface soil samples focussed in the oil collection oven will be collected to confirm previous analytical results.

3.20 SWMU 32 - Battery Collection Area (Building 31)

3.20.1 Site Status

This SWMU is part of IR Site 10 and has been identified as requiring a first phase RFI. Previous sample results indicate the following.

Soil

Low concentrations of organic compounds were detected in the surface soils. An associated risk assessment indicated no risk with this media.

Groundwater

Results detected low levels of organic compounds and metals above regulatory standards.

3.20.2 Media Potentially Requiring Corrective Measures

- Site soils have not been adequately characterized. Additional soils and sediment samples will be collected to confirm results of previous studies.

3.21 SWMU 37 - Waste Oil Storage Area - Building 200

3.21.1 Site Status

The RCRA Corrective Action Permit has identified this unit as requiring a first phase RFI. Previous analytical data indicates the following.

Soil

Elevated levels of oil and grease were detected in a single sample collected form this SWMU.

Sediment

Oil and grease was detected in sediment samples collected from the Unit.

3.21.2 Media Potentially Requiring Corrective Measures

- Additional surface soil samples will be collected to confirm previous analytical data.

3.22 SWMU 39 - Former Battery Drain Area Building 3158

3.22.1 Site Status

This unit also has been identified as requiring a first phase RFI encompassing surface soils. Previous visual inspections did not indicate signs of a release from the storage of batteries.

3.22.2 Media Potentially Requiring Corrective Measures

A series of surface soil samples will be collected in order to address this unit.

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

3.23.1 Site Status

The RCRA 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 3.7.1, has been conducted at this site. The Interim Remedial Action is designed to include soils at SWMU 45.

3.23.2 Media Potentially Requiring Corrective Measures

Contingent on the results of the Interim Remedial Action.

3.24 SWMU 46 - Pole Storage yard Covered Pad

3.24.1 Site Status

Previous Studies indicated this SWMU as being used as a Public Works Department hazardous waste storage area to store transformers and drums of PCB-contaminated materials. This unit has been identified as requiring a first phase RFI. A VSI team did not observe evidence of a release to the environment.

3.24.2 Media Potentially Requiring Corrective Measures

A series of surface and subsurface soil and wipe samples (from the covered pad) will be collected to address this SWMU.

3.25 SWMU 51 - New AMID Storage Pad/Building 379

3.25.1 Site Status

This SWMU consists of a curbed concrete storage pad outside of Building 379 and has been identified to receive a first phase RFI. Visual inspections of the unit indicated oil stains at two drain valves and from a 200-gallon tank.

3.25.2 Media Potentially Requiring Corrective Measures

A series of surface soil samples will be collected to address this unit.

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

3.26.1 Site Status

The RCRA 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. The sample analytical results indicate the following:

Soil

VOCs are largely absent; a trace concentration of carbon disulfide was detected in one sample, and trace concentrations of toluene and (m-,p-)xylene with low concentrations of carbon disulfide and methylene chloride were detected in another. SVOC data 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 material developed from a ferromanganous, igneous rock.

3.26.2 Media Potentially Requiring Corrective Measures

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

- Soils have not been adequately characterized. The RCRA 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.

3.27 <u>AOC C Transformer Storage Pad</u>

3.27.1 Site Status

This AOC is comprised of two raised concrete pads used to store transformers and is to receive a first phase RFI. Visual inspections of the unit identified areas of standing oil and releases through cracks in the concrete.

3.27.2 Media Potentially Requiring Corrective Measures

A series of surface soil and wipe samples will be collected to address this SWMU.

3.28 AOC D Ensenada Honda Sediments

3.28.1 Site Status

Concerns regarding this AOC are related to the releases, to the sediments, from SWMUs 1, 2, 3, 7, and 8. Each of these units have been previously discussed.

3.28.2 Media Potentially Requiring Corrective Measures

Sediment samples will be collected along the sore line adjacent to the above SWMUs.

4.0 DATA COLLECTION STRATEGY AND REQUIREMENTS

This section provides a description of the overall approach and strategy for collecting environmental samples and other data at the SWMUs/AOCs as well as the data collection requirements for each individual SWMU/AOC.

4.1 Data Collection Strategy

4.1.1 Intended Uses of Data

Environmental samples and other field measurements are being collected in order to provide a set of data that can be used to determine the nature, extent and rate of migration of hazardous constituents in selected environmental media at each SWMU/AOC identified in the permit as requiring investigation.

The data collected during the course of the site investigation will also be used for the following:

- To monitor health and safety conditions during field activities.
- To characterize the wastes contained and/or managed.
- To screen from further investigation those areas which do not pose a threat to human health or environment.
- To develop data for the evaluation of corrective measures.

In accordance with the RCRA Corrective Action Permit (Module III, Section A.5, Page 23) results of previous investigations will be incorporated into this data set in order to satisfy the RFI requirements.

4.1.2 Quality Assurance Program

A Quality Assurance (QA) program will be established in order to assess the precision and accuracy of the data collected. The purpose of a QA Program is to establish policies for the implementation of regulatory requirements and to provide an internal means for control and review so that the work performed meets project requirements. Project QA objectives are:

- Scientific data will be of a quality sufficient to meet scientific scrutiny.
- Data will be gathered/developed in accordance with procedures appropriate for the intended use of the data.
- Data will be of acceptable precision, accuracy, completeness, representativeness, and comparability as required by the project.

The fundamental mechanisms that will be employed to achieve these quality goals can be categorized as prevention, assessment, and correction:

- Prevention of errors through planning, documented instructions and procedures, and careful selection and training of skilled, qualified personnel.
- Assessment of all quality assurance sampling reports furnished by the laboratory.
- Correction for prevention of reoccurrence of conditions adverse to quality.

4.1.2.1 Data Quality Objectives

Data quality objectives (DQOs) are qualitative or quantitative statements developed by the data users to specify the quality of data needed from a particular data collection activity to support a specific decision. The DQOs are expressed in terms of precision, accuracy, representativeness, completeness, and comparability. Definitions for these terms are given in Table 4-1.

The Activity Coordinator, in conjunction with the Navy Technical Representative (NTR) is responsible for defining the DQOs. The intended use of the data, analytical measurements, and the availability of resources are integral in development of DQOs. DQOs define the level of uncertainty in the data that is acceptable for each specific activity during the investigation. This uncertainty includes both field sampling error and analytical instrument error. Ideally, zero uncertainty is the goal; however, the variables associated with sampling and analysis contribute to a degree of uncertainty in any data generated. It is an overall program objective to keep the total uncertainty within an acceptable range, so as not to hinder the intended use of the data. To achieve this objective, specific data quality requirements such as detection limits, criteria for accuracy and precision, sample representativeness, data comparability, and data completeness have been specified.

The goals for precision, accuracy, and completeness for this project will be assessed using results from internal as well as field quality control samples. The following criteria will be used to evaluate the data:

- Accuracy and precision will be assessed through the use of spike (matrix and blank) recoveries. The data must satisfy the QC acceptance criteria given in the analytical methods. The specific performance objectives for each analytical parameter are shown in Tables 4-3 and 4-4.

- Precision will also be determined by the calculated relative percent difference between duplicate analyses. The duplicate analyses can be either spiked duplicate analyses or simply duplicate analyses of a sample. The precision goals are of less than 25 percent RPD for aqueous samples. However, for matrix spike/matrix spike duplicate analyses, the precision goals established for the EPA protocols must be met.

- Completeness - the objectives for completeness are of 90 to 95 percent.

4.1.2.2 Data Quality Level

The data quality level for this project is Level IV (or D), which is defined in Section 1.3.1 of "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation

Restoration Program" (NEESA 20.2-047B). Level IV (or D) permits the use of non-CLP methods but requires that the methods used must be EPA methods or be equivalent to EPA methods as presented in Tables 7.1 through 7.5 of the NEESA 20.2-047B document. The laboratory that will be contracted to conduct these analyses will be NEESA approved, i.e., the laboratory must successfully analyze a performance sample, undergo an on-site audit, correct any deficiency found during the audit, and provide Monthly Progress Reports to NEESA.

In Level IV (or D), a matrix spike and a matrix spike duplicate are required for volatiles, semivolatiles, and all gas chromatographic (GC) analysis for every 20 samples of similar matrix. For metals analysis, a duplicate and a matrix spike are required for every 20 samples of similar matrix. The analytical procedures to be used for this project along with the Practical Quantitation Limits are provided in Section 9.0 of this plan.

All measurements will be made so that results are representative of the media and conditions being measured. All data will be calculated and reported in units consistent with the practice for reporting similar data to allow comparability of data bases among organizations.

4.1.3 Environmental Media Selection

The RCRA Corrective Action Permit specifies the environmental media (soil, groundwater, surface water/sediment) to be sampled at each SWMU/AOC. Air sampling is not required at any of the SWMUs/AOCs.

Full RFIs may require sample collection from the soil, groundwater, and surface water/sediment. First phase RFIs require sample collection from the soil media (sample collection from the other media are contingent on the results of the soil sampling). Sampling of environmental media at some SWMUs is contingent on results of Interim Remedial Actions.

In accordance with the RCRA Corrective Action Permit (Module III, Section A.4, Page 23) results of the Supplemental Investigation can be used to satisfy RFI requirements at selected SWMUs/AOCs. In these cases, environmental media that have been adequately characterized are not resampled during the RFI.

4.1.4 Determining the Number of Sampling Points

In order to determine the number of environmental samples to be collected at a given SWMU/AOC, the following factors must be evaluated:

- The media to be sampled
- The size of the SWMU/AOC
- Existing information regarding SWMU/AOC's operational history
- visible evidence of contamination

Soil samples will be collected in a judgmental (i.e., focused) manner or according to a grid system. In general, soil samples will be collected in a focused manner at the smaller SWMUs/AOCs where operational history is well defined (e.g., an oil water separator) and/or there is visible evidence of contamination.

Soil sampling stations will be located according to a square grid system at the larger SWMUs/AOCs where the location of potential contamination is not well defined. The grid sampling system was developed using the procedures outlined in Gilbert (1987). In determining the grid spacing, the following assumptions were made:

- The size of a potentially contaminated area ("hotspot") is less than 20 feet in size.
- The hotspot is assumed to be circular.
- The power of the study is 80 percent.

According to this scenario, a 100-foot by 100-foot sampling grid will locate any hot spot larger than 18 feet.

In some cases, the judgmental and systematic grid sampling techniques will be combined. This will be done at larger SWMUs/AOCs that have isolated areas where contamination is expected.

Another consideration for soil sampling is whether or not samples should be collected from the subsurface. Surface soil samples (0 to 1 foot depth) will be collected from those SWMUs/AOCs where potential contaminants are expected to be limited to the shallow soil zone. Soil borings will

be advanced at those SWMUs/AOCs where contaminants are expected at depth (e.g., underground storage tanks). The soil borings will have standard split-spoon samples collected continuously from the ground surface to the boring termination. From each soil boring, a surface soil sample and two subsurface soil samples (from the interval immediately above the water table and from an interval displaying visual or instrumental [PID/FID] visible evidence of contamination or one which is representative of subsurface conditions) will be submitted for analytical testing.

Groundwater samples will be collected from existing or newly installed monitoring wells at selected SWMUs/AOCs. Generally, a minimum of one upgradient monitoring well and three downgradient monitoring wells will be sampled.

For larger SWMUs/AOCs, additional downgradient monitoring wells may be added. In some cases a monitoring well network will be shared by SWMUs/AOCs located in close proximity.

Sediment samples will be collected from SWMUs 1, 2, 3, 11/45, 13, 25, and 32. At SWMU 3 sediment samples will be collected in a grid system surrounding the landfill. The grid is designed to detect potential runoff from the landfill (locations may be moved based on field observations of leachate, etc.). At SWMUs 11 and 45, sediment samples will be collected in a focused manner. Samples will be collected from selected access points along the underground tunnels and at the intake and outfall. At SWMUs 1 and 2, sediment samples will be collected at equally spaced locations along the SWMU's perimeter.

4.1.5 Comparability of Data With Previous Investigations

The Corrective Action Permit (Module III, Section A.4, Page 23) contains provisions for utilizing analytical results from previous investigations to satisfy RFI requirements. The results of the Supplemental Investigation, conducted in 1992, will be used for this purpose. All data collected during the RFI will be calculated and reported in units consistent with the reporting practice used in the Supplemental Investigation. This will allow for comparability and combination of the two databases.

4.2 Data Collection Requirements at SWMUs/AOCs

This section presents the data collection requirements for each SWMU/AOC. The data collection requirements are based on the data collection strategy presented in Section 4.1. Sample collection and other field investigation procedures are described in Section 5.0 (Field Investigation and Sampling Procedures).

The following discussion of the data collection requirements will include the following information for each SWMU/AOC:

- Media to be sampled
- Number and location of samples
- Sample analysis
- Sampling rationale
- Sample types (composite vs. grab, etc.)
- Additional data to be measured (pH, temperature, etc.)

Table 4-2 provides a summary of the sampling requirements and analytical methods for each SWMU/AOC. Analytical parameters selected for each SWMU/AOC are based on the site's operational history and existing environmental data generated during previous investigations. Samples will also be collected at selected SWMUs/AOCs for Corrective Measures Data analysis. The Corrective Measures Data analytical parameters selected for each SWMU/AOC are based on the potentially applicable corrective measures technologies identified in the Pre-Investigation Corrective Measures Screening Evaluation Report (Baker, 1994).

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

Four separate media will be investigated at this site: surface and subsurface soil; sediments and groundwater. The soil and sediment programs are designed to provide information which will confirm the results of previous investigations (Supplemental Investigation) as well as provide data from areas of previous disposal. Taken together, these programs will provide adequate characterization of these media. The groundwater program will be more extensive to augment previous investigations and provide an adequate monitoring system.

A total of up to 15 surface soil samples, to be analyzed for the full Appendix IX list of parameters (including explosives and asbestos); will be collected. Five surface soil sample locations (shown on Figure 4-1) have been carefully selected to provide maximum characterization coverage. The locations are specifically either: 1) in areas where waste disposal took place; or 2) where previous sampling was performed. Surface soil samples will also to be collected from the two proposed monitoring wells located within the northeast portion of the SWMU. Additional surface soil samples will be collected from the proposed soil borings located along areas of previous disposal activities (west portion of SWMU).

A total of 16 subsurface soil samples will be collected during field activities. Two subsurface samples will be obtained from each soil boring and groundwater monitoring well. One sample will be collected from the interval immediately above the water table. A second sample will be collected from a point between the ground surface and the sample collected above the water table. The sample interval to be analyzed will be determined based on visual observations of potential contamination, photoionization detector (PID) measurements, or representativeness of subsurface conditions.

Both surface and subsurface soil samples will be analyzed for Appendix IX parameters as well as explosives and asbestos as presented on Table 4-2.

Three sediment samples (0 to 6 inches) will be obtained from along Esenada Honda at the locations shown on Figure 4-1. These samples are evenly spaced along the margin of the SWMU and are designed to confirm the results of samples collected during the supplemental investigation. In the event that the access to the proposed location is not possible, due to thickness of vegetation in Mangrove swamp, a sediment sample will be collected at the northeast corner of the SWMU near the road leading to the Coast Guard pier. Analysis of these samples will include Appendix IX parameters, explosives, asbestos, and total organic carbon (TOC).

During field activities, the slopes of SWMU 1 will be inspected for evidence of leachate breakout and ponded water in surface drainageways. If leachate breakout and/or ponded surface water are observed, surface water and sediment samples will be collected. Provisions for three surface water and three sediment samples have been included into this work plan. Surface water and sediment samples will be analyzed for Appendix IX parameters, explosives, asbestos, and TOC. In addition, surface water samples will be analyzed for hardness.

There is an existing background monitoring well on site (5GW01) and three downgradient wells which were not able to be located during the last field work. Up to four new monitoring wells will be installed as part of the RFI. Monitoring well locations are presented on Figure 4-1. One round of groundwater samples will be collected from the monitoring wells. These samples will be analyzed for the parameters listed on Table 4-2.

The proposed monitoring well network provides for one upgradient monitoring well (5GW01) and four downgradient wells. The well adjacent to the Coast Guard Pier is designed to monitor any component of flow which may be exiting the site to Ensenada Honda northward as a result of radial flow off the topographic high. It is intended that the three existing downgradient wells will be located and refurbished if possible. If they cannot be located, or there is any question regarding their integrity, they will be replaced at approximately the same locations since they were installed in technically appropriate locations previously. These three wells will monitor groundwater exiting the site in what is expected to be the primary flow direction. The screened interval of each monitoring well will span the water table. Groundwater will be analyzed for Appendix IX parameters, explosives, and asbestos.

Additional data will also be collected from the monitoring wells, including:

- pH
- Temperature
- Specific conductance
- Water level
- In-situ hydraulic conductivity tests

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

Sampling at this SWMU will include surface and subsurface soil, surface water and sediment, and groundwater. Soils and sediments have been extensively sampled during previous investigations and the RFI program is designed to confirm the results of the earlier work (Supplemental Investigation). Combined, the various programs will adequately characterize soils and sediments. Groundwater has not been characterized in the past and therefore will be subjected to a more vigorous RFI.

A total of eight surface soil samples will be collected. Surface samples will be taken as the initial sample at the three new groundwater monitoring well locations. The remaining two (as shown on Figure 4-2) surface samples are located at the two soil borings within the actual disposal area. These samples will be analyzed for Appendix IX, explosives, and asbestos.

Three sediment samples will be obtained at the locations shown on Figure 4-2. These samples, to be analyzed for Appendix IX, will augment previous results (Supplemental Investigation) and will characterize sediments from immediately off-shore from the SWMU. As discussed in the previous section, the fill slope at SWMU (Figure 4-2) will be visually inspected for evidence of leachate breakout and ponded water in surface drainageways. If leachate breakout and/or ponded surface water are observed, surface water and sediment samples will be collected. Up to a total of three surface water and three sediment samples will be obtained and analyzed for the parameters presented on Table 4-2.

Three soil borings and three new monitoring wells will be installed as part of this RFI (Figure 4-2). Two subsurface soil samples will be collected from each boring, as discussed in Section 4.2.1, for a total of 16 samples. All subsurface soil samples will be analyzed for the parameters presented on Table 4-2.

The proposed monitoring well network provides for one upgradient background monitoring well (existing well 6GW01), two downgradient monitoring wells, and one well through the center of the suspected waste disposal area. The screened interval of each monitoring well will span the water table. The monitoring well network is designed to provide groundwater characterization for the entire SWMU by assessing background groundwater quality as it enters the site and then comparing downgradient groundwater quality to see if quality was degraded during transit under the site. One round of groundwater samples will be collected from each well and analyzed for the parameters listed on Table 4-2.

Additional data will also be collected from the monitoring wells, including:

- pH
- Temperature
- Specific conductance

- Water level
- In-situ hydraulic conductivity tests

4.2.3 SWMU 3 - Station Landfill

The Station Landfill has been operating for quite some time and there are no known records of what, if any, development plan was employed. It is believed that the landfill was started by placing waste directly on low-lying areas and continuing the operation in succeeding lifts until the present topography has resulted. Considering the age of the landfill and the filling approach, it is assumed that waste is in direct contact with the groundwater due to settling of the waste into the soft sediments and the creation of mounded conditions within the fill present because of differing permeabilities in the filled material. Mantling the fill is a relatively thin veneer of soil which, in the active portion, is daily cover.

The potential concerns at the landfill are:

- Surface and subsurface materials
- Surface water and sediment as it relates to drainage features on or exiting the landfill
- Leachate breakouts along the perimeter of the landfill
- Groundwater, and
- Sediments off-shore from the landfill

<u>Geophysical Survey</u>

The confirmation study contained a map which indicated a "suspected area of Post Waste Disposal" and an area of "current" landfill operation. This area has been transferred to Figure 4-3. In an attempt to confirm this geometry of landfilling, a conductivity survey will be conducted over the full extent of the area. Traverses will be made infrequently across the fill to assess signature characteristics. Surveys will be concentrated on the perimeter of the landfill to attempt to establish the margin of waste deposition. A conceptual conductivity grid has been identified on Figure 4-3. Field conditions will be taken into consideration prior to finalizing the conductivity program.

Surface Soil Sampling

The soils used at the site are not expected to vary widely in geologic or chemical composition and, therefore, a limited program of surface soil sampling is proposed. A total of up to 16 surface soil samples will be obtained during the RFI. The conceptual locations for the samples is shown in Figure 4-3. Comprising the 16 samples are 10 locations strictly identified for surface soil sampling along with the six soil boring locations where the first sample interval will be retained for analysis.

In all cases, contact with waste at the site will be avoided. All surface samples will be subjected to full Appendix IX analysis along with explosives and asbestos.

Subsurface Sampling

A total of six soil borings will be advanced throughout the landfill in approximately the locations shown on Figure 4-3. Boring locations will be finalized based on the results of the conductivity survey. Samples will be collected from 0 - 1 feet (surface soils discussed above), from just above the water table and from the natural material below the waste (if distinguishable). In addition, the sample exhibiting the highest PID/FID reading or visually the most contaminated will be retained (unless already included using the other criteria). This will result in up to 12 subsurface samples. Each sample will be analyzed for Appendix IX parameters, explosives and asbestos.

Landfill Surface Water and Sediment

The initial task to be completed at the landfill will be to perform a walkover survey of the site to ascertain what, if any, drainage features are present. It should be realized that the intent of the landfill grading is to minimize drainage features and allow run-off to sheet flow radially. This survey will be done in conjunction with the conductivity work.

Surface water samples will be for Appendix IX, explosives, asbestos, and hardness. Sediment samples will be analyzed for the same parameters except TOC will replace hardness. For planning purposes, a total of five sediment samples and five surface water samples has been assumed.

Leachate Breakouts

The perimeter of the landfill will be inspected as part of the walkovers. As accessibility allows, the outer edge of the landfill will be walked with particular attention paid to seeps or leachate breakouts. If any of these features are found, the water exiting the landfill and associated sediment will be sampled and subjected to Appendix IX explosives, asbestos, TOC (sediment) and hardness (water) analyses. For planning purposes, a total of five water and sediment samples has been assumed.

Groundwater

The eight existing wells will be sampled as a part of the RFI. Analysis for the Appendix IX parameters, explosives and asbestos will be performed (Table 4-2). This information will provide a point of comparison for previously collected data and a good foundation for future, regulatory required, sampling.

Off-Shore Sediment Sampling

Off-shore surface sediment sampling locations are presented on Figure 4-3. A total of 17 grab samples will be collected from the 0 to 6 inch interval. Each sample will be analyzed for the parameters listed on Table 4-2. The sampling stations are spaced evenly along the shoreline at approximately 500 feet intervals. The distribution of these sampling stations is designed to detect contaminants which have accumulated in the sediments as a result of runoff or leachate migration from the landfill. If leachate, drainage ditches or other avenues of contaminant runoff are detected in the field, the sampling stations may be moved to focus offshore of these areas. Finally, to further enhance the sampling efforts, sampling of off-shore sediments will be done at low tide.

4.2.4 SWMU 7 - Tow Way Fuel Farm

The Tow Way Fuel Farm has been the subject of intense scrutiny for quite some time as a result of regulatory requirements imposed under the Puerto Rican EQB UST Regulations. During the course of investigations conducted at the site, the soils and groundwater have been thoroughly examined. The various reports containing the results of the investigations have been previously submitted to the EPA. The "Corrective Action Plan Tow Way Fuel Facility" (Blasland, Bouck and Lee,

September 1994) provides an excellent summary of site characterization to date. In addition, limited further investigations are planned to address concerns related to SWMU 8.

Efforts are presently underway to transfer responsibility for SWMU 7 from the UST contractor to the RFI contractor. All previous investigations will be reviewed to establish what additional efforts will be needed to fulfill the RFI requirements. The results of this review with proposed additional investigations will be provided in an addendum to this workplan.

The sediments in Ensenada Honda will be sampled following the general pattern shown on Figure 4-4. A total of five sediment samples will be obtained with three samples equally spaced along the SWMU's shoreline at a distance of approximately 50 from shore and two samples to be obtained from points approximately 200 feet offshore. The samples will be analyzed for Appendix IX parameters. This pattern and density of samples should provide a reasonable and defensible indication of whether the Tow Way Fuel Farm is negatively impacting the Honda sediment quality.

4.2.5 SWMU 8 - Tow Way Fuel Farm Disposal Pits

SWMU 8 addresses three recently discovered pits and an unknown number of other pits within the Tow Way Fuel Farm that were used for sludge disposal. Whenever fuel (especially heavier end fuels) tanks are cleaned out there is a certain amount of sludge present at the bottom. Pre-RCRA regulations, it was common industry practice to excavate a pit near tank access points for the disposal of the sludges. The Navy reportedly followed this technique at the Tow Way Fuel Farm. Repeated site inspections and a review of historical air photos has failed to provide an indication of the pit locations; however, recently a long-term employee identified three locations of pits. Figure 4-4 and 4-5 provides a general overview of the site.

The initial investigatory step at this unit will be to conduct limited GPR survey in the areas around the tanks. Geophysical work will be done around all sides of the tanks. There is a very steep slope from Forrestal Drive upwards to the Building 53 substation (unfortunately, topography was not available for this submission).

A total of seven test pits will be excavated at locations based on results of the GPR to assess subsurface conditions (Figure 4-5). At each location up to as many as three subsurface samples will be collected. One sample will be collected of the disposed sludge and one soil sample will be collected at a point approximately two feet below the disposed sludge. A third subsurface sample will be collected just above the water table. At the three known disposal pits, a single soil boring will be advanced to the top of the water table. Subsurface samples will be collected at the same intervals as the test pits. It should be noted that the deepest subsurface sample (just above the water table) may not be collected if the water table is encountered a short distance below the intermediate sample (two feet below the pit). Each subsurface sample will be analyzed for total petroleum hydrocarbons only.

Groundwater, by virtue of previously detected releases, is a media of concern for the RFI. As described for the soils program, a comprehensive groundwater monitoring system has been installed in the area of the Tow Way which is capable of providing continuing characterization of groundwater conditions. The monitoring program is shown on Figure 4-5. Wells on the site were sampled for VOCs and TPH which is adequate for purposes of the RFI since only contamination from fuels is expected. Finally, there is presently in place and operating a groundwater treatment program which is actively recovering free product.

This data and monitoring program is presently under review. An addendum to this workplan will be provided that will address any necessary additional investigations.

4.2.6 SWMU 9 - Disposal Pits Associated with Tanks 212 - 217

This SWMU is comprised of three areas:

- Area A (tanks 212 and 213)
- Area B (tanks 214 and 215)
- Area C (tanks 216 and 217)

Three burial pits have recently been discovered through contact with a long-term employee. The pit locations are shown on Figures 4-6 and 4-7.

To locate other possible pits, a ground-penetrating radar survey will be conducted over and around the tanks. There are three purposes to conducting the surveys:

- To define the locations of the tanks and associated services.
- To locate, if possible, some or all of the disposal pits.
- Using these two items of information, to establish test pit and well locations that examine areas of disposal and avoid damaging the operating tank system.

A five foot GPR grid will be established to a distance of 75 feet beyond the tanks at which point a 10-foot grid will be established to a point 150 feet away from the tanks. Initial results will be field interpreted and used to guide further investigations.

Soil sampling locations are presented on Figure 4-6 for Areas A and B and on Figure 4-7 for Area C. At each tank pad (Areas A, B, and C) two surface soil samples (0 to 1 foot) will be collected for a total of six samples. Surface samples will be analyzed for VOCs, SVOCs, and RCRA metals.

Surrounding each tank will be a series of three test pits excavated at locations based on the results of the geophysical survey. Two of these locations correspond to the known disposal pits at Tank 212 and Tank 215 (Figure 4-6). One additional test pit will be excavated at the known disposal pit associated with Tanks 216 and 217 (Figure 4-7). Two subsurface soil samples will be collected from each test pit (for a total of 36 samples) and analyzed for the parameters presented on Table 4-2. One sample will be collected of the disposed sludge and a second sample from the soil underlying the sludge material (just above the water table). Each test pit will be excavated to an estimated depth of 12 to 14 feet unless groundwater or bedrock is encountered first. At a minimum, excavation will continue to a point at least two feet below the buried sludge. Should refusal be encountered prior to reaching the sludge, the test pit will be relocated within the same vicinity and re-excavated.

Prior to test pit excavation, plastic sheeting will be placed on the ground to either side of the test pit. This procedure will allow for potentially contaminated soil to be kept separate from noncontaminated soil. Upon completion of sampling activities, all excavated soils will be returned

to the test pit replacing the soil in the same order in which it was removed (i.e., bottom soil placed first). All plastic sheeting will be discarded as nonhazardous debris.

There are currently 10 existing monitoring wells at this SWMU. This includes three wells at Area A, three wells at Area B and four wells at Area C. Four additional monitoring wells will be installed as part of the RFI and existing wells will be redeveloped and refurbished as necessary. Monitoring well locations are presented on Figure 4-6 for Areas A and B and on Figure 4-7 for Area C. Two subsurface soil samples will be collected from each new monitoring in the same manner as discussed in previous sections and analyzed as presented on Table 4-2. One round of groundwater samples will be collected from the monitoring wells. These samples will be analyzed for the parameters listed on Table 4-2.

The proposed monitoring well network provides upgradient and downgradient monitoring at each tank area taking into account the possibility of radial flow from the topographic highs. The screened interval of each monitoring well will span the water table. The monitoring well network is designed to provide groundwater characterization for the entire SWMU. Final on-ground locations for the monitoring wells will be selected based on the results of the GPR survey and the soil boring program.

Additional data will also be collected from the monitoring wells, including:

- pH
- Temperature
- Specific conductance
- Water level
- In-situ hydraulic conductivity tests

4.2.7 SWMUs 11 and 45 - Old Power Plant, Building 38 (IR Site 16)

The media to be sampled at these SWMUs include (refer to Section 3.9):

- The Building 38 interior
- Soil in the vicinity of the USTs

- Sediment inside the cooling water tunnels
- Groundwater

Building Interior

The contaminant of concern for the Building 38 interior is PCBs. Although the structure is reported to contain asbestos containing materials (ACM), it has not been considered as a release related problem as part of this RFI; therefore, provisions for asbestos sampling had not been included. 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. Building 38 is a bomb proof concrete structure that was constructed in 1944 which measures 150 ft. x 110 ft. and is 61 ft. in height.

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, wipe samples at the wall/floor intersection and from the wall at a point approximately two feet off the floor will be obtained. No plans of the building interior were available during the preparation of this workplan. The grid will be established so as to maximize sampling in the area of waste storage. In addition, up to 5 extra samples will be taken at any obvious spill points.

USTs

Four monitoring wells will be installed in the vicinity of the USTs (Figure 4-8). Due to the flat topography at this SWMU, uncertainties exist as to the direction of groundwater flow; therefore, a well has been positioned to each side of the USTs. This positioning should allow for an accurate determination of groundwater flow as well as assessing groundwater chemistry. Each well will be advanced to bedrock (estimated depth of 20 feet) with the entire length of the water table being screened. Subsurface samples will be collected at continuous intervals with one surface (0 to 1 foot) and two subsurface samples submitted for the analyses presented on Table 4-2. One subsurface sample will be collected from the interval immediately above the water table. A second sample will be collected from a point between the ground surface and the water table based on PID/FID readings and visual observations.

In addition to the above monitoring wells, four HydroPunch™/temporary wells will be installed at the locations presented on Figure 4-8 to assess groundwater conditions along the perimeter of this SWMU. The HydroPunch™ will be advanced a minimum distance of five feet into the water table prior to sampling. In the event that a temporary well is necessary, due to slow recharge or unavailability of the HydroPunch™ system, a minimum of five feet of well screen will be installed. The well screen will not be backfilled but the formation will be allowed to collapse around the screen. No subsurface soil samples will be collected for laboratory analysis.

A one-time groundwater sampling event will be conducted from these four stations for the parameters listed on Table 4-2. Following this sampling event, each station will be abandoned and the resulting borehole backfilled to the ground surface.

An interim remedial action will be undertaken at the USTs prior to the RFI. [The 60% Design for this work was submitted for EPA review and approval in August 1995.]

Cooling Water Tunnels

Sediment samples will be collected from selected access points along the cooling water intake tunnel terminating in Puerca Bay (Figure 4-8). A total of nine sediment samples will be collected at the locations shown (0 to 6 inch depth). These samples will be analyzed for the parameters listed on Table 4-2. The selected sample locations will focus on the portions of the tunnels which are closest to Building 38 and at the termination of the tunnel in Puerca Bay. In addition, three sediment samples will be obtained in a radial pattern within 50 feet of the tunnel mouth. The results of these samples will be used to verify results obtained during the supplemental investigation.

The power house has another tunnel for cooling water discharge that leads towards Ensenada Honda. This is now known to be the discharge tunnel based on a set of old drawings found recently during work for the Interim Corrective Measure work. The beginnings of this tunnel can be seen leaving the building area and heading perpendicular (approximately) towards the paved road. Through other investigations, the alignment of the tunnel has been determined at least as far as Boiler Building 1936 (Figure 4-8). Repeated attempts to locate the tunnel beyond this point have not been successful, and therefore, the tunnel alignment cannot be verified.

As part of the Interim Remedial Action, the tunnel will be cleaned at least as far as the boiler house and sealed off. The end of the cooling tunnel at Ensenada Honda also will be sealed using reinforced concrete. This measure will effectively seal off the cooling tunnel from transporting any potentially contaminated media into Ensenada Honda. Therefore, no additional sampling of the tunnel beyond the boiler house is planned. Two sediment samples will be collected along the cooling tunnel at the locations shown on Figure 4-8 and analyzed according to Table 4-2.

In addition, three sediment samples will be obtained in a radial pattern within 50 feet of the outfall in Ensenada Honda. These samples are not shown on the figure at this time since the outfall is apparently submerged and will have to be found during the RFI.

Soils

PCB contamination has been established in the soils near Building 38. Extensive soil sampling was performed to identify the nature and extent of the contamination and to provide sufficient data to design a corrective action. This information was obtained in 1992 by Versar, Inc. and reported in the "Remedial Investigation/Feasibility Study for Site 16 Naval Station Roosevelt Roads Puerto Rico." (May 15, 1992)

Based on the RI/FS results, a remedial alternative consisting of soil removal and disposal off-site with confirmatory sampling has been performed. The Project Close-out Report (May 1995) has been submitted. All remaining soils contain less than 10 ppm PCBs.

The extensive pre-removal sampling, soil removal, and post-removal confirmatory sampling address the requirement for an RFI at this SWMU.

4.2.8 Area of Concern B - Former Site of Building 25

The RFI will include sampling of soil and groundwater at this AOC (refer to Section 3.12).

A total of six surface soil samples will be collected; one from each of the locations presented on Figure 4-9. Additionally, two subsurface samples will be collected from each of the two soil borings

and three monitoring wells for a total of 10 samples. All surface and subsurface samples will be analyzed for the parameters listed on Table 4-2 (Surface soil analyses will include asbestos for possible corrective measures decisions). Soil boring sample selection criteria and monitoring well installation will be consistent with the procedures discussed in previous sections.

The soil sampling locations were selected to focus on the immediate vicinity of the former Building 25 since possible releases to soils from wastes stored on the pad triggered the need for the RFI. It should be noted that a first phase RFI will be conducted at SWMU 6 which is immediately adjacent to the AOC B. The results of both investigations will be used to characterize this AOC.

One round of groundwater samples will be collected from the monitoring wells. The samples will be analyzed for the parameters listed in Table 4-2.

The proposed monitoring well network provides upgradient (background) and downgradient monitoring at this AOC. The screened interval of each monitoring well will span the water table. In addition to providing groundwater characterization for this AOC, the monitoring well network will, if required, provide groundwater monitoring for the nearby SWMU 6 (a first phase soil RFI SWMU; see Figure 4-9).

Additional data will also be collected from the monitoring wells, including:

- pH
- Temperature
- Specific conductance
- Water level
- In-situ hydraulic conductivity tests

4.2.9 First Phase RFIs

This section addresses those SWMUs requiring a first phase RFI. The First Phase RFI are limited to the sampling of the soil media. Investigation of selected other environmental media are contingent on the results of the soil investigation. First Phase RFI are designed to assess whether any releases

from these SWMUs/AOCs have occurred. It differs from a full RFI in the extent and degree of investigations required.

4.2.9.1 SWMU 6 - Building 145 Site 11

Soil sampling locations are presented on Figure 4-9. A soil boring will be advanced at each sampling station. A total of three soil borings will be advanced at this SWMU along with the collection of two additional surface soil sample locations. One surface and two subsurface (from the interval directly above the water table and an interval containing visible contamination) soil samples will be collected from each boring. The soil borings will be advanced to the water table. The soil samples will be analyzed for the parameters listed on Table 4-2. It should be noted that this SWMU is immediately adjacent to AOC B and the investigations for both areas provide overlapping coverage. The results of both investigations will be employed to characterize this SWMU.

Previous site visits have noted standing water in the building itself (at the low point). Should water be present during the RFI, a grab sample will be obtained and analyzed for those parameters in Table 4-2. This will provide some indication of whether the concrete surfaces comprising the building interior are surficially contaminated.

The soil sampling locations were selected to focus on the immediate vicinity of Building 145. Samples at depth are included because the unit is partially buried.

4.2.9.2 SWMU 10 - Substation 2/Building 90

This SWMU consists of Substation 2 (Building 90) where electrical transformers were formerly repaired. These operations resulted in PCB containing transformer oils being released to the ground. This SWMU comprises the former IR Site 15. Remedial action (excavation) has taken place at this SWMU and the Project Close-out Report has been provided. Confirmatory soil samples collected from the excavation were used to satisfy the first phase RFI requirements for this SWMU. The results of the confirmatory sampling were reported separately and will only be summarized in the RFI report for information.

Concerns regarding the potential for solvents used int he PCB oil migrating through subsurface soil and into the groundwater exist for this SWMU. To address this concern, a series of three HydroPunches™ or temporary wells will be installed for the purpose of collecting a single round of groundwater samples.

Locations of the three HydroPunches™/temporary wells are presented on Figure 4-10. At each station, sampling tools will be advanced a minimum of five to seven feet into the water table prior to sample collection. The intention is to collect samples from the uppermost portion of the water table to determine the presence or absence if any immiscible layer. No subsurface soil samples will be submitted for laboratory analysis. Groundwater samples will be analyzed for VOCs, SVOCs, and PCBs, as presented on Table 4-2.

Following sample collection, all sampling tools/well screens will be removed and the boreholes backfilled to the ground surface.

4.2.9.3 SWMU 12 - Fire Training Pit Oil/Water Separator

Site 17
(SWMU 12/14)

Soil sampling locations are presented on Figure 4-11. The separator evidences no structural problems and, therefore, the concern regarding potential releases stems from possible overtopping. To assess this potential, a series of four surficial soil samples, to be taken within one foot of the edge of the separator, will be obtained at the locations shown. Should visible signs of release be present, sampling locations will be modified to sample in apparently affected areas. The soil samples will be analyzed for the parameters listed on Table 4-2. Full Appendix IX sampling is not required for the site since only oily waters were managed.

4.2.9.4 SWMU 13 - Pest Control Shop Area (Building 258)

The results of the Supplemental Investigation indicate that there are no significant risks posed by the site to human health. Limited sampling within the drainage ditch receiving runoff from the site indicates that:

- Chlordane exceeded its AWQC
- Chlordane, DDT, DDD, DDE exceeded their respective NOAA ER-M

- Zinc exceeded its NOAA ER-M, and
- Copper and lead exceeded their NOAA ER-L

Since pesticides were managed at the site, additional sampling within the drainage appears warranted. In addition, some surficial soil samples around the former building site and between the building site and the drainage will be obtained to provide full spectrum analyses which will validate previous sampling episodes.

Five sediment samples will be taken along the drainage ditch at the locations shown on Figure 4-12. This sampling program, consisting of samples taken at approximately 100 foot intervals, provides reasonable sample density both upstream and downstream of the site to characterize ditch sediments. The sediment samples will be analyzed for Appendix IX constituents and TOC.

Five surface soil samples, to be taken from 0 - 1 foot, will be obtained at the locations shown on Figure 4-12. These samples will be analyzed for Appendix IX constituents. This pattern of sampling provides reasonable site coverage to characterize and also provides some redundancy of sampling with previous investigations so that the existing data can be utilized fully in understanding the site.

Four surface soil samples will be collected near surface soil station 18SS103 (Supplemental Investigation). These will be analyzed for arsenic to confirm previous analytical results which indicated a somewhat elevated arsenic level.

4.2.9.5 <u>SWMU 14 - Fire Training Pit Area</u> Site 17 (SWMU 12/14)

The new fire training pit, which is a concrete-lined pit, was constructed at the same site as the former pit which had no release controls. Concern with regard to possible releases from this unit reside with the older unit not the new pit. The Navy has no reliable information which indicates the location of a third, temporary, fire pit.

To address this SWMU, the first phase RFI will consist of a limited slam-bar soil gas survey followed by soil sampling. Two rings of soil gas points, at 10-foot intervals, will be investigated. The first ring will be at a distance of 3 feet away from the concrete apron while the second will be

13 feet away. Based on the results of this soil gas survey, a minimum of five soil sampling locations will be selected (a possible array of sampling points is shown on Figure 4-11). Soil samples will be obtained from a depth of approximately 3 feet in a hand-augered hole.

The soil samples will be analyzed for the parameters contained in Table 4-2.

4.2.9.6 SWMU 23 - Oil Water Separator Tanks (Oil Spill Control Area)

Soil Sampling locations are presented on Figure 4-13. A surface soil sample (0 to 1 foot) will be collected at each location. A total of two soil samples will be collected at this SWMU. The samples will be analyzed for the parameters listed on Table 4-2.

The soil sampling locations may be modified based on field observations of areas of visible contamination (e.g. staining) and potential contaminant release (drainage, etc.). Also, the concrete pad will be inspected for cracks. If sizeable cracks are found, they will be cleaned out and, if fully penetrating, samples will be obtained of the subsurface material.

4.2.9.7 SWMU 24 - Oil Water Separator (Oil Spill Control Area)

The concern at this site is for releases which may have occurred to the surface soils as a result of overtapping of the unit (the unit visually appears structurally sound). The separator is surrounded on three sides by asphalt and one side by grass.

Concerns regarding potential for overtapping will be addressed through the collection of a single surficial soil sample (0 to 1 foot) collected from the grassed area (an area of approximately 8 x 8 feet). The preliminary sample location is shown on Figure 4-13; however, the actual field location will be selected based on visual observation of staining, stressed vegetation, etc., although it will be immediately adjacent to the unit on the grassed area.

The soil sample will be analyzed for the parameters shown on Table 4-2.

4.2.9.8 SWMU 25 - DRMO Storage Yard (Building 2009)

Soil sampling locations are presented on Figure 4-14. One surface soil sample (0 to 1 feet) will be collected at each sampling station. A total nine soil samples will be collected at this SWMU. The locations shown correspond to the stained area seen during the RFA.

The soil sample locations will focus on the material storage racks area. Due to the small size of this SWMU, nine soil samples will serve to adequately characterize soil quality. The sampling locations may be modified based on field observations (e.g. staining, etc.).

A single sample of the drainage ditch sediments will be obtained if a sufficient amount of sediment found to be present in the concrete line ditch. The sample will be obtained in the general location shown on Figure 4-14.

All samples will be analyzed for the full list of Appendix IX parameters.

4.2.9.9 SWMU 26 - Storage Area Behind Building 544

Proposed possible soil sampling locations are presented on Figure 4-15. A surface soil sample (0 to 1 feet) will be collected at each sampling location. A total of up to five soil samples will be collected. The soil samples will be analyzed for Appendix IX parameters,

Building 544 was demolished sometime after 1988. The soils (after drum removal) from the area where the drums were seen was bulldozed to a point approximately 20 feet away as shown on the figure. There is no existing information to indicate that contaminants may be present at a particular area within this SWMU. A slam bar soil survey will be performed in the area where the drums were, the area between the former building and the present site of the storage area soils and in the soil piles originating from the drum storage area. Based on the results of the survey, sample locations will be selected that will be representative of site conditions. At a minimum, two samples will be obtained from the surficial soils in the former storage area and three will be obtained from the soil piles. Analysis will be for Appendix IX parameters.

4.2.9.10 SWMU 30 - Former Incinerator Area

SWMU 30 actually consists of two relatively discrete areas as shown on Figure 4-16. One area is the incinerator itself while the other is the location of a former UST recently removed under the purview of the Puerto Rican UST Regulations. Both these areas will be addressed in the RFI.

The best information available indicates that the incinerator presently at the site may not ever have been operated; however, in 1983 it replaced a previous incinerator which did operate. Based on this site history, a first phase RFI for soils is warranted.

A total of five surface soil samples will be taken from the area of the incinerator as shown on Figure 4-16. Two samples will be obtained from each end of the incinerator either immediately off the concrete pad or within three feet of the incinerator. In addition, the combustion chamber and any ash retention area which may be present will be visually examined. If ash is found to be present, a sample will be obtained for laboratory analysis. The soil samples immediately adjacent to the incinerator will be analyzed for the full Appendix IX list of constituents. The remaining three samples will be analyzed for VOCs, SVOCs, and RCRA metals.

As indicated, the tank was removed under the UST regulations. Petroleum contaminated soils were discovered during excavations that were addressed at that time. Monitoring wells were installed and sampled. The site characterization report (Blasland, Bouck & Lee, October 1994) indicated total petroleum hydrocarbon (TPH) concentrations in soil ranging from below detection limits to a maximum of 9,800 mg/kg. A volume of 918 cubic yards of contaminated soils was estimated. Collected groundwater samples did not detect dissolved TPH concentrations in excess of the Puerto Rico EQB target level (50 mg/l). Additionally, a qualitative risk assessment indicated an extremely low risk. Given the extent of work performed, the requirements of the RFI will be met by the work under the UST program. While this is the case, groundwater appears to still require some additional work.

It is not known for certain what was held in the tank although evidence to date suggests that it was petroleum fuel for the incinerator. The possibility exists that flammable waste liquids could have been placed in the tank at some point. For this reason, and considering that the tank and soil are gone, groundwater samples will be obtained from up to two downgradient wells. The wells will be

selected based on the results of the UST program as provided in its report. These samples will be analyzed for Appendix IX parameters and TPH. The results of the analyses will serve to verify whether a problem beyond that associated petroleum contamination is present.

4.2.9.11 SWMU 31 - Waste Oil Collection Area

Soil sampling locations are presented on Figure 4-17. Four soil borings will be advanced in the vicinity of the Building 2022. One surface and two subsurface soil samples will be collected (in a manner consistent with other SWMUs) from each boring which will be advanced to the water table. Four additional surface soil samples will be collected from an area that may have been the site of previous uncontrolled storage (see Figure 4-14). All soil samples will be analyzed for the parameters listed on Table 4-2.

The soil sampling locations were selected to focus on these two areas. Due to the small size of these areas, four samples at each will serve to adequately characterize soil. The sampling locations may be modified based on field observations (e.g. staining, etc.); however, the proposed locations at Building 2022 already address known stains.

4.2.9.12 SWMU 32 - Battery Collection Area (Building 31)

The SWMU and proposed soil sampling locations are presented on Figure 4-17. A soil boring will be advanced at each sampling station. A total of four soil borings will be advanced at this SWMU. The locations shown are approximate - actual locations will be selected based on field conditions. One surface (0 to 1 foot) and two subsurface soil samples will be collected from each boring. The soil borings will be advanced to the water table. Samples will be analyzed for the parameters listed on Table 4-2. Volatiles and semivolatiles are included because of the potential for repeated spills of materials containing these constituents. Full RCRA metals are included to address possible release from battery management operations.

Due to the small size of the SWMU, four soil borings will serve to adequately characterize soil quality in this area.

The drawing shows a "drain" immediately to the east of the unit. Recent walkovers of the site have not yielded a precise location for this drain. During the RFI, efforts will be made to locate this drain. It should be noted that the area is dynamic and changes character and use frequently. The drain which was once there may have been removed or paved over. If found, the interior will be examined for collected sediments. A sample of the sediments will be obtained if a sufficient sampling volume is present. The sediment sample (if taken) will be analyzed for the full Appendix IX list of parameters.

4.2.9.13 SWMU 37 - Waste Oil Storage Area - Building 200

Soil sampling locations are presented on Figure 4-18. A surface soil sample (0 to 1 feet) will be collected at each sampling location or as appropriate based on field observations. A total of three soil samples will be collected. The soil samples will be analyzed for the parameters listed on Table 4-2.

This SWMU is bounded by soil on the north and west sides. It is bounded by impermeable tarmac on the south and east sides. The sampling locations are focused on the soil on the north and west sides of the SWMU. Due to the small size of the SWMU, three soil samples will serve to adequately characterize soil quality in this area.

4.2.9.14 SWMU 39 - Former Battery Drain Area Building 3158

Soil sampling locations are presented on Figure 4-19. A surface soil sample (0 to 1 feet) will be collected at each sampling location. Two soil samples will be collected at this SWMU. The soil samples will be analyzed only for RCRA metals since only battery management practices could have caused releases at this unit.

This SWMU is located on the southwest side of Building 3158. The sampling locations are focused on this area. Due to the small size of the SWMU, two soil samples will serve to adequately characterize soil quality in this area. No background samples are proposed since comparisons of sample results will be made to RCRA corrective action clean-up levels.

4.2.9.15 SWMU 46 - Pole Storage Yard Covered Pad

Soil sampling locations are presented on Figure 4-20. A surface soil sample (0 to 1 foot) will be collected at each sampling location. A total of nine soil samples will be collected. Two surface soil samples will be analyzed for full Appendix IX and the remaining samples will be analyzed for VOCs, SVOCs, PCBs, and RCRA metals.

The pad was used for the storage of electrical equipment and, therefore, it is a concern that releases of oils containing PCBs may have occurred to the soils immediately surrounding the pad. To address this concern, two surficial soil samples will be taken on each long side of the pad and one each in the middle of both ends. These locations may be altered based on field conditions. In addition, pads designated as being used for drum storage were also apparently present on the site although there is no evidence of them now. To address possible releases from these pads, the samples shown on the figure will be obtained.

Additionally, two wipe samples will be obtained from locations on the existing pad. These samples, designed to assess whether spills may have repeatedly occurred, will be analyzed only for PCBs.

Previous drawings have indicated the presence of "contaminated soil area" in this general vicinity. No information exists regarding whether these soils have been removed or are there now. Two soil borings will be advanced to the water table in this area. One surface soil and two subsurface soil samples will be collected using the same criteria at other SWMUs for a total of six samples. From one of the soil borings at the "contaminated soil area," the surface soil sample and the sample collected from above the water table will be analyzed for Appendix IX parameters. The intermediate sample from this boring will be analyzed for VOCs, SVOCs, PCBs, and RCRA metals. The intermediate sample from the second boring in this area will be analyzed for Appendix IX while the surface and deep samples will be analyzed VOCs, SVOCs, PCBs, and RCRA metals.

4.2.9.16 SWMU 51 - New AIMD Storage Pad Building 379

Soil sampling locations are presented on Figure 4-21. A surface soil sample (0 to 1 feet) will be collected at each sampling location or at areas visually evidencing a release. A total of five soil

samples will be collected at this SWMU. The soil samples will be analyzed for the parameters listed in Table 4-2.

This SWMU is located within an asphalt-covered lot. There is a drainage ditch to the north and east of this SWMU. The soil sampling locations were selected to determine if contaminants have migrated across the lot, toward the drainage ditch. Samples will be collected at 50-foot intervals along the asphalt-soil boundary (a two-foot offset from the asphalt will be maintained for sampling to avoid measuring affects of the pavement itself). Due to the configuration of the ditch, five soil samples will serve to adequately characterize soil quality in this area.

Consideration was given to sampling sediment within the drainage swale; however, sediment sampling is not included. Any spills/releases from the SWMU must first impact the soil between the asphalt and the swale. Given this, sampling of the soil off the pavement will provide a true indication of any releases from SWMU 51. In addition, the 200-gallon tank has been removed from the site limiting the potential for a recent release. Considering this, the sampling of surface water within the swale was considered unnecessary at this time.

4.2.9.17 Area of Concern (AOC) C - Transformer Storage Pads

Soil sampling locations are presented on Figure 4-20. A surface soil sample (0 to 1 feet) will be collected at each sampling location. A total of 12 soil samples will be collected at this AOC. Three soil samples will be analyzed for Appendix IX parameters. The remaining samples will be analyzed for VOCs, SVOCs, PCBs, and RCRA metals.

The potential releases from this area pertain to possible spills in handling and drainage from the pads. Based on this, the proposed sampling locations are all reasonably close to the pads where releases are most likely. Soil sample locations will be altered as necessary based on pad structural considerations or visible evidence of release. Additionally, up to four samples will be obtained from areas in the general vicinity of the pads where evidence suggests transient off-pad storage of electrical equipment.

Finally, wipe samples for PCBs will be collected from each pad as shown on the figure. This will indicate whether PCB contamination exists and will allow remedial activities to be designed and enacted.

This approach will provide a suitable density and area of coverage of samples to adequately identify whether releases have occurred from the management of PCB-containing electrical equipment.

A previous report referenced a "Creosote Timber Storage Area" near these pads. This area does not now exist. When it was in use, creosoted timbers were stored temporarily prior to use on base. No creosoteing processes took place on site, therefore, there is no potential for a release.

4.2.9.18 AOC D Ensenada Honda Sediments

The concern with the sediments of Ensenada Honda is mainly the possibility of releases to the Honda sediments from SWMUs 1, 2, 3, 7, and 8. Each of these has a detailed sediment sampling program described in their respective work plan sections. Sampling locations for AOC D are presented on the figures for SWMUs 1, 2, 3, 7 and 8 (Figures 4-1, 4-2, 4-3 and 4-4).

No surface water samples are planned for the RFI in Ensenada Honda. Water fluxes in and out of the Honda with the tide on a daily basis. Any surface waters taken from the Honda would therefore not be representative of waters potentially affected by off-site waste migration.

4.3 Background Samples

4.3.1 Soil Background Samples

Background samples, consisting of surface and subsurface soil and groundwater, will be collected from a series of four monitoring wells which will be installed near the perimeter fence north of Gate 2. At each location a surface soil sample (0 to 1 foot) and two subsurface samples will be obtained. Consistent with SWMU-specific borings, one subsurface sample will be collected from the interval immediately above the water table and an intermediate sample from an interval between the ground surface and the water table. The intermediate sample will be collected at the discretion of the on-site geologist.

Each monitoring well will be screened across the water table. Groundwater samples collected from these wells will be analyzed for full Appendix IX constituents.

Sediment samples will be collected at SWMU 3 (Station Landfill) as part of the RFI. The northernmost sediment sample collected along the western side of this SWMU will serve as the background sediment for NSRR. This sample will be analyzed for the parameters listed on Table 4-2.

5.0 FIELD INVESTIGATION AND SAMPLING PROCEDURES

Except for wipe sampling, the sampling procedures are presented as Standard Operating Procedures (SOPs) in Appendix B. These consist of the following:

F101 - Borehole and Sample Logging
F102 - Soil and Rock Sample Acquisition
F103 - Monitoring Well Installation
F104 - Groundwater Sample Acquisition
F105 - Surface Water and Sediment Sample Acquisition
F106 - Test Pit and Trench Excavation
F201 - On-Site Water Quality Testing
F202 - Water level, Water-Product Level, and Well Depth Measurements
F203 - Photoionization Detector (PID)
F204 - Flame Ionization Detector (FID)
F208 - Bacharach Combustible Gas/Oxygen Meter and Personal Gas Monitor
F303 - Field Logbook
F402 - Slug Testing
F501 - Decontamination of Drilling Rigs and Monitoring Well Materials
F502 - Decontamination of Sampling and Monitoring Equipment
F504 - Handling of Site Investigation Wastes
F703 - Geophysics - Ground Penetrating Radar

Wipe sampling will be conducted as described in the guidance document:

"A Compendium of Superfund Field Operations Methods," USEPA, EPA/540/P87/001, December 1987.

Other sections of DCQAP describe the implementation, justification, and design of the sampling operation. In Section 4.0, the rationale, description of the field operations, and a summary of the samples to be collected is presented. Section 6.0 describes the responsibilities of the project staff in implementing the sampling program. Sample handling procedures, including sample containers, preservatives, and holding times are discussed in Section 7.1 and summarized in Tables 7-1, 7-2, and 7-3.

6.0 PROJECT ORGANIZATION

Key personnel responsible for quality assurance throughout the duration of the RFI are identified below. Subcontractors will be used to perform laboratory analysis, data validation, drilling and monitoring well installation, and surveying. Specific subcontractors have not yet been identified. Figure 6-1 shows the project organization, lines of authority, and support personnel/organizations. Resumes of key project personnel are provided as Appendix A.

The responsibilities of some key personnel are presented below:

- The Program Manager, Mr. John W. Mentz, has final responsibility and authority for all work performed under the project. He will manage the day-to-day operations of the entire contract and the Navy CLEAN Program Management Office. He will provide overall program direction, client contact, and quality assurance. From a quality perspective, the Program Manager is responsible for:

  - Ensuring, through an effective quality assurance program, that program and project direction is implemented and accomplished

  - Approving and funding the quality assurance program

  - Participating actively in the quality assurance process

  - Assisting the Quality Assurance Officers, as necessary

  Mr. Mentz is with Baker Environmental, Inc., Coraopolis, Pennsylvania and can be reached at (412) 269-2007.

- The Deputy Program Manager, Mr. Raymond P. Wattras will serve as the primary technical contact with responsibilities for budget and schedule control, project management, and health and safety issues. From a quality perspective, the Deputy Program Manager has responsibilities similar to those outlined above for the

Program Manager. Mr. Wattras is with Baker Environmental, Inc., Coraopolis, Pennsylvania and can be reached at (412) 269-2008.

- The Activity Coordinator, Mr. Thomas C. Fuller, P.G., is responsible for the overall technical oversight for the CTO. He will maintain close contact with LANTDIV and NSRR representatives. Mr. Fuller is with Baker Environmental, Inc., Coraopolis, Pennsylvania, and can be reached at (412) 269-2065.

- The Project Manager, Mr. Christopher D. Boes, P.G., is responsible for managing all work for this CTO, from initiation to final closeout. He is responsible for maintaining budget, schedule, and technical performance as well as quality performance for the CTO. The Project Manager shall receive support from all project management staff and use the capabilities of the technical staff. The Project Manager is responsible for implementing and maintaining all aspects of this Quality Assurance Program for a CTO. Mr. Boes is with Baker Environmental, Inc., Coraopolis, Pennsylvania and can be reached at (412) 269-6020.

- The technical staff is responsible for maintaining quality in the tasks in which they are performing. Senior technical staff also may be used for technical review of project documents, as necessary.

In addition to the project organization described above, the organization that will be used to manage data for this project is described in Section 2.2 of the Data Management Plan.

7.0 SAMPLE AND DOCUMENT CUSTODY PROCEDURES

The following SOPs fully describe the sample and document custody procedures to be used for the field program:

F301 - Sample Preservation and Handling
F302 - Chain-of-Custody
F304 - QA/QC Samples

Tables 7-1, 7-2, and 7-3 summarize the sample containers, preservatives, and holding times to be used for the field program.

8.0 CALIBRATION PROCEDURES AND FREQUENCY

8.1 Field Instruments

The calibration procedures for the water quality instruments (pH meter, conductivity meter, and thermometer), the photoionization detector, and the flame ionization detector that will be utilized for the field program are described in the following SOPs in Appendix B:

F202 - Water Level, Water-Product Level, and Well Depth Measurements
F203 - Photoionization Detector (PID)
F204 - Flame Ionization Detector (FID)

The frequency of calibration for these instruments is also provided in their respective SOPs.

Requirements for documentation of calibration, including recording of usage, maintenance, calibration, and repair, is described in:

F303 - Field Logbook

All standards used for calibration will be from the National Institute of Standards and Technology (NIST), traceable to NIST standards, or other accepted standards (i.e., USEPA).

8.2 Laboratory Instruments

The laboratory's procedures for calibration and related quality control measures are to be in accordance with the protocols presented in "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846, November 1986, 3rd Edition. Formal calibration procedures are established to ensure that instrumentation and equipment used for sample analysis are accurately calibrated and properly functioning. These procedures apply to all instruments and equipment quantities. All calibrations are performed by laboratory personnel or external agencies using standard reference materials per method specifications. The Laboratory Quality Assurance Plan (LQAP) will provide more detail on procedures and frequency. This will be available when the laboratory subcontractor is obtained for this project.

All calibrations are recorded on in-house calibration forms or instrument vendor forms or in dedicated bound notebooks. The following data are recorded for all calibrations: the date, target readings, actual readings, instrument identification number, and the analyst's initials. Other data may be recorded depending upon the calibration performed.

Only properly calibrated and operating equipment and instrumentation are used. Equipment and instrumentation not meeting the specified calibration criteria are to be segregated from active equipment whenever possible. Such equipment is repaired and recalibrated before reuse.

All equipment is uniquely identified, either by serial number or internal calibration number, to allow traceability between equipment and calibration records. Recognized procedures (ASTM, USEPA, or manufacturer's procedures) are used for calibration whenever available.

8.2.1 Method Calibration

Method calibration is performed as part of the laboratory analytical procedure (calibration curves, tuning). Calibration curves are prepared using five standards in graduated amounts across the appropriate range of analysis. New calibration curves are prepared whenever new reagents or standards are prepared or yearly, whichever is more frequent.

8.2.2 GC/MS System Calibration Procedure

This section outlines the requirements for the calibration of GC/MS (or GC/MSD) systems for the determination of organic compounds. The following operations are performed in support of these requirements:

- Documentation of GC/MS mass calibration and abundance pattern
- Documentation of GC/MS response factor stability
- Internal standard response and retention time monitoring

Tuning and Mass Calibration

It is necessary to establish that a given GC/MS system meets the standard mass spectral abundance criteria prior to initiating data collection. This is accomplished through the analysis of p-bromofluorobenzene (BFB) for volatile compounds or decafluorotri-phenylphosphine (DFTPP) for semivolatile compounds. The BFB or DFTPP criteria are met before any blanks, standards, or samples are analyzed.

A GC/MS system used for organic compound analysis is tuned to meet the criteria specified in SW-846 for BFB analysis (volatile compounds) or DFTPP (semivolatile compounds) for an injection of 50 nanograms (ng) of BFB or DFTPP. The analysis is performed separately from standard or blank analysis. These criteria are demonstrated every 12 hours of operation. Background subtraction, if required, is straight forward to eliminate column bleed or instrument background ions. Calibration documentation is in the form of a bar graph spectrum and a mass listing.

GC/MS System Calibration

After tuning criteria have been met and prior to sample analysis, the GC/MS system is initially calibrated at five concentrations utilizing the compounds to be analyzed to determine the linearity of response. Internal and surrogate standards are used with each calibration standard. Standards are analyzed under the same conditions as the samples.

- Relative Response Factor (RRF) Calculation - The USEPA specifies the internal standard to be used on a compound-by-compound basis for quantification. The relative response factor (RRF) is calculated for each compound at each concentration level.

- System Performance Check - a system performance check is performed and the minimum average relative response factors are met before the calibration curve is used.

- Calibration Check - a calibration check is performed and the criteria are met before the calibration curve is used. The percent relative standard deviation (%RSD) is calculated using the relative response factors (RRF) from the initial calibration.

- Continuing Calibration - a calibration check standard containing all semivolatile or volatile compounds and surrogates is run each 12 hours of analysis. a system performance check is performed. The criteria are the same as for the initial calibration system performance check. a calibration check is also performed. The percent difference is determined for each CCC.

The % Difference for each CCC must be less than or equal to 25.0 percent. The system performance check and calibration check criteria must be met before sample analysis can be performed. The continuing calibration is recorded on the continuing calibration forms.

8.2.3 System Calibration Procedure for Metals Analysis

This section outlines the requirements for the calibration of atomic absorption (AA) and Inductively Coupled Plasma (ICP) systems for the determination of metals. The following are performed in support of these requirements:

- Documentation of standard response
- Correlation coefficient monitoring

The AA or ICP system is initially calibrated with a calibration blank and five calibration standards. The standard concentrations are determined as follows. One standard is at a concentration near, but above, the MDL. The other concentrations correspond to the expected range of concentrations found in the actual samples. For AA systems, the calibration standards are prepared fresh each time an analysis is to be performed and discarded after use. The standards contain the same reagents at the same concentrations as will result in the samples following preparation.

This five point calibration is performed daily or before each use for metals analysis by ICP. For metals analysis by AA, the five point calibration is performed whenever new calibration standards are prepared.

Correlation Coefficient Calculation

The data points of the blank and the five calibration standards are utilized to calculate the slope, the intercept, and the correlation coefficient of the best fit line. An acceptable correlation coefficient must be achieved before sample analysis may begin. An acceptable correlation coefficient is >0.997 for AA analyses and >0.9999 for ICP analysis.

Calibration Verification

The initial calibration curve is verified on each working day by the measurement of one mid-range calibration standard. For analysis by AA or ICP, the acceptance criterion for the recovery of the verification standards is ±15 percent of the expected recovery for all metal standards except for the standard for mercury. The acceptance criterion for the recovery of the mercury standard is ±20 percent of the expected recovery. When measurements exceed the control limits, the analysis is terminated, the problem corrected, the instrument recalibrated, and the calibration reverified.

8.2.4 System Calibration Procedure for Inorganic Analyses

This section outlines the requirements that are used for calibration of colorimetric systems for analyses of inorganic parameters. The following are performed in support of these requirements:

- Documentation of standard response
- Correlation coefficient monitoring

The system is initially calibrated with a blank and five calibration standards. Standard concentrations are one standard at a concentration near, but above, the MDL with additional concentrations corresponding to the expected range of concentrations found in actual samples. Standards contain the same reagents at the same concentrations as will be present in samples following preparation.

Correlation Coefficient Calculation

Data points of the blank and five calibration standards are utilized to calculate slope, intercept, and correlation coefficient of a best fit line. An acceptable correlation coefficient is achieved before sample analysis may begin. An acceptable correlation coefficient is >0.99 for all systems.

Calibration Verification

The initial calibration curve is verified on each working day by the measurement of two calibration standards. One standard is at a concentration near the low end of the calibration curve and one standard is at the high end of the curve. The acceptance criteria for recovery of verification standards is ±10 percent of the expected recovery. When measurements exceed control limits, analysis is terminated, the problem is corrected, the instrument is recalibrated, and the calibration is reverified.

8.2.5 Periodic Calibration

Periodic calibration is performed on equipment required in analyses but not routinely calibrated as part of the analytical methodology. Equipment that falls within this category includes ovens, refrigerators, and balances. The calibration is recorded either on specified forms or in bound notebooks. Discussed below are the equipment, the calibration performed, and the frequency at which the calibration is performed.

- Balances are calibrated weekly with class S weights.
- The pH meter is calibrated daily with pH 4 and 7 buffer solutions and checked with pH 10 buffer solution.
- The temperatures of the refrigerators are recorded daily.
- All liquid in glass thermometers are calibrated annually with the N.B.S. certified thermometer. Dial thermometers are calibrated quarterly.

- The N.B.S. Certified Thermometer is checked annually at the ice point.

The following equipment must maintain the following temperatures:

- Sample Storage & Refrigerators: 4° ± 2°C
- Water Bath, Mercury: 95° ± 2°C.

9.0 ANALYTICAL PROCEDURES

9.1 Field Analysis

The field instruments will be operated in accordance with the following SOPs, provided in Appendix B:

F202 - Water Level, Water-Product Level, and Well Depth Measurements
F203 - Photoionization Detector (PID)
F204 - Flame Ionization Detector (FID)
F208 - Bacharach Combustible Gas/Oxygen Meter and Personal Gas Monitor

9.2 Laboratory Analysis

The samples that will be collected during the investigation will be analyzed for constituents listed in Table 9-1. Parameters will be analyzed using analytical methods indicated. Compounds and the corresponding method performance limits also are shown.

The laboratory that will be subcontracted with to perform the analyses will be NEESA Approved. The NEESA Approval process is described in the NEESA 20.2-047B document. As part of this process the laboratory must furnish their LQAP. This LQAP will provide a description of the laboratory facilities, laboratory credentials, laboratory equipment and source of supplies. In addition, the QA/QC procedures the laboratory will use to ensure the generation of scientifically valid and defensible data will be presented. The LQAP will also contain the necessary SOPs which describe the analytical procedures in sufficient detail to allow selection of the methods that will meet the Data Quality Objectives of the project.

10.0 DATA REDUCTION, VALIDATION AND REPORTING

10.1 Database

The database will consist of data records, tabular displays, and graphical displays. The data record allows cross-reference of sample codes and location with lab numbers, components, and analysis results. The tabular displays will present raw data, applicable media, and sorting by potential stratification. The graphical displays will show sampling grids, geographical extent of contamination, and features affecting transport of contaminants. All information will be accessible to USEPA in a form that is compatible with USEPA's computers. Additional details regarding the database for the project is discussed in the Data Management Plan (DMP).

10.2 Field Data Procedures

The requirements for recordkeeping in field notebooks are described in Appendix B as the SOP:

F303 - Field Logbook

a rigorous data control program will insure that all documents for the investigations are accounted for when they are completed. Accountable documents include items such as log books, field data records, correspondence, chain-of-custody records, analytical reports, data packages, photographs, computer disks, and reports. The project manager is responsible for maintaining a project file in which all accountable documents will be inventoried. Filing for the project will be conducted according to the SOP:

A008 - Filing

These SOPs are contained in Appendix B.

10.3 Laboratory Data Procedures

The following procedures summarize the practices routinely used by laboratory staff for data reduction, validation, and reporting. Numerical analyses, including manual calculations, are documented and subjected to quality control review. Records of numerical analyses are legible and complete enough to permit reconstruction of the work by a qualified individual other than the originator. The equations and procedures used for calculations, as well as the units, are specified in the referenced analytical protocols.

Data Validation

Data validation of all laboratory analytical results will be conducted by an independent, third-party data validation subcontractor in accordance with the methodologies presented in Appendix D.

Analytical Reports

The following are required of analytical reports:

- Data is presented in a tabular format.
- Analytical reports are approved by appropriate laboratory personnel.
- The following information is included on the report: client name and address, report date, sample date, analysis dates, number of samples, purchase order number, project number, and project type. All pages are numbered.
- The sample numbers and corresponding laboratory numbers are identified.
- The parameters analyzed, report units, and values are identified.
- Method, trip, and field blank results are reported.
- Matrix spike, matrix spike duplicate, and replicate recoveries are reported.
- Surrogate recoveries are reported.
- Holding times and sample analysis dates are reported.
- The detection limit of the procedure is identified.

- Consistent significant figures are used.
- Referenced footnotes are used when applicable.
- Blank results are not subtracted from sample results; they are treated according to the NEESA data validation guidelines.
- a letter of transmittal accompanies the report if any anomalies are associated with the data. The letter specifies these anomalies.

All laboratory procedures for data reduction, validation, and reporting will be presented in the LQAP. The laboratory selected for this project will be NEESA-approved. The subcontractor's LQAP shall describe the mechanism for periodic reporting to management on the performance of measurement systems and data quality. These reports should include:

- Periodic assessment of analytical data accuracy, precision, and completeness.
- Performance audits results.
- System audits results.
- Significant QA problems and recommended solution.
- Corrective action results.

The analytical laboratory shall maintain detailed procedures of laboratory recordkeeping in order to support the validity of all analytical work. Each data set report submitted to the Project Manager should contain the laboratory Project Manager's and QA Officer's written verification that the approved analytical method (without modification) was performed and all QA/QC checks were within the established protocol limits on all samples. If any QA problems are encountered during sample analysis, the laboratory will inform the Project Manager in writing. The laboratory QA Officer will provide the Project Manager reports of their QA audits by external agencies and of internal audits by their QA department upon request.

The Field Team Leader will report to the Project Manager on a frequent basis regarding progress of the field work and quality control issues associated with the field activities. All reports will be documented in a field logbook.

After the field work has been completed and the final analyses have been performed and checked, a final quality assurance report will be prepared for inclusion into the project final report (e.g., RFI Report). The report will summarize the quality assurance and audit information, indicating any corrective actions taken and the overall results of QA compliance. The Project Manager will prepare this final summary in coordination with the contract laboratory.

11.0 INTERNAL QUALITY CONTROL CHECKS

11.1 Field Internal Quality Control Checks

Field internal quality control checks to be used during the RFI include field duplicates, equipment rinsates, field blanks, and trip blanks. A breakdown by type of sample with which the QA/QC samples will be submitted to the laboratories is given in Table 11-1.

TABLE 11-1

QC SAMPLE FREQUENCY

Media	Trip Blanks	Equipment Rinsates	Field Blanks	Field Duplicates
Water	One per cooler containing VOAs	5 percent or one per day of sampling	One per source per event	5 percent
Soil, Sediment, Wipe	One per cooler containing VOAs	5 percent or one per day of sampling	One per source per event	5 percent

11.2 Types of QC Samples

Documentation of the analyses of the following types of QC samples is maintained in the laboratory bench notebooks and/or the specific client or project files.

Trip Blank

Analysis of trip blanks is performed to monitor possible contamination during shipment and collection of samples. Trip blanks are initiated in the laboratory prior to the shipping of sample packs. A corresponding trip blank is prepared for each set of samples to be analyzed for volatile organic compounds.

Trip blank samples are prepared by adding four drops of concentrated hydrochloric acid and then filling the container with deionized water (ASTM Type II). The trip blanks accompany the samples

through shipment to the sample site, sample collection, shipment to the laboratory, and storage of the samples.

Method Blank

Analysis of method blanks is performed to verify that method interferences caused by contamination in reagents, glassware, solvents, etc. are minimized and known.

Method blanks are initiated by the analyst prior to the preparation and/or analysis of the sample set. A method blank consists of a volume of deionized water or organic-free water equal to the sample volume which is carried through the entire analytical procedure. For solid samples to be analyzed by GC/MS, the method blank consists of a purified solid matrix approximately equal to the sample weight. A method blank is analyzed with each set of samples or at the very least, daily. If the analytical data of the method blank indicates excessive contamination, the source of contaminant will be determined. The samples may be reanalyzed or the data may be processed as is depending upon the nature and extent of the contamination.

Replicate Sample Analysis

Replicate sample analysis is performed to demonstrate the precision of an analysis. An interlaboratory replicate sample is initiated by the analyst prior to sample preparation and carried through the entire analytical procedure. The frequency of interlaboratory replicate analysis for each analyte is summarized in Table 11-2.

Spike Analysis

Spike analysis is performed to demonstrate the accuracy of an analysis. The analyst initiates the spike prior to sample preparation and analysis by adding a known amount of analyte(s) to a sample. The spike sample is carried through the entire analytical procedure. The frequency of spike analysis for each analyte(s) is summarized in Table 11-2.

TABLE 11-2

QA/QC ANALYSIS FREQUENCY*

Parameter	Replicate	Spike
Metals		
Liquids by flame AA or ICP	10%	10%
Solids by flame AA or ICP	10%	10%
All analyses by furnace AA	10%	10%
General Chemistry		
Cation Exchange Capacity	10%	10%
Oil and Grease	10%	10%
Total Organic Carbon	10%	10%
Total Petroleum Hydrocarbons	10%	10%

*For organic analyses see MS/MSD section.

Surrogate Standards

Surrogate standard analysis is performed to monitor the preparation and analyses of samples. All samples and blanks analyzed by GC/MS are fortified with a surrogate spiking solution prior to extraction or purging. Similarly, surrogate standards are added to samples, standards and blanks and analyzed by gas chromatography procedures to monitor the performance of the extraction, cleanup (when used) and analytical system. For example, two surrogate standards are used for the analysis of pesticide/PCBs by Method SW-846 8080.

Internal Standards

Internal standard analyses are performed to monitor system stability. Prior to injection or purging, internal standards are added to all blanks and samples analyzed by GC/MS.

Matrix Spike/Matrix Spike duplicates (MS/MSD)

Determines the accuracy and precision of certain analytical methods. Where appropriate, MS/MSDs will be employed. For example, for GC and GC/MS analyses of organic compounds a MS/MSD are analyzed for every 20 samples of similar matrix.

11.3 Laboratory Control Limits

Prior to the analysis of actual samples, quality control checks are made (e.g., spike recoveries, duplicates, blanks) to determine that the precision and accuracy are within accepted control limits. For the analysis of volatile and semivolatile organics by gas chromatographic procedures, the process is described in Section 8.0 of SW-846 Method 8000. The acceptance criteria for precision and accuracy are given in the QC Acceptance Criteria tables at the end of each determinative method (e.g., Tables 6 and 8 in SW-846 Method 8240).

Whenever an out-of-control situation occurs, the cause is determined. Any needed corrective actions are taken.

Method Blanks

For metals analyses, the following criteria are used for method blank analysis:

- If the concentration of the method blank is less than or equal to the detection level, no correction of sample results is performed.

- If the concentration of the blank is above the detection level for any group of samples associated with a particular blank, the concentration of the sample with the least concentrated analyte must be 10 times the blank concentration, or all samples associated with the blank and less than 10 times the blank concentration must be redigested (reprepared) and reanalyzed.

The sample value is not corrected for the blank value unless, for AA and ICP analysis, a sufficient amount of sample is not available for reanalysis. In this case, the sample value is corrected for the blank value.

For GC/MS analyses, the following criteria are used for method blank analysis:

- A method blank for volatiles analysis must contain no greater than five times the detection limit of common laboratory solvents (common laboratory solvents are: methylene chloride, acetone, toluene, 2-butanone, and chloroform).

- A method blank for semivolatiles analysis must contain no greater than five times the detection limit of common phthalate esters.

- For all other compounds not listed above, the method blank must contain less than the detection limit of any single compound. If a method blank exceeds the criteria, the analytical system is considered to be out of control. The source of the contamination is investigated and appropriate corrective measures are taken and documented before sample analysis proceeds. All samples processed with a method blank that is out of control (i.e., contaminated) are reextracted/repurged and reanalyzed.

Surrogate Standards

For method blank surrogate standard analysis, corrective action is taken if any one of the following conditions exist:

- Recovery of any one surrogate compound in the volatile fraction is outside the required surrogate standard recovery limit.

- Recovery of any one surrogate compound in either of the semivolatile fraction is outside surrogate standard recovery limits.

Corrective action will include the following:

- A check of the calculations for errors; a check of the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and a check of instrument performance.

- Recalculation or reinjection/repurging of the blank or extract if the above corrective actions fail to solve the problem.

- Reextraction and reanalysis of the blank. For sample surrogate standard analysis, corrective action is taken if any one of the following conditions exist:

  - Recovery of any one surrogate compounds in the volatile fraction is outside the surrogate spike recovery limits.

  - Recovery of any one surrogate compound in either semivolatile fraction is below 10 percent.

  - Recoveries of two or more surrogate compounds in either semivolatile fraction are outside surrogate spike recovery limits.

Corrective action will include the following:

- A check of the calculations for errors; a check of the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and a check of instrument performance.

- Recalculating or reanalysis of the sample or extract if the above corrective action fails to solve the problem.

- Reextraction and reanalysis of the sample if none of the above are a problem.

11.4 Quality Assurance Review of Reports, Plans, and Specifications

Prior to issuance of a final report, it is reviewed by knowledgeable members of the project staff or the Project Manager. This review addresses whether:

- The report satisfies the scope of work, client requirements, and pertinent regulatory requirements.

- Assumptions are clearly stated, justified, and documented.
- A reference is cited for any information utilized in report preparation that originated outside the project.
- The report correctly and accurately presents the results obtained by the work.
- The tables and figures presented in the report are prepared, checked, and approved according to requirements.
- The report figures are signed and dated by the appropriate members of the project staff and project management.
- The typed report has been proofread and punctuation, grammar, capitalization, and spelling are correct.

12.0 PERFORMANCE AND SYSTEM AUDITS

A field audit may be conducted during the field investigation to verify that sampling is being performed according to the plan. The checklist provided in Table 12-1 is used for audits. At the appropriate time, the Project Manager will conduct field audits. A report will be submitted within 30 calendar days of completion of the audit. Serious deficiencies will be reported within 24 hours of the time of discovery of the deficiency, including actions taken or to be taken to correct such deficiencies.

The analytical subcontractor's LQAP must describe the external and internal performance evaluation tests and audits required to monitor the capability and performance of the total measurement process. These include system audits as required by Federal and State regulatory agencies to obtain and maintain laboratory certifications, commercial clients with auditing programs, and subscription to commercial auditing agencies. In addition, performance audits such as USEPA's Performance Evaluation Studies (drinking water and wastewater series), client sponsored performance evaluations, various government proficiency test samples to maintain laboratory certifications, and internal blind quality assurance samples should be discussed. In addition, the LQAP should define the acceptance criteria for the laboratory.

Laboratories that participate in the CLEAN Installation Restoration Program are required to obtain NEESA approval. This process consists of on-site laboratory audits, submittal of the LQAP, monthly reports, and periodic analyses of performance evaluation samples. Baker's responsibility is to ensure that the laboratory subcontractors selected have current NEESA certification. The NEESA Approval Process is described in the NEESA 20.2-047B document.

13.0 PREVENTIVE MAINTENANCE

13.1 Field Maintenance

Preventative maintenance, including a list of critical spare parts, for the field instruments are given as the following SOPs in Appendix B:

F202 - Water Level, Water-Product Level, and Well Depth Measurement
F203 - Photoionization Detector (PID)
F204 - Flame Ionization Detector (FID)
F208 - Bacharach Combustible Gas/Oxygen Meter and Personal Gas Monitor

13.2 Laboratory Maintenance

Preventive maintenance is an organized program of actions to prevent instruments and equipment from failing during use and to maintain proper performance of equipment and instruments. A comprehensive preventive maintenance program is implemented to increase the reliability of the measurement system. The preventive maintenance program addresses the following:

- Schedules of important preventive maintenance tasks that are carried out to minimize downtime.

- Lists of critical spare parts that are available to minimize downtime.

The laboratory maintains histories, in instrument/equipment logs, of all major equipment. Trouble shooting, maintenance, and spare parts inventory are recorded in the logs. Instruments and equipment are maintained periodically according to SW-846, third edition requirements, manufacturer's recommendation, and/or service contracts.

The modern analytical laboratory depends heavily upon instrumentation and equipment; therefore, cleaning and preventive maintenance are primary considerations in the sustained production of satisfactory data. Specific requirements for proper care of laboratory instrumentation and equipment are contained in the manufacturer's instructions; however, some general guidelines are considered.

equipment are contained in the manufacturer's instructions; however, some general guidelines are considered.

- Special precautions are taken to avoid spillage of corrosive chemicals on or around equipment and instrumentation not only to extend the life of the item, but also to eliminate contamination.

- Where available, covers are placed on instrumentation when not in use.

- Instrument parts are cleaned as required (i.e., mirrors, probes, detector cells).

The analytical subcontractor has not been identified at this time. The LQAP for the selected laboratory should contain a section concerning Preventive Maintenance, which will include a spare parts list, as well as the source(s) of spare parts and repairs.

14.0 DATA MEASUREMENT ASSESSMENT PROCEDURES

14.1 Overall Project Assessment

Overall data quality will be assessed by a thorough understanding of the data quality objectives which are stated during the design phase of the investigation. By maintaining thorough documentation of all decisions made during each phase of sampling, performing field and laboratory audits, thoroughly reviewing the analytical data as they are generated by the laboratory, and providing appropriate feedback as problems arise in the field or at the laboratory, data accuracy, precision, and completeness will be closely monitored.

14.2 Field Quality Assessment

To assure that all field data are collected accurately and correctly, specific written instructions will be issued to all personnel involved in field data acquisition by the Project Manager. The Project Manager will perform field audit(s) during the investigation to document that the appropriate procedures are being followed with respect to sample (and blank) collection. These audits will include a thorough review of the field books used by the project personnel to insure that all tasks were performed as specified in the instructions. The field audits will necessarily enable the data quality to be assessed with regard to the field operations.

The evaluation (data review) of field blanks, and other field QC samples will provide definitive indications of the data quality. If a problem that can be isolated arises, corrective actions can be instituted for future field efforts.

14.3 Laboratory Data Quality Assessment

As part of the analytical QA/QC program, the laboratory applies precision and accuracy criteria for each parameter that is analyzed. When analysis of a sample set is completed, QC data generated are reviewed and evaluated to ensure acceptance criteria are met. These criteria are method and matrix specific.

QA/QC data review is based on the following criteria:

- Method Blank Evaluation - The method blank results are evaluated for high readings characteristic of background contamination. If high blank values are observed, laboratory glassware and reagents are checked for contamination and the analysis of future samples halted until the system can be brought under control. A high background is defined as a background value sufficient to result in a difference in the sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid. A method blank must contain no greater than two times the parameter detection limit for most parameters.

- Trip Blank Evaluation - Trip blank results are evaluated for high readings similar to the method blanks described above. If high trip blank readings are encountered (i.e. a value sufficient to result in a difference in sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid), procedures for sample collection, shipment, and laboratory analysis are reviewed. If both the method and the trip blanks exhibit significant background contamination, the source of contamination is probably within the laboratory. Ambient air in the laboratory and reagents are checked as possible sources of contamination.

- Standard Calibration Curve Verification - The calibration curve or midpoint calibration standard (check standard) is evaluated daily to determine curve linearity through its full range and that sample values are within the range defined by the low and high standards. If the curve is not linear, sample values are corrected. If average response factors are used to calculate sample concentrations, these factors are verified on a daily basis. Verification of calibration curves and response factors is accomplished when the evaluated response for any parameter varies from the calibrated response by less than ranges specified in Section 7.0.

- Duplicate Sample Analyses - Duplicate sample analyses are used to determine the precision of the analytical method for the sample matrix. Two types of duplicate samples are analyzed for this project, field and interlaboratory. Duplicate results are used to calculate precision as defined by the RPD. If interlaboratory duplicate

values exceeds the control limit, the sample set are reanalyzed for the parameter in question. Precision limits are updated periodically following review of data.

$$RPD = \frac{S(1) - S(2)}{M} \times 100$$

Where: S(1) is the result of sample 1 of duplicate pair

S(2) is the result of sample 2 of duplicate pair

M is the mean of S(1) and S(2)

- Reference Sample Analyses - The results of reference sample analysis are compared with true values, and the percent recovery of the reference sample is calculated. If correction is required (excessive or inadequate percent recovery), the reference sample is reanalyzed to demonstrate that the corrective action has been successful.

- Surrogate Standard Analyses - Surrogate standard determinations are performed on all samples and blanks for GC/MS analyses. All samples and blanks are fortified with surrogate spiking compounds before purging or extraction to monitor preparation and analysis of samples. Recoveries must meet specific criteria. If acceptance criteria are not met, corrective action is taken to correct the problem and the affected sample is reanalyzed.

- Matrix Spike Analyses - The observed recovery of a spike added to a sample versus theoretical spike recovery is used to calculate accuracy as defined by the percent recovery (% R). If the accuracy value exceeds the control limit for the given parameter, the appropriate laboratory personnel are notified and corrective action is taken before the sample set is reanalyzed for the parameter in question.

$$\% R = \frac{T - B}{S} \times 100$$

Where: T is the total amount of analyte

B is the background concentration of analyte

S is the amount of analyte spiked into a sample or blank

For completeness, it is expected that the methodology proposed for chemical characterization of the samples will meet QC acceptance criteria for at least 95% of all sample data. To ensure this completeness goal, sample data that does not meet the established criteria will be recollected, reextracted, or reanalyzed. Completeness is the percentage of the total measurements made which are judged to be valid measurements.

Data representativeness will be ensured through the use of appropriate analytical procedures, and analysis of samples performed within the allowed holding times.

Comparability is a qualitative characteristic of the data. By using standard methods for sampling and analyses, data generated in past or future investigations will be comparable with this investigation data.

15.0 CORRECTIVE ACTION

Corrective action is taken whenever a nonconformance occurs. A nonconformance is defined as an event which is beyond the limits established for a particular operation by the plan. Nonconformances can occur in a number of activities. Such activities include sampling procedures, sample receipt, sample storage, sample analysis, data reporting, and computations.

The following personnel are responsible for detecting and reporting nonconformances:

- Project Staff - during testing and preparation and verification of numerical analyses

- Laboratory Staff - during the preparation for analyses, performance of analytical procedures, calibration of equipment, and quality control activities

15.1 Corrective Action

Nonconformances are documented by the person originating or identifying it. Documentation includes the following:

- Identification of the individual(s) originating or identifying the nonconformance
- Description of the nonconformance
- Any required approval signatures (initials)
- Corrective action taken
- Corrective action completion date

Documentation of the nonconformance and corrective action taken is kept by the analyst and become part of the QA/QC files for the project.

The NEESA contract representative (NCR), along with the contract project director, will be notified of a nonconformance and corrective action taken, if one of the following is true:

- A nonconformance causes a delay in work beyond the schedule completion date.
- A nonconformance affects information already reported.

- A nonconformance affects the validity of the data.

15.2 Limits of Operation

The limits of operation that are used to identify nonconformances are established by the contents of the plan and by control limits produced by statistical analyses. The quality control check samples must compare favorably to the published USEPA or laboratory method performance criteria. For example, the analytical process is out of control and unacceptable if the recovery value is outside the laboratory control limits established by analyzing many standards and performing a statistical analysis of the data. Generally, the control limits are set at ±3 times the standard deviation.

16.0 QUALITY ASSURANCE REPORTING PROCEDURES

The Project Manager will be responsible for assessing the performance of measurement systems and data quality related to the field investigation. A written record will be maintained of the results of laboratory QC reports and other periodic assessments of measurement, data accuracy, precision and completeness; performance and system audits; and any significant QA problems and recommended solutions. Each deliverable will contain a QA/QC assessment section. Also, a QA/QC assessment will be performed any time a significant problem is identified. A timetable for the project is presented in the Work Plan.

The contractor's Project Manager will keep in contact with the Navy Technical Representative and NSRR representatives through informal, verbal reports during the project as well as through monthly progress reports. These reports will include any changes in the QAPP. The final report for the project will include a separate QA section which summarizes data quality information contained in the periodic reports submitted to management and the client.

All reports are managed and secured in accordance with Baker's document control system (DCS). The documents to be managed by the DCS include CTO work plans, cost estimates, design documents, data and reports generated by CTO technical teams, results of laboratory analyses, agency file documents, QA reports and status reports. The DCS system also provides accountability for field documentation including such items as field logbooks, field data records, sample tags, chain-of-custody records, and photographs.

FIGURES

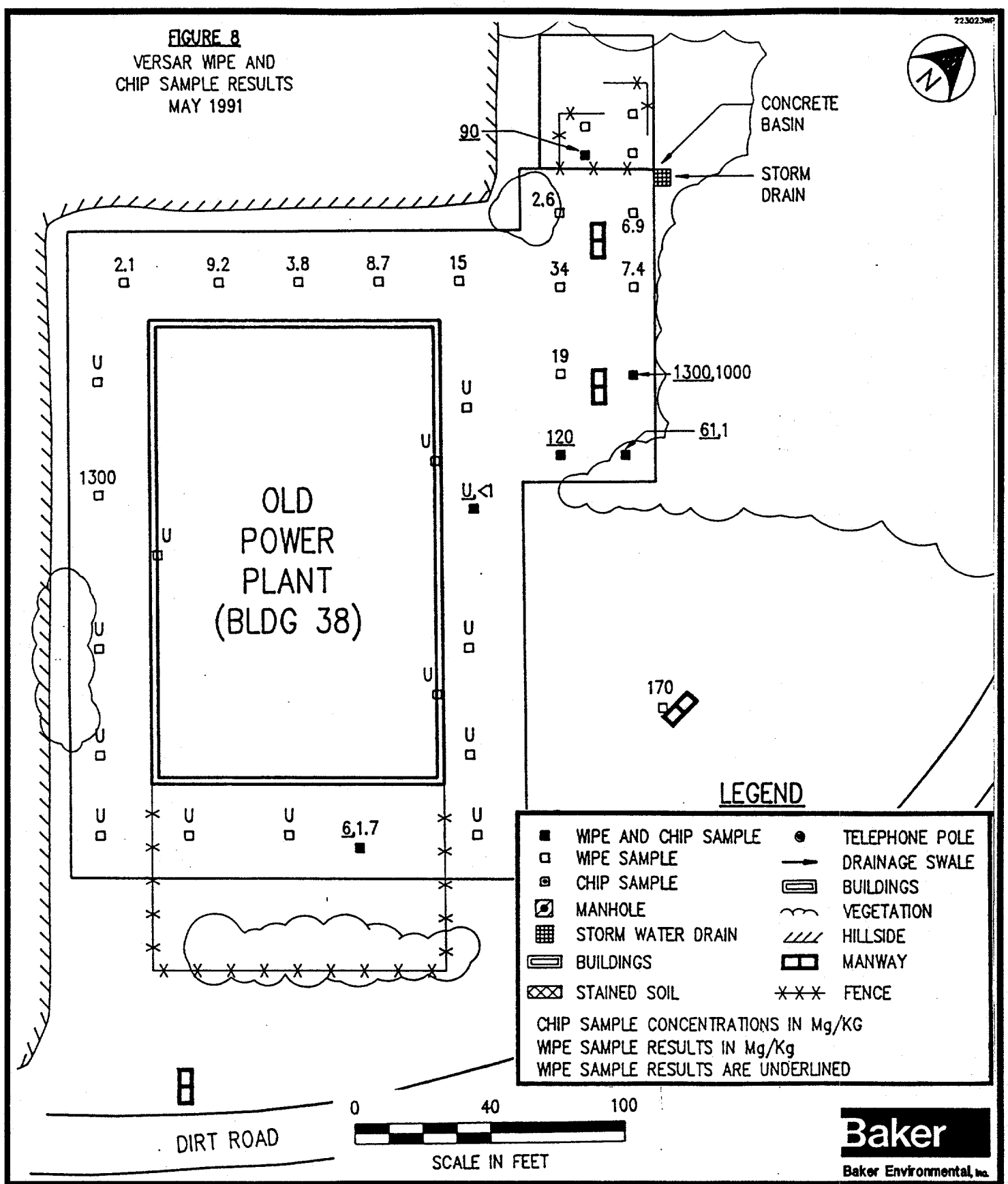
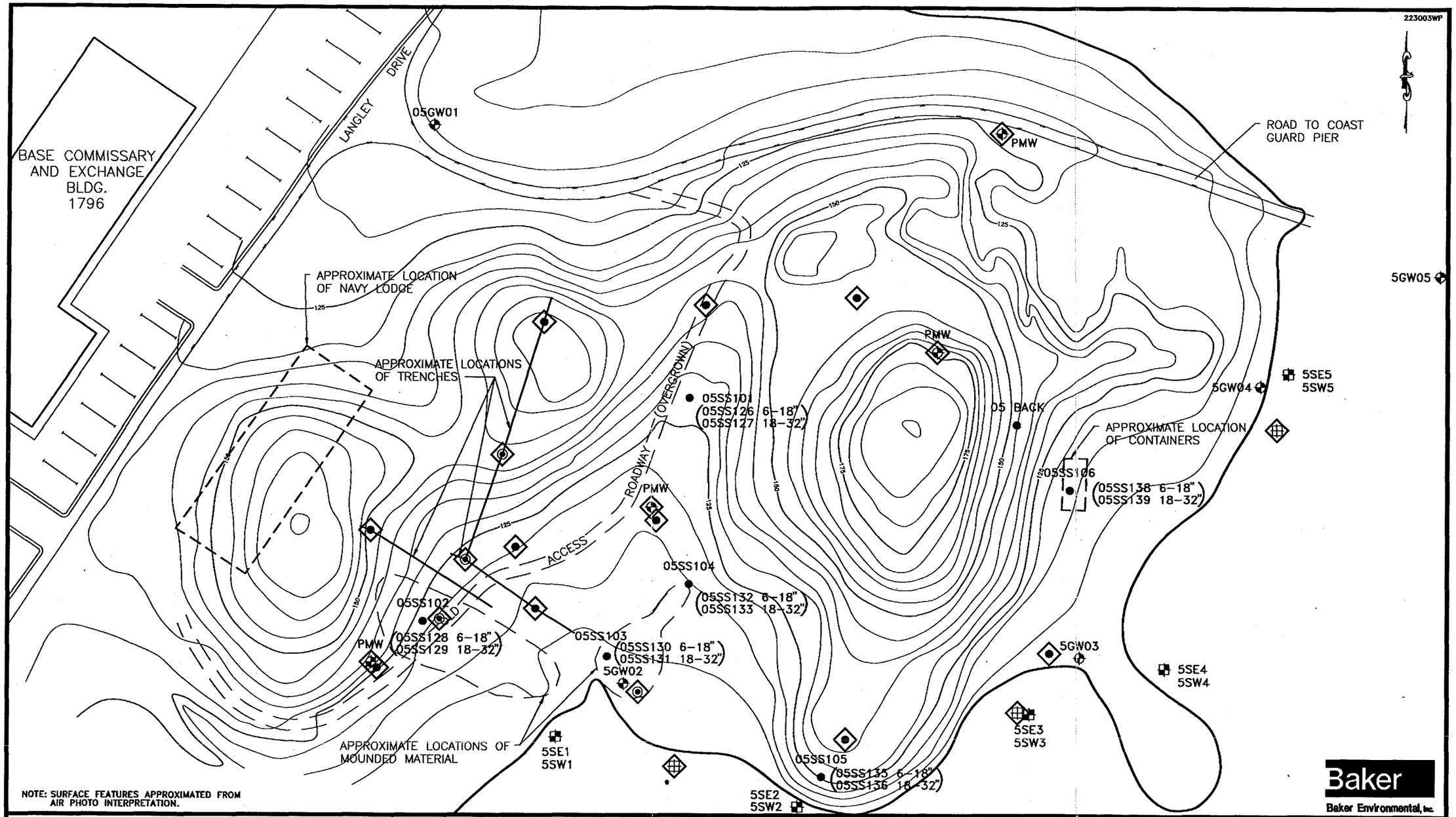


FIGURE 3-1
PREVIOUS SAMPLING LOCATIONS
SWMU 11 – OLD POWER PLANT, BLDG. 38
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE: SURFACE FEATURES APPROXIMATED FROM AIR PHOTO INTERPRETATION.

LEGEND

- EXISTING MONITORING WELL LOCATION (CONFIRMATION STUDY)
- PROPOSED MONITORING WELL LOCATION
- 1992 SOIL SAMPLING LOCATIONS (APPROXIMATE)
- SEDIMENT/SURFACE WATER SAMPLE (SUPPLEMENTAL INVESTIGATION)
- PROPOSED SEDIMENT SAMPLE LOCATION
- PROPOSED SURFACE SOIL SAMPLE LOCATION
- PROPOSED SOIL BORING LOCATION
- 125 SURFACE ELEVATION CONTOUR

SOURCE: LANTDIV, FEB. 1992

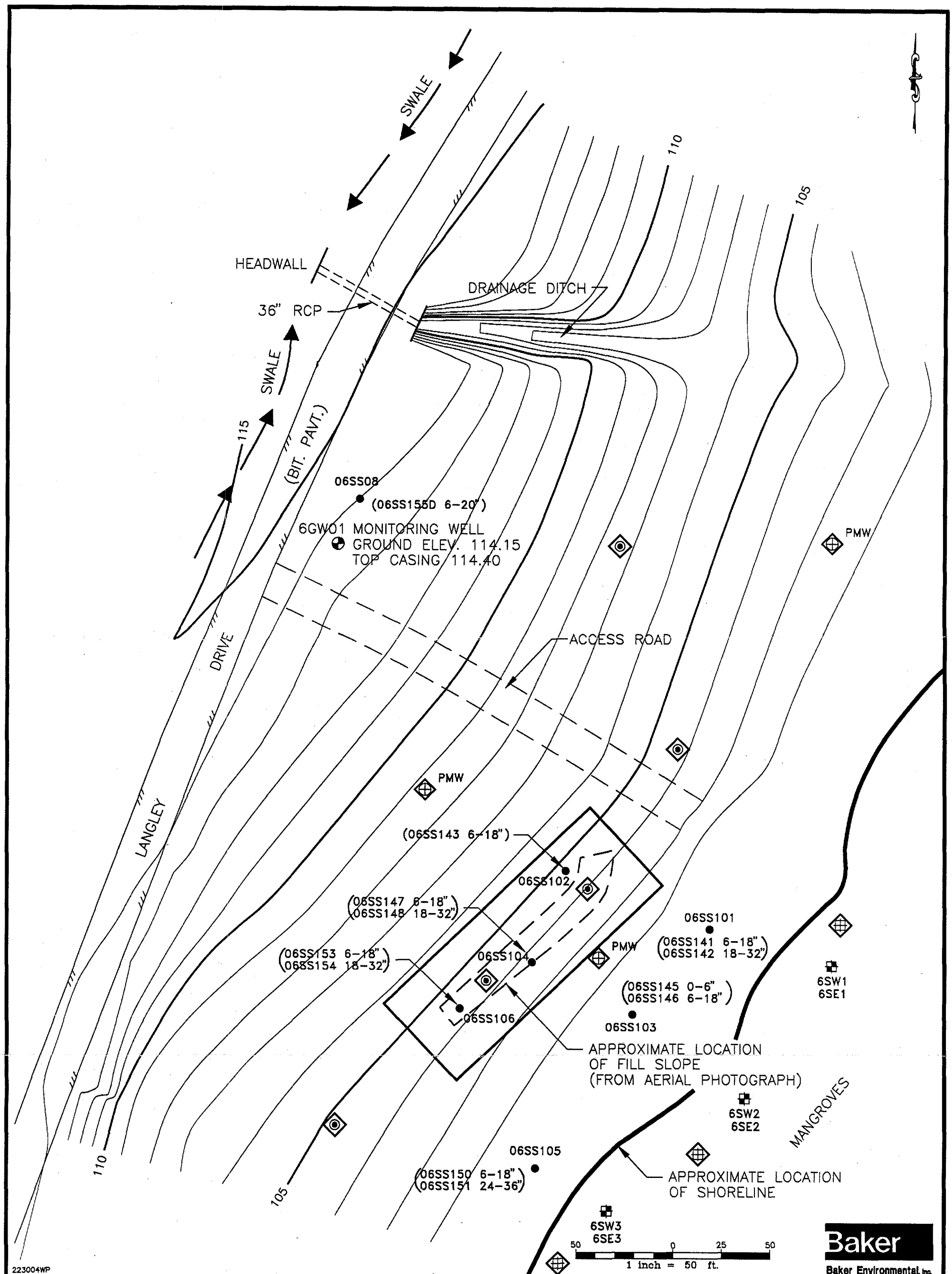
160 0 80 160 320

1 inch = 160 ft.

FIGURE 4-1
PROPOSED SAMPLING LOCATIONS
RFI – SWMU 1
ARMY CREMATOR DISPOSAL SITE

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

00170BB3Z



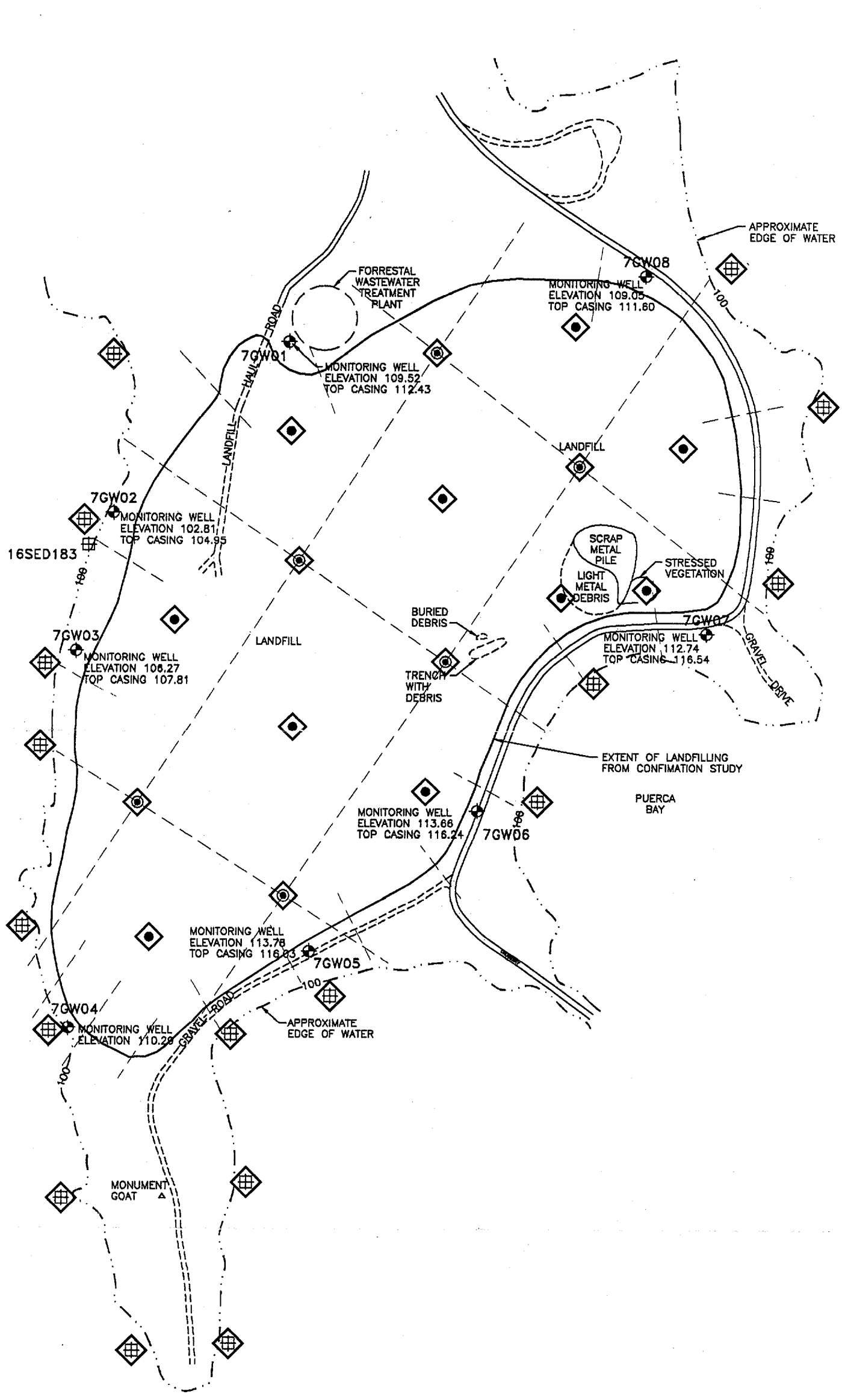
LEGEND

- 6GW01 EXISTING MONITORING WELL LOCATION
- PROPOSED MONITORING WELL LOCATION
- 1992 SOIL SAMPLING LOCATIONS (APPROXIMATE)
- PROPOSED SOIL BORING LOCATION
- 110 SURFACE ELEVATION CONTOUR
- SURFACE WATER DRAINAGE DIRECTION
- SURFACE WATER/SEDIMENT SAMPLE (SUPPLEMENTAL INVESTIGATION)
- PROPOSED SEDIMENT SAMPLE LOCATION
- PROPOSED SURFACE SOIL SAMPLE LOCATION

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-2
PROPOSED SAMPLING LOCATIONS
RFI - SWMU 2
LANGLEY DRIVE DISPOSAL SITE

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



223005WP

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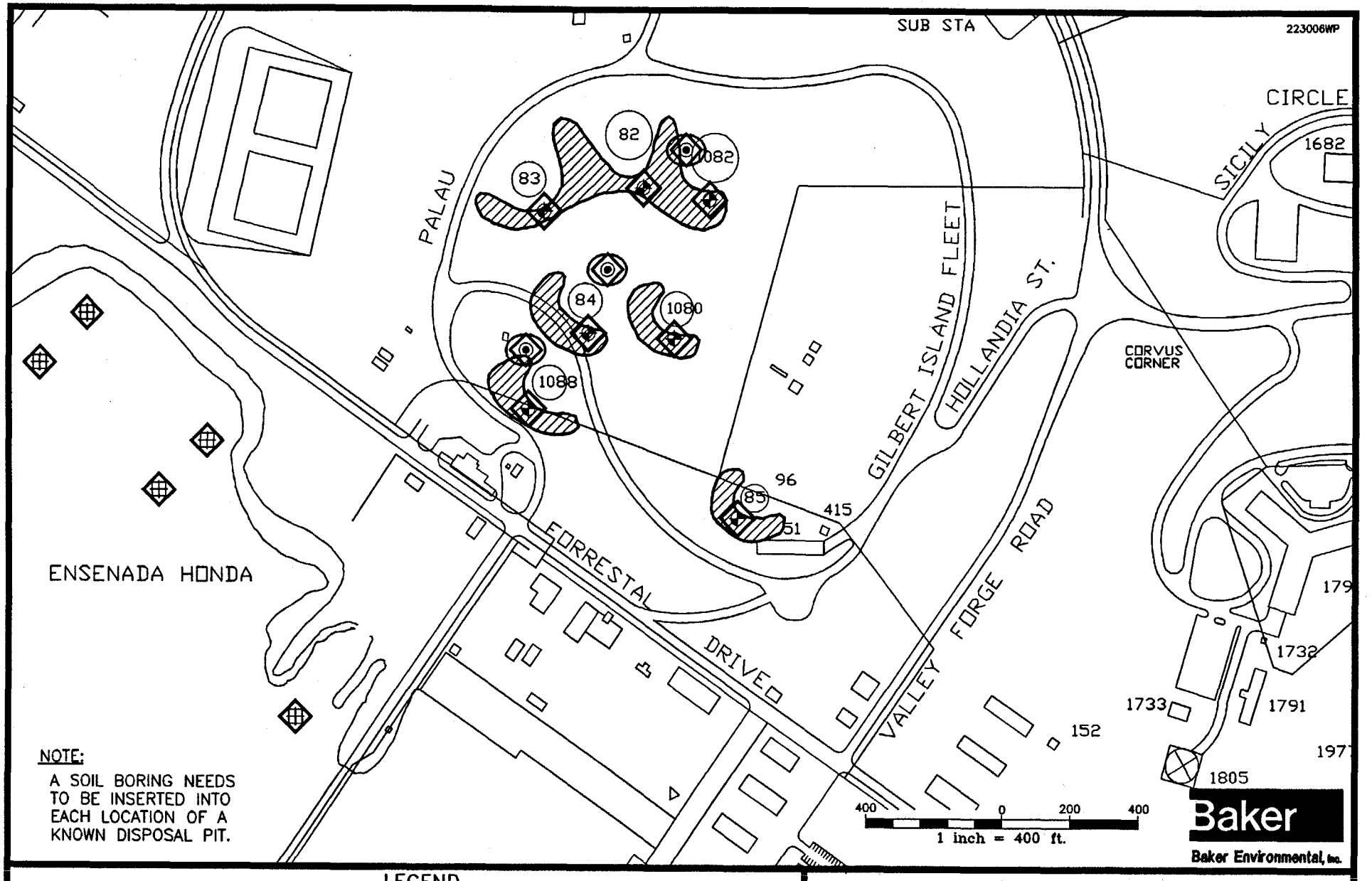
LEGEND

- SEDIMENT SAMPLE LOCATION
- PROPOSED SEDIMENT SAMPLE LOCATION
- EXISTING MONITORING WELL LOCATION
- PROPOSED SOIL BORING LOCATION (SURFACE SAMPLES INCLUDED)
- PROPOSED SURFACE SOIL SAMPLING LOCATION
- CONCEPTUAL CONDUCTIVITY TRAVERSES

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-3
PROPOSED SAMPLING LOCATIONS
RFI SWMU 3
BASE LANDFILL

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

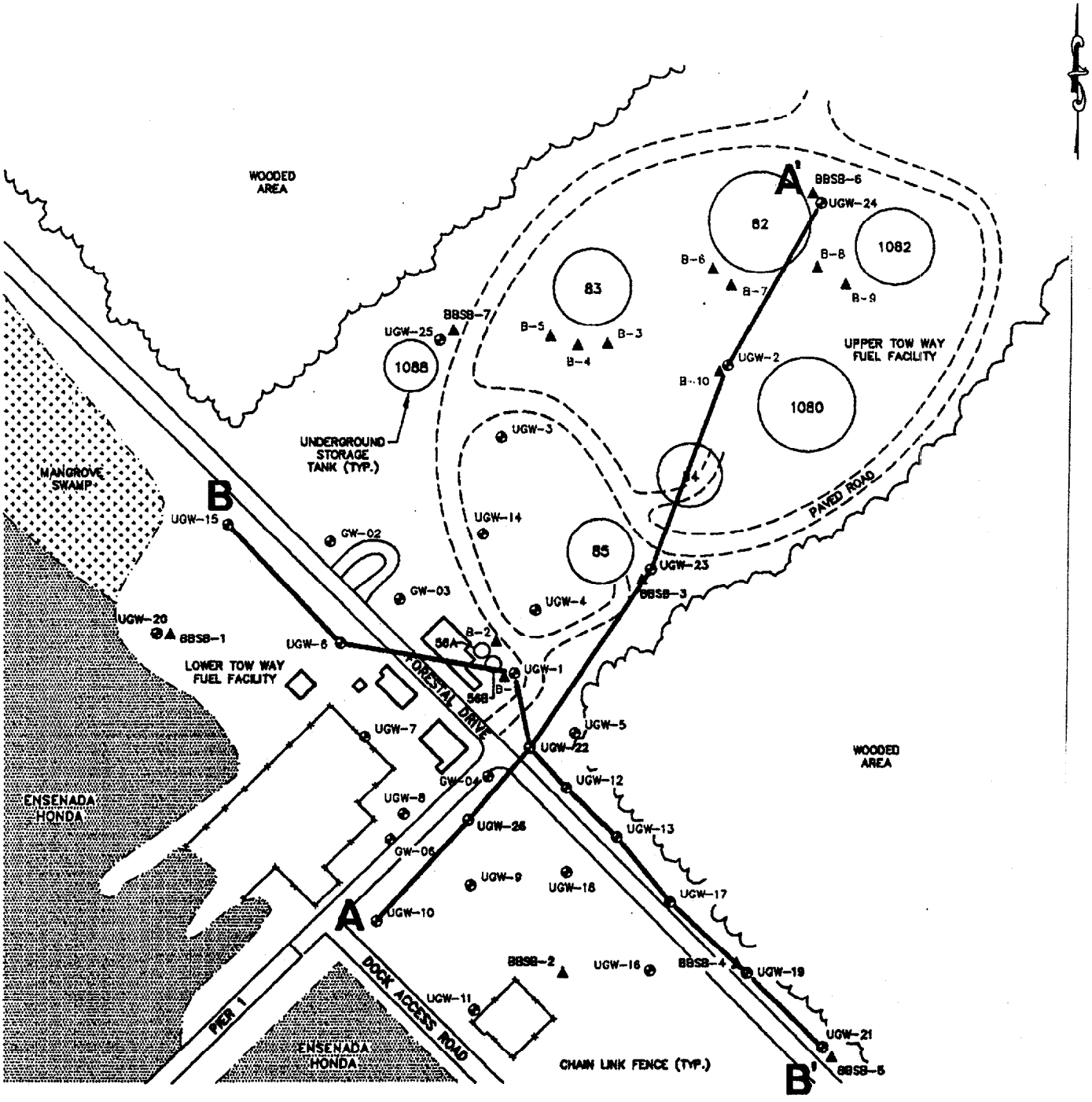


LEGEND

- PROPOSED SOIL BORING LOCATION
- PROPOSED TEST PIT LOCATION
- PROPOSED SEDIMENT SAMPLE LOCATION
- APPROXIMATE LOCATION OF KNOWN DISPOSAL PIT
- AREA FOR GPR SURVEY

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-4
PROPOSED RFI SAMPLING PLAN
SWMUs 7 AND 8 TOW WAY FUEL FARM
AOC D
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- ⊕ MONITORING WELL
- ▲ SOIL BORING
- ⊕ MONITORING WELL INSTALLED BY BB&L (1993)
- ▲ SOIL BORING INSTALLED BY BB&L (1993)

B——B' GEOLOGIC CROSS-SECTION LOCATIONS

SOURCE: BLASLAND, BOUCK & LEE, INC.

FIGURE 4-5
EXISTING BORING/WELL LOCATIONS
SWMUs 7 AND 8
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

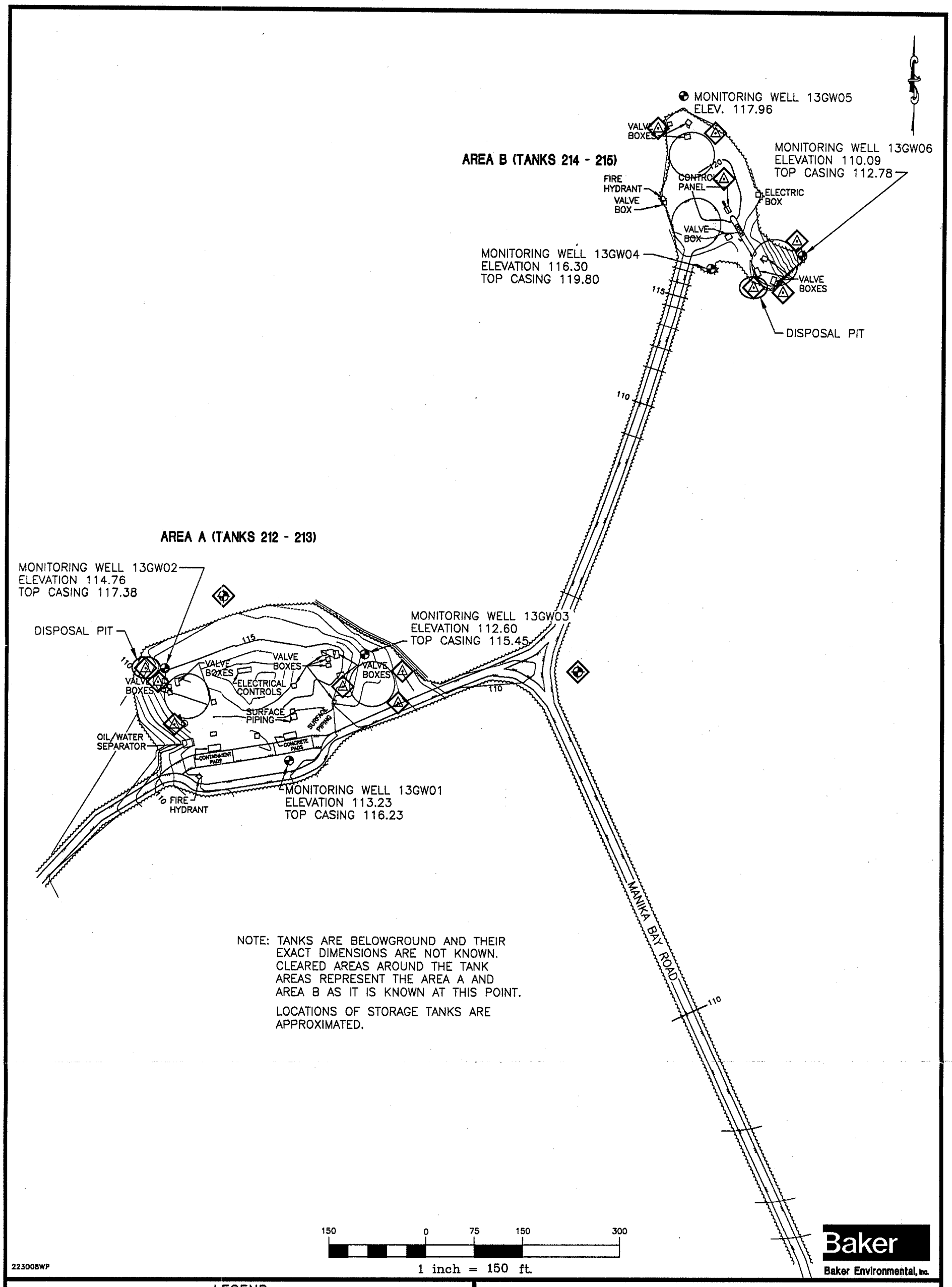
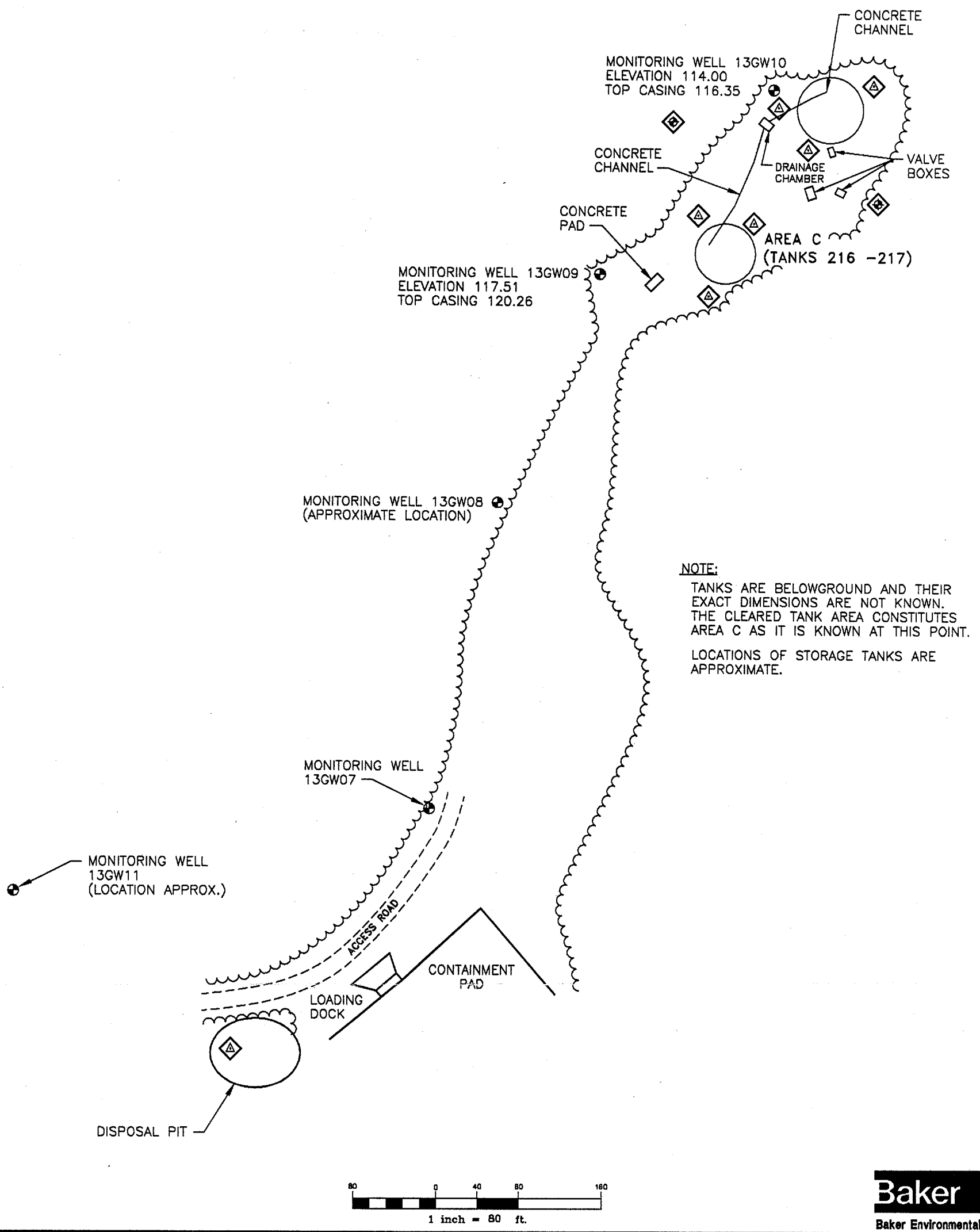


FIGURE 4-6
PROPOSED SAMPLING LOCATIONS
RFI - SWMU 9, AREAS A AND B
TANKS 212 - 215

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

00170BB42



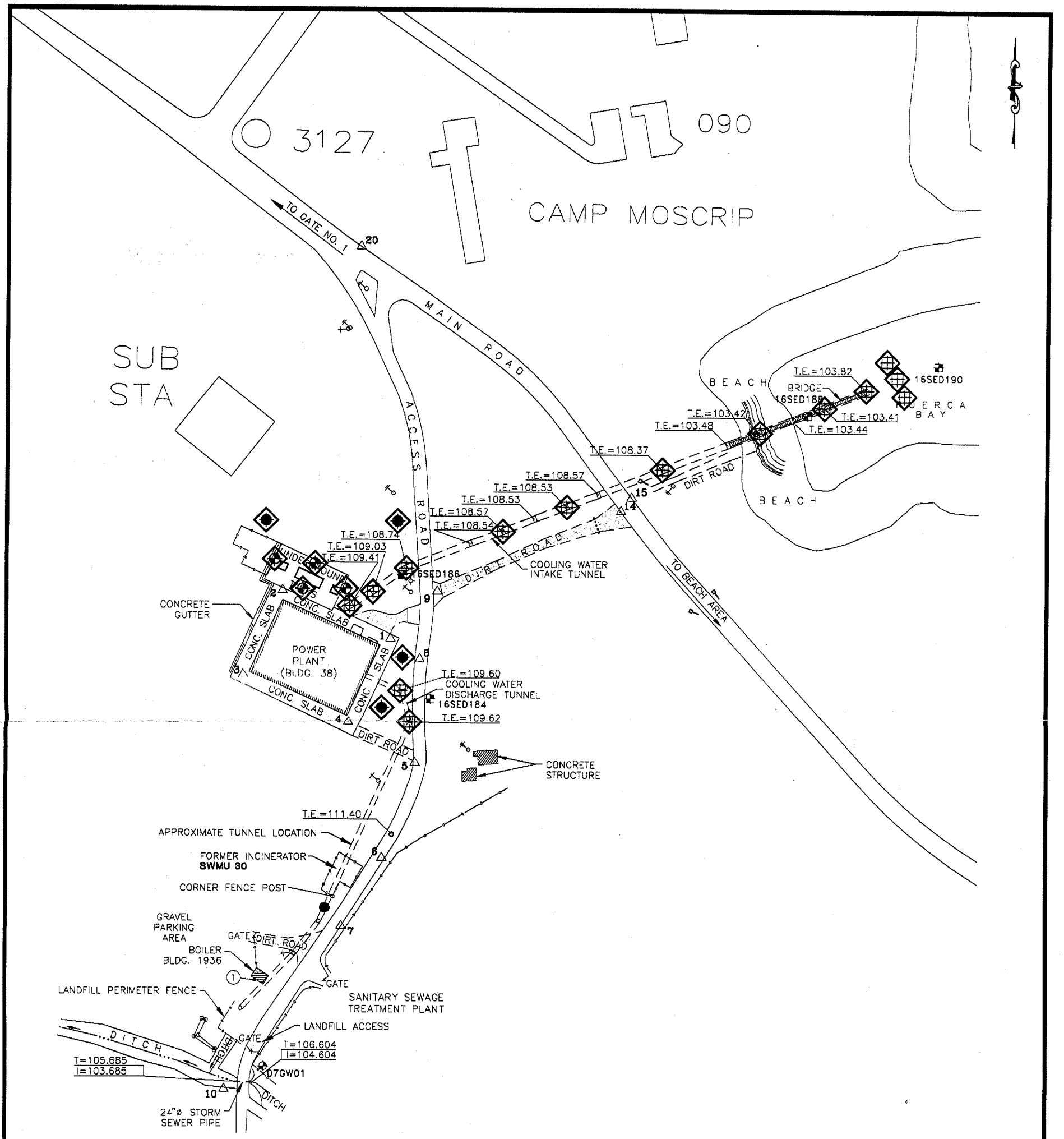
LEGEND

- PROPOSED TEST PIT LOCATION
- PROPOSED MONITORING WELL LOCATION
- 13GW07 EXISTING MONITORING WELL LOCATION
- APPROXIMATE LOCATION OF DISPOSAL PIT

SOURCE: BAKER ENVIRONMENTAL, INC., MAY 1994

FIGURE 4-7
PROPOSED SAMPLING LOCATIONS
RFI - SWMU 9, AREA C
TANKS 216 - 217

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



ROOSEVELT ROADS LANDFILL

NOTE: THREE SEDIMENT SAMPLES TO BE COLLECTED IN RADIAL PATTERN AT TUNNEL OUTFALL IN ENSENADA HONDA WHEN LOCATED.

150 0 75 150
1 inch = 150 ft.

223027WP

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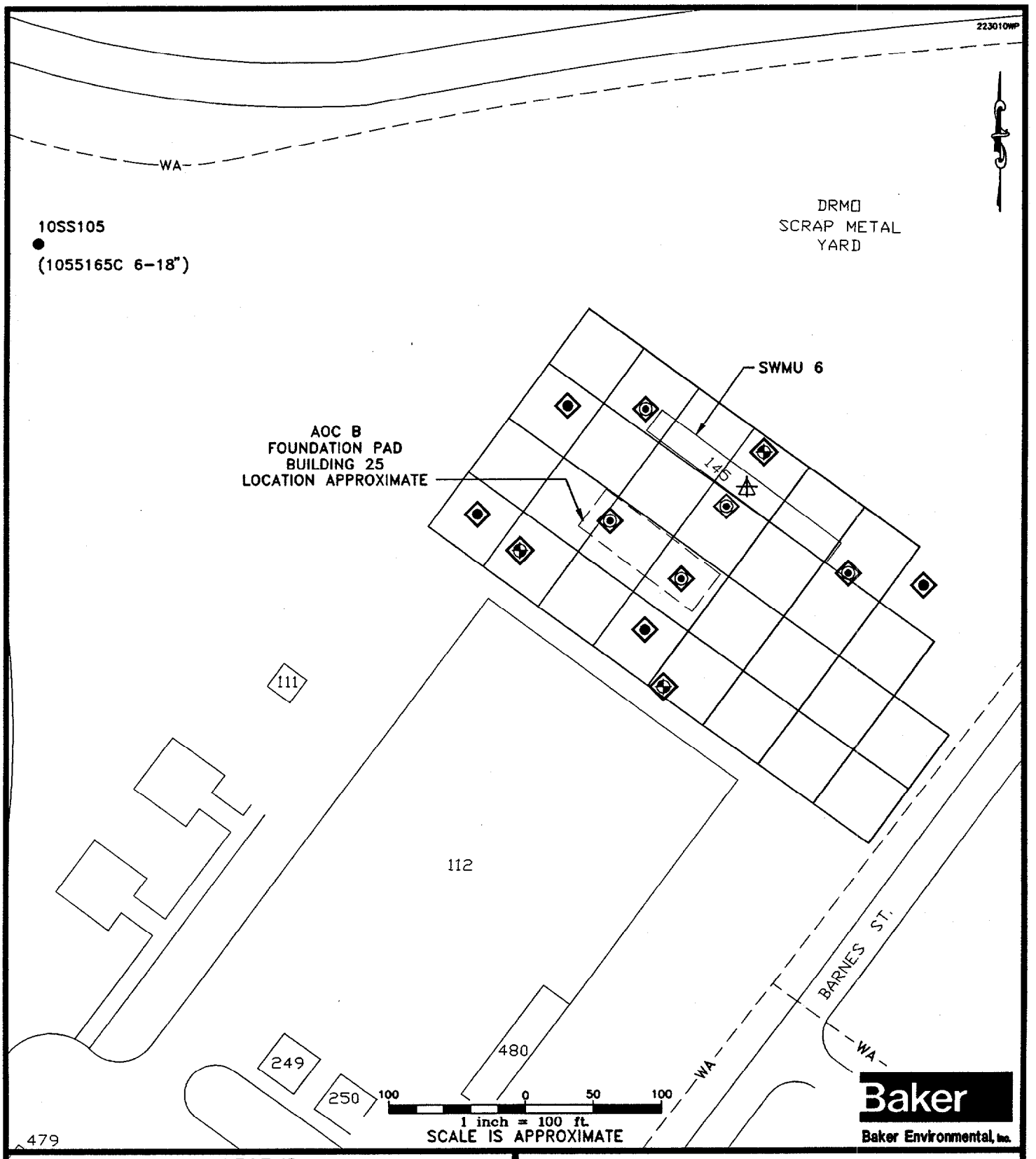
LEGEND

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

FIGURE 4-8
PROPOSED SAMPLING LOCATIONS
RFI-SWMU 11/45

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



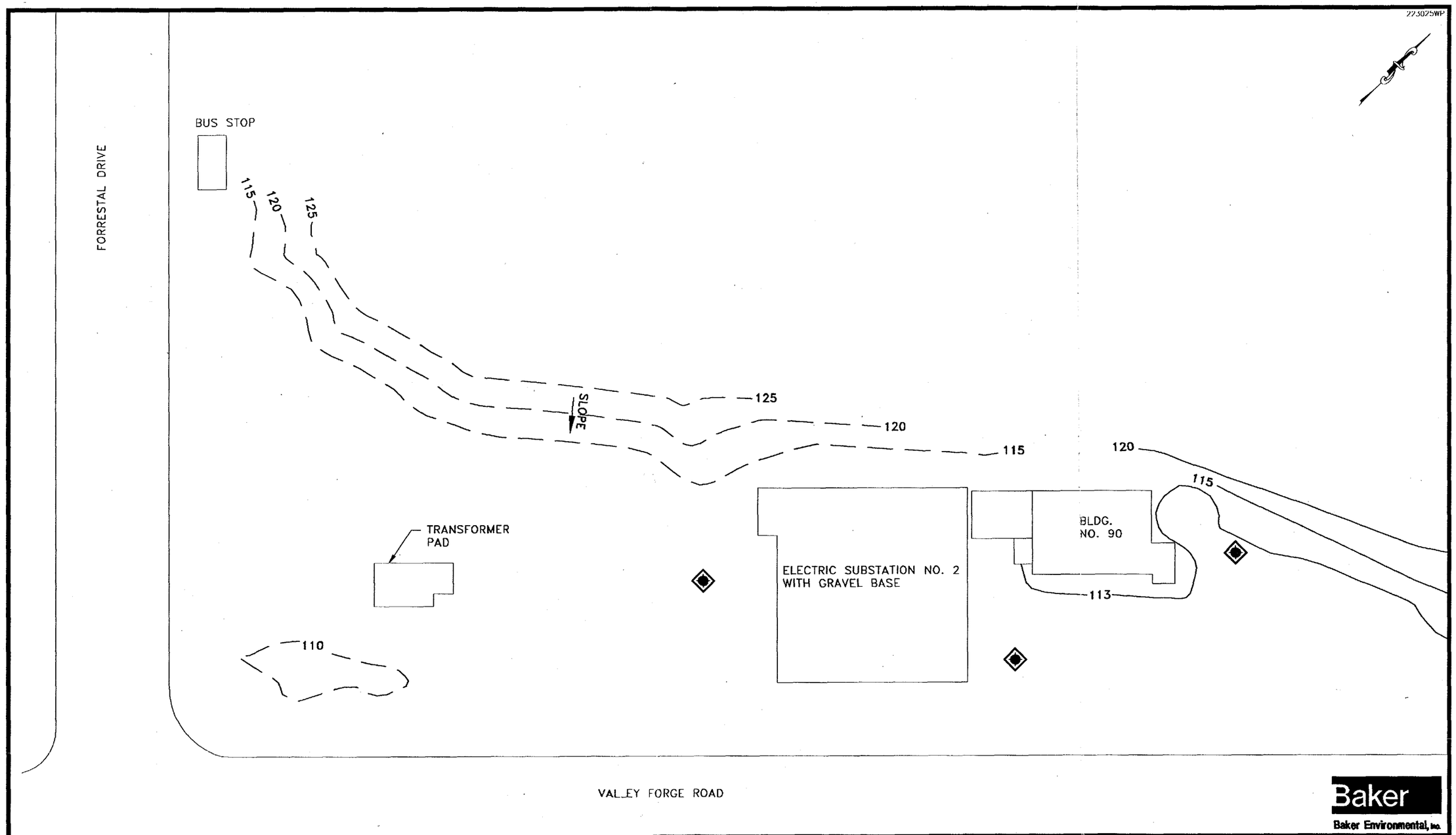
LEGEND

- 10SS105 — 1992 SOIL SAMPLE LOCATION (APPROXIMATE)
- 249 — STATION STRUCTURE
- WA — WATERLINE?
- PROPOSED SOIL BORING
- PROPOSED MONITORING WELL
- PROPOSED SURFACE SOIL
- POTENTIAL SURFACE WATER SAMPLE LOCATION

SOURCE: STATION PUBLIC WORKS BASE MAP, FEB. 1992
SOURCE: BAKER ENVIRONMENTAL GPS SURVEY, NOV. 1992

FIGURE 4-9
PROPOSED SAMPLING LOCATIONS
RFI – AOC B AND SWMU 6
BUILDING 25 STORAGE AREA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

120 – CONTOUR LINE WITH ELEVATION

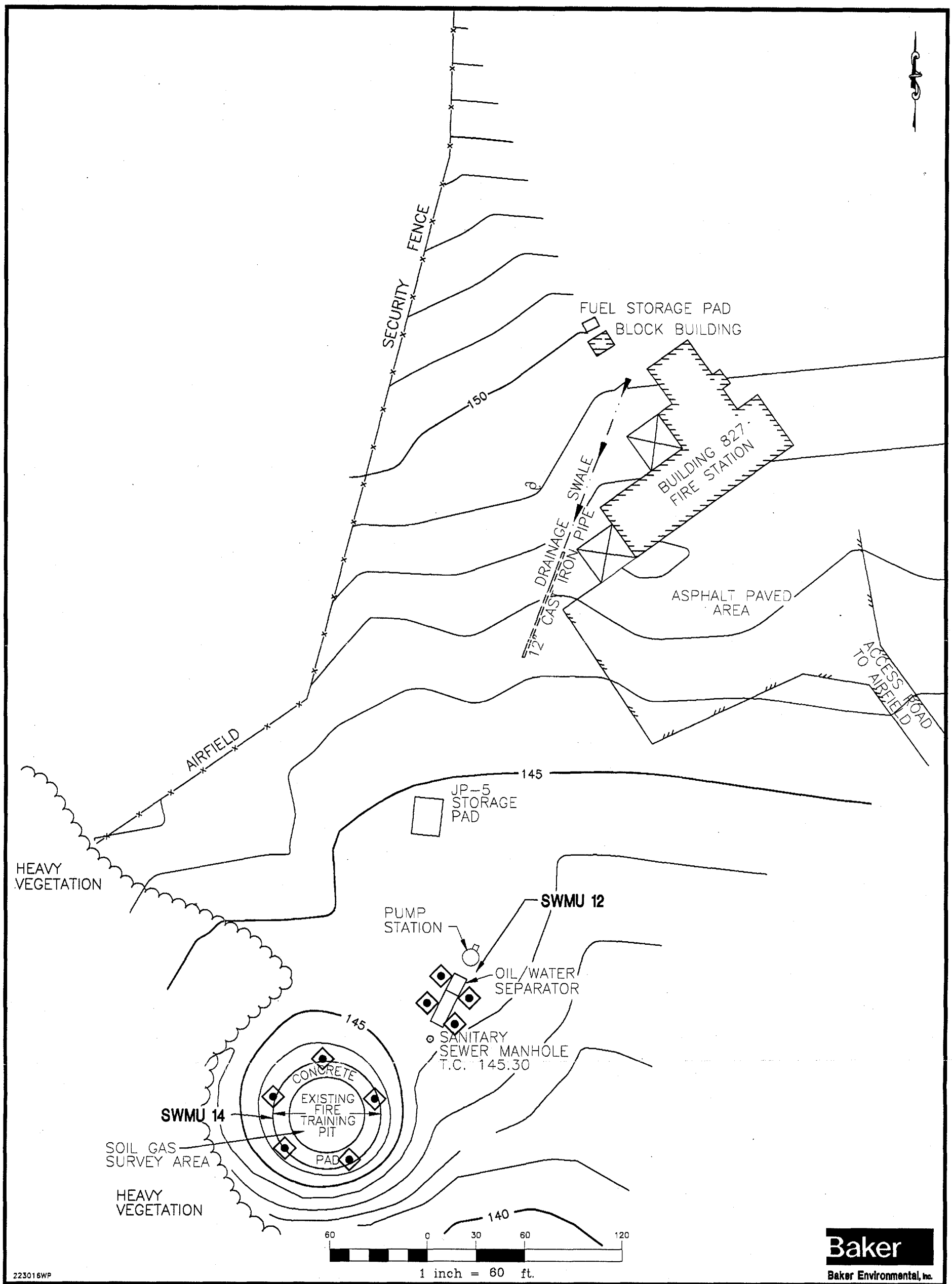
– BUILDING OR STRUCTURE

– PROPOSED HYDROPUNCH LOCATION

FIGURE 4–10
PROPOSED SAMPLING LOCATIONS
RFI–SWMU 10 SUBSTATION 2/BUILDING 90

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

00170 BB5Z



LEGEND

- PROPOSED SOIL SAMPLING LOCATION
- 145 SURFACE ELEVATION CONTOUR
- SURFACE WATER DRAINAGE DIRECTION

FIGURE 4-11
PROPOSED SAMPLING LOCATIONS
RFI - SWMU 12 AND 14

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

18SS106
(18SS181D 18–32")

MONITORING WELL 18GW01
ELEVATION 113.16
TOP CASING 113.91

HEADWALL

HEADWALL

CONCRETE PAD

RAISED PADS

DRAINAGE DITCH

FORRESTAL

CONCRETE PAD

CUT–OFF UTILITY POLES

MONITORING WELL [NO NUMBER]
ELEVATION 109.26
TOP CASING 112.26

18SED108

APPROXIMATE FORMER LOCATION OF BLDG. 258

18SS104
(18SS179 6–18")

CONCRETE PAD

MONITORING WELL 18GW02
ELEVATION 109.82
TOP CASING 110.82

DRIVE

18SS103
(18SS176 6–18")
(18SS177 18–32")

18SS102
(18SS174 6–18")
(18SS175 18–32")

MONITORING WELL 18GW03
ELEVATION 109.02
TOP CASING 109.52

FENCE

CONCRETE ENDWALL

18SS101
(18SS172 6–18")
(18SS173 18–32")

50 0 25 50 100

1 inch = 50 ft.

223011WP

Baker

Baker Environmental, Inc.

LEGEND

18GW03 EXISTING MONITORING WELL LOCATION (CONFIRMATION STUDY)

18SS102 1992 SOIL SAMPLE LOCATIONS (APPROXIMATE)

18SED108 1992 SEDIMENT SAMPLE LOCATION

DRAINAGE DITCH/SURFACE DRAINAGE FLOW DIRECTION

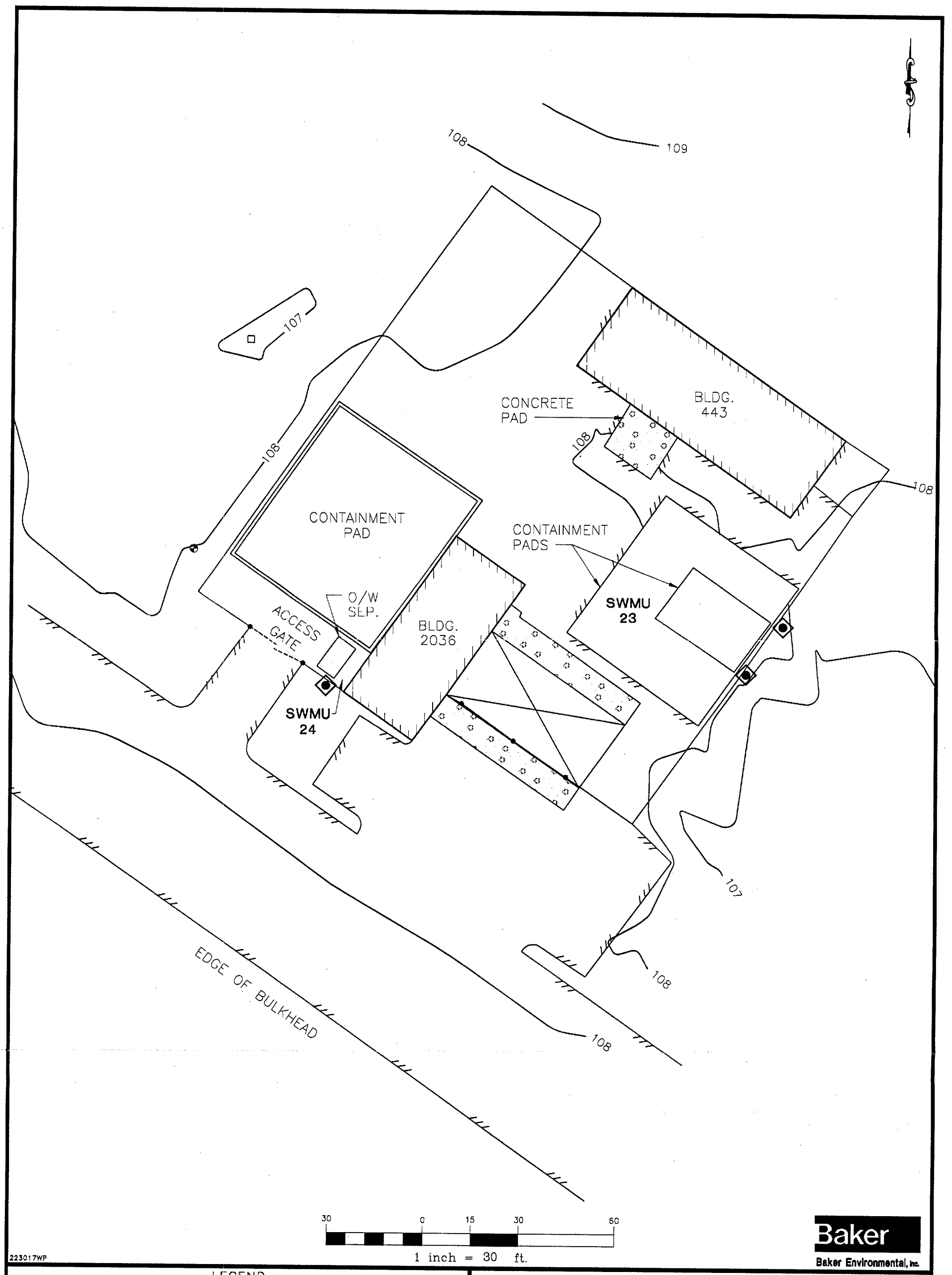
PROPOSED SEDIMENT SAMPLE LOCATION

PROPOSED SURFACE SOIL SAMPLE LOCATION

SOURCE: BAKER ENVIRONMENTAL, INC., MAY 1994

FIGURE 4–12
PROPOSED SAMPLING LOCATIONS
RFI – SWMU 13
PEST CONTROL SHOP AND SURROUNDING AREAS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- PROPOSED SOIL SAMPLING LOCATION
- EXISTING MONITORING WELL LOCATION
- 108 SURFACE ELEVATION CONTOUR

FIGURE 4-13
PROPOSED SAMPLING LOCATIONS
RFI - SWMUs 23 AND 24

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

223012WP

HEAVY
VEGETATION

FORRESTAL DRIVE

18" RCP

PAVED CHANNEL

PARKING AREA

120

125

130

135

FENCE

BUILDING 1973

125

OPEN STORAGE YARD

CONCRETE CHANNEL

DRUM STORAGE AREA

MANHOLE

INLET

LOADING RAMP

SWMU 25

MATERIAL STORAGE RACKS

18" RCP

BLDG. 2009

BUILDING 2010

FENCE

140

130

135

140

HEADWALL

Baker

Baker Environmental, Inc.

LEGEND

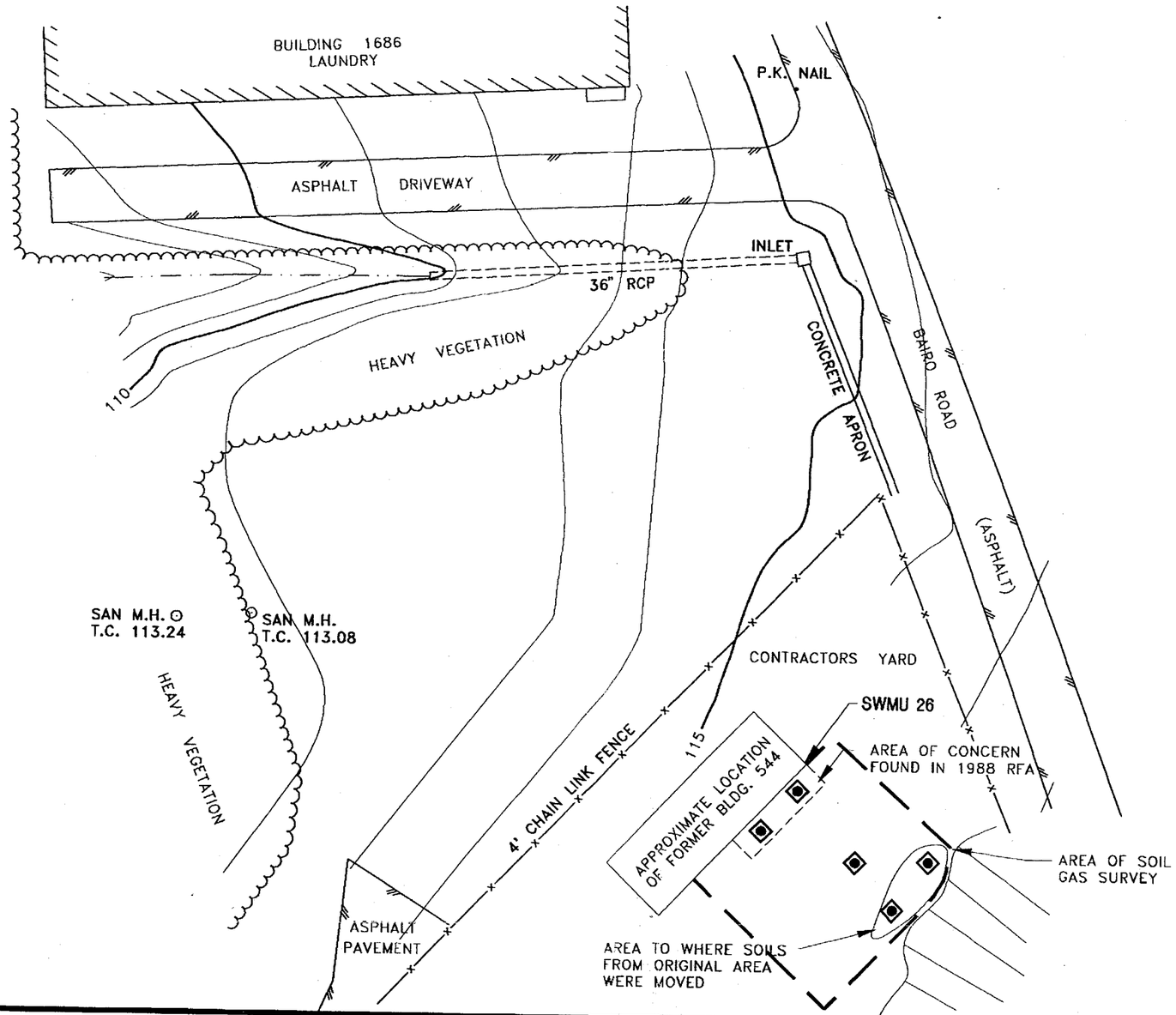
- PROPOSED SOIL SAMPLING LOCATION
- 130 SURFACE ELEVATION CONTOUR
- PROPOSED SEDIMENT SAMPLE LOCATION
- AREA OF STAINING APPROXIMATED FROM 1988 RFA PHOTO

60 0 30 60 120

1 inch = 60 ft.

FIGURE 4-14
PROPOSED SAMPLING LOCATIONS
RFI - SWMU 25

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



Baker
Baker Environmental, Inc.

LEGEND

◆ PROPOSED SOIL SAMPLING LOCATION

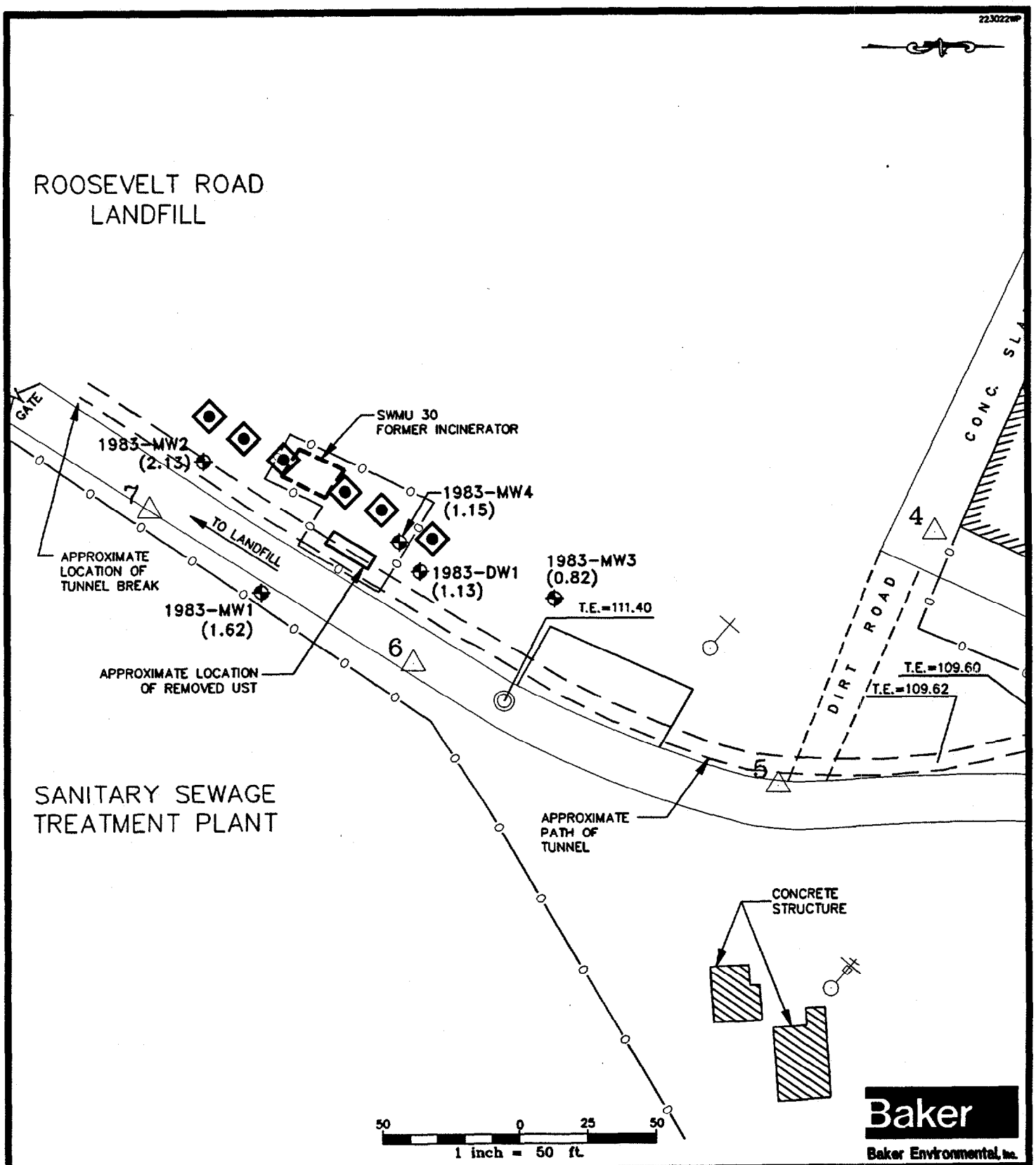
110 SURFACE ELEVATION CONTOURS

50 0 25 50 100

1 inch = 50 ft.

FIGURE 4-15
PROPOSED SAMPLING LOCATIONS
RFI – SWMU 26
BUILDING 544 AREA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



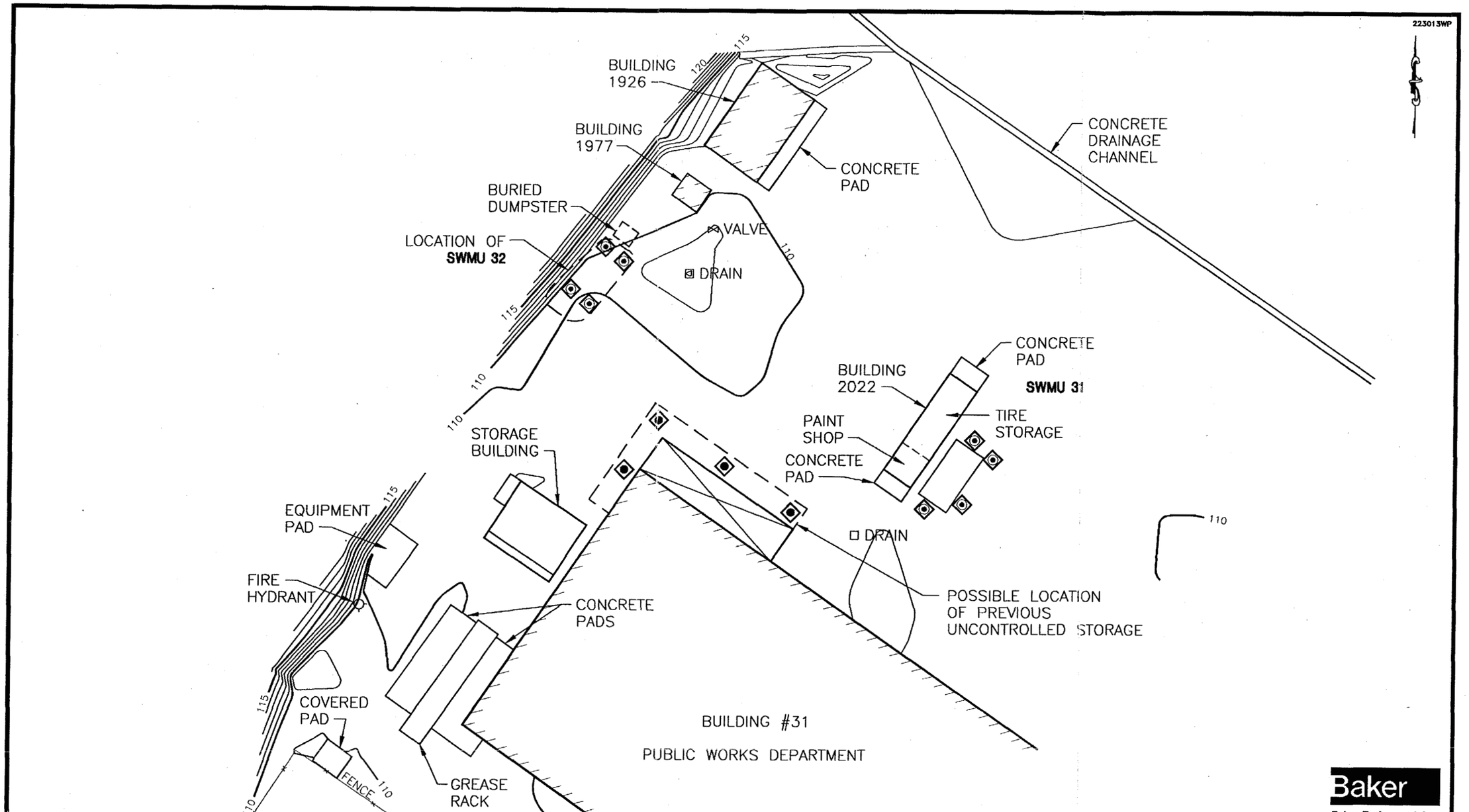
LEGEND

- PROPOSED SURFACE SOIL SAMPLE LOCATION
- EXISTING MONITORING WELL LOCATION (BLASLAND, BOUCK & LEE, INC. 1994)
- (1.13) GROUNDWATER ELEV. (1994)

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-16
PROPOSED SAMPLING LOCATIONS
SWMU 30 FORMER INCINERATOR AREA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- PROPOSED SOIL BORING LOCATION
- PROPOSED SOIL SAMPLING LOCATION
- 110 SURFACE ELEVATION CONTOUR

60 0 30 60 120

1 inch = 60 ft.

FIGURE 4-17
PROPOSED SAMPLING LOCATIONS
RFI – SWMU 31 WASTE OIL COLLECTION AREA
RFI – SWMU 32 BATTERY COLLECTION BUILDING 31

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

00170RRL7

223016WP

COVERED STORAGE
STORAGE CONTAINERS
ABOVE GROUND PIPING
115
SWMU 37
BITUMINOUS PAVEMENT
CONCRETE PAVEMENT
COVERED STORAGE
115
115
115
BUILDING 200
115
TRANSFORMER
GRASS AREA
TRAILER
CONCRETE CHANNEL
CONTAINMENT AREA
FUEL STORAGE
CONCRETE CHANNEL
115

Baker
Baker Environmental, Inc.

LEGEND

◆ PROPOSED SOIL SAMPLING LOCATION

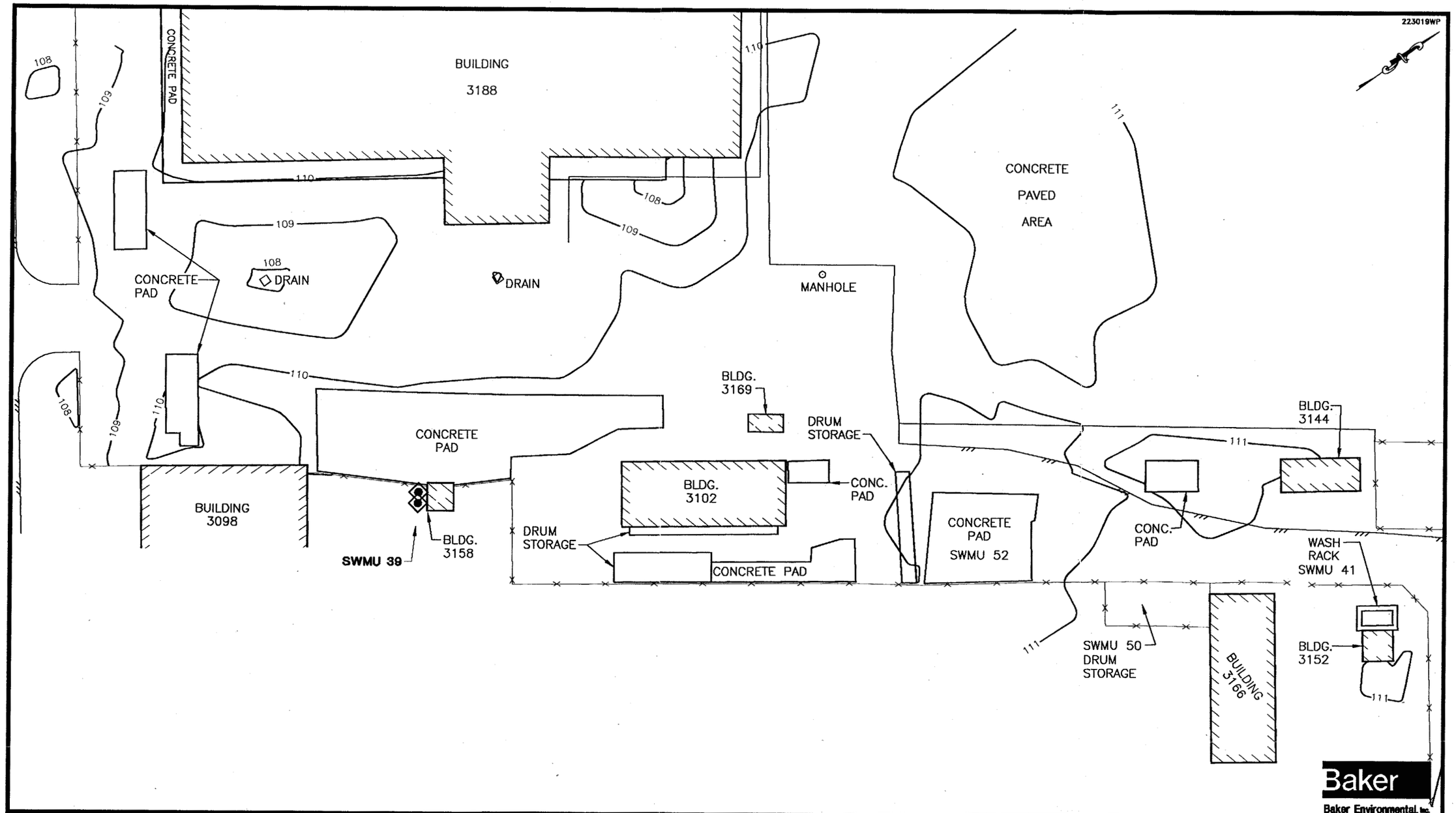
115 SURFACE ELEVATION CONTOUR

100 0 50 100 200

1 inch = 100 ft.

FIGURE 4-18
PROPOSED SAMPLING LOCATIONS
RFI – SWMU 37

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

PROPOSED SOIL SAMPLING LOCATION

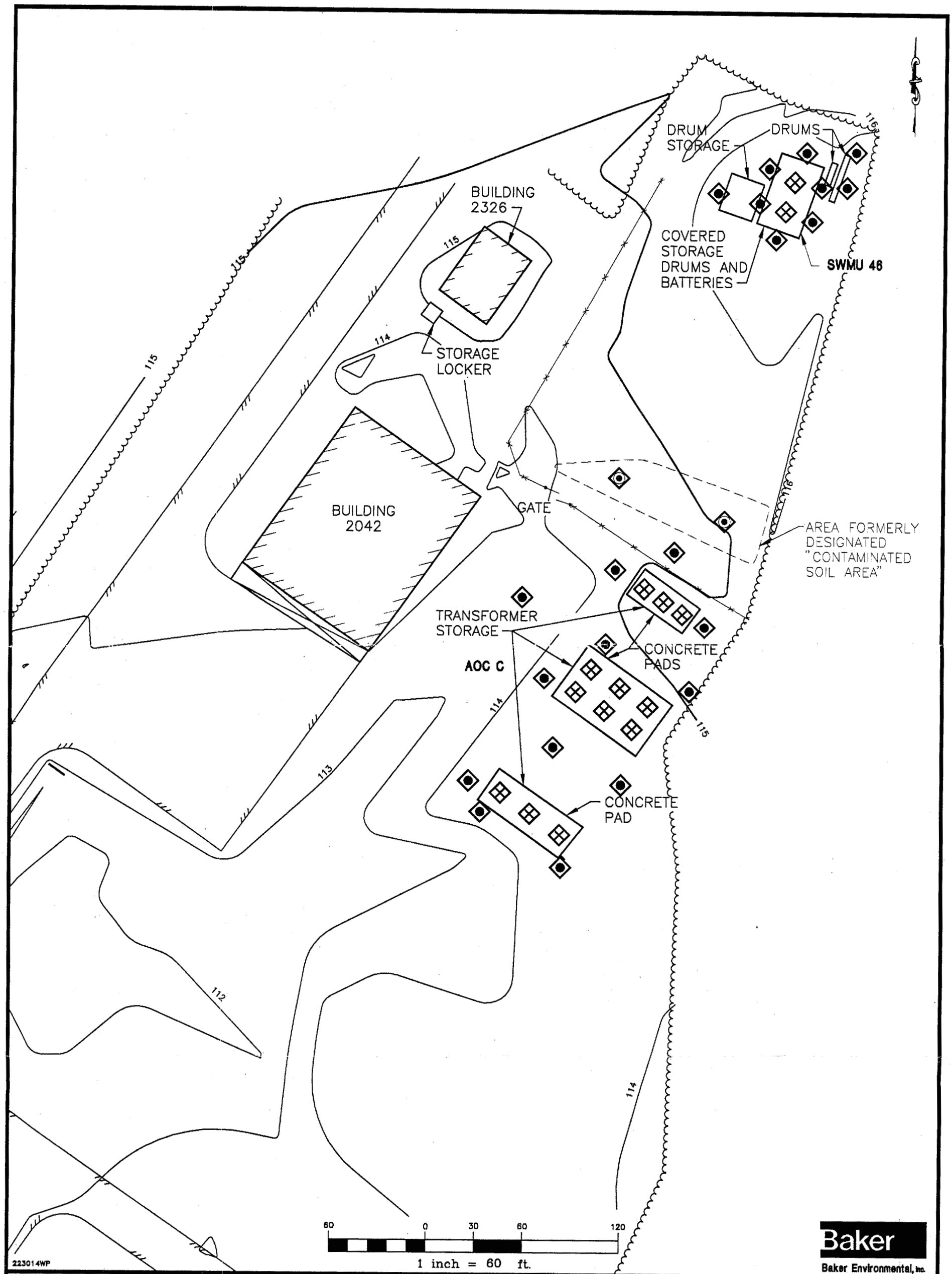
111 SURFACE ELEVATION CONTOUR

60 0 30 60 120

1 inch = 60 ft.

FIGURE 4-19
PROPOSED SAMPLING LOCATIONS
RFI – SWMU 39

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- PROPOSED SOIL BORING LOCATIONS
- PROPOSED SOIL SAMPLING LOCATIONS
- PROPOSED WIPE SAMPLE LOCATION
- 115 SURFACE ELEVATION CONTOUR

FIGURE 4-20
PROPOSED SAMPLING LOCATIONS
RFI – SWMU 46 POLE STORAGE YARD
AOC C TRANSFORMER STORAGE PAD

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

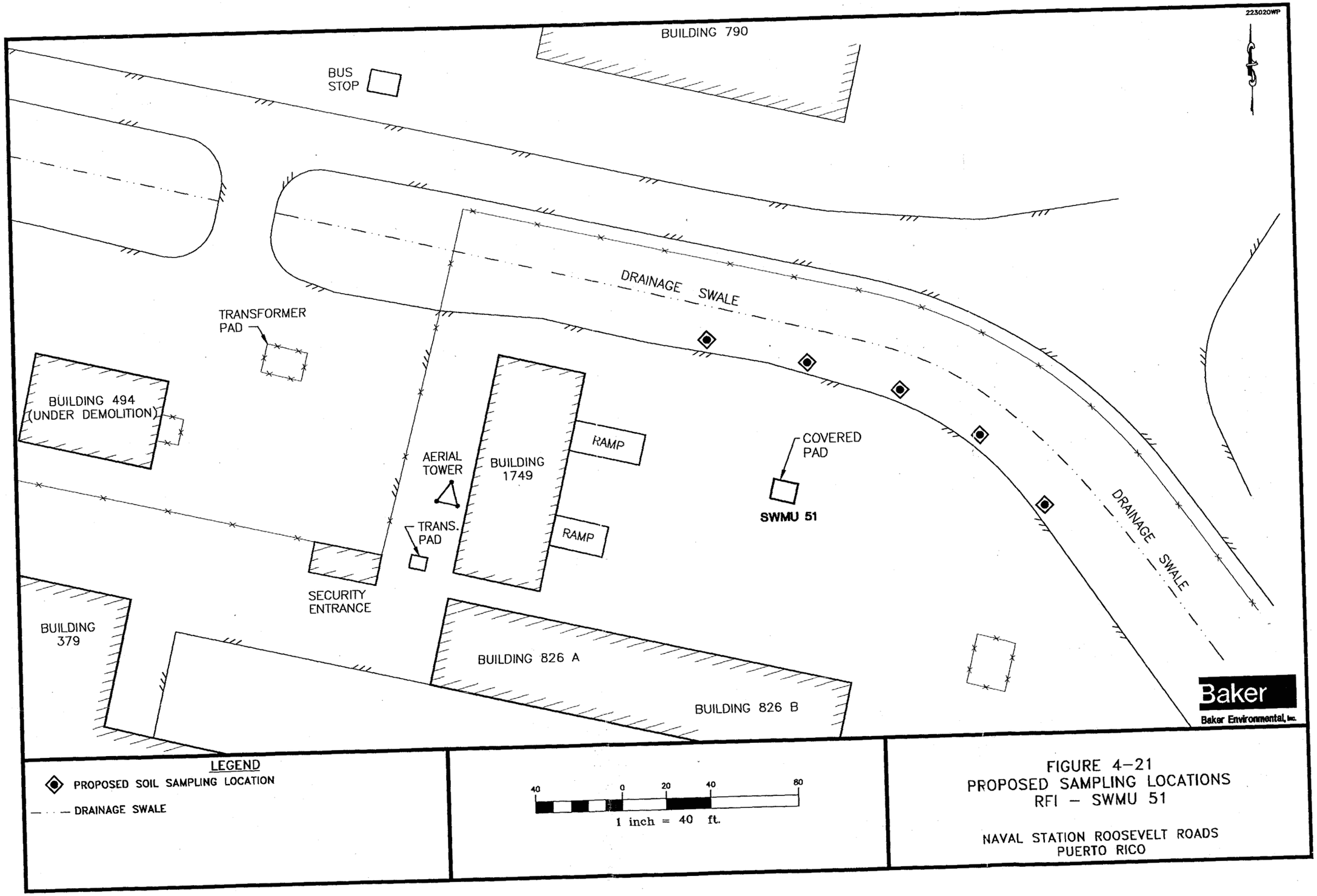
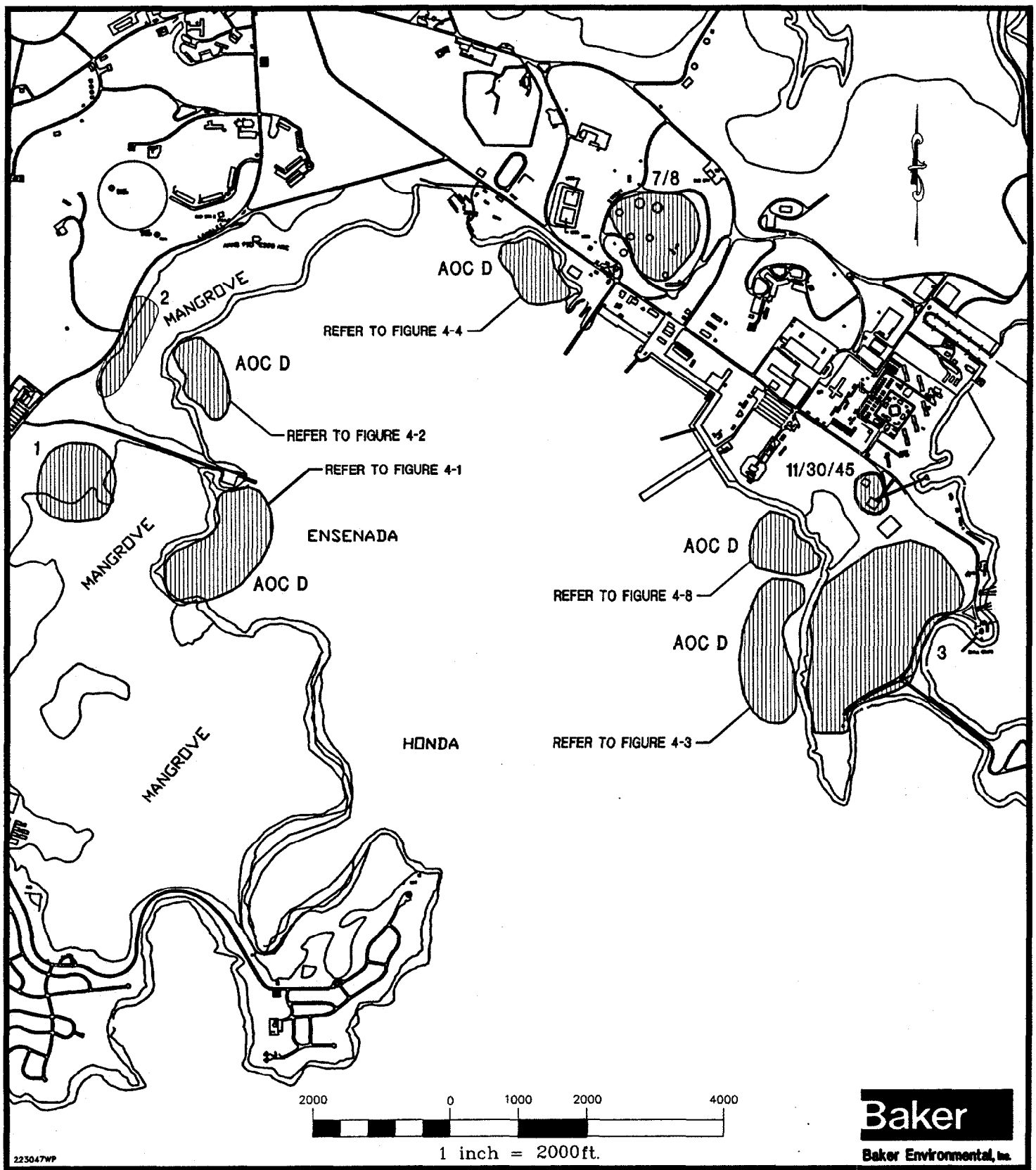


FIGURE 4-21
PROPOSED SAMPLING LOCATIONS
RFI – SWMU 51

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

– SMWU/AOC

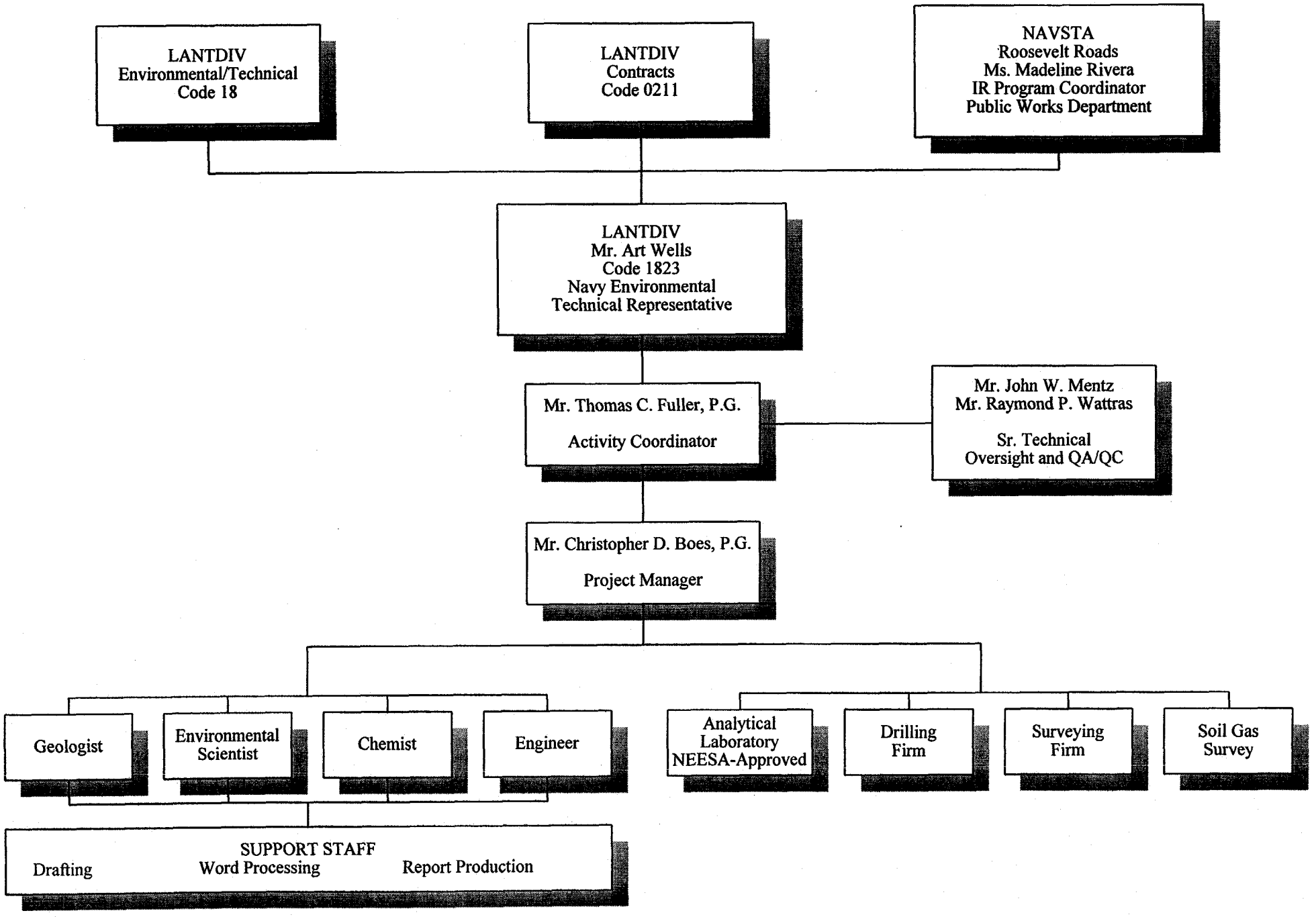
SOURCE: LANTDIV, FEB. 1992

FIGURE 4-22
PROPOSED SAMPLE LOCATIONS
AOC D ENSENADA HONDA

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

FIGURE 6-1

PROJECT ORGANIZATION



TABLES

TABLE 1-1

SWMUs/AOC MEDIA SUBJECT TO CORRECTIVE 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[1]
#2 Langley Drive Disposal Site	Yes	Yes	Yes	Full
#3 Base Landfill	Yes	Yes	Yes	Full
#6 Building 145	No	Yes	No	First Phase[2]
#7 Tow Way Fuel Farm	Yes	Yes	No	Full
#8 Tow Way Fuel Farm - Disposal Pits	Yes	Yes	No	Full
#9 Tank 212-217 Sludge Burial Pits	Yes	Yes	Contingent[3]	Full
#10 Substation 2/Bldg. 90	Yes	Yes	No	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
#30 Former Incinerator	Yes	No	No	
#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
AOC #D/Ensenada Honda Sediments	No	No	Yes	First Phase

Notes: (1) Full RFIs are conducted where releases were established during previous investigations. The purpose of the full RFI is to determine the nature, rate, direction, and extent of hazardous waste or hazardous constituents.

(2) The purpose of the first phase RFI is to confirm any releases from these SWMUs and/or AOC.

(3) Contingent requirements are pending results of ongoing investigation or closure activities.

TABLE 2-1

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
B. Data Collection Quality Assurance Plan The Permittee shall prepare a plan to document all monitoring procedures: sampling, field measurements, and sample analysis performed during the investigation to characterize the environmental setting, source, and contamination, so as to ensure that all information, data and resulting decisions are technically sound, statistically valid, and properly documented. 1. Data Collection Strategy The strategy section of the Data Collection Quality Assurance Plan shall include but not be limited to the following:	
a. Description of the intended uses for the data, and the necessary level of precision and accuracy for these intended uses	4.1.1 and 4.1.2.2
b. Description of methods and procedures to be used to assess the precision, accuracy and completeness of the measurement data	4.1.2.1
c. Description of the rationale used to assure that the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition or an environmental condition. Examples of factors which shall be considered and discussed include:	
(i) Environmental conditions at the time of sampling	3.0
(ii) Number of sampling points	4.1.4
(iii) Representativeness of selected media	4.1.3
(iv) Representativeness of selected analytical parameters	4.2 and 9.0
d. Description of the measures to be taken to assure that the following data sets can be compared to each other	
(i) RFI data generated by the Permittee over some time period	4.1.5
(ii) RFI data generated by an outside laboratory or consultant versus data generated by the Permittee	4.1.5
(iii) Data generated by separate consultants or laboratories	4.1.5
(iv) Data generated by an outside consultant or laboratory over some time period	4.1.5

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 2-1 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
e. Details relating to the schedule and information to be provided in quality assurance reports. The reports should include but not be limited to:	
(i) Periodic assessment of measurement data accuracy, precision, and completeness	10.3
(ii) Results of performance audits	10.3 and 12.0
(iii) Results of system audits	10.3 and 12.0
(iv) Significant quality assurance problems and recommended solutions	10.3
(v) Resolutions of previously stated problems	10.3
2. Sampling The Sampling section of the Data Collection Quality Assurance Plan shall discuss	
a. Selecting appropriate sampling locations, depths, etc.	4.2
b. Providing a statistically sufficient number of sampling sites	4.1.4 and 4.2
c. Measuring all necessary ancillary data	4.2
d. Determining conditions under which sampling should be conducted	5.0 and SOPs F101, F102, F104, and F105
e. Determining which media are to be sampled (e.g., groundwater, air, soil, sediment, etc.)	4.1.3
f. Determining which parameters are to be measured and where	4.2
g. Selecting the frequency of sampling and length of sampling period	4.2
h. Selecting the types of sample (e.g., composites versus grabs) and number of samples to be collected	4.1.4 and 4.2
i. Measures to be taken to prevent contamination of the sampling equipment and cross-contamination between sampling points	5.0 and SOPs F501 and F502
j. Documenting field sampling operations and procedures, including	

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 2-1 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
(i) Documentation of procedures for preparation of reagents or supplies which become an integral part of the sample (e.g., filters and adsorbing reagents)	SOP F301
(ii) Procedures and forms for recording the exact location and specific considerations associated with sample acquisition	SOPs F302 and F303
(iii) Documentation of specific sample preservation method	7.0 and SOPs F301 and F303
(iv) Calibration of field devices	8.1 and SOPs F202, F203, F204, and F208
(v) Collection of replicate samples	11.2 and SOPs F302 and F303
(vi) Submission of field-biased blanks, where appropriate	11.2 and SOPs F302 and F303
(vii) Potential interferences present at the facility	SOP F303
(viii) Construction materials and techniques, associated with monitoring wells and piezometers	SOPs F103 and F303
(ix) Field equipment listing and sample containers	SOPs F101, F102, F104, F105, F301, and F303
(x) Sample order	SOPs F101, F102, F104, and F105
(xi) Decontamination procedures	SOPs F501 and F502
k. Selecting appropriate sample containers	7.0 and SOP F301
l. Sample preservation	7.0 and SOP F301
m. Chain-of-custody, including	
(i) Standardized field tracking reporting forms to establish sample custody in the field prior to and during shipment	7.0 and SOP F302
(ii) Pre-prepared sample labels containing all information necessary for effective sample tracking	7.0 and SOP F302

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 2-1 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
3. Field Measurements The Field Measurements section of the Data Collection Quality Assurance Plan shall discuss:	
a. Selecting appropriate field measurement locations, depths, etc.	4.2
b. Providing a statistically sufficient number of field measurements	4.1.4 and 4.2
c. Measuring all necessary ancillary data	4.2
d. Determining conditions under which field measurements should be conducted	5.0 and SOPs F101, F102, F104, and F105
e. Determining which media are to be addressed by appropriate field measurements (e.g., groundwater, air, soil, sediment, etc.)	4.1.3
f. Determining which parameters are to be measured and where	4.2
g. Selecting the frequency of field measurement and length of field measurements period	4.2
h. Documenting field measurement operations and procedures, including	
(i) Procedures and forms for recording raw data and the exact location , time, and facility-specific considerations associated with the data acquisition	SOP F303
(ii) Calibration of field devices	8.0 and SOPs F202, F203, F204, and F208
(iii) Collection of replicate measurements	11.2 and SOPs F302 and F303
(iv) Submission of field-biased blanks, where appropriate	11.2 and SOPs F302 and F303
(v) Potential interferences present at the facility	SOP F303
(vi) Construction materials and techniques associated with monitoring wells and piezometers used to collect field data	SOPs F301 and F303
(vii) Field equipment listing	SOPs F301 and F303
(viii) Order in which field measurements were made	SOPs F101, F102, F104, F105, F201, and F402

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 2-1 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
(ix) Decontamination procedures	SOPs F501 and F502
4. Sample Analysis The Sample Analysis section of the Data Collection Quality Assurance Plan shall specify the following:	
a. Chain-of-custody procedures, including	
(i) Identification of a responsible party to act as sample custodian at the laboratory facility authorized to sign for incoming field samples, obtain documents of shipment, and verify the data entered onto the sample custody records	7.0 and SOP F302
(ii) Provision for a laboratory sample custody log consisting of serially numbered standard lab-tracking report sheets	7.0 and SOP F302
(iii) Specification of laboratory sample custody procedures for sample handling, storage, and dispersement for analysis	7.0 and SOP F302
b. Sample storage procedures and storage times	7.0 and SOP F301
c. Sample preparation methods	7.0 and SOP F301
d. Analytical procedures, including	
(i) Scope and application of the procedure	9.2
(ii) Sample matrix	9.2
(iii) Potential interferences	9.2
(iv) Precision and accuracy of the methodology	9.2
(v) Method detection limits	9.2
e. Calibration procedures and frequency	8.0
f. Data reduction, validation and reporting	10.0
g. Internal quality control checks, laboratory performance and systems audits and frequency, including	
(i) Method blank(s)	11.2 and 11.3
(ii) Laboratory control sample(s)	11.2 and 11.3
(iii) Calibration check sample(s)	11.2 and 11.3
(iv) Replicate sample(s)	11.2 and 11.3

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 2-1 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
(v) Matrix-spiked sample(s)	11.2 and 11.3
(vi) "Blind" quality control sample(s)	11.2 and 11.3
(vii) Control charts	11.2 and 11.3
(viii) Surrogate samples	11.2 and 11.3
(ix) Zero and span gases	11.2 and 11.3
(x) Reagent quality control checks	11.2 and 11.3
h. Preventive maintenance procedures and schedules	13.0 and SOPs F202, F203, F204, and F208
i. Corrective action (for laboratory problems)	11.3
j. Turnaround time	4.2

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 3-1

SWMUs REQUIRING FIRST PHASE RFI

SWMU/AOC	Name
6	Building 145
10	Substation 2/Building 90
12	Fire Training Pit Oil/Water Separator
13	Old Pest 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
30	Former Incinerator
31	Waste Oil Collection Area/Buildings 31 and 2022
32	PWD Storage Yard/Battery Collection Area/Building 31
37	Waste Oil Storage Area/Building 200
39	Building 3158/Former Battery Drain Area
46	Pole Storage Yard Covered Pad
51	New AIMD Storage Pad/Building 379
C	Transformer Storage Pad
D	Ensenada Honda Sediments

TABLE 3-2

Versar May 1991 Wipe and Chip Sample Results
Arochlor, PCB Concentration (µg/m²)

Wipe Sample No.	1016Q	1221Q	1232Q	1242Q	1248Q	1254Q	1260Q
RR16TW01	5 U	5 U	5 U	5 U	5 U	10 U	170
RR16W17	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W18	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	6 A
RR16W19	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	120
RR16W20	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	61
RR16W21	5 U	5 U	5 U	5 U	5 U	10 U	1,300
RR16W22	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	19 A
RR16W23	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	34
RR16W24	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	7.4
RR16W25	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	2.6
RR16W26	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	6.9 Y
RR16W27	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	90
RR16W28	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W29	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	4.2 Y
RR16W30	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W31	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W32	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W33	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W01	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W02	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W03	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	49 Y
RR16W04	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W05	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W06	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	15
RR16W07	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	8.7
RR16W08	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	3.8
RR16W09	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	9.2
RR16W10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	2.1 A
RR16W11	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W12	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1.9 Z

TABLE 3-2

Versar May 1991 Wipe and Chip Sample Results
Arochlor, PCB Concentration (µg/m²)

Wipe Sample No.	1016Q	1221Q	1232Q	1242Q	1248Q	1254Q	1260Q
RR16W13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W15	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
RR16W16	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U

Arochlor, PCB Concentration (mg/kg)

Chip Sample No.	1016Q	1221Q	1232Q	1242Q	1248Q	1254Q	1260Q
RR16C01	0.0245 U	0.0245 U	0.0245 U	0.0245 U	0.0245 U	0.049 U	0.45
RR16C02	0.0245 U	0.0245 U	0.0245 U	0.0245 U	0.0245 U	0.0495 U	0.25
RR16C03	0.0245 U	0.0245 U	0.0245 U	0.0245 U	0.0245 U	0.0245 U	1
RR16C04	25 U	25 U	25 U	25 U	25 U	49.5 U	1,000
RR16C05	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	4.95 U	43
RR16C06	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.0495 U	1.7

Notes:

U = Undetected; numerical value is one-half detection limit.
A = Suggests the presence of PCB in the quantitation analysis, however, the result did not confirm in the secondary analysis.
Y = The results were reported from the confirmation analysis under single point calibration.
Z = The results were reported below the detection limits.

TABLE 4-1

DEFINITIONS OF DATA QUALITY INDICATORS

PRECISION	A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is expressed in terms of the standard deviation. Comparison of replicate values is best expressed as the relative percent difference (RPD). Various measures of precision exist depending upon the "prescribed similar conditions".
ACCURACY	The degree of agreement of a measurement (or an average of replicate measurements), X, with an accepted reference or true value, T, expressed as the difference between the two values, X-T. Accuracy is a measure of the bias in a system.
REPRESENTATIVENESS	Expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental concern.
COMPLETENESS	A measure of the amount of the valid data obtained from the measurement system compared to the amount that was expected under "normal" conditions.
COMPARABILITY	Expresses the confidence with which one data set can be compared with another.
UNCERTAINTY	The likelihood of all types of errors associated with a particular decision.

TABLE 4-2
SUMMARY OF SAMPLING AND ANALYTICAL PROGRAMS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

SWMU/AOC	MEDIA	NUMBER OF SAMPLES	ANALYSIS	ANALYTICAL METHOD
1	Surface Soil	16	Appendix IX (1) Explosives Asbestos	See (1) 8330 600/M4-E2-020
	Subsurface Soil	16	Appendix IX (1) Explosives Asbestos	See (1) 8330 600/M4-E2-020
	Sediment	3 (from Ensenada Honda) 3 (from surface drainage)	Appendix IX (1) Explosives Asbestos Total Organic Carbon	See (1) 8330 600/M4-E2-020 415.1
	Surface Water	3 (surface drainage)	Appendix IX (1) Explosives Asbestos Hardness	See (1) 8330 600/M4-E2-020 130.2
	Groundwater	8	Appendix IX (1) Explosives Asbestos Sodium pH Specific Conductance Temperature	See (1) 8330 600/M4-E2-020 6010/7770 9040 9050 170.1
2	Surface Soil	8	Appendix IX (1) Explosives Asbestos	See (1) 8330 600/M4-E2-020
	Subsurface Soil	16	Appendix IX (1) Explosives Asbestos	See (1) 8330 600/M4-E2-020
	Sediment	~~2~~ 3 (from Ensenada Honda) 3 (from surface drainage)	Appendix IX (1) Explosives Asbestos Total Organic Carbon	See (1) 8330 600/M4-E2-020 415.1

Note: (1) List of Appendix IX parameters and method numbers presented on Table 9-1.

TABLE 4-2 (Continued)
SUMMARY OF SAMPLING AND ANALYTICAL PROGARAMS

SWMU/AOC	MEDIA	NUMBER OF SAMPLES	ANALYSIS	ANALYTICAL METHOD
2	Surface Water	3 (from surface drainage)	Appendix IX (1) Explosives Asbestos Hardness	See (1) 8330 600/M4-E2-020 130.2
	Groundwater	4	Appendix IX (1) Explosives Asbestos pH Specific Conductance Temperature	See (1) 8330 600/M4-E2-020 9040 9050 170.1
		1	Corrective Measures Data: Eh Total Organic Carbon Chemical Oxygen Demand Total Suspended Solids	 - - 415.1 SM 508B EPL 160.2
3	Surface Soil	16	Appendix IX (1) Explosives Asbestos	See (1) 8330 600/M4-E2-020
	Subsurface Soil	12	Appendix IX (1) Explosives Asbestos	See (1) 8330 600/M4-E2-020
	Surface Water	5 (from leachate breakout) 5 (from surface drainage)	Appendix IX (1) Explosives Asbestos Hardness	See (1) 8330 600/M4-E2-020 130.2
	Sediment	17 (from bay) 5 (from leachate breakout) 5 (from surface drainage)	Appendix IX (1) Explosives Asbestos Total Organic Carbon	8240 8250 8080 415.1

List of Appendix IX parameters and method numbers presented on Table 9-1.

TABLE 4-2 (Continued)
SUMMARY OF SAMPLING AND ANALYTICAL PROGARAMS

SWMU/AOC	MEDIA	NUMBER OF SAMPLES	ANALYSIS	ANALYTICAL METHOD
3	Groundwater	8	Appendix IX (1)	See (1)
			Explosives	8330
			Asbestos	600/M4-E2-020
			pH	9040
			Specific Conductance	9050
			Temperature	170.1
7	Sediment	5	Appendix IX (1)	See (1)
			Total Organic Carbon	415.1
8	Subsurface Soil	21	Total Petroleum Hydrocarbons	Modified 8015
9	Surface Soil	6	Volatiles	8240
			Semivolatiles	8270
			RCRA Metals	SW-846
			Total Petroleum Hydrocarbons	Modified 8015
	Subsurface Soil	~~44~~ 46	Volatiles	8240
			Semivolatiles	8270
			RCRA Metals	SW-846
			Total Petroleum Hydrocarbons	Modified 8015
		1	Corrective Measures Data:	
			Grain Size (hydrometer)	ASTM D422
			Moisture Content	ASTM D698
			Total Organic Carbon	415.1
			pH	904.5
			Eh	- -
			Biological Oxygen Demand	405.1
			Chemical Oxygen Demand	SM 508B
			Humic Content	- -

1) Appendix IX parameters and method numbers presented on Table 9-1.

TABLE 4-2 (Continued)
SUMMARY OF SAMPLING AND ANALYTICAL PROGARAMS

SWMU/AOC	MEDIA	NUMBER OF SAMPLES	ANALYSIS	ANALYTICAL METHOD
9	Groundwater	14	Volatiles	8240
			Semivolatiles	8270
			RCRA Metals	SW-846
			pH	9040
			Specific Conductance	9050
			Temperature	170.1
			Total Petroleum Hydrocarbons	Modified 8015
		1	Corrective Measures Data:	
			Oil and Grease	413.1
			Total Suspended Solids	160.2
			pH	9045
			Eh	- -
			Total Organic Carbon	415.1
			Chemical Oxygen Demand	SW 508B
			Biological Oxygen Demand	405.1
			Nitrogen	350.2
			Phosphorous	365.2
11/45	Concrete (Wipe Samples)	56	PCBs	8080
	Surface Soil	4	Volatiles	8240
			Semivolatiles	8270
			PCBs	8080
			RCRA Metals	SW-846
	Subsurface Soil	8	Volatiles	8240
			Semivolatiles	8250
			PCBs	8080
			RCRA Metals	SW-846
	Sediment (From Cooling Tunnels)	17	Volatiles	8240
			Semivolatiles	8270
			PCBs	8080
			RCRA Metals	SW-846
	Groundwater	8	Volatiles	8240
			Semivolatiles	8270
			PCBs	8080
			RCRA Metals	SW-846

Note: (1) Appendix IX parameters and method numbers presented on Table 9-1.

TABLE 4-2 (Continued)
SUMMARY OF SAMPLING AND ANALYTICAL PROGARAMS

SWMU/AOC	MEDIA	NUMBER OF SAMPLES	ANALYSIS	ANALYTICAL METHOD
AOC B	Surface Soil	7	Appendix IX (1)	See (1)
			Asbestos	600/M4-E2-020
			Total Petroleum Hydrocarbons	Modified 8015
	Subsurface Soil	10	Appendix IX (1)	See (1)
			Total Petroleum Hydrocarbons	Modified 8015
		1	Corrective Measures Data:	
			Grain Size (hydrometer)	ASTM D422
			Moisture Content	ASTM D698
			Total Organic Carbon	415.1
			pH	904.5
			Eh	--
			Biological Oxygen Demand	405.1
			Chemical Oxygen Demand	SM 508B
			Humic Content	--
	Groundwater	3	Appendix IX (1)	See (1)
			Total Petroleum Hydrocarbons	Modified 8015
			pH	9040
			Specific Conductance	9050
			Temperature	170.1
		1	Corrective Measures Data:	
			Eh	--
			Total Organic Carbon	415.1
			Chemical Oxygen Demand	SM 508B
			Total Suspended Solids	160.2
6	Surface Soil	5	Appendix IX (1)	See (1)
	Subsurface Soil	6	Appendix IX (1)	See (1)
6	Conditional Surface Water	1		

Note: (1) Appendix IX parameters and method numbers presented on Table 9-1.

TABLE 4-2 (Continued)
SUMMARY OF SAMPLING AND ANALYTICAL PROGARAMS

SWMU/AOC	MEDIA	NUMBER OF SAMPLES	ANALYSIS	ANALYTICAL METHOD
10	Groundwater	4	Volatiles	8240
			Semivolatiles	8270
			PCB	8080
			pH	9040
			Specific Conductance	9050
12	Surface Soil	4	Volatiles	8240
			Semivolatiles	8270
			PCB	8080
			Total Petroleum Hydrocarbons	Modified 8015
13	Surface Soil	5 4	Appendix IX (1)	See (1)
		4	Arsenic	SW-846
	Sediment	5	Appendix IX (1)	See (1)
14	Surface Soil	5	Volatiles	8240
			Semivolatiles	8270
			PCBs	8080
			Total Petroleum Hydrocarbons	Modified 8015
23	Surface Soil	2	Volatiles	8240
			Semivolatiles	8270
			Total Petroleum Hydrocarbons	Modified 8015
24	Surface Soil	1	Volatiles	8240
			Semivolatiles	8250
			Total Petroleum Hydrocarbons	Modified 8015
25	Surface Soil	9	Appendix IX (1)	See (1)
	Sediment	1	Appendix IX (1)	See (1)

Note: (1) Appendix IX parameters and method numbers presented on Table 9-1.

TABLE 4-2 (Continued)
SUMMARY OF SAMPLING AND ANALYTICAL PROGARAMS

26	Surface Soil	5	Appendix IX (1)	See (1)
30	Surface Soil	2	Appendix IX (1)	See (1)
		3	Volatiles Semivolatiles RCRA Metals	8240 8270 SW-846
	Groundwater	2	Appendix IX	See (1)
31	Surface Soil	4 Bldg. 2022	Appendix IX Total Petroleum Hydrocarbons	See (1) Modified 8015
	Subsurface Soil	8 Bldg. 2022	Appendix IX Total Petroleum Hydrocarbons	See (1) Modified 8015
	Surface Soil	4 Bldg. 31	Appendix IX (1) Total Petroleum Hydrocarbons	See (1) Modified 8015
32	Surface Soil	4	Volatiles Semivolatiles PCBs RCRA Metals	8240 8270 8080 SW-846
	Subsurface Soil	8	Volatiles Semivolatiles PCBs RCRA Metals	8240 8270 8080 SW-846
	Sediment	1	Appendix IX (1)	See (1)
37	Surface Soil	3	Volatiles Semivolatiles PCBs	8240 8270 8080
39	Surface Soil	2	RCRA Metals	SW-846
46	Surface Soil	3	Appendix IX (1)	See (1)
		9	Volatiles Semivolatiles PCBs RCRA Metals	8240 8270 8080 SW-846
	Subsurface Soil	2	Appendix IX (1)	See (1)
		2	Volatiles Semivolatiles PCBs RCRA Metals	8240 8270 8080 SW-846
	Concrete (Wipe Samples)	2	PCBs	8080

Note: Appendix IX parameters and method numbers presented on Table 9-1.

TABLE 4-2 (Continued)
SUMMARY OF SAMPLING AND ANALYTICAL PROGARAMS

51	Surface Soil	5	Volatiles Semivolatiles	8240 8270
AOC C	Surface Soil	3	Appendix IX (1)	See (1)
		9	Volatiles Semivolatiles PCBs RCRA Metals	8240 8270 8080 SW-846
	Concrete (Wipe Samples)	12	PCBs	8080
Background	Surface Soil	4	Appendix IX (1)	8240
	Subsurface Soil	8	Appendix IX (1)	8080
	Groundwater	4	Appendix IX (1)	

Note: (1) Appendix IX parameters and method numbers presented on Table 9-1.

TABLE 4-3

QC ACCEPTANCE CRITERIA[a]

Parameter	Range for Q (µg/L)	Limits for s (µg/L)	Range for $\bar{x}$ (µg/L)	Range , p, p_s (%)
Benzene	12.8-27.2	6.9	15.2-26.0	37-151
Bromodichloromethane	13.1-26.9	6.4	10.1-28.0	35-155
Bromoform	14.2-25.8	5.4	11.4-31.1	45-169
Bromomethane	2.8-37.2	17.9	D-41.2	D-242
Carbon tetrachloride	14.6-25.4	5.2	17.2-23.5	70-140
Chlorobenzene	13.2-26.8	6.3	16.4-27.4	37-160
2-Chloroethylvinyl ether	D-44.8	25.9	D-50.4	D-305
Chloroform	13.5-26.5	6.1	13.7-24.2	51-138
Chloromethane	D-40.8	19.8	D-45.9	D-273
Dibromochloromethane	13.5-26.5	6.1	13.8-26.6	53-149
1,2-Dichlorobenzene	12.6-27.4	7.1	11.8-34.7	18-190
1,3-Dichlorobenzene	14.6-25.4	5.5	17.0-28.8	59-156
1,4-Dichlorobenzene	12.6-27.4	7.1	11.8-34.7	18-190
1,1-Dichloroethane	14.5-25.5	5.1	14.2-28.4	59-155
1,2-Dichloroethane	13.6-26.4	6.0	14.3-27.4	49-155
1,1-Dichloroethene	10.1-29.9	9.1	3.7-42.3	D-234
trans-1,2-Dichloroethene	13.9-26.1	5.7	13.6-28.4	54-156
1,2-Dichloropropane	6.8-33.2	13.8	3.8-36.2	D-210
cis-1,3-Dichloropropene	4.8-35.2	15.8	1.0-39.0	D-227
trans-1,3-Dichloropropene	10.0-30.0	10.4	7.6-32.4	17-183
Ethyl benzene	11.8-28.2	7.5	17.4-26.7	37-162
Methylene chloride	12.1-27.9	7.4	D-41.0	D-221
1,1,2,2-Tetrachloroethane	12.1-27.9	7.4	13.5-27.2	46-157
Tetrachloroethene	14.7-25.3	5.0	17.0-26.6	64-148
Toluene	14.9-25.1	4.8	16.6-26.7	47-150
1,1,1-Trichloroethane	15.0-25.0	4.6	13.7-30.1	52-162
1,1,2-Trichloroethane	14.2-25.8	5.5	14.3-27.1	52-150

TABLE 4-3 (Continued)

QC ACCEPTANCE CRITERIA[a]

Parameter	Range for Q (µg/L)	Limits for s (µg/L)	Range for $\bar{x}$ (µg/L)	Range , p, p_s (%)
Trichloroethene	13.3-26.7	6.6	18.5-27.6	71-157
Trichlorofluoromethane	9.6-30.4	10.0	8.9-31.5	17-181
Vinyl chloride	0.8-39.2	20.0	D-43.5	D-251

Q = Concentration measured in QC check sample, in µg/L.
s = Standard deviation of four recovery measurements, in µg/L.
$\bar{x}$ = Average recovery for four recovery measurements, in µg/L.
p, p_s = Percent recovery measured.
D = Detected; result must be greater than zero.

a) This table is taken from SW-846 Method 8240.

Criteria were calculated assuming a QC check sample concentration of 20 µg/L.

TABLE 4-4

QC ACCEPTANCE CRITERIA[a]

Parameter	Test conc. (µg/L)	Limits for s (µg/L)	Range for $\bar{x}$ (µg/L)	Range , p, p_s (%)
Acenaphthene	100	27.6	60.1-132.3	47-145
Acenaphthylene	100	40.2	53.5-126.0	33-145
Aldrin	100	39.0	7.2-152.2	D-166
Anthracene	100	32.0	43.4-118.0	27-133
Benzo(a)anthracene	100	27.6	41.8-133.0	33-143
Benzo(b)fluoranthene	100	38.8	42.0-140.4	24-159
Benzo(k)fluoranthene	100	32.3	25.2-145.7	11-162
Benzo(a)pyrene	100	39.0	31.7-148.0	17-163
Benzo(g,h,i)perylene	100	58.9	D-195.0	D-219
Benzyl butyl phythalate	100	23.4	D-139.9	D-152
б-BHC	100	31.5	41.5-130.6	24-149
δ-BHC	100	21.6	D-100.0	D-110
Bis(2-chloroethyl)ether	100	55.0	42.9-126.0	12-158
Bis(2-chloroethoxy)methane	100	34.5	49.2-164.7	33-184
bis(2-chloroisopropyl)ether	100	46.3	62.8-138.6	36-166
Bis(2-ethylhexyl)phthalate	100	41.1	28.9-136.8	8-158
4-Bromophenyl phenyl ether	100	23.0	64.9-114.4	53-127
2-Chloronaphthalene	100	13.0	64.5-113.5	60-118
4-Chlorophenyl phenyl ether	100	33.4	38.4-144.7	25-158
Chrysene	100	48.3	44.1-139.9	17-168
4-4'-DDD	100	31.0	D-134.5	D-145
4-4'-DDE	100	32.0	19.2-119.7	4-136
4,4'-DDT	100	61.6	D-170.6	D-203
Dibenzo(a,h)anthracene	100	70.0	D-199.7	D-227
Di-n-butyl phthalate	100	16.7	8.4-111.0	1-118
1,2-Dichlorobenzene	100	30.9	48.6-112.0	32-129
1,3-Dichlorobenzene	100	41.7	16.7-153.9	D-172

TABLE 4-4 (Continued)

QC ACCEPTANCE CRITERIA[a]

Parameter	Test conc. (µg/L)	Limits for s (µg/L)	Range for $\bar{x}$ (µg/L)	Range , p, p_s (%)
1,4-Dichlorobenzene	100	32.1	37.3-105.7	20-124
3,3'-Dichlorobenzidine	100	71.4	8.2-212.5	D-562
Dieldrin	100	30.7	44.3-119.3	29-136
Diethyl phthalate	100	26.5	D-100.0	D-114
Dimethyl phthalate	100	23.2	D-100.0	D-112
2,4-Dinitrotoluene	100	21.8	47.5-126.9	39-139
2,6-Dinitrotoluene	100	29.6	68.1-136.7	50-158
Di-n-octylphthalate	100	31.4	18.6-131.8	4-146
Endosulfan sulfate	100	16.7	D-103.5	D-107
Endrin aldehyde	100	32.5	D-188.8	D-209
Fluoranthene	100	32.8	42.9-121.3	26-137
Fluorene	100	20.7	71.6-108.4	59-121
Heptachlor	100	37.2	D-172.2	D-192
Heptachlor epoxide	100	54.7	70.9-109.4	26-155
Hexachlorobenzene	100	24.9	7.8-141.5	D-152
Hexachlorobutadiene	100	26.3	37.8-102.2	24-116
Hexachloroethane	100	24.5	55.2-100.0	40-113
Indeno(1,2,3-cd)pyrene	100	44.6	D-150.9	D-171
Isophorone	100	63.3	46.6-180.2	21-196
Naphthalene	100	30.1	35.6-119.6	21-133
Nitrobenzene	100	39.3	54.3-157.6	35-180
N-Nitrosodi-n-propylamine	100	55.4	13.6-197.9	D-230
PCB-1260	100	54.2	19.3-121.0	D-164
Phenanthrene	100	20.6	65.2-108.7	54-120
Pyrene	100	25.2	69.6-100.0	52-115
1,2,4-Trichlorobenzene	100	28.1	57.3-129.2	44-142
4-Chloro-3-methylphenol	100	37.2	40.8-127.9	22-147

TABLE 4-4 (Continued)

QC ACCEPTANCE CRITERIA[a]

Parameter	Test conc. (µg/L)	Limits for s (µg/L)	Range for $\bar{x}$ (µg/L)	Range , p, p_s (%)
2-Chlorophenol	100	28.7	36.2-120.4	23-134
2,4-Chlorophenol	100	26.4	52.5-121.7	39-135
2,4-Dimethylphenol	100	26.1	41.8-109.0	32-119
2,4-Dinitrophenol	100	49.8	D-172.9	D-191
2-Methyl-4,6-dinitrophenol	100	93.2	53.0-100.0	D-181
2-Nitrophenol	100	35.2	45.0-166.7	29-182
4-Nitrophenol	100	47.2	13.0-106.5	D-132
Pentachlorophenol	100	48.9	38.1-151.8	14-176
Phenol	100	22.6	16.6-100.0	5-112
2,4,6-Trichlorophenol	100	31.7	52.4-129.2	37-144

s = Standard deviation of four recovery measurements, in µg/L.
$\bar{x}$ = Average recovery for four recovery measurements, in µg/L.
p, p_s = Percent recovery measured.
D = Detected; result must be greater than zero.

a) This table is taken from SW-846n Method 8270.

TABLE 7-1

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR WATER SAMPLES

Parameter	Container	Preservation	Holding Time
Volatiles	Two 40-ml vials with teflon septum caps	Cool to 4°C HCl pH <2	14 days (7 days if unpreserved)
Semivolatiles	1-liter amber glass bottle with teflon caps	Cool to 4°C	7 days to extraction 40 days from extraction to analysis
Pesticides/PCBs	1-liter amber glass bottle with teflon caps	Cool to 4°C	7 days to extraction 40 days from extraction to analysis
RCRA Metals	1-liter polyethylene bottle	HNO_3 to pH <2	Metals 180 days, Mercury 28 days
pH	N/A	N/A	Immediately
Specific Conductance	N/A	N/A	Immediately
Temperature	N/A	N/A	Immediately
Total Petroleum Hydrocarbon	1-liter amber glass bottle with teflon caps	Cool to 4°C HCl pH <2	28 days
Explosives	1-liter amber glass bottle with teflon caps	Cool to 4°C	7 days to extraction 40 days from extraction to analysis
Total Organic Carbon	2x40 ml glass	Cool to 4°C H_2SO_4 to pH <2	28 days
Chemical Oxygen Demand	1-250 ml polyethylene bottle	Cool to 4°C H_2SO_4 to pH <2	28 days
Total Suspended Solids	1-500 ml polyethylene bottle	Cool to 4°C	7 days
Hardness	1-150 ml polyethylene bottle	HNO_3 to pH <2	6 months
Asbestos	1-liter glass bottle	Cool to 4°C	48 hours

N/A - Not Applicable.

TABLE 7-2

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOIL AND SEDIMENT SAMPLES

Parameter	Container	Preservation	Holding Time*
Volatiles	2 x 120-ml wide-mouth glass vials	Cool to 4°C	14 days
Semivolatiles	8-oz wide-mouth glass jar	Cool to 4°C	14 days to extraction 40 days from extraction to analysis
Pesticides/PCBs	8-oz wide-mouth glass jar	Cool to 4°C	7 days to extraction 40 days from extraction to analysis
RCRA Metals	8-oz wide-mouth glass jar	Cool to 4°C	Metals 180 days, Mercury 28 days
Cation Exchange Capacity	8-oz glass jar with teflon liner	Cool to 4°C	N/A
Grain Size Distribution	one 5-gal plastic bucket	N/A	N/A
Oil and Grease	8-oz glass jar with teflon liner	Cool to 4°C	28 days
Total Organic Carbon	8-oz glass jar with teflon liner	Cool to 4°C	28 days
Total Petroleum Hydrocarbons	8-oz glass jar with teflon liner	Cool to 4°C	28 days

* Holding time for CLP methods are based on validated time of sample receipt as stated in the CLP Statement of Work. Holding time for EPA SW-846 methods are based on the time of sample collection.

TABLE 7-3

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR WIPE SAMPLES

Parameter	Container	Preservation	Holding Time
PCBs	8-oz wide-mouth glass jar	Cool to 4°C	7 days to extraction 40 days from extraction to analysis

TABLE 9-1

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Volatiles	Quantitation Limits*		Method Number
	Water (µg/L)	Low Soil (µg/kg)	
Acetone	100	100	8240
Acetonitrile	100	100	8240
Acrolein	5	5	8240
Acrylonitrile	5	5	8240
Methyl Chloride	100	100	8240
Benzene	5	5	8240
Bromodichloromethane	10	10	8240
Bromoform	5	5	8240
Bromomethane	10	10	8240
Carbon Disulfide	5	5	8240
Carbon Tetrachloride	5	5	8240
Chlorobenzene	5	5	8240
2-Chloro-1,3-butadiene	5	5	8240
Chloroethane	10	10	8240
Chlorodibromomethane	5	5	8240
Chloroform	5	5	8240
Chloromethane	10	10	8240
3-Chloropropene	5	5	8240
1,2-Dibromo-3-chloropropane	5	5	8240
Dibromomethane	5	5	8240
trans-1,4-dichloro-2butene	100	100	8240
Dichlorodifluoromethane	5	5	8240
Dibromomethane	5	5	8240
1,1-Dichloroethane	5	5	8240
1,2-Dichloroethane	5	5	8240
trans-1,2-Dichloroethylene	5	5	8240
1,1-Dichloroethylene	5	5	8240
Dichloromethane	5	5	8240
1,2-Dichloropropane	5	5	8240
cis-1,3-Dichloropropene	5	5	8240
trans-1,3-Dichloropropene	5	5	8240
1,4-Dioxane	150	150	8240

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Volatiles	Quantitation Limits*		Method Number
	Water (µg/L)	Low Soil (µg/kg)	
Ethyl benzene	5	5	8240
Ethyl cyanide	100	100	8240
Ethyl methacrylate	5	5	8240
2-Hexanone	50	50	8240
Iodomethane	5	5	8240
Isobutyl alcohol	50	50	8240
Methacrylonitrile	100	100	8240
Methyl ethyl ketone	100	100	8240
Methyl methacrylate	5	50	8240
4-Methyl-2-pentanone	50	50	8240
Pentachloroethane	10	10	8240
Styrene	5	5	8240
1,1,1,2-Tetrachloroethane	5	5	8240
1,1,2,2-Tetrachloroethane	5	5	8240
Tetrachloroethene	5	5	8240
Toluene	5	5	8240
1,1,1-Trichloroethane	5	5	8240
1,1,2-Trichloroethane	5	5	8240
Trichloroethene	5	5	8240
Trichlorofluoromethane	5	NA	8240
1,2,3-Trichloropropane	5	5	8240
Vinyl Acetate	50	50	8240
Vinyl Chloride	10	10	8240
Xylene	5	5	8240

* Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, will be higher.

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Semivolatiles	Quantitation Limits*		Method Number
	Water (µg/L)	Low Soil (µg/kg)	
Acenaphthene	10	660	8270
Acenaphthylene	10	660	8270
Acetophenone	10	NA	8270
2-Acetylaminofluorene	20	NA	8270
4-Aminobiphenyl	20	NA	8270
Aniline	10	NA	8270
Anthracene	10	660	8270
Aramite	20	NA	8270
Benzo(a)anthracene	10	660	8270
Benzo(b)fluoranthene	10	660	8270
Benzo(k)fluoranthene	10	660	8270
Benzo(g,h,i)perylene	10	660	8270
Benzo(a)pyrene	10	660	8270
Benzyl alcohol	20	1,300	8270
Bis(2-chloroethoxyl)methane	10	660	8270
Bis(2-chloroethyl)ether	10	660	8270
Bis(2-chloro-1-methyl ethyl)ether	10	660	8270
Bis(2-ethylhexyl)phthalate	10	660	8270
4-Bromophenyl phenyl ether	10	660	8270
Butyl benzyl phthalate	10	660	8270
p-Chloroaniline	20	1,300	8270
Chlorobenzilate	10	NA	8270
p-Chloro-m-cresol	20	1,300	8270
2-chloronaphthalene	10	660	8270
2-Chlorophenol	10	660	8270
4-chlorophenyl phenyl ether	10	660	8270
Chrysene	10	660	8270
o,m,p-Cresol	10	660	8270
Diallate	10	NA	8270
Dibenzofuran	10	660	8270
Di-n-butyl phthalate	10	660	8270
Dibenzo(a,h)anthracene	10	660	8270

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Semivolatiles	Quantitation Limits*		Method Number
	Water (µg/L)	Low Soil (µg/kg)	
o-Dichlorobenzene	10	660	8270
m-Dichlorobenzene	10	660	8270
p-Dichlorobenzene	10	660	8270
3,3'-Dichlorobenzidine	20	1,300	8270
2,4-Dichlorophenol	10	660	8270
2,6-Dichlorophenol	10	NA	8270
Diethylphthalate	10	660	8270
Dimethoate	20	NA'	8270
p-(Dimethylamino)azobenzene	10	NA	8270
7,12-Dimethyl benz(a)anthracene	10	NA	8270
3,3-Dimethyl benzidine	10	NA	8270
dimethylphenenthylamine	10	NA	8270
2,4-dimethylphenol	10	660	8270
Dimethyl phthalate	10	660	8270
m-Dinitrobenzene	20	NA	8270
4,6-Dinitro-o-cresol	50	3,300	8270
2,4-Dinitrophenol	50	3,300	8270
2,4-Dinitrotoluene	10	660	8270
2,6-dinitrotoluene	10	660	8270
Di-n-octylphthalate	10	660	8270
Diphenylamine	10	NA	8270
Di-n-propylnitrosamine	10	NA	8270
Ethylmethanesulfonate	20	NA	8270
Fluoranthene	10	660	8270
Fluorene	10	660	8270
Hexachlorobenzene	10	660	8270
Hexachlorobutadiene	10	660	8270
Hexachlorocyclopentadiene	10	660	8270
Hexachloroethane	10	660	8270
Hexachloropropene	10	NA	8270
Indeno(1,2,3-dc)pyrene	10	660	8270
Isodrin	20	NA	8270

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Semivolatiles	Quantitation Limits*		Method Number
	Water (µg/L)	Low Soil (µg/kg)	
Isophorone	10	660	8270
Isosafrole	10	NA	8270
Kepone	20	NA	8270
Methapyrilene	100	NA	8270
3-Methylcholanthrene	10	NA	8270
Methyl methanesulfonate	10	NA	8270
2-Methylnaphthalene	10	660	8270
Naphthalene	10	660	8270
1,4-Naphthoquinone	10	NA	8270
1-Naphthylamine	10	NA	8270
2-Naphthylamine	10	NA	8270
o-Nitroaniline	50	3,300	8270
m-Nitroaniline	50	3,300	8270
p-Nitroaniline	20	NA	8270
Nitrobenzene	10	660	8270
o-Nitrophenol	10	660	8270
p-Nitrophenol	50	3,300	8270
4-Nitroquinoline-1-oxide	40	NA	8270
n-Nitrosodi-n-butylamine	10	NA	8270
n-Nitrosodiethylamine	20	NA	8270
n-Nitrosodimethyllamine	20	NA	8270
n-Nitrosodiphenylamine	10	660	8270
n-Nitrosomethylethylamine	20	NA	8270
n-Nitrosomorpholine	10	NA	8270
n-Nitrosopiperidine	20	NA	8270
n-Nitrosopyrrolidine	40	NA	8270
5-Nitro-o-toluidine	10	NA	8270
Pentachlorbenzene	10	NA	8270
Pentachloronitrobenzene	20	NA	8270
Pentachlorophenol	50	3,300	8270
Phenacetin	20	ND	8270
Phenanthrene	10	660	8270

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Semivolatiles	Quantitation Limits*		Method Number
	Water (µg/L)	Low Soil (µg/kg)	
Phenol	10	660	8270
Phorate	10	NA	8270
p-Phenylenediamine	10	NA	8270
2-PicolinPronamidee	10	NA	8270
Pyrene	10	660	8270
Pyridine	10	NA	8270
Safrole	10	NA	8270
1,2,4,5-Tetrachlorobenzene	10	NA	8270
2,3,4,6-Tetrachlorophenol	10	N A	8270
o-Toluidine	10	NA	8270
1,2,4-Trichlorobenzene	10	660	8270
2,4,5-Trichlorophenol	10	660	8270
2,4,6-Trichlorophenol	10	660	8270
O,O,O-Triethyl-Phosphorotrioate	10	NA	8270
sym-Trinitrobenzene	10	660	8270

* Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, will be higher.

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Pesticides	Quantitation Limits[1]		Method Number
	Water (µg/L)	Low Soil (µg/kg)	
Aldrin	0.04	2.7	8080
alpha-BHC	0.03	2	8080
beta-BHC	0.06	4	8080
delta-BHC	0.09	6	8080
Lindane	0.05	1.7	8080
Chlordane	0.14	9.4	8080
4,4'-DDT	0.12	8	8080
4,4'-DDE	0.04	2.7	8080
4,4'-DDD	0.11	7.4	8080
Dieldrin	0.02	1.3	8080
Endosulfan I	0.14	9.4	8080
Endosulfan II	0.04	2.7	8080
Endosulfan sulfate	0.66	44	8080
Endrin	0.06	4	8080
Toxaphene	2.4	160	8080
Endrin Aldehyde	0.1	3.3	8080
Heptachlor	0.03	2	8080
Heptachlor epoxide	0.83	56	8080
Methyoxychlor	1.8	120	8080
Aroclor-1016	NA	NA	8080
Aroclor-1221	NA	NA	8080
Aroclor-1232	NA	NA	8080
Aroclor-1242	0.65	44	8080
Aroclor-1248	NA	NA	8080
Aroclor-1254	NA	NA	8080
Aroclor-1260	NA	NA	8080

(1) Practical Quantitation Limits taken from "Test Methods for Evaluating Solid Wastes," USEPA, SW-846, November 1986.

NA = Not Available

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Dioxins (SW-846 Method 8280)	Quantitation Limits[1]		Method Number
	Water (µg/L)	Low Soil (µg/kg)	
PCDD's	0.01	NA	8280
PCDF's	0.01	NA	8280
2,3,7,8-TCDD	0.005	0.17	8280

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Chlorinated Herbicides	Practical Quantitation Limits		Method Number
	Water (µg/L)	Soil/Sediment (µg/kg)	
2,4-Dichlorophenoxyacetic acid	12	804	8150
Dinoseb	0.7	46.9	8150
2,4,5-T	2	134	8150
Silvex	1.7	11.4	8150

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Analyte	Method Number	MDL (µg/L)	Method Description
Antimony	6010	32	Inductively Cupled Plasma
Arsenic	7060	1	AA Graphite Furnace
Barium	6010	2	Inductively Coupled Plasma
Beryllium	6010	0.3	Inductively Coupled Plasma
Cadmium	6010	4	Inductively Coupled Plasma
Chromium	6010	7	Inductively Coupled Plasma
Cobalt	6010	7	Inductively Coupled Plasma
Copper	6010	6	Inductively Coupled Plasma
Lead	7421	1	AA Graphite Furnace
Mercury	7470	0.2	Cold Vapor AA
Nickel	6010	40	Inductively Doupled Plasma
Selenium	7741	2	AA Graphite Furnace
Silver	6010	7	Inductively Coupled Plasma
Thallium	7841	1	AA Graphite Furnace
Tin	6010	1,000	Inductively Coupled Plasma
Vanadium	6010	8	Inductively Cuopled Plasma
Zinc	6010	2	Inductively Coupled Plasma
Cyanide	9010	5	Colorimetric
Sulfide	9030	1,000	Titrimetric, Iodine

TABLE 12-1

SYSTEM AUDIT CHECKLIST - FIELD OPERATIONS

Project No. _____ Date _____

Project Name & Location _____ Name & Signature of Auditor _____

Team Members _____ Name & Signature of Field Team _____

Yes _____ No _____ 1. Is there a set of accountable field documents checked out to the Site Manager?
Comments: _____

Yes _____ No _____ 2. Is the transfer of field operations from the Site Manager to field participants documented in a log book?
Comments: _____

Yes _____ No _____ 3. Is there a written list of sampling locations and descriptions?
Comments: _____

Yes _____ No _____ 4. Are samples collected as stated in the project plan or as directed by the Site Manager?
Comments: _____

Yes _____ No _____ 5. Are samples collected in the type of container specified in the project plan or as directed by the Site Manager?
Comments: _____

Yes _____ No _____ 6. Are samples preserved as specified in the project plan or as directed by the Site Manager?
Comments: _____

TABLE 12-1
SYSTEM AUDIT CHECKLIST - FIELD OPERATIONS
PAGE TWO

Yes _____ No _____ 7. Are the number, frequency and type of samples collected as specified in the project plan or as directed by the Site Manager?
Comments: _____

Yes _____ No _____ 8. Are the number, frequency and type of measurements taken as specified in the project plan or as directed by the Site Manager?
Comments: _____

Yes _____ No _____ 9. Are samples identified with sample labels?
Comments: _____

Yes _____ No _____ 10. Are blank and duplicate samples properly identified?
Comments: _____

Yes _____ No _____ 11. Are sample and serial numbers for samples split with other organizations recorded in a log book or on a chain-of-custody record?
Comments: _____

Yes _____ No _____ 12. Are samples listed on a chain-of-custody record?
Comments: _____

Yes _____ No _____ 13. Is chain-of-custody documented and maintained?
Comments: _____

Yes _____ No _____ 14. Are quality assurance checks performed as directed?
Comments: _____

TABLE 12-1
SYSTEM AUDIT CHECKLIST - FIELD OPERATIONS
PAGE THREE

Yes _____ No _____ 15. Are photographs documented in logbooks as required?
Comments: _____
_____
_____

Yes _____ No _____ 16. Are all documents accounted for?
Comments: _____
_____
_____

Yes _____ No _____ 17. Have any documents been voided or destroyed?
Comments: _____
_____
_____

APPENDIX A
RESUMES OF KEY PERSONNEL

Baker

Raymond P. Wattras

Project Manager

EDUCATION: University of Pittsburgh
M.S., Public Works Engineering and Administration, 1993
B.S., Environmental Biology, 1979

EXPERIENCE:

General Qualifications

Mr. Wattras has over 13 years of experience in the environmental field, serving in the capacity of Project Manager for the past 10 years. This experience was gained under the Navy CLEAN Contract for the Atlantic Division, Naval Facilities Engineering Command (1991 - Present); the State of Pennsylvania's General Technical Assistance Contract (1990); and EPA's ARCs III (1989 - 1990), REM III (1986 - 1990), and REM/FIT Contracts (1984 - 1986).

As a Project Manager, Mr. Wattras has managed multi-discipline teams in conducting CERCLA remedial investigations and feasibility studies (RI/FS), CERCLA Site Inspections, treatability studies, engineering evaluations, property assessments, and HRS scoring. Mr. Wattras is experienced in managing small to large-scale hydrogeologic investigations, soil investigations, surface water/sediment investigations, aquatic surveys, and waste characterizations. These studies have involved the investigation of the following: mercury disposal; floating petroleum product on groundwater; dissolved solvents in groundwater; disposal of listed wastes in soil; pesticide and PCB soil and sediment contamination; wood tar (PAHs) surface impoundments; metals in groundwater and soil; BTEX in soil and groundwater; PCB soil contamination; chemical agents (i.e., mustard, blister) in abandoned landfills; and ordnance identification and removal.

Mr. Wattras has managed treatability studies and feasibility studies and has gained knowledge in the following areas: biological treatment systems; soil washing; thermal treatment; in- situ soil vapor extraction; groundwater collection; air sparging; soil removal and containment (capping); alternative water supplies; and stabilization.

In addition, Mr. Wattras has management experience in the following areas: contract negotiations; preparation of Project Plans; preparation of technical specifications and procurement of drilling, analytical, aerial, and specialty (e.g., ordnance) subcontractors; data management; sample collection and analysis; technical report preparation; human health and ecological risk assessment; engineering analysis; health and safety; quality assurance/quality control; preparation of Proposed Remedial Action Plans (PRAP) and Record of Decision (ROD) documents, technical resource planning and guidance; budget and schedule monitoring; and administrative reporting.

Specific project management and relevant technical experience is outlined below.

Specific Project and Program Management Experience

- Mr. Wattras currently serves as the Deputy Program Manager for Baker's Comprehensive Long-Term Environmental Action Navy (CLEAN) Program for the Atlantic Division, Naval Facilities Engineering Command. In this position, he assists the Program Manager in the overall management and administration of this 10-year, 100 million dollar contract. Under this contract, Baker provides engineering services in the areas of site characterization, risk assessment, engineering evaluations, treatability studies, spill prevention planning, air toxics inventories, tank management, and design. Mr. Wattras has recently been tasked with this assignment in January 1995.

- Mr. Wattras also serves as the Activity Coordinator for MCB Camp Lejeune, North Carolina, under the Navy CLEAN Program. As an Activity Coordinator, he is the focal point of contact between LANTDIV and Baker and oversees the management of over 30 contract task orders total approximately 18 million dollars. In this position, Mr. Wattras provides technical and contractual direction to six project managers and technical support staff who are responsible for implementing the contract task orders. Mr. Wattras is also involved with LANTDIV's long-term planning with respect to adhering to the requirements of the Federal Facilities Agreement (FAA) established for this NPL Activity. This planning is accomplished via the preparation of a yearly Site Management Plan as required by the FFA. In addition, Mr. Wattras is a member of the MCB Camp Lejeune Partnering Team, which is comprised of representatives from LANTDIV, MCB Camp Lejeune, EPA Region IV, North Carolina DEHNR, and the RAC contractor. As an Activity Coordinator, Mr. Wattras participates in Technical Review Meetings and Public Meetings, as required. Mr. Wattras has served in this capacity for the last four years.

- Currently serves as the Activity Coordinator for NRTF Driver, Virginia. This Activity has been closed as part of the Base Realignment and Closure (BRAC) Program. Under the BRAC Program, areas of environmental concern must be investigated and remediated prior to transfer of property to private or public entities. As the Activity Coordinator, Mr. Wattras is LANTDIV's primary contact for the various contract task orders involving site investigations, feasibility studies, and remedial design. In this position, Mr. Wattras provides project management oversight for six contract task orders. The various studies and design tasks are expected to be completed in late 1995. Mr. Wattras has served in this capacity since November 1994.

- Mr. Wattras has managed RI/FS projects for EPA Region III, the Pennsylvania Department of Environmental Resources (PADER), and the Department of the Navy. A summary of the types of projects managed by Mr. Wattras is given below.

  - Operable Unit No. 1, MCB Camp Lejeune, North Carolina - This operable unit consisted of three sites in a highly industrialized area of the base. An interim ROD was signed in 1993 to begin remediation of TCE contamination in the shallow aquifer. The interim remedial action involved pumping wells to contain the migration of two solvent-based plumes, onsite treatment, and discharge via the Base's STP. In 1994, a final ROD was signed to focus on remediating the source areas. In addition, remediation of pesticide and PCB contaminated soil at one of the three sites will be conducted. Remediation was

initiated for the groundwater in late 1994. Remediation of soil is expected to commence in early 1995.

- Operable Unit No. 2, MCB Camp Lejeune, North Carolina - This operable unit consisted of three sites. Two of the three sites involved random disposal (surficial and subsurface) of wastes including PCBs, pesticides, solvents, construction debris, batteries, and drums. The third site involved an active fire training facility. A removal action was conducted during the RI phase to remove surficial drums and buried drums which presented potential hazards to human health and the environment. The final ROD involved groundwater pumping and onsite treatment (300 gpm treatment facility), and the excavation and removal of soil contaminated with pesticides, PCBs, and PAHs. The RI/FS and design phase were expedited and construction was initiated within 15 months following the signing of the ROD.

- Operable Unit No. 3, MCB Camp Lejeune, North Carolina - This operable unit consists of one site, which reportedly received mercury wastes. An extensive soil, groundwater, and surface water/sediment characterization study was performed as part of the RI. In addition, an ecological investigation consisting of a benthic, fish, and shellfish study was conducted to assess potential bioaccumulation of mercury. Based on the results of the RI, and the human health and ecological risk assessments, a No Action ROD was signed in 1993.

- Operable Unit No. 4, MCB Camp Lejeune, North Carolina - This operable unit consists of three former disposal areas which reportedly received chemical warfare materials (CWM), pesticide wastes, PCBs, and solvents. Currently, this project is in the FS stage. Remediation may be required at two of the three sites. One site is contaminated with high concentrations of solvents in groundwater. Treatability studies have been initiated to evaluate an innovative insitu technology called "in well aeration." If successful, this remediation technique would treat the groundwater insitu without the costs of groundwater extraction and discharge. At the second site, onsite collection and treatment of two seeps contaminated with heavy metals may be required. However, remediation at this site is dependent on the results of the ecological risk assessment, which has not been finalized.

- Osborne Landfill Site, Mercer County, Pennsylvania - This 10-acre former landfill involved PCB contaminated soil and chlorinated organic groundwater contamination. Studies included soil characterizations via drilling and test pitting, geophysical investigations, groundwater studies of four potable water aquifers under the site, surface water/sediment investigations, bioassays to evaluate wetland sediments, and treatability studies to evaluate soil washing. The Record of Decision involved placement of a slurry wall around the landfill, construction of a cap, and groundwater remediation via pumping and onsite treatment.

- Croyden TCE Site, Bucks County, Pennsylvania - This site involved significant TCE contamination, including DNAPL, of a potable supply aquifer in the community of Croyden, Pennsylvania. The cause of the problem was believed to be from discharges from numerous facilities (chemical plants, dry cleaning, wood refinishing) in an industrial section of the community. Because several residential supply wells were found to be contaminated, an

interim remedial action for construction of an alternate water supply was implemented. The final ROD involved groundwater pumping and onsite treatment. Three phases of investigations were required due to the complexity of the site.

- Westline Site, Bradford County, Pennsylvania - This site involved historical disposal of wood tar wastes generated during the production of chemicals from wood. The final ROD involved the excavation and offsite incineration of over 5,000 cubic yards of wood tar/soil and long-term groundwater monitoring. The primary contaminants of concern in the wastes and soil involved PAHs.

- Saltvile Disposal Site, Virginia - This site involved the disposal of manufacturing wastes in a 10-acre surface impoundment. The contaminant of concern involved mercury contamination throughout the waste impoundment. The mercury was also detected in leachate and in downstream sediment and fish along an adjacent stream. The ROD involved leachate collection and treatment, and containment of the impoundment. Fishing advisories were also established.

- Provides technical support to the Atlantic Division, Naval Facilities Engineering Command in the preparation of Site Management Plans, which are required under the existing Federal Facilities Agreement. The SMPs identify upcoming investigations at the military installation, along with project milestones. The SMP addresses a planning period from FY 1992 through FY 2001.

- Managed CERCLA Site Inspections at eleven potential areas of concern where contamination may have been caused by past disposal practices. These projects involved the collection of samples from soil, groundwater, surface water, and sediment for determining whether an RI/FS is warranted, or no further action (delisting from the DON's IR Program).

- Managed a Site Assessment for a two military construction (MCON) projects. These projects involved soil and groundwater investigations to assess the risk of undertaking construction activities at the sites.

- Managed the collection of information to undertake an HRS scoring of 11 Naval Activities. This project involved a significant level of coordination and data management to meet the Navy's tight schedule with the EPA.

- Managed a site characterization of a jet fuel storage facility involving a hydrogeologic investigation and an investigation of the tank farm drainage system. The problem involved floating product on the groundwater as a result of historical overfilling. A product recovery system and soil removal alternative were implemented.

- Managed several projects assisting EPA with the technical oversight of site investigations and feasibility studies conducted by potentially responsible parties. Project tasks required the review of Project Plans, field oversight involving split sampling, and evaluation of technical reports.

Field Sampling Experience

Under the EPA REM/FIT Contract, Mr. Wattras served as an environmental scientist by participating in numerous field investigative projects as a field team leader. Mr. Wattras was responsible for mobilizing/demobilizing equipment and personnel, coordinating field investigations and personnel, sampling and analysis, and reporting.

As an associate engineer in the development of the effluent guidelines for the foundry industry (1982-1983), Mr. Wattras participated in the sampling of industrial (foundry) plant process waters, collection of process flow data, and evaluation of treatment processes.

Community Relations

- Participated in the development of community relations plans for Superfund Sites.
- Provided technical support to the U.S. EPA (1986-1989) and the Department of the Navy during public meetings and technical review committee meetings. This support included describing proposed field operations plans, explaining the results of the remedial investigation, and describing potential alternatives for remediating the site.

Additional Qualifications

OSHA Health and Safety Courses for CERCLA Investigations (40-hour, 1984) (Supervisory, 1986) (8-hour refresher, 1993)

Various Project Management Courses and Seminars

Memberships

HMCRI

Presentations/Publications

"Accelerated Remediation Under Navy CLEAN Through Partnering and Fast Track Design," 1995 Federal Environmental Restoration Conference, Atlanta, Georgia.

"Expedited Approach for Investigating Multiple Sites at Military Installations," 1993 Federal Environmental Restoration Conference, Washington, D. C.

"Characterization of Floating Product (Jet Fuel) in Groundwater at the GPIA," Twenty-Third Mid-Atlantic Industrial Waste Conference (1991), Pittsburgh, Pennsylvania.

"Westline Site: Case Study of A Superfund Site in the Allegheny National Forest," Western Pennsylvania Water Pollution Control Association, Pittsburgh.

Date of Resume Revision:	1/95
Baker Date of Hire:	4/90
Years with Baker:	4
Years with Other Firms:	11

Baker

John W. Mentz

Project Manager

EDUCATION: Pennsylvania State University
B.S., Geology, 1972

EXPERIENCE:

General Qualifications

Mr. Mentz is a Senior Project Manager with over 22 years experience in project and program management. He has gained extensive experience and progressive responsibility in a variety of geotechnical areas, including evaluation and remediation of contamination of soil, surface water, and groundwater by hazardous and mining waste; geological investigations to assess/predict groundwater conditions, evaluate mining problems, and define coal and other mineral resources; underground well injection; inventories of various mining-related features with potential adverse health, safety, and environmental consequences; regulatory assessment and compliance; and impact assessments. His program and project management experience is summarized below:

Specific Experience

- Program Manager for Baker's Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, providing technical leadership, program and administrative guidance, and program-level quality assurance/quality control. The CLEAN Program was implemented to provide the Navy with comprehensive technical and administrative support for environmental activities in the areas of:

  - Installation Restoration
  - Hazardous Waste Management and Regulatory Compliance
  - Underground Storage Tank (UST) Program
  - Spill Prevention Control and Countermeasures
  - Emergency Spill Response
  - Water Supply System/Sewage Treatment Plant Evaluations
  - Toxic Substance Control Act Compliance
  - Solid Waste Management
  - Air Toxics
  - Program Administration

  Mr. Mentz directs activities in all of these technical areas at Federal facilities (Navy, Marine Corps, Air Force, and Army) in the Mid-Atlantic states, Caribbean, Atlantic, Mediterranean, and European Countries for the Atlantic and Chesapeake Divisions, Naval Facilities Engineering Command. To date, more than 300 tasks ranging in size from $5,000 to $2.5M have been authorized. Mr. Mentz has managed the performance of more than $45M in technical services under this contract in the last four years.

- Project Manager for Environmental Baseline Survey at Hays Army Ammunition Plant, Hays, Pennsylvania, a Government-owned, contractor-operated shell casing production and storage facility. The survey included characterization of all media at the property, which included above-ground and underground storage tanks, the manufacturing plant, at wastewater treatment facility, transformer storage area, and 3,000 feet of railroad siding.

- Task Manager for soil, surface water and sediment characterization survey at the U.S. Department of Energy's Pittsburgh Energy Technology Center.

- Project Manager for Installation Restoration Program Stage 2 Remedial Investigation at Dover AFB, Delaware. Conducted for the U.S. Air Force Occupational and Environmental Health Laboratory, this $1.8M program included 12 individual sites -- fuel spills/leaks, former landfill and construction rubble fills, fire training areas, and hazardous material storage areas.

- Project Manager for Installation Restoration Program Remedial Investigation/Feasibility Study and UST Removal Program at Lowry AFB, Denver, Colorado. This $1.9M program included 7 sites - landfills, fire training areas, former coal and fly ash disposal areas, an auto hobby shop, and an UST area.

- At Lowry AFB, coordinated location and sampling of contents of 19 abandoned USTs. Managed completion of UST removal pre-design survey and preparation of draft plans and specifications for UST removal.

- Project Manager for Installation Restoration Program Phase II, Stage 1 Confirmation/ Quantification Study at Charleston AFB, South Carolina. Ten sites here included landfills, hazardous material spill and storage areas, and PCB spill sites.

- Led the effort to develop and summarize potential site characterization costs for 81 mixed-waste CERCLA sites at DOE's Hanford, Washington Reservation, and coordinated a prioritization and scheduling analysis of the Hanford CERCLA sites.

- Managed studies at several Superfund sites, including feasibility study field support for an industrial facility/Superfund site in southeastern Pennsylvania with contaminants emanating from leaking underground TCE and fuel oil storage tanks.

- Evaluated the feasibility of various alternatives for cleanup of TCE-contaminated soils and groundwater at an abandoned solvent recovery facility near Dover, Delaware.

- Participated in cleanup of TCE-contaminated soils via excavation and removal at one site, excavation and soil aeration (shredding) at another site. Both projects included pre- and post-remediation groundwater monitoring.

- Designed and completed a groundwater monitoring program at an industrial research facility to identify the presence and movement of contaminants toward two adjacent municipal pumping wells.

- Evaluated a subsurface gasoline spill and subsequent implementation of a recovery program.

- As Program Manager for a USEPA/ODW, Groundwater Protection Branch technical support contract, Mr. Mentz gained valuable experience with the Agency's Underground Injection Control Program, which was initiated to ensure proper regulation of underground injection of both hazardous and nonhazardous wastes. That contract provided technical and training support to EPA Headquarters and a number of the Agency's regional offices. Mr. Mentz coordinated all contract efforts and provided technical input during execution of tasks.

- Technical input on varied environmental studies, including dredge spoil disposal/shoreline reclamation, and water supply (reservoir siting).

- A broad range of studies designed and conducted by Mr. Mentz were aimed at assessing surface water and groundwater resources to quantify mining-related pollutants (chemical and sediment), pinpoint sources of those pollutants and project pollution production potential, and recommend pollution abatement/control strategies. Such projects have included:

  - Investigation of methods to improve performance of surface mine sedimentation basins.

  - Technical and economic evaluation of available mine closure alternatives.

  - Assessment of partial inundation of abandoned sections of underground mines to reduce pollution formation.

  - Portions of an Office of Surface Mining "Abandoned Mined Lands Reclamation Control Technology Handbook," which discussed mine drainage control and sealing of underground openings.

  - Investigation of a borehole dewatering system to control fracture-dominated groundwater inflow into active underground mines.

- Mr. Mentz has extensive experience in planning and conducting inventories of various active and inactive mining-related features. He has conducted inventories of abandoned surface and underground coal mines and resultant pollution, waste piles, subsidence, and other hazardous features in Pennsylvania, West Virginia, Maryland, Ohio, Kentucky, and western Colorado (non-coal mines). Mr. Mentz managed an inventory of active coal waste embankments in West Virginia, Maryland, Virginia, and Eastern Kentucky. He also coordinated a nationwide assessment of off-site coal-handling facilities.

- Mr. Mentz led the team that developed content requirements and format guidelines of state abandoned mined land reclamation plans for the U.S. Office of Surface Mining in compliance with 30 CFR 884.13. That effort included development of a model state plan to guide state reclamation agencies in the preparation of their state plans for OSM submission.

- Mr. Mentz has extensive experience in the area of mineral resource evaluation. He has conducted or participated in many site-specific coal resource evaluations throughout Appalachia and in Texas. He also conducted analyses of all four Pennsylvania anthracite fields and a 3,700-square mile portion of central Pennsylvania's bituminous coal fields. In addition, he has managed or participated in numerous non-coal resource evaluations at specific sites for limestone, sandstone, and uranium.

Baker

Thomas C. Fuller, P.G.

Project Manager

EDUCATION: St. Lawrence University
B.S., Geology, 1973
New York State University College at Oneonta
Graduate Geology Courses

REGISTRATION: Certified Professional Geologist - State of Indiana #436

EXPERIENCE:

General Qualifications

Mr. Fuller has over 19 years of experience on a wide variety of geological/hydrogeological projects. Included in this experience is extensive project management of both very large projects (RCRA and CERCLA), and numerous smaller scale jobs. Specific projects/programs have included management of RI/FSs for both industry and government clients, review of RCRA Part B applications, review of CERCLA RI/FS and RCRA Facility Investigation (RFI) work plans, preparation of work plans for RI/FSs, RFIs, groundwater quality assessment programs and corrective action for solid and hazardous waste management units; management and performance of field investigations for geological, foundation, and/or groundwater conditions; construction management including administration of contracts, data reduction, and report preparation; and project management of personnel, schedules, and product.

Administrative and technical management have been a part of duties for a period of over seven years, the first as a Section Manager and then as a Department Head, and now program administration support for a Navy CLEAN contract. In these capacities, responsibilities have included technical project input; project management; RCRA specialist consulting, personnel management; personnel acquisition; control of work loads and project flow; assignment of task managers, and technical support to junior staff.

Project Experience

- Project Manager and Activity Coordinator on the Navy CLEAN program through the U.S. Navy, Atlantic Division (LANTDIV). Performs technical QA/QC on program deliverables, manages individual CTOs, acts as Activity Coordinator for all CLEAN projects in Puerto Rico and the Washington Navy Yard and assists senior management in program and contract administration and Federal marketing.

- Project Manager for CTOs under the CLEAN program addressing a wide variety of areas including PA/SIs, RI/FSs, RFIs, and miscellaneous investigations of particular environmental problems. This role encompasses the full range of activities from project initiation, investigation, reporting and technical negotiations with the appropriate regulatory agencies.

- Project Manager for a biological treatment program at Craney Island Fuel Farm for LANTDIV. Project involved a biological treatment cell that has remediated more than 70,000 cy of petroleum-contaminated soil using indigenous microbes enhanced by fertilizer and maintenance of optimal moisture content. Site has been permitted to receive other off-site, petroleum-contaminated sites.

- Project Manager for a full-scale RI/FS in Watertown, New York, area. The project was a PRP lead (New York state-listed site) driven by a consent order. Included in the work were major investigatory phases (including dye tracing of aquifers, landfill drilling, monitoring well installation, geophysical investigations, ecological assessment) and performance of a full risk assessment and feasibility study leading to remedial design. The project contained three landfills, two former lagoons, five UST (both petroleum and hazardous waste) sites, and approximately 12 other potential areas of concern. Project management on this job included all client interface, negotiations with the agency, lead technical guidance, planning and tracking of field investigations, control of subcontracting and subcontractor performance, and management of all project personnel (approximately 10 to 15 at any one time).

- Project Manager for a number of smaller scale projects. Representative among these are:

  - A limited RI/FS at the Niagara Falls AFB for a fire-training area;
  - Multiple UST and UST-related projects;
  - Environmental audits of existing industrial facilities; and,
  - Multiple property assessments related to real estate transfers.

- Involvement in these project extends through client liaison, negotiation with lead agencies, active management of entire project or mentoring of junior staff and technically guiding task managers.

- Task Manager of an extensive hydrogeological site investigation at the Modern Landfill, Lewiston, New York. Project was in support of a major expansion as well as to bring the facility into full compliance with the appropriate NYSCRR Part 360 regulations. Included was the preparation of a work plan for state approval, installation of approximately 25 monitoring points (both piezometers and wells) and final reporting to the state.

- Responsible for preparing and presenting the groundwater portion of a three-day RCRA Orientation seminar. Seminar was designed for new state and EPA employees, especially permit writers, to acquaint them with the RCRA regulations and permitting process. Presentations were made to nearly all of the regions (in many cases, a number of times) during the course of the program.

- Project Geologist and Task Manager for Part B application review as part of the EPA RCRA Implementation Team. Responsible for technical evaluation of the groundwater portions of the application. Primary thrust of this program was the examination of submittals to determine, based on results of interim status monitoring and site hydrogeologic characterization information, whether the proposed/in-place groundwater program was appropriate as to type and capable of performing to the necessary level. Project included review of applications from commercial waste disposal facilities (surface impoundments, landfills), oil refineries (land treatment units), chemical plants, and large manufacturing facilities (waste piles) throughout the continental states and the Caribbean. Also included in work under this contract was the review of a number of RI/FS work plans for technical

adequacy, and the drafting of permanent status RCRA operating permits, including HSWA response items, for a variety of facilities.

- Primary reviewer of Hazardous and Solid Waste Amendments (HSWA) responses from various facilities under the corrective action program. Activities included report review, identification of Solid Waste Management Units (SWMUs), preparation of RCRA Facility Assessment reports (RFAs), performance of site inspections, and development of conclusions and recommendations for agency's use in enacting/requiring possible corrective actions.

- Project Coordinator for a CERCLA Superfund site in eastern Ohio. Responsible for coordinating all communication among the EPA, OEPA, PRP group and the PRP group's other technical consultant. Also served as project manager for a variety of technical aspects of the project including preparation of work plans, health and safety plans, quality assurance project plans, and engineering estimates of remedial alternatives.

- Project Manager/Principal Investigator for a number of RCRA-driven groundwater quality assessment programs for industrial facilities. Duties include management of the plan from inception through completion including design of investigations, negotiations with appropriate agencies, direction of field program, data analysis, and reporting.

- Deputy Project Manager and Project Geologist for groundwater investigation work plan development at a major chemical plant in South Charleston, West Virginia. This plan was designed to assess groundwater conditions around two impoundments and an abandoned industrial landfill.

- Task Manager/Project Geologist for development of a groundwater investigation work plan at Bethlehem Steel's Johnstown plant. The study was related to a large area containing numerous individual disposal areas including those used for spent pickle liquor, lime stabilized spent pickle liquor sludge, hot forming sludge, slag, and solid industrial waste.

- Field Investigations Leader for a study of radionuclide migration via groundwater for a Department of Energy site in Lewiston, New York. Activities included well installation and sampling, geologic characterization, health and safety program compliance monitoring, and subsequent data reduction and analysis.

- Project Geologist for a TCE contaminant plume tracking investigation for a steel concern in Milwaukee, Wisconsin. Project involved well installation, groundwater sampling, review of analytical data, interpretation of results and subsequent report preparation.

- Project Geologist for a coal pile leachate study in Dunkirk, New York for Niagara Mohawk Power Corporation. Study included well installation and monitoring mandated by state agency for permit compliance.

- Project Geologist for a well installation and monitoring program for Union Carbide, Chicago. Duties included field investigation, well installation and development, data reduction and report preparation.

- Project Geologist for a hydrogeologic/geologic investigation and ground movement instrumentation installation program at Terrapin Point, Niagara Falls for the New York State Parks and Recreation Commission.

- Task Coordinator for geologic data reduction and subsequent data presentation for a major geological investigation in the Middle East which included an 8,000-page final report.

- Field Geologist for the initial siting studies for a UPH-CAES plan in Maryland which included a deep drilling program.

- Writer of a geologic field manual for the 1620-MW Susitna hydroelectric project (winter investigation) for the Alaska Power Authority.

- Field Investigations Leader on a groundwater and subsurface soils investigation for a hydroelectric facility on the Saranac River for New York State Electric and Gas.

- Site Project Engineer for the construction of $1.5 million emergency stabilization toe berms and horizontal drains for a uranium tailings dam in Uravan, Colorado for Union Carbide Corporation.

- Site Project Engineer for the Terrapin Point rock removal and viewing area restoration project for the New York State Parks and Recreation Commission, Niagara Falls.

AFFILIATIONS

ASTM Member (Committee D-18)

Baker

Christopher D. Boes, P.G.

Senior Geologist

EDUCATION: University of Pittsburgh at Johnstown
B.S., Geology, 1979
University of Pittsburgh
Post Graduate Courses, Geology & Civil Engineering

REGISTRATION: Professional Geologist, Pennsylvania, 1994 - #699-G

EXPERIENCE:

General Qualifications

Mr. Boes is a Senior Geologist with over 14 years of experience. The majority of this experience has been related to hazardous waste site investigations and geotechnical projects involving foundation parameters for highway construction, multi-story structures and wastewater treatment facilities. Other projects have included landslide remediation and dam reconstructions.

Since joining Baker Environmental, Inc., Mr. Boes has been involved in the environmental characterization of various industrial sites along with evaluation and interpretation of hydrological test data from groundwater sampling events and investigations.

Environmental Site Assessments

- Mr. Boes is the Senior Geologist and Site Manger for the remedial investigation of a creosote contaminated site for the Pennsylvania Department of Environmental Resources (PADER) under the General Technical Assistance Contract (GTAC).

- Also for PADER under GTAC, Mr. Boes served as Project Geologist assisting in the design of a monitoring well network and aquifer pumping test and survey of soil gas in the vicinity of a dry cleaning business.

- Project Geologist for another PADER GTAC Program site where he assisted in preparing the Work Plan for a remedial investigation at the site of a former service station.

- Mr. Boes has served as both Project Manager and Project Geologist on several Phase I and II site investigations for a variety of properties and determined if potential liabilities existed due to past activities. Responsibilities included proposal preparation, project administration, field supervision, sample collection, data interpretation and report preparation.

- Project Geologist for a Phase I site investigation in Clairton, Pennsylvania for Duquesne Light Co. Responsibilities included subcontract preparation, site inspection of drilling and test pits, groundwater sampling, and interpretation of hydrogeological and contaminant migration data.

- Project Manager for a Phase I site investigation for Chambers Development, Corp. in Pittsburgh, Pennsylvania. Mr. Boes developed and implemented a field investigation program to sample a former foundry for volatile organic compounds and metals contamination. Mr. Boes prepared the final report which was submitted to the client.

- Project Manager for a Phase I and soil/groundwater assessments related to a former truck fleet operations facility and former underground storage tanks for International Paper, Erie, Pennsylvania. Project involved the use of soil gas survey methods and installation of groundwater monitoring wells.

- Project Geologist for a site investigation and remedial action feasibility study at 100-acre former refinery and asphalt plant facility owned by SOHIO Oil Company. Responsibilities included groundwater sampling, slug tests, groundwater contouring, hydrogeologic calculations and assessment of contaminants found in site soils and groundwater.

- Project Geologist for subsurface investigation at LTV Steel Company's Aliquippa, Pennsylvania plant, regarding ammonia contamination. Project included monitoring well installation and sampling, river sampling and performance of an aquifer pumping test.

- Project Geologist for preliminary assessment for potential residual landfill site for USS/Kobe Steel, Lorain, Ohio. Responsibilities included subcontract preparation, site activities, review of landfill regulations and preparation of report.

- Project Geologist for Phase I of a groundwater cleanup plan related to the feasibility study to close a former lagoon at U.S. Steel's, Clairton, Pennsylvania plant. Responsibilities included preparation of subcontracts, installation of 18 monitoring wells, preparation of report and interaction with the Pennsylvania Department of Environmental Resources (PADER).

RCRA Experience

- Project Geologist for environmental sampling and development of groundwater quality abatement and assessment plans under RCRA for two sites in Ohio for LTV Steel Company.

- Project Geologist for two sites in Pennsylvania and one site in Maryland for Bethlehem Steel Corp. Responsibilities included environmental sampling, development of groundwater quality abatement and assessment plans, analysis of active groundwater drawdown activities.

- Project Manager for ongoing RCRA Facility Investigation at Naval Station Roosevelt Roads, Puerto Rico. Project involved multiple sites within the station and included the sampling of surface soils, surface water/sediment and installation of monitoring wells.

CERCLA Experience

- Project Geologist at a Superfund site in Burlington County, New Jersey. Responsibilities included preparation of a Phase II work plan, subcontract specifications and technical presentations related to capped landfill.

- On-site Coordinator for a USEPA Superfund site in Cecil County, Maryland. The project related to the remedial design of an extraction and treatment system for contaminated groundwater at a former sand and gravel quarry. Responsibilities included subcontract preparation, installation of 12 monitoring wells, site clearing activities, groundwater sampling and performance of three aquifer pumping tests.

Navy CLEAN Program

- Project Geologist for Remedial Investigation at Naval Radio Transmission Facility in Driver, Virginia. Responsible for installation of monitoring wells and the drilling of soil borings. Also responsible for report preparation.

- Project Geologist for Site Investigations at Naval Weapons Station Yorktown, Virginia. Responsible for development and sampling of monitoring wells, sampling of surface and shallow soil samples, and performance of well hydraulic conductivity tests.

Geotechnical Experience

- Engineering Geologist for a project for Pennsylvania Department of Transportation (PADOT), District 11-0, I-279, Pittsburgh, Pennsylvania. Participated in design and stability of cut and fill slopes. Responsibilities included on-site coordination of up to seven drilling rigs, preparation of geologic cross sections and report preparation.

- Engineering Geologist for a 54-story office center for USS Realty, Pittsburgh, Pennsylvania. Responsible for the inspection of bulk blasting operations and determination of suitable foundation material.

- Engineering Geologist for mini subsidence events in Western Pennsylvania, West Virginia, Kentucky and Illinois for the Office of Surface Mining. Responsibilities included cost estimates, specification writing and on-site management.

- Engineering Geologist for reconstruction of failing earthen dam for the Hazelton, Pennsylvania Water Authority. Responsibilities included on-site inspection, materials verification and construction management.

- Engineering Geologist for industrial contractor at American Float Glass, Kingsport, Tennessee. Responsible for the inspection and materials verifications for the installation of approximately 130 auger-cast pilings.

Baker

Barbara J. Cummings, I.H.I.T.

Industrial Hygienist

EDUCATION: Indiana University of Pennsylvania
B.S., Environmental Health, minor in Safety Sciences, 1987

CERTIFICATION: Certified as an Industrial Hygienist in Training (IHIT) by the American Board of Industrial Hygiene (ABIH)

OSHA HAZWOPER Certified:
40-hour Training
8-hour Supervisory Training
8-hour Annual Refresher Training
Standard First Aid/Adult CPR Training

EXPERIENCE:

General Qualifications

Ms. Cummings has broad industrial hygiene, environmental compliance, and safety experience in the manufacturing and consulting environment. Prior to joining Baker Environmental, Inc., she was employed by a Fortune 100 Manufacturing Company as an Industrial Hygienist, and Health and Safety Supervisor. As an Industrial Hygienist and Health and Safety Supervisor she was responsible for an in-house asbestos maintenance program, all industrial hygiene, environmental and safety programs related to OSHA and RCRA compliance. She has also worked with several local communities in areas related to safety and the environment.

Ms. Cummings has attended seminars on hazardous waste site analysis, community right-to-know, spill response, incipient fire brigade training, indoor air quality, radiation safety, and an industrial hygiene comprehensive review course. She has completed 40-hour training and 8-hour supervisory training under OSHA Standard 29 CFR 1910.120 (HAZWOPER), is certified in Standard First Aid and Adult CPR, and has received training on the X-Ray fluorescanner (XRF) analyzer training. Since August of 1991, Ms. Cummings has worked under the Navy CLEAN Contract as a Project Health and Safety Officer providing safety, industrial hygiene, and field operation/field sampling services, and as a Risk Assessment specialist, conducting preliminary and baseline risk assessments for EE/CAs, PA/SIs, and RI/FSs.

Health and Safety Plan Development/Site Auditing

- Develop Health and Safety Plans (HASPs) under the Navy CLEAN Contract for Underground Storage Tank Operations, Site Inspections, Remedial Investigations, and other field programs that cover a wide variety of safety and industrial hygiene concerns such as: chemical safety (numerous volatile, semivolatile, pesticide/herbicide, and metal constituents); physical safety (heavy equipment operations, confined space entry, and heat stress); and environmental safety (hazardous flora and fauna).

- Provide field support for various RI field programs conducted in Virginia, North Carolina, and Puerto Rico, as a Site Health and Safety Officer, Field Team Leader, and Environmental Sampler.

- Conduct periodic review of Health and Safety Plans submitted by Baker's subcontractors under the CLEAN Program.

- Enhance the Medical Surveillance, Respiratory Protection, Hazard Communication and Training Programs within Baker.

- Perform site safety and health audits during remedial investigation activities.

- Provide extensive support in additional areas of the Navy CLEAN Contract, such as QA/QC of project plans, SOP development, safety program development, and risk assessment.

Industrial Hygiene/Risk Assessment

- Reevaluated and revised plant Respiratory Protection Program including selection and use of equipment, qualitative fit-testing, program compliance, and training.

- Conducted noise surveys to evaluate employee exposure to new/redesigned packaging lines and process equipment, and evaluated Hearing Conservation Program, in an effort to enforce noncompliance areas through education and training.

- Conducted heat stress monitoring to evaluate employee safety in hot-processing environments.

- Routinely monitored employee exposure to grain dust, phosphine gas, and laboratory solvents in addition to, conducting experimental "area" and "personal" air monitoring for the carcinogenic bacteria aflatoxin, found in stored grains.

- Compared capture velocities for laboratory hoods and LEV systems to evaluate OSHA and ANSI compliance.

- Conducted audiometric exams under the supervision of a certified audiometric technician.

- Completely revised plant Hazard Communication Program, including: rewriting the current program; developing a training video for plant employees; managing MSDS inventory to control chemical use; and implementing a plant-wide MSDS control program.

- Responded to employee complaints on a regular basis to ensure a positive approach to a safe and healthful work environment.

- Responsible for evaluating personal protective equipment uses, to determine applicability to work situations.

- Worked with management and supervision to develop a Job Safety Analysis for all facility job postings, and conducted departmental safety audits to evaluate OSHA compliance.

- Responsible for conducting accident investigations and making recommendations for preventing future accidents, while working with plant contractors to maintain safe work practices according to plant policy.
- Redesigned employee work stations, including training, to improve ergonomic design and reduce injury.
- Worked with plant safety committee to resolve employee concerns.

- Responsible for conducting an extensive air monitoring program that monitored ambient perimeter locations surrounding a coal tar waste remediation site with the results of these analyses being entered into a health risk assessment model designed specifically for the project. Air monitoring concerns included volatile organic compounds (VOCs), polynuclear aromatics (PNAs), and selected metals.

- Conducted several Baseline Risk Assessments and Risk Evaluations for sites under the Navy CLEAN contract, according to established EPA protocols and guidelines.

Asbestos Program Management

- Served as the program manager for an extensive in-house asbestos maintenance program, and directed trained employees in the removal and maintenance of asbestos.

- Served as project manager during large-scale abatement projects which included evaluating contractor bids, serving as an on-site industrial hygienist and assuring regulatory compliance. Remained "on-call" for emergency asbestos removal.

- Initiated the removal of asbestos-containing material (ACM) product inventory to reduce employee exposures.

- Conducted routine air monitoring to evaluate employee exposures and determine background levels plant-wide.

- Conducted extensive asbestos building inspections for public, private, and governmental organizations locally and abroad, that culminated in the development of project design specifications, work specifications, and overall program responsibilities.

- Worked with management personnel in developing the Department of Defense Dependents Schools' (DODDS) AHERA reinspection format.

- Served as the on-site industrial hygienist for several small- and large-scale asbestos abatement projects.

Environmental

- Responsible for submitting applications for permits to install (PTI) and permits to operate (PTO) to local and state agencies for dust collection equipment emitting particulate to the ambient environment.

- Responsible for SARA Title III compliance at a manufacturing facility and the submittal of annual reports.

- Supervised the removal of hazardous waste, i.e., PCBs, ignitable solvent wastes and mercury capacitors.
- Assisted in the development of a manufacturing facilities SPCC plan.

- Revised/reevaluated NPDES permit to submit for renewal to the state agency.

- Served as the "contact person" at a manufacturing facility for all environmental concerns.

Training

- Conducted a variety of training for labor and management personnel in the areas of:

  -- Asbestos Management Program
  -- Respiratory Protection
  -- Pesticide Application
  -- Hearing Conservation
  -- Safety Orientation
  -- Job Safety Analysis Development
  -- Accident Investigation
  -- Hazard Communication

- Conducted training sessions in multiple manufacturing facilities as a means of educating concerned personnel on a broad-range of asbestos issues.

- Developed and implemented a hazard communication training video directed towards employees at a specific plant location.

PROFESSIONAL AFFILIATIONS:

American Industrial Hygiene Association

APPENDIX B
STANDARD OPERATING PROCEDURES

SOP F101
Borehole and Sample Logging

BOREHOLE AND SAMPLE LOGGING
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BOREHOLE AND SAMPLE LOGGING

1.0 PURPOSE

This SOP provides general reference information and technical guidance on borehole and sample logging. Borehole logs provide information that is used in the determination of geological conditions, assessment of contaminant distribution, and the evaluation of remedial actions.

2.0 SCOPE

This SOP provides descriptions of the standard techniques for borehole and sample logging. These techniques shall be used to provide consistent descriptions of subsurface lithology for each boring that is logged. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer may develop adequate classifications through careful, thorough observation and consistent application of the classification procedure.

3.0 DEFINITIONS

Soil classifications and terms are given in Sections 5.2 and 5.3. Rock classification and terms are presented in Section 5.4.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that field personnel responsible for borehole logging are familiar with these procedures. It also is the responsibility of the Project Manager to ensure that the appropriate documents (e.g., test boring logs, field logbooks, etc.) have been correctly and completely filled out by the drilling inspector.

Field Team Leader - The Field Team Leader is responsible for the overall supervision of the drilling and boring activities, and for ensuring that each borehole is completely logged by the responsible drilling inspector. The Field Team Leader also is responsible for ensuring that all drilling inspectors have been briefed on these procedures.

Drilling Inspector - The drilling inspector (site geologist) is responsible for the direct supervision of boring and sampling activities. It is the Drilling Inspector's responsibility to log each boring, document subsurface conditions, complete the appropriate forms, and direct the drilling crew (or drilling supervisor).

5.0 PROCEDURES

The classification of soil and rock is one of the most important jobs of a drilling inspector or site geologist. It is imperative that the drilling inspector understand and accurately use the field classification system described in this SOP to maintain a consistent flow of information. This identification is based on both visual examination and manual tests. The results of the boring activities, including soil and rock classifications, shall be recorded on a Field Test Boring Record (see Figure 1) or the field notebook.

5.1 Test Boring Record

Each boring shall be fully described in a Field Test Boring Record (Figure 1). The drilling inspector shall log the boring, as it is being drilled, by recording relevant data on the Boring Record. It may be more appropriate to record the boring information in a bound field log book in cases where the information will not easily fit on the boring record. Field Test Boring Records may then be transcribed from the field log book, but must be completed at a minimum, on a weekly basis. The Field Test Boring Records must be completely filled out and signed prior to demobilization from the field activity. Field Test Boring Records must also be legible. Completed Field Test Boring Records shall be converted to report format using a Test Boring Record. An example of a completed Test Boring Record is provided in Attachment A.

The data which is to be included on the Boring Records, when applicable is listed below.

1. Project name, location, and Contract Task Order Number.
2. Date(s).
3. Identifying number and location of each boring.
4. If required, soil classifications and associated depths in accordance with the Unified Soil Classification System (see Section 5.2 and Attachment B). These classifications will be noted in the field by the drilling inspector and revised, if necessary, based on

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TEST BORING RECORD

PROJECT: _____
S.O. NO.: _____ BORING NO.: _____
COORDINATES: EAST: _____ NORTH: _____
ELEVATION: SURFACE: _____ TOP OF PVC CASING: _____

RIG:									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)									
LENGTH									
TYPE									
HAMMER WT.									
FALL									
STICK UP									

REMARKS:

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	Lab. Class. or Pen. Rate	PID (ppm)	Visual Description	Elevation
1							
2							
3							
4							
5							
6							
7							
8							
9							
10						Match to Sheet 2	

DRILLING CO.: _____ BAKER REP.: _____
DRILLER: _____ BORING NO.: _____ SHEET 1 OF 2

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Baker Environmental, Inc.

TEST BORING RECORD

PROJECT: _____

S.O. NO.: _____ BORING NO.: _____

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	Lab. Class. or Pen. Rate	PID (ppm)	Visual Description	Elevation
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
0							

DRILLING CO.: _____ BAKER REP.: _____

DRILLER: _____ BORING NO.: _____ SHEET 2 OF 2

laboratory analysis and review. Both field determined USCS soil classification and a soil description shall be included on the log.

5. Depth limits, and the type and number of samples taken.

6. The number of blows required for each six-inch penetration of a split-spoon sampler and for each 12-inch penetration of casing. The percentage of sample recovered, hammer weight, fall length, and hydraulic pressures to push thin-walled tubes.

7. Depth to water as first encountered during drilling operations, along with the method of determination. Any distinct water bearing zones shall also be delineated.

8. Loss of drilling fluid and the interval over which loss occurred.

9. Identification of equipment used, including type of drilling rig, auger types and sizes, etc.

10. Start date and completion dates for the boring.

11. Name of the drilling company and the driller.

12. Size and length of the casing used in each hole.

13. Observations of visual contamination.

14. Field instrument readings (i.e., photoionization detector, organic vapor analyzer).

As the boring is advanced, the inspector shall evaluate the samples and the cuttings to determine the location of each stratigraphic unit. The descriptions should contain color, grain-size, consistency moisture, etc., in addition to the USCS classification category (Section 5.3.7).

Each sample collected for chemical or geotechnical analysis shall be handled as described in SOP #F102.

5.2 Soil Classification

The data shall be recorded on a Field Test Boring Record, or in a field logbook. The method of deriving the classification should be described, or reference made to this SOP or other applicable manuals. Both the soil classification and the soil descriptions must be entered on the Field Test Boring Record. If required, the soil classification shall consist of the two-letter USCS classification; the soil description shall be much more detailed.

Where required, soils will be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Attachment B and identifies soil types on the basis of grain-size and liquid limits, and categorizes them through the use of two letters. Although some laboratory testing is required for full USCS classification, preliminary classifications may be made in the field.

Fine-grained soils are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition; peat is designated by "Pt." Coarse-grained soils are divided into sand (S) or gravel (G). The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

The second letter of the two-letter USCS symbol provides information about the grain size distribution of granular soil, or the plasticity characteristics of fine-grained soils. These second letter modifiers are (P) poorly graded/well sorted, (W) well graded/poorly sorted, (C) clayey, (M) silty, (L) low plasticity, or (H) high plasticity.

5.3 Soil Descriptions

The Test Boring Records shall contain complete soil descriptions in addition to the two-letter USCS classification, if required. Soil descriptions include the following components: grain size identification with descriptive terms indicating the relative percentage of each grain size, color, consistency or relative density, moisture content, organic content, plasticity, and other pertinent observations such as visual contamination, HNu measurements, etc. A summary of the soil description components is given in Attachment C.

5.3.1 Grain Size Identification

In nature, soils are comprised of varying size, shape, and combinations of the various grain types. The following terms are used to indicate soil grain size:

Size	Size Limits
Cobbles	3-inches to 12-inches
Coarse gravel	3/4-inches to 3-inches
Fine gravel	4.76 mm (# 4 sieve size) to 3/4-inches
Coarse sand	2 mm (# 10 sieve size) to 4.76 mm
Medium sand	0.42 mm (# 40 sieve size) to 2 mm
Fine sand	0.074 mm (# 200 sieve size) to 0.42 mm
Silt	0.002 mm to 0.074 mm
Clay	less than 0.002 mm

The proportion of each grain size (by weight percent) is indicated using the descriptive terms:

Trace	0 to 10 percent
Little	10 to 20 percent
Some	20 to 35 percent
And (or an adjective form of the grain size, i.e., sandy, silty, clayey)	35 to 50 percent

Some examples of soil grain size descriptions are:

- Silty fine sand: 50 to 65 percent fine sand and 35 to 50 percent silt.
- Medium to coarse sand, some silt: 65 to 90 percent medium to coarse sand, 20 to 35 percent silt.
- Fine sandy silt, trace clay: 50 to 65 percent silt, 35 to 50 percent fine sand, and 0 to 10 percent clay.

The soil type may be classified as noncohesive, granular soils or as cohesive, fine-grained soils as discussed in Section 5.3.3. The grain shape of a soil usually does not need to be determined unless unusual or unique features are readily apparent.

5.3.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light-gray" or "blue-gray". Since color can be utilized in correlating units

between sampling locations, it is important for color descriptions to be consistent between borings.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors because sampling devices tend to smear the sample surface creating color variations between interior and exterior.

The term "mottled" shall be used to indicate soil irregularly marked with spots of different colors. Soil color charts shall not be used unless specified by the Project Manager.

5.3.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the drilling inspector first shall identify the soil type. Granular soils contain predominantly sands and gravels. These types of soil are noncohesive (particles do not adhere well when compressed). Conversely, fine-grained soils which contain predominantly silts and clays are cohesive (particles will adhere when compressed).

The density of noncohesive, granular soils or the consistency of cohesive soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to ASTM D-1586. Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a two-inch outside diameter 12-inches into the material using a 140-pound hammer falling freely through 30-inches. In cases were geotechnical information is required, the standard penetration test is performed by driving the sampler through an 18-inch sample interval, the number of blows will then be recorded for each six-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of the sample interval. It is important to note that if gravel and rock fragments are broken by the sampler, or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This must be noted on the Field Test Boring Record and referenced to the sample number. In cases where soil sampling for environmental analytical analysis is required, 24-inch spoon barrels can be used in order to obtain a sufficient quantity of sample for required analysis. Accordingly, the second and third six-inch increments will be used to calculate the relative density.

The relative density designations for noncohesive soils are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	Less than 4
Loose	4 to 10
Medium dense	10 to 30
Dense	30 to 50
Very dense	Greater than 50

The consistency of cohesive soils is also determined by blow counts as shown:

Designation	Standard Penetration Resistance (Blows per Foot)
Very Soft	Less than 2
Soft	2 to 4
Medium Stiff	4 to 8
Stiff	8 to 15
Very Stiff	15 to 30
Hard	Over 30

5.3.4 Moisture Content

Moisture content is estimated in the field according to four categories: dry, damp, moist, and wet:

Designation	Moisture Content	Descriptive
Dry	0 to 10 percent	Little/no perceptible moisture
Damp	10 to 20 percent	Some perceptible moisture - not compactable
Moist	20 to 35 percent	Compactable
Wet	35 to 50 percent	Above compactable range

Little or no water should appear in dry soil. Wet soils appear to contain all the water they can possibly hold (i.e., saturated). Damp and moist are subjective. Laboratory tests for water content shall be performed if the natural water content is important.

5.3.5 Stratification

Stratification can only be determined after the split-barrel sampler is opened. Typically, bedding thicknesses are described as follows:

Designation	Bedding Spacing
Indistinct	No bedding apparent
Laminated	Less than 1/2-inch
Very thin	1/2-inch to 1-inch
Thin	1-inch to 4-inches
Medium	4-inches to 1-foot
Thick	1-foot to 3-feet
Massive	Greater than three feet

5.3.6 Texture/Fabric/Bedding

The texture/fabric/bedding of a soil shall be described, where appropriate. Texture is described as the relative angularity of the soil particles: rounded, subrounded, subangular, angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation or orientation. The bedding structure also shall be noted (e.g., stratified, lensatic, nonstratified, heterogeneous varved, etc.).

5.3.7 Summary of Soil Descriptions

In summary, soils shall be classified in a similar manner by each drilling inspector. The soil description shall include:

- Soil grain size with appropriate descriptors
- Color
- Relative density and/or consistency
- Moisture content
- Stratification
- Texture/fabric/bedding
- Other distinguishing features

These descriptors are evaluated and the soil classified according the USCS system. All information, measurements and observations shall be legibly recorded on a Field Test Boring Record.

5.4 Sedimentary Rock Classifications

Rocks are grouped into three main divisions: sedimentary, igneous, and metamorphic. Sedimentary rocks are the most predominant type exposed at the earth's surface. As such, this section will consider only classification of sedimentary rocks. Standard geologic references should be used for the complete classification of sedimentary, igneous and metamorphic rocks.

For the purpose of completing the Field Test Boring Record in the field, sedimentary rocks should be classified using the following hierarchy:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Rock Quality Designation
- Weathering
- Other characteristics

5.4.1 Rock Type

There are numerous names for sedimentary rocks such as sandstone, shale, siltstone, claystone, conglomerate, limestone, dolomite, coal, etc. The drilling inspector should select the most appropriate rock type based on experience. Some of the references listed in Section 7.0 provide a more complete discussion of sedimentary rock types.

In addition to selecting a rock type, the drilling inspector should record the grain size (and composition of grains and cement, if apparent) on the Field Test Boring Record. The following designation should be used to describe grain size in sedimentary rocks:

Designation	Grain Size Diameter
Cobbles	Greater than 64 mm (2.5-inches)
Pebbles	4 mm (0.16-inches) to 64 mm
Granules	2 mm (0.08-inches) to 4mm
Very Coarse Sand	1 mm to 2 mm
Coarse Sand	0.5 mm to 1 mm
Medium Sand	0.25 mm to 0.5 mm
Fine Sand	0.125 mm to 0.25 mm
Very Fine Sand	0.0625 mm to 0.125 mm
Silt	0.0039 mm to 0.0625 mm
Clay	Smaller than 0.0039 mm

For individual boundaries of grain size, a scale can be used for coarse-grained rocks. However, the division between silt and clay likely will not be measurable in the field. This boundary shall be determined by use of a hand lens. If the grains cannot be seen with the unaided eye, but are distinguishable with a hand lens (5x magnification) the grain size is silt. If the grains are not distinguishable with a hand lens, the grain size is clay.

5.4.2 Color

The color of rock can be determined in a manner similar to that for soil samples. Rock cores or fragments shall be classified while wet, when possible. Rock color charts shall not be used unless specified by the Project Manager.

5.4.3 Bedding Thickness

The bedding thickness designation for soils (Section 5.3.5) shall also be used for rock descriptions.

5.4.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness follows:

- Very Soft - Very soft indicates that the rock is easily gouged by a knife, easily scratched by a fingernail, and/or easily broken by hand
- Soft - Soft indicates that the rock may be gouged by a knife, scratched by a fingernail, difficult to break by hand, and/or powders when hit by a hammer.
- Medium Hard - Medium hard indicates that the rock is easily scratched by a knife and/or is easily broken when hit by a hammer.
- Hard - Hard indicates that the rock is difficult to scratch with a knife but may be broken with a hammer.
- Very Hard - Very hard indicates that the rock is difficult to break with a hammer.

Note the difference in usage between the words "scratch" and "gouge". A scratch shall be considered a slight depression in the rock while a gouge is much deeper.

5.4.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is measured and is described by the following terms:

- Very Broken - Less than a two-inch spacing between fractures
- Broken - A two-inch to one-foot spacing between fractures
- Blocky - A one-foot to three-foot spacing between fractures
- Massive - A three-foot to ten-foot spacing between fractures

5.4.6 Rock Quality Designation

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding four inches and dividing by the total length of core run:

$$RQD\ (\%) = r/l \times 100$$

Where:

r = Total length of all pieces of the lithologic unit being measured, which are greater than four inches, and have resulted from natural breaks. Natural breaks include slickenslides, joints, compaction slicks, bedding plane partings (not caused by drilling) friable zones, etc.

l = Total length of core run.

The results of the RQD calculations shall be recorded on the Field Test Boring Record.

5.4.7 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and also is useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Decomposed - Soft to very soft, bedding and fractures indistinct, no cementation.

- Highly weathered - very soft to soft, with medium hard relic rock fragments, little to moderate cementation. Vugs and openings in bedding and fracture planes, some of which may be filled.

- Weathered - Soft to medium hard. Good cementation, bedding and fractures are pronounced. Uniformly stained.

- Slightly weathered - Medium hard. Fractures pronounced, nonuniform staining, bedding distinct.

- Fresh - Medium hard to hard. No staining. Fractures may be present, bedding may or may not be distinct.

5.4.8 Other Characteristics

The following items should be included in rock description, where applicable:

- Description of contacts between rock units (sharp or gradational)
- Stratification
- Description of any filled cavities
- Cementation (calcareous, siliceous, hematitic, etc.)
- Description of joints and open fractures (with strike and dip, if possible)
- Observation of the presence of fossils

5.4.9 Additional Terms

The following terms also are used to further identify rocks:

- Seam - thin (12-inches or less), probably continuous layer.

- Some - Indicates significant (15 to 40 percent) amounts of an accessory material.

- Few - Indicates insignificant (0 to 15 percent) amounts of an accessory material.

- Interbedded - Indicates thin or very thin alternating seams of material occurring in approximately equal amounts.

- Interlayered - Indicates thick alternating seams of material occurring in approximately equal amounts.

6.0 QUALITY ASSURANCE RECORDS

Quality Assurance Records shall consist of completed Field Test Boring Records and Test Boring Records.

7.0 REFERENCES

1. American Society for Testing and Materials, 1990. Standard Methods for Classification of Soils for Engineering Purposes. ASTM Method D2487-90, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

2. American Society for Testing and Materials, 1990. Standard Practice for Description and Identification of Soils (Visual - Manual Procedure). ASTM Method D2488-90, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

SOP F102
Soil and Rock Sample Acquisition

SOIL AND ROCK SAMPLE ACQUISITION
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SOIL AND ROCK SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this procedure is to describe the handling of rock cores and subsurface soil samples collected during drilling operations. Surface soil sampling also is described.

2.0 SCOPE

The methods described in this SOP are applicable for the recovery of subsurface soil and rock samples acquired by coring operations or soil sampling techniques such as split-barrel sampling and thin-walled tube sampling. Procedures for the collection of surface soil samples also are discussed. This SOP does not discuss drilling techniques or well installation procedures. ASTM procedures for "Penetration Test and Split-Barrel Sampling of Soils," "Thin-Walled Tube Sampling of Soils," and "Diamond Core Drilling for Site Investigation" have been included as Attachments A through C, respectively.

3.0 DEFINITIONS

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outer diameter (O.D.) and 18 to 54 inches length. A stationary piston device is included in the sampler to reduce sample disturbance and increase recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into unconsolidated materials using a drive weight mounted on the drilling string. A standard split-spoon sampler (used for performing Standard Penetration Tests) is two inches O.D. and 1-3/8-inches inner diameter (I.D.). This standard spoon is available in two common lengths providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively.

Grab Sample - An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes. Grab samples are associated with surface water,

groundwater, wastewater, waste, contaminated surfaces, soil, and sediment sampling. Grab samples are typically used to characterize the media at a particular instant in time.

Composite Samples - A sample collected over time that typically consists of a series of discrete samples which are combined or "composited". Two types of composite samples are listed below:

- Areal Composite: A sample collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from grid points.

- Vertical Composite: A sample collected from individual grab samples collected from a vertical cross section. Vertical composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes and estuaries.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that, where applicable, project-specific plans are in accordance with these procedures, or that other approved procedures are developed. Furthermore, the Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Drilling Inspector - It is the responsibility of the drilling inspector to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The Drilling Inspector is responsible for the proper acquisition of rock cores and subsurface soil samples.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of samples.

5.0 PROCEDURES

Subsurface soil and rock samples are used to characterize the three-dimensional subsurface stratigraphy. This characterization can indicate the potential for migration of contaminants from various sites. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of subsurface soil samples. Where the remedial activities may include in-situ treatment, or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Surface soil samples serve to characterize the extent of surface contamination at various sites. These samples may be collected during initial site screening to determine gross contamination levels and levels of personal protection required as part of more intensive field sampling activities, to gather more detailed site data during design, or to determine the need for, or success of, cleanup actions.

Site construction activities may require that the engineering and physical properties of soil and rock be determined. Soil types, bearing strength, compressibility, permeability, plasticity, and moisture content are some of the geotechnical characteristics that may be determined by laboratory tests of soil samples. Rock quality, strength, stratigraphy, structure, etc. often are needed to design and construct deep foundations or remedial components.

5.1 Subsurface Soil Samples

This section discusses three methods for collecting subsurface soil samples: (1) split-spoon sampling; (2) shelby tube sampling; and, (3) bucket auger sampling. All three methods yield samples suitable for laboratory analysis. Copies of the ASTM procedures for split-spoon sampling and shelby-tube sampling are provided in Attachments A and B, respectively.

5.1.1 Split-Barrel (Split-Spoon) Sampling

The following procedures are to be used for split-spoon, geotechnical soil sampling:

1. Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation.

2. Side-discharge bits are permissible. A bottom-discharge bit should not be used. The process of jetting through the sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

3. The two-inch O.D. split-barrel (not for geotech) sampler should be driven with blows from a 140-pound hammer falling 30 inches in accordance with ASTM D1586-84, Standard Penetration Test.

4. Repeat this operation at intervals not longer than 5 feet in homogeneous strata, or as specified in the Sampling and Analysis Plan.

5. Record on the Field Test Boring Record or field logbook the number of blows required to effect each six inches of penetration or fraction thereof. The first six inches is considered to be a seating drive. The sum of the number of blows required for the second and third six inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last one foot of penetration. (If less than one foot is penetrated, the logs shall state the number of blows and the fraction of one foot penetrated.) In cases where samples are driven 24 inches, the sum of second and third six-inch increments will be used to calculate the penetration resistance. (Refusal of the SPT will be noted as 50 blows over an interval equal to or less than 6 inches; the interval driven will be noted with the blow count.)

6. Bring the sampler to the surface and remove both ends and one half of the split-spoon such that the soil recovered rests in the remaining half of the barrel. Describe carefully the recovery (length), composition, structure, consistency, color, condition, etc. of the recovered soil according to SOP F101; then put into jars without ramming. Jars with samples not taken for chemical analysis should be tightly closed, to prevent evaporation of the soil moisture. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms (see SOP F302). Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area.

In addition to collecting soils for geotechnical purposes, split-spoon sampling can be employed to obtain samples for environmental analytical analysis. The following procedures are to be used for split-spoon, environmental soil sampling:

1. Follow sample collection procedures 1 through 6 as outlined in Section 5.2.1.

2. After sample collection, remove the soil from the split-spoon sampler. Prior to filling laboratory containers, the soil sample should be mixed thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. Soil samples for volatile organic compounds should not be mixed. Further, sample containers for volatile organic compounds analyses should be filled completely without head space remaining in the container to minimize volatilization.

3. Record all pertinent sampling information such as soil description, sample depth, sample number, sample location, and time of sample collection in the Field Test Boring Record or field logbook. In addition, label, tag, and number the sample bottle(s).

4. Pack the samples for shipping (see SOP F300). Attach seal to the shipping package. Make sure that Chain-of-Custody Forms and Sample Request Forms are properly filled out and enclosed or attached (see SOP F301).

5. Decontaminate the split-spoon sample as described in SOP F501. Replace disposable latex gloves between sample stations to prevent cross-contaminating samples.

For obtaining composite soil samples (see Definitions), a slightly modified approach is employed. Each individual discrete soil sample from the desired sample interval will be placed into a stainless-steel, decontaminated bowl (or other appropriate container) prior to filling the laboratory sample containers. Special care should be taken to cover the bowl between samples with aluminum foil to minimize volatilization. Immediately after obtaining soils from the desired sampling interval, the sample to be analyzed for Volatile Organic Compounds (VOCs) should be collected. In the event that a composite sample is required, care should be taken to obtain a representative sampling of each sample interval. The remaining soils should be thoroughly mixed. Adequate mixing can be achieved by stirring in a circular fashion and occasionally turning the soils over. Once the remaining soils have been thoroughly combined, samples for analyses other than VOCs should be placed into the appropriate sampling containers.

5.1.2 Thin-Wall (Shelby Tube) Sampling

When it is desired to take undisturbed samples of soil for physical laboratory testing, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method applies:

1. Clean out the hole to the sampling elevation, being careful to minimize the chance for disturbance or contamination of the material to be sampled.

2. The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

3. The sampler must be of a stationary piston-type, to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

4. With the sampling tube resting on the bottom of the hole and the water level in the boring at the natural groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed further than the length provided for the soil sample. Allow a free space in the tube for cuttings and sludge.

5. After pushing the tube, the sample should sit 5 to 15 minutes prior to removal. Immediately before removal, the sample must be sheared by rotating the rods with a pipe wrench a minimum of two revolutions.

6. Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil, from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape them into place and then dip the ends in wax to seal them.

7. Affix labels to the tubes and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and indicate the top of the sample. Complete chain-of-custody and other required forms (see SOP F302). Do not allow tubes to freeze, and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

8. From soil removed from the ends of the tube, make a careful description using the methods presented in SOP F101.

9. When thin-wall tube samplers are used to collect soil for certain chemical analyses, it may be necessary to avoid using wax, newspaper, or other fillers. The SAP for each site should address specific materials allowed dependent on analytes being tested.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dension or Pitcher cores can be used in conjunction with the tube samplers to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and, therefore, their use should be weighed against the increased cost and the need for an

undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt should be made with a split-spoon sampler at the same depth so that at least one sample can be obtained for classification purposes.

5.1.3 Bucket (Hand) Auger Sampling

Hand augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required.

When a vertical sampling interval has been established, one auger bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a decontaminated bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole. The bucket auger should be decontaminated between samples as outlined in SOP F502.

In addition to hand augering, powered augers can be used to advance a boring for subsurface soil collection. However, this type of equipment is technically a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range for this equipment. It is used to advance a hole to the required sample depth, at which point a hand auger is usually used to collect the sample.

5.2 Surface Soil Samples

Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. For loosely packed surface soils, stainless steel (organic analyses) or plastic (inorganic analyses) scoops or trowels, can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

1. Use a soil auger for deep samples (greater than 12 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collecting the sample.

2. Immediately transfer the sample to the appropriate sample container. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, chain-of-custody record, and other required forms.

3. Classify and record a description of the sample, as discussed in SOP F101. Descriptions for surface soil samples should be recorded in the field logbook; descriptions for soil samples collected with power or hand augers shall be recorded on a Field Test Boring Record.

4. Store the sampling utensil in a plastic bag until decontamination or disposal. Use a new or freshly-decontaminated sampling utensil for each sample taken.

5. Pack and ship as described in SOP F304.

6. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site or on a sketch in the field logbook.

7. When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles should be full) should be placed in a stainless steel bucket (or other appropriate container), mixed thoroughly using a decontaminated stainless steel spatula or trowel, and a composite sample collected. In some cases, as delineated in project-specific sampling and analysis plans, laboratory compositing of the samples may be more appropriate than field compositing. Samples to be analyzed for parameters sensitive to volatilization should be composited and placed into the appropriate sample bottles immediately upon collection.

5.3 Rock Cores

Once rock coring has been completed and the core recovered, the rock core must be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery, as well as the rock quality designation (RQD) (see SOP F101). If split-barrels are used, the core may be measured and classified in the split barrel after opening and then transferred to a core box.

Each core shall be described and classified on a Field Test Boring Record using a uniform system as presented in SOP F101. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of hydrated formations) or oxidation of the core, the core must be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores must be placed in the sequence of recovery in wooden or plastic core boxes provided by the drilling contractor. Rock cores from different borings shall not be placed in the same core box. The core boxes should be constructed to accommodate 10 to 20 linear feet of core and should be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and the run number shall be marked on the wooden partitions with indelible ink. The order of placing cores shall be the same in all core boxes. The top of each core obtained should be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, any empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data pertaining to the box's contents. At a minimum, the following information must be included:

- Project name
- Date
- CTO number
- Boring number

- Footage (depths)
- Run number(s)
- Recovery
- Rock Quality Designation (RQD)
- Box number (x of x)

It is also useful to draw a large diagram of the core in the box, on the inside of the box top. This provides more room for elevations, run numbers, recoveries, comments, etc., than could be entered on the upper edges of partitions or spaces in the core box.

For easy retrieval when core boxes are stacked, the sides and ends of the box should also be labeled and include CTO number, boring number, top and bottom depths of core and box number.

Due to the weight of the core, a filled core box should always be handled by two people. Core boxes stored on site should be protected from the weather. The core boxes should be removed from the site in a careful manner as soon as possible. Exposure to extreme heat or cold should be avoided whenever possible. Arrangements should be made to dispose of or return the core samples to the client for completion of the project.

6.0 QUALITY ASSURANCE RECORDS

Where applicable, Field Test Boring Records and Test Boring Records will serve as the quality assurance records for subsurface soil samples, rock cores and near surface soil samples collected with a hand or power auger. Observations shall be recorded in the Field Logbook as described in SOP F303. Chain-of-Custody records shall be completed for samples collected for laboratory analysis as described in SOP F101 and SOP F302.

7.0 REFERENCES

1. American Society for Testing and Materials, 1987. Standard Method for Penetration Test and Split-Barrel Sampling of Soils. ASTM Method D1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

2. American Society for Testing and Materials, 1987. Standard Practice for Thin-Walled

Tube Sampling of Soils. Method D1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

3. American Society for Testing and Materials, 1987. Standard Practice for Diamond Core Drilling for Site Investigation. Method D2113-83 (1987), Annual Book of Standards ASTM, Philadelphia, Pennsylvania.

4. U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

ATTACHMENT A

ASTM D1586-84
STANDARD METHOD FOR PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS

Designation: D 1586 - 84 (Reapproved 1992)$^{\epsilon 1}$

Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DOD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

$^{\epsilon 1}$NOTE—Editorial changes were made throughout October 1992.

1. Scope

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4633 Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems[2]

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard*

3.1.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.1.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.1.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.1.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.1.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.1.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.9 ΔN—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.1.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.1.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.1.12 *SPT*—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

4. Significance and Use

4.1 This test method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Sept. 11, 1984. Published November 1984. Originally published as D 1586 - 58 T. Last previous edition D 1586 - 67 (1974).

[2] *Annual Book of ASTM Standards*, Vol 04.08.

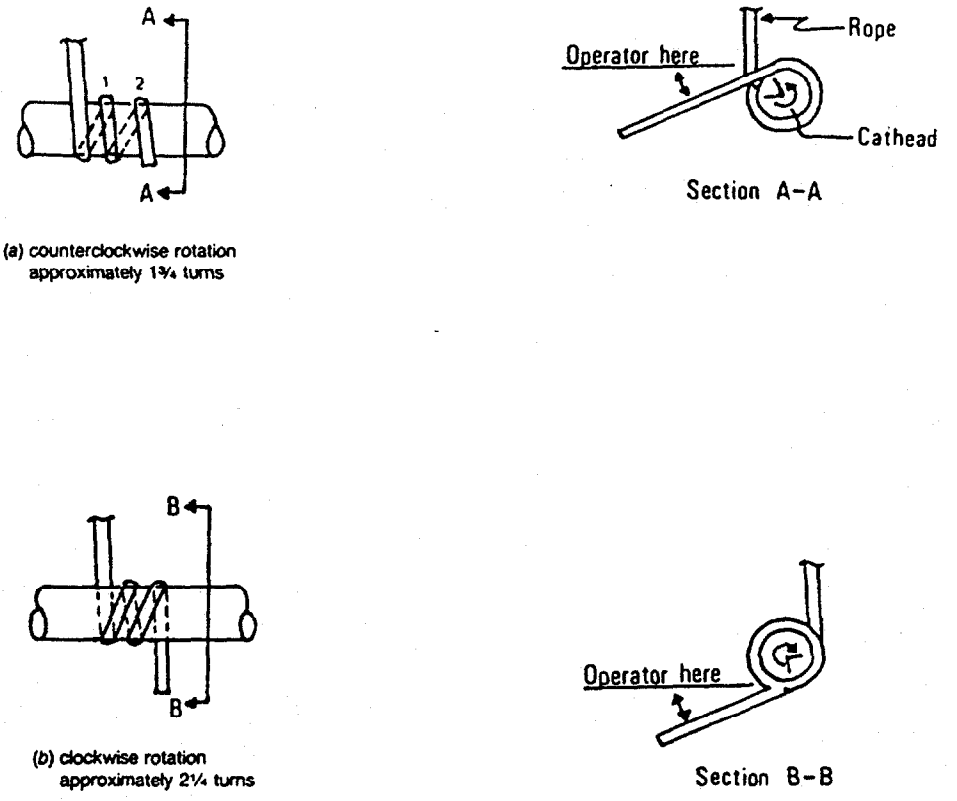


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

NOTE 1—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

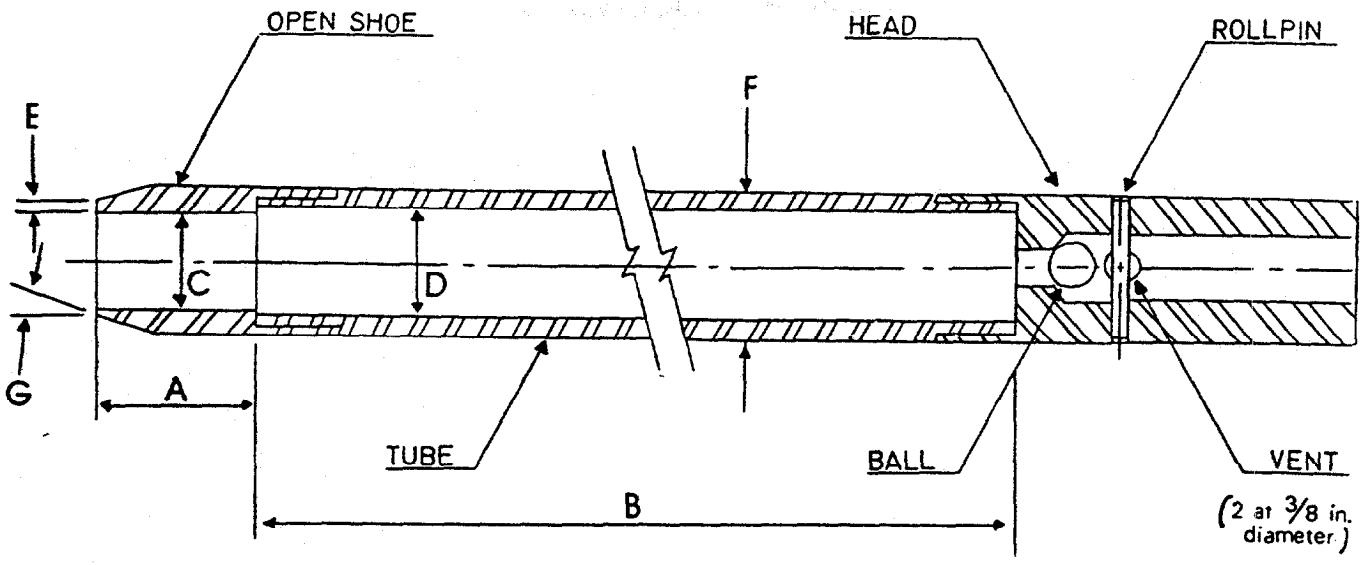
NOTE 2—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 − 0.00 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 − 0.00 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

FIG. 2 Split-Barrel Sampler

the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-

kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb (63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,

8.1.2 Names of crew,

8.1.3 Type and make of drilling machine,

8.1.4 Weather conditions,

8.1.5 Date and time of start and finish of boring,

8.1.6 Boring number and location (station and coordinates, if available and applicable),

8.1.7 Surface elevation, if available,

8.1.8 Method of advancing and cleaning the boring,

8.1.9 Method of keeping boring open,

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.1.11 Location of strata changes,

8.1.12 Size of casing, depth of cased portion of boring,

8.1.13 Equipment and method of driving sampler,

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,

8.2.2 Description of soil,

8.2.3 Strata changes within sample,

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 *Precision*—A valid estimate of test precision has not been determined because it is too costly to conduct the necessary inter-laboratory (field) tests. Subcommittee D18.02 welcomes proposals to allow development of a valid precision statement.

9.2 *Bias*—Because there is no reference material for this test method, there can be no bias statement.

9.3 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.4 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.5 The variability in N-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting N on the basis of comparative energies. A method for energy measurement and N-value adjustment is given in Test Method D 4633.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; split-barrel sampling; standard penetration test

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

ATTACHMENT B

ASTM D1587-83

STANDARD PRACTICE FOR THIN-WALLED TUBE SAMPLING OF SOILS

Designation: D 1587 - 83

Standard Practice for Thin-Walled Tube Sampling of Soils[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This practice has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of structural properties. Thin-walled tubes used in piston, plug, or rotary-type samplers, such as the Denison or Pitcher, must comply with the portions of this practice which describe the thin-walled tubes (5.3).

NOTE 1—This practice does not apply to liners used within the above samplers.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Summary of Practice

3.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil, removing the soil-filled tube, and sealing the ends to prevent the soil from being disturbed or losing moisture.

4. Significance and Use

4.1 This practice, or Practice D 3550, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of structural properties or other tests that might be influenced by soil disturbance.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole; that does not disturb the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

5.2 *Sampler Insertion Equipment,* shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

5.3 *Thin-Walled Tubes,* should be manufactured as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. and be made of metal having adequate strength for use in the soil and formation intended. Tubes shall be clean and free of all surface irregularities including projecting weld seams.

5.3.1 *Length of Tubes*—See Table 1 and 6.4.

5.3.2 *Tolerances,* shall be within the limits shown in Table 2.

5.3.3 *Inside Clearance Ratio,* should be 1 % or as specified by the engineer or geologist for the soil and formation to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled. See Fig. 1 for definition of inside clearance ratio.

5.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating. Tubes which will contain samples for more than 72 h shall be coated. The type of coating to be used may vary depending upon the material to be sampled. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, and others. Type of coating must be specified by the engineer or geologist if storage will exceed 72 h. Plating of the tubes or alternate base metals may be specified by the engineer or geologist.

5.4 *Sampler Head,* serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a suitable check valve and a venting area to the outside equal to or greater than the area through the check valve. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

6. Procedure

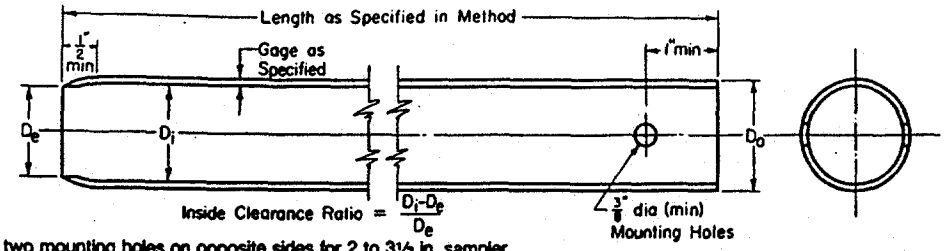
6.1 Clean out the borehole to sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the sampling operation.

6.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or hollow stem auger as carefully as

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Aug. 17, 1983. Published October 1983. Originally published as D 1587 - 58 T. Last previous edition D 1587 - 74.

[2] *Annual Book of ASTM Standards,* Vol 04.08.



NOTE 1—Minimum of two mounting holes on opposite sides for 2 to 3½ in. sampler.
NOTE 2—Minimum of four mounting holes spaced at 90° for samplers 4 in. and larger.
NOTE 3—Tube held with hardened screws.
NOTE 4—Two-inch outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalents

in.	mm
⅜	6.77
½	12.7
1	25.4
2	50.8
3½	88.9
4	101.6

FIG. 1 Thin-Walled Tube for Sampling

TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter:			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Clearance ratio, %	1	1	1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

	Nominal Tube Diameters from Table 1[A] Tolerances, in.		
Size Outside Diameter	2	3	5
Outside diameter	+0.007 −0.000	+0.010 −0.000	+0.015 −0.000
Inside diameter	+0.000 −0.007	+0.000 −0.010	+0.000 −0.015
Wall thickness	±0.007	±0.010	±0.015
Ovality	0.015	0.020	0.030
Straightness	0.030/ft	0.030/ft	0.030/ft

[A] Intermediate or larger diameters should be proportional. Tolerances shown are essentially standard commercial manufacturing tolerances for seamless steel mechanical tubing. Specify only two of the first three tolerances; that is, O.D. and I.D., or O.D. and Wall, or I.D. and Wall.

possible to avoid disturbance of the material to be sampled.

NOTE 2—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

6.3 Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler without rotation by a continuous relatively rapid motion.

6.4 Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

NOTE 3—Weight of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

6.5 When the formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. Other methods, as directed by the engineer or geologist, may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

6.6 In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. for sludge-end cuttings.

NOTE 4—The tube may be rotated to shear bottom of the sample after pressing is complete.

6.7 Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

7. Preparation for Shipment

7.1 Upon removal of the tube, measure the length of sample in the tube. Remove the disturbed material in the upper end of the tube and measure the length again. Seal the upper end of the tube. Remove at least 1 in. of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.
NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample. Assure that the

markings or labels are adequate to survive transportation and storage.

8. Report

8.1 The appropriate information is required as follows:

8.1.1 Name and location of the project,

8.1.2 Boring number and precise location on project,

8.1.3 Surface elevation or reference to a datum,

8.1.4 Date and time of boring—start and finish,

8.1.5 Depth to top of sample and number of sample,

8.1.6 Description of sampler: size, type of metal, type of coating,

8.1.7 Method of sampler insertion: push or drive,

8.1.8 Method of drilling, size of hole, casing, and drilling fluid used,

8.1.9 Depth to groundwater level: date and time measured,

8.1.10 Any possible current or tidal effect on water level,

8.1.11 Soil description in accordance with Practice D 2488,

8.1.12 Length of sampler advance, and

8.1.13 Recovery: length of sample obtained.

9. Precision and Bias

9.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

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ATTACHMENT C

ASTM D2113-83 (1987)

STANDARD PRACTICE FOR DIAMOND CORE DRILLING FOR SITE INVESTIGATION

Designation: D 2113 – 83 (Reapproved 1987)

Standard Practice for Diamond Core Drilling for Site Investigation[1]

This standard is issued under the fixed designation D 2113; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes equipment and procedures for diamond core drilling to secure core samples of rock and some soils that are too hard to sample by soil-sampling methods. This method is described in the context of obtaining data for foundation design and geotechnical engineering purposes rather than for mineral and mining exploration.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

3. Significance and Use

3.1 This practice is used to obtain core specimens of superior quality that reflect the in-situ conditions of the material and structure and which are suitable for standard physical-properties tests and structural-integrity determination.

4. Apparatus

4.1 *Drilling Machine,* capable of providing rotation, feed, and retraction by hydraulic or mechanical means to the drill rods.

4.2 *Fluid Pump or Air Compressor,* capable of delivering sufficient volume and pressure for the diameter and depth of hole to be drilled.

4.3 *Core barrels,* as required:

4.3.1 *Single Tube Type, WG Design,* consisting of a hollow steel tube, with a head at one end threaded for drill rod, and a threaded connection for a reaming shell and core bit at the other end. A core lifter, or retainer located within the core bit is normal, but may be omitted at the discretion of the geologist or engineer.

4.3.2 *Double Tube, Swivel-Type, WG Design*—An assembly of two concentric steel tubes joined and supported at the upper end by means of a ball or roller-bearing swivel arranged to permit rotation of the outer tube without causing rotation of the inner tube. The upper end of the outer tube, or removable head, is threaded for drill rod. A threaded connection is provided on the lower end of the outer tube for a reaming shell and core bit. A core lifter located within the core bit is normal but may be omitted at the discretion of the geologist or engineer.

4.3.3 *Double-Tube, Swivel-Type, WT Design,* is essentially the same as the double tube, swivel-type, WG design, except that the WT design has thinner tube walls, a reduced annular area between the tubes, and takes a larger core from the same diameter bore hole. The core lifter is located within the core bit.

4.3.4 *Double Tube, Swivel Type, WM Design,* is similar to the double tube, swivel-type, WG design, except that the inner tube is threaded at its lower end to receive a core lifter case that effectively extends the inner tube well into the core bit, thus minimizing exposure of the core to the drilling fluid. A core lifter is contained within the core lifter case on the inner tube.

4.3.5 *Double Tube Swivel-Type, Large-Diameter Design,* is similar to the double tube, swivel-type, WM design, with the addition of a ball valve, to control fluid flow, in all three available sizes and the addition of a sludge barrel, to catch heavy cuttings, on the two larger sizes. The large-diameter design double tube, swivel-type, core barrels are available in three core per hole sizes as follows: 2¾ in. (69.85 mm) by 3⅞ in. (98.43 mm), 4 in. (101.6 mm) by 5½ in. (139.7 mm), and 6 in. (152.4 mm) by 7¾ in. (196.85 mm). Their use is generally reserved for very detailed investigative work or where other methods do not yield adequate recovery.

4.3.6 *Double Tube, Swivel-Type, Retrievable Inner-Tube Method,* in which the core-laden inner-tube assembly is retrieved to the surface and an empty inner-tube assembly returned to the face of the borehole through the matching large-bore drill rods without need for withdrawal and replacement of the drill rods in the borehole. The inner-tube assembly consists of an inner tube with removable core lifter case and core lifter at one end and a removable inner-tube head, swivel bearing, suspension adjustment, and latching device with release mechanism on the opposite end. The inner-tube latching device locks into a complementary recess in the wall of the outer tube such that the outer tube may be rotated without causing rotation of the inner tube and such that the latch may be actuated and the inner-tube assembly transported by appropriate surface control. The outer tube is threaded for the matching, large-bore drill rod and internally configured to receive the inner-tube latching device at one end and threaded for a reaming shell and bit, or bit only, at the other end.

4.4 *Longitudinally Split Inner Tubes*—As opposed to conventional cylindrical inner tubes, allow inspection of, and access to, the core by simply removing one of the two halves. They are not standardized but are available for most core barrels including many of the retrievable inner-tube types.

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved June 24, 1983. Published August 1983. Originally published as D 2113 – 62 T. Last previous edition D 2113 – 70 (1976).

[2] *Annual Book of ASTM Standards,* Vol 04.08.

4.5 *Core Bits*—Core bits shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide slugs, or strips, hard-faced with various hard surfacing materials or furnished in saw-tooth form, all as appropriate to the formation being cored and with concurrence of the geologist or engineer. Bit matrix material, crown shape, water-way type, location and number of water ways, diamond size and carat weight, and bit facing materials shall be for general purpose use unless otherwise approved by the geologist or engineer. Nominal size of some bits is shown in Table 1.

NOTE 1—Size designation (letter symbols) used throughout the text and in Tables 1, 2, and 3 are those standardized by the Diamond Core Drill Manufacturers' Assoc. (DCDMA). Inch dimensions in the tables have been rounded to the nearest hundredth of an inch.

4.6 *Reaming Shells*, shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide strips or slugs, hard faced with various types of hard surfacing materials, or furnished blank, all as appropriate to the formation being cored.

4.7 *Core Lifters*—Core lifters of the split-ring type, either plain or hard-faced, shall be furnished and maintained, along with core-lifter cases or inner-tube extensions or inner-tube shoes, in good condition. Basket or finger-type lifters, together with any necessary adapters, shall be on the job and available for use with each core barrel if so directed by the geologist or engineer.

4.8 *Casings:*

4.8.1 *Drive Pipe or Drive Casing*, shall be standard weight (schedule 40), extra-heavy (schedule 80), double extra-heavy (schedule 160) pipe or W-design flush-joint casing as required by the nature of the overburden or the placement method. Drive pipe or W-design casing shall be of sufficient diameter to pass the largest core barrel to be used, and it shall be driven to bed rock or to firm seating at an elevation below water-sensitive formation. A hardened drive shoe is to be used as a cutting edge and thread protection device on the bottom of the drive pipe or casing. The drive shoe inside diameter shall be large enough to pass the tools intended for use, and the shoe and pipe or casing shall be free from burrs or obstructions.

4.8.2 *Casing*—When necessary to case through formations already penetrated by the borehole or when no drive casing has been set, auxiliary casing shall be provided to fit inside the borehole to allow use of the next smaller core barrel. Standard sizes of telescoping casing are shown in Table 2. Casing bits have an obstruction in their interior and will not pass the next smaller casing size. Use a casing shoe if additional telescoping is anticipated.

4.8.3 *Casing Liner*—Plastic pipe or sheet-metal pipe may be used to line an existing large-diameter casing. Liners, so used, should not be driven, and care should be taken to maintain true alignment throughout the length of the liner.

4.8.4 *Hollow Stem Auger*—Hollow stem auger may be used as casing for coring.

4.9 *Drill Rods:*

4.9.1 *Drill Rods of Tubular Steel Construction* are normally used to transmit feed, rotation, and retraction forces from the drilling machine to the core barrel. Drill-rod sizes that are presently standardized are shown in Table 3.

4.9.2 Large bore drill rods used with retrievable inner-tube core barrels are not standardized. Drill rods used with retrievable inner-tube core barrels should be those manufactured by the core-barrel manufacturer specifically for the core barrel.

4.9.3 *Composite Drill Rods* are specifically constructed from two or more materials intended to provide specific properties such as light weight or electrical nonconductivity.

4.9.4 *Nonmagnetic Drill Rods* are manufactured of nonferrous materials such as aluminum or brass and are used primarily for hole survey work. Some nonmagnetic rods have left-hand threads in order to further their value in survey work. No standard exists for nonmagnetic rods.

4.10 *Auxiliary Equipment*, shall be furnished as required by the work and shall include: roller rock bits, drag bits, chopping bits, boulder busters, fishtail bits, pipe wrenches, core barrel wrenches, lubrication equipment, core boxes, and marking devices. Other recommended equipment includes:

TABLE 1 Core Bit Sizes

Size Designation	Outside Diameter		Inside Diameter	
	in.	mm	in.	mm
RWT	1.16	29.5	0.375	18.7
EWT	1.47	37.3	0.905	22.9
EWG, EWM	1.47	37.3	0.845	21.4
AWT	1.88	47.6	1.281	32.5
AWG, AWM	1.88	47.6	1.185	30.0
BWT	2.35	59.5	1.750	44.5
BWG, BWM	2.35	59.5	1.655	42.0
NWT	2.97	75.3	2.313	58.7
NWG, NWM	2.97	75.3	2.155	54.7
2¾ × 3⅞	3.84	97.5	2.69	68.3
HWT	3.89	98.8	3.187	80.9
HWG, . . .	3.89	98.8	3.000	76.2
4 × 5½	5.44	138.0	3.97	100.8
6 × 7¾	7.66	194.4	5.97	151.6

TABLE 2 Casing Sizes

Size Designation	Outside Diameter		Inside Diameter		Threads per in.	Will Fit Hole Drilled with Core Bit Size
	in.	mm	in.	mm		
RW	1.144	36.5	1.19	30.1	5	EWT, EWG, EWM
EW	1.81	46.0	1.50	38.1	4	AWT, AWG, AWM
AW	2.25	57.1	1.91	48.4	4	BWT, BWG, BWM
BW	2.88	73.0	2.38	60.3	4	NWT, NWG, NWM
NW	3.50	88.9	3.00	76.2	4	HWT, HWG
HW	4.50	114.3	4.00	101.6	4	4 × 5½
PW	5.50	139.7	5.00	127.0	3	6 × 7¾
SW	6.63	168.2	6.00	152.4	3	6 × 7¾
UW	7.63	193.6	7.00	177.8	2	. . .
ZW	8.63	219.0	8.00	203.2	2	. . .

TABLE 3 Drill Rods

Size Designation	Rod and Coupling Outside Diameter		Rod Inside Diameter		Coupling Bore, Threads		
	in.	mm	in.	mm	in.	mm	per in.
RW	1.09	27.7	0.72	18.2	0.41	10.3	4
EW	1.38	34.9	1.00	25.4	0.44	11.1	3
AW	1.72	43.6	1.34	34.1	0.63	15.8	3
BW	2.13	53.9	1.75	44.4	0.75	19.0	3
NW	2.63	66.6	2.25	57.1	1.38	34.9	3
HW	3.50	88.9	3.06	77.7	2.38	60.3	3

core splitter, rod wicking, pump-out tools or extruders, and hand sieve or strainer.

5. Transportation and Storage of Core Containers

5.1 *Core Boxes,* shall be constructed of wood or other durable material for the protection and storage of cores while enroute from the drill site to the laboratory or other processing point. All core boxes shall be provided with longitudinal separators and recovered cores shall be laid out as a book would read, from left to right and top to bottom, within the longitudinal separators. Spacer blocks or plugs shall be marked and inserted into the core column within the separators to indicate the beginning of each coring run. The beginning point of storage in each core box is the upper left-hand corner. The upper left-hand corner of a hinged core box is the left corner when the hinge is on the far side of the box and the box is right-side up. All hinged core boxes must be permanently marked on the outside to indicate the top and the bottom. All other core boxes must be permanently marked on the outside to indicate the top and the bottom and additionally, must be permanently marked internally to indicate the upper-left corner of the bottom with the letters UL or a splotch of red paint not less than 1 in.[2] Lid or cover fitting(s) for core boxes must be of such quality as to ensure against mix up of the core in the event of impact or upsetting of the core box during transportation.

5.2 Transportation of cores from the drill site to the laboratory or other processing point shall be in durable core boxes so padded or suspended as to be isolated from shock or impact transmitted to the transporter by rough terrain or careless operation.

5.3 Storage of cores, after initial testing or inspection at the laboratory or other processing point, may be in cardboard or similar less costly boxes provided all layout and marking requirements as specified in 5.1 are followed. Additional spacer blocks or plugs shall be added if necessary at time of storage to explain missing core. Cores shall be stored for a period of time specified by the engineer but should not normally be discarded prior to completion of the project for which they were taken.

6. Procedure

6.1 Use core-drilling procedures when formations are encountered that are too hard to be sampled by soil-sampling methods. A 1-in. (25.4-mm) or less penetration for 50 blows in accordance with Method D 1586 or other criteria established by the geologist or engineer, shall indicate that soil-sampling methods are not applicable.

6.1.1 Seat the casing on bedrock or in a firm formation to prevent raveling of the borehole and to prevent loss of drilling fluid. Level the surface of the rock or hard formation at the bottom of the casing when necessary, using the appropriate bits. Casing may be omitted if the borehole will stand open without the casing.

6.1.2 Begin the core drilling using an N-size double-tube swivel-type core barrel or other size or type approved by the engineer. Continue core drilling until core blockage occurs or until the net length of the core barrel has been drilled in. Remove the core barrel from the hole and disassemble it as necessary to remove the core. Reassemble the core barrel and return it to the hole. Resume coring.

6.1.3 Place the recovered core in the core box with the upper (surface) end of the core at the upper-left corner of the core box as described in 5.1. Continue boxing core with appropriate markings, spacers, and blocks as described in 5.1. Wrap soft or friable cores or those which change materially upon drying in plastic film or seal in wax, or both, when such treatment is required by the engineer. Use spacer blocks or slugs properly marked to indicate any noticeable gap in recovered core which might indicate a change or void in the formation. Fit fracture, bedded, or jointed pieces of core together as they naturally occurred.

6.1.4 Stop the core drilling when soft materials are encountered that produce less than 50 % recovery. If necessary, secure samples of soft materials in accordance with the procedures described in Method D 1586, Practice D 1587, or Practice D 3550, or by any other method acceptable to the geologist or engineer. Resume diamond core drilling when refusal materials as described in 6.1 are again encountered.

6.2 Subsurface structure, including the dip of strata, the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described. Take special care to obtain and record information about these features. If conditions prevent the continued advance of the core drilling, the hole should be cemented and redrilled, or reamed and cased, or cased and advanced with the next smaller-size core barrel, as required by the geologist or engineer.

6.3 Drilling mud or grouting techniques must be approved by the geologist or engineer prior to their use in the borehole.

6.4 *Compatibility of Equipment:*

6.4.1 Whenever possible, core barrels and drill rods should be selected from the same letter-size designation to ensure maximum efficiency. See Tables 1 and 3.

6.4.2 Never use a combination of pump, drill rod, and core barrel that yields a clear-water up-hole velocity of less than 120 ft/min.

6.4.3 Never use a combination of air compressor, drill rod, and core barrel that yields a clear-air up-hole velocity of less than 3000 ft/min.

7. Boring Log

7.1 The boring log shall include the following:

7.1.1 Project identification, boring number, location, date boring began, date boring completed, and driller's name.

7.1.2 Elevation of the ground surface.

7.1.3 Elevation of or depth to ground water and raising or lowering of level including the dates and the times measured.

7.1.4 Elevations or depths at which drilling fluid return was lost.

7.1.5 Size, type, and design of core barrel used. Size, type, and set of core bit and reaming shell used. Size, type, and length of all casing used. Description of any movements of the casing.

7.1.6 Length of each core run and the length or percentage, or both, of the core recovered.

7.1.7 Geologist's or engineer's description of the formation recovered in each run.

7.1.8 Driller's description, if no engineer or geologist is present, of the formation recovered in each run.

7.1.9 Subsurface structure description, including dip of strata and jointing, cavities, fissures, and any other observations made by the geologist or engineer that could yield information regarding the formation.

7.1.10 Depth, thickness, and apparent nature of the filling of each cavity or soft seam encountered, including opinions gained from the feel or appearance of the inside of the inner tube when core is lost. Record opinions as such.

7.1.11 Any change in the character of the drilling fluid or drilling fluid return.

7.1.12 Tidal and current information when the borehole is sufficiently close to a body of water to be affected.

7.1.13 Drilling time in minutes per foot and bit pressure in pound-force per square inch gage when applicable.

7.1.14 Notations of character of drilling, that is, soft, slow, easy, smooth, etc.

8. Precision and Bias

8.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

NOTE 2—Inclusion of the following tables and use of letter symbols in the foregoing text is not intended to limit the practice to use of DCDMA tools. The table and text references are included as a convenience to the user since the vast majority of tools in use do meet DCDMA dimensional standards. Similar equipment of approximately equal size on the metric standard system is acceptable unless otherwise stipulated by the engineer or geologist.

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SOP F103
Monitoring Well Installation

MONITORING WELL INSTALLATION
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MONITORING WELL INSTALLATION

1.0 PURPOSE

The purpose of this procedure is to provide general guidance and reference material regarding the installation of monitoring wells at various sites.

2.0 SCOPE

This SOP describes the methods of installing a groundwater monitoring well, and creating a Monitoring Well Installation Record. This SOP does not discuss drilling, soil sampling, borehole logging or related activities. These other activities are discussed in SOPs F102 and F101 entitled Soil and Rock Sample Acquisition, and Borehole and Sample Logging, respectively.

3.0 DEFINITIONS

Monitoring Well - A monitoring well is a well which is properly screened, cased, and sealed to intercept a discrete zone of the subsurface, and is capable of providing a groundwater level and sample representative of the zone being monitored.

Piezometer - A piezometer is a pipe or tube inserted into an aquifer or other water-bearing zone, open to water flow at the bottom, open to the atmosphere at the top, and used to measure water level elevations. Piezometers are not used for the collection of groundwater quality samples or aquifer characteristic data other than water level elevations.

Drive Point - A monitoring well which includes a screen casing and hardened point fabricated from stainless steel that is driven into the soil to complete the well. The drive point can also be installed by hand augering to try to formulate a sand pack around the screen.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that field personnel installing monitoring wells are familiar with these procedures. The Project Manager also is

responsible for ensuring that all appropriate documents (e.g., test boring logs, monitoring well construction logs, etc.) have been correctly and completely filled out by the drilling inspector.

Field Team Leader - The Field Team Leader is responsible for the overall supervision of all drilling, boring and well installation activities, and for ensuring that the well is completely and correctly installed and logged. The Field Team Leader also is responsible for ensuring that all drilling inspectors have been briefed on these procedures. The Field Team Leader is responsible to provide copies of the well construction logs and field log books to the Project File via the Project Manager on a weekly basis, unless otherwise specified by the Project Manager.

Drilling Inspector (Site Geologist) - The Drilling Inspector or Site Geologist is responsible for the direct supervision of drilling and well installation activities. It is the Drilling Inspector's responsibility to record details of the well installation, document subsurface conditions, complete the appropriate forms, supervise the drilling crew (or drilling supervisor), and record quantities of the drillers billable labor and materials.

5.0 PROCEDURES

The objectives for the use of each monitoring well and of the entire array of wells must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, may require different types of construction. During all phases of the well design (both office and field), attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used.

The objectives for installing monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for groundwater contamination.
- Determining aquifer characteristics (e.g., hydraulic conductivity).
- Facilitating site remediation via injection or recovery.

In cases where only the groundwater flow direction or velocity needs to be determined, cluster piezometers or wells (i.e., wells completed to different depths in different boreholes at one data collection station) may be used. For groundwater quality monitoring or aquifer characteristic

determination, monitoring wells or cluster wells should be used. In areas that are inaccessible to drill rigs (i.e., unstable surface soils), driven wells (drive points) may be used.

Siting of monitoring wells shall be performed after a preliminary estimation of groundwater flow direction. Typically, site visits, topographic mapping, regional/local hydrogeologic information, previously installed piezometers or monitoring wells, or information supplied by local drilling companies will provide information for siting wells. Flexibility should be maintained, so that well locations may be modified during the field investigation to account for site conditions (e.g., underground utilities). The elevation and horizontal location of all monitoring wells shall be determined through a site survey upon completion of well installation.

Guidelines for Navy underground storage tank (UST) monitoring well construction are given in Attachment A.

5.1 Well Installation

The methods discussed in this section are applicable to shallow, small diameter monitoring wells. Project-specific modifications to these methods shall be documented in the Sampling and Analysis Plan. These modifications may include larger diameter shallow wells, extraction wells, deep monitoring wells requiring surface casing and other specially constructed well types. Typical shallow monitoring well construction details are shown in Figures A-1 and A-2 in Attachment A for wells with flush-mounted and stick-up wells, respectively.

Note that these procedures discuss well installation using a PVC screen and riser pipe. Other materials such as stainless steel or Teflon also are available. However, PVC generally is much less expensive and easier to work with than either stainless steel or Teflon. A disadvantage to using PVC is the potential for degradation of the materials, or release (leaching) of constituents into the groundwater. Because of these concerns, justification for using PVC must be developed on a project-specific basis. The checklist shown in Attachment B provides a format for developing this justification.

Upon completion of each boring (refer to SOP F101 and F102 for Borehole and Sample Logging, and Soil and Rock Sample Acquisition, respectively), monitoring wells will usually

be constructed using either two-inch or four-inch inside diameter (I.D.) screen and riser. Schedule 40 PVC, threaded, flush-joint casings with a continuous #10 slot (0.010-inch), threaded, flush-joint PVC screen. A larger or smaller diameter screen may be used to accommodate site-specific geologic conditions. If wells are to be constructed over 100 feet in length, or in high traffic areas, or under other unusual conditions, Schedule 80 PVC may be used because of its greater strength.

An appropriate length of well screen shall be installed in each boring. The length of screen typically varies from 1 to 20 feet depending on site-specific conditions. For UST and/or light non-aqueous phase liquid (INAPL) applications, the screen should be installed such that at least two-feet of screen is above the water table and the remainder of the screen extends below the water surface so that free product can enter the well. Should very shallow water table conditions be encountered, the screened interval in both the saturated and unsaturated zones may be reduced to ensure an adequate well seal above the screened interval. If this situation is expected, it should be addressed in the project plans, as necessary. A six-inch section of PVC casing may be placed at the bottom of each screen to act as a settling cup for fines which may pass through the filter pack and screen.

Other applications may call for different screen placement depending on the zone to be monitored and the expected contaminants. For example, monitoring for dense non-aqueous phase liquids *(DNAPLS)* may require placing the screened interval in a "sump" at the base of the aquifer. Depending on the purpose of the monitoring well, the riser pipe may extend from the top of the screened interval to either six inches below the ground surface (for flush-mounted wells) to between approximately one and two feet above the ground surface for wells completed with stick-up.

The annular space around the screen is to be successfully backfilled with a well graded quartz-sand, sodium bentonite and cement/bentonite grout as the hollow-stem augers are being withdrawn from the borehole. The sand size used in well construction will be appropriate for the formation monitored by the well. Sand shall carefully be placed, preferably via tremie pipe, from the bottom of the boring to a minimum of two feet (or 20 percent of the total screen length) above the top of the screened interval. A lesser distance above the top of the screened interval may be packed with sand if the well is very shallow to allow for placement of sealing materials.

A sodium bentonite seal at least two- to three-foot thick shall be place above the sand pack. The bentonite shall be allowed to hydrate for at least 20 minutes before further completion of the well. Deionized water will be added to the well to hydrate the bentonite, if necessary. For deep wells, a bentonite slurry may be more appropriate than pellets due to problems with bridging in the annular space.

The annular space above the bentonite seal will be backfilled with a cement-bentonite grout consisting of three to four percent bentonite powder (by dry weight) and seven gallons of potable water per 94 pound bag of portland cement. The grout mixture shall be specified in the project plans. The grout will be tremied into the annular space, preferably with a side-discharge tremie pipe, into annular spaces greater than ten feet high. If the annular space is less than ten feet high, the grout may be poured directly into the annular space.

The depth intervals of all backfill materials shall be measured with a weighted measuring tape to the nearest 0.1 foot and recorded on the Field Monitoring Well Construction Record or in a field logbook.

5.2 Drive Points

Drive points may be constructed in one of two ways. If the drive point is hammered into place, no other well construction will take place. (Note that the well assembly is fabricated from 2-inch diameter stainless steel and includes a screen casing, and hardened point). If a hand augered borehole is used, the following procedure will be utilized: a 4-inch diameter hand auger will be advanced to the desired depth below the water table. If the borehole collapses, a 5-inch diameter PVC pipe could be hammered into the collapsing borehole and reaugered to clean out the soils until final depth is achieved. A 2-inch diameter drive point will be placed in the open borehole. A sand pack will be placed around the drive point to a depth that is approximately 1 foot above the screened interval (if conditions permit). A bentonite seal will be placed above the sand pack to the top of the borehole. Grout will not be used in drive points. Because of the anticipated marsh conditions, concrete surface completion will not be required. The drive points will be sampled according to SOP F104, "Groundwater Sample Acquisition." After installation, the drive points will be developed. To assist with the development, the well screens will be cleaned with a wire brush and distilled water, and then developed according to Section 5.3 of SOP F103 "Monitoring Well Installation."

5.3 Surface Completion

There are several methods for surface completion of monitoring wells. Two such methods are discussed below.

The first method considers wells completed with stick-up. The aboveground section of the PVC riser pipe will be protected by installation of a four or six-inch diameter, five-foot long steel casing with locking cap and lock into the cement grout. The bottom of the surface casing will be placed at a minimum of 2-1/2, but not more than 3-1/2 feet below the ground surface. For very shallow wells, a steel casing of less than five-feet in length may be used, as space permits. The protective steel casing shall not fully penetrate the bentonite seal.

The top of each well will be protected with the installation of three, three-inch diameter, five-foot long steel pipes for UST projects (four for IR projects) and have a concrete apron. The steel pipes shall be embedded to a minimum depth of 2.5-feet in 3,000 psi concrete. Each pipe shall also be filled with concrete. A concrete apron approximately five-feet by five-feet by 0.5-feet thick shall be placed at the same time the pipes are installed. The steel pipes shall be painted with day-glo yellow paint, or equivalent.

The second method considers flush-mounted wells, typically installed in traffic areas. The monitoring well shall be completed at the surface using a "flush" mount type cover. If the well is installed through a paved or concrete surface, the annular space shall be grouted to a depth of at least 2.5-feet and the well shall be finished with a concrete collar. If the well has not been installed through a paved or concrete surface, the well shall be completed by construction of a five-foot by five-foot by 0.5-foot thick apron made of 3,000 psi concrete. The concrete shall be crowned to meet the finished grade of the surrounding pavement, as required. If appropriate, the vault around the buried wellhead will have a water drain to the surrounding soil and a watertight cover.

Project specific tasks may require that all monitoring wells shall be labeled by metal stamping on the exterior of the protective steel casing locking cap, and also by labeling on the exterior of the steel casing or manhole cover in accordance with applicable state and local requirements. For underground storage tank applications, the labeling shall consist of the letters UGW (UST Groundwater), and a number specific to each well. A sign reading "Not For Potable Use or Disposal" also shall be firmly attached to each well. Alternately, well identification

information may be stamped on a metal plate and attached to the well protective steel casing or embedded in the concrete apron, if appropriate.

5.4 Well Development

There are two stages of well development, initial and sampling. Sampling development is described in SOP F104, Groundwater Sample Acquisition. Initial development takes place after the completion materials have stabilized, as the last part of well construction.

The purposes of the initial development are to stabilize and increase the permeability of the filter pack around the well screen, to restore the permeability of the formation which may have been reduced by the drilling operations, and to remove fine-grained materials that may have entered the well or filter pack during installation. The selection of the well development method typically is based on drilling methods, well construction and installation details, and the characteristics of the formation. Any equipment that is introduced into the well during development shall be decontaminated in accordance with the SOP F501, entitled "Decontamination of Drilling Rigs and Monitoring Well Materials." A detailed discussion of well development is provided in Driscoll, 1986.

Well development shall not be initiated until a minimum of 24 hours has elapsed subsequent to well completion. This time period will allow the cement grout to set. Wells typically are developed using bailers, low-yield pumping, or surging with a surge block or air. The appropriate method shall be specified in the project plans.

In general, all wells shall be developed until well water runs relatively clear of fine-grained materials. Note that the water in some wells does not clear with continued development. Typical limits placed on well development may include any one of the following:

- Clarity of water based on visual determination.
- A minimum pumping time period (typically one hour for shallow wells 10 to 30 feet deep).
- A minimum borehole volume (typically five borehole volumes) or until well goes dry.
- Stability of specific conductance and temperature measurements (typically less than 10 percent change between three successive measurements).

In addition, a volume equal to any water added during drilling will be removed above and beyond the requirement specified above.

Well development limits shall be specified in project-specific plans. A record of the well development (Figure A-3 in Attachment A) also shall be completed to document the development process.

Usually, a minimum period of two weeks should elapse between the end of initial development and the first sampling event for a well. This equilibration period allows groundwater unaffected by the installation of the well to occupy the vicinity of the screened interval. However, this stabilization period may be adjusted based upon project-specific requirements.

5.5 Contaminated Materials Handling

SOP F504, entitled "Handling of Site Investigation Derived Waste," discusses the procedures to be used for the handling of auger cuttings, decontamination water, steam pad water, and development and purge water. Specific handling procedures should be delineated in the project plans. In general, all site investigation generated wastes shall be containerized unless otherwise specified by LANTDIV. The disposition of these wastes shall be determined after receipt of the appropriate analytical results.

5.6 Well Construction Logs

Field Well Construction Logs shall be completed by the Drilling Inspector for each monitoring well installed. These logs preferably shall be completed as the well is being constructed. However, due to space limitations on this form it may be more practical to record well installation information in the field logbook and later transfer it to the Well Construction Log. If well construction information is recorded in the field logbook, it must be transferred to the appropriate form within five days, and prior to demobilization from the field.

Field Well Construction Logs (in Attachment C), shall include not only well construction information, but also information pertaining to the amount of materials used for construction. Some of the following items shall be recorded on the Field Well Construction Log, or in the field logbook, as appropriate:

- Project name and location.
- CTO number.
- Date and weather.
- Well identification designation.
- Drilling company and driller.
- Top of casing elevation (information collected after the site survey).
- Pay items including amount of screen and riser pipe used, amounts of cement, bentonite and sand used, and other well construction items.
- Well casing and borehole diameters.
- Elevations of (or depth to) top of steel casing, bottom of well, top of filter pack, top of bentonite seal, top of screen.

The information on the Field Well Construction Log will be used to generate a final Well Construction Log which combines the Field Boring and Well Construction Logs into one package. An example of all three documents is presented in Attachment C.

6.0 QUALITY ASSURANCE RECORDS

The Field Well Construction Record is the principle quality assurance record generated from well installation activities. Additionally, a Field Well Development Record shall also be completed, as well as pertinent comments in the field logbook.

7.0 REFERENCES

1. Driscoll, Fletcher, G. Groundwater and Wells , Johnson division. St. Paul, Minnesota. 2nd ed. 1986.

2. Roscoe Moss Company. Handbook of Ground Water Development. John Wiley & Sons. New York. 1990.

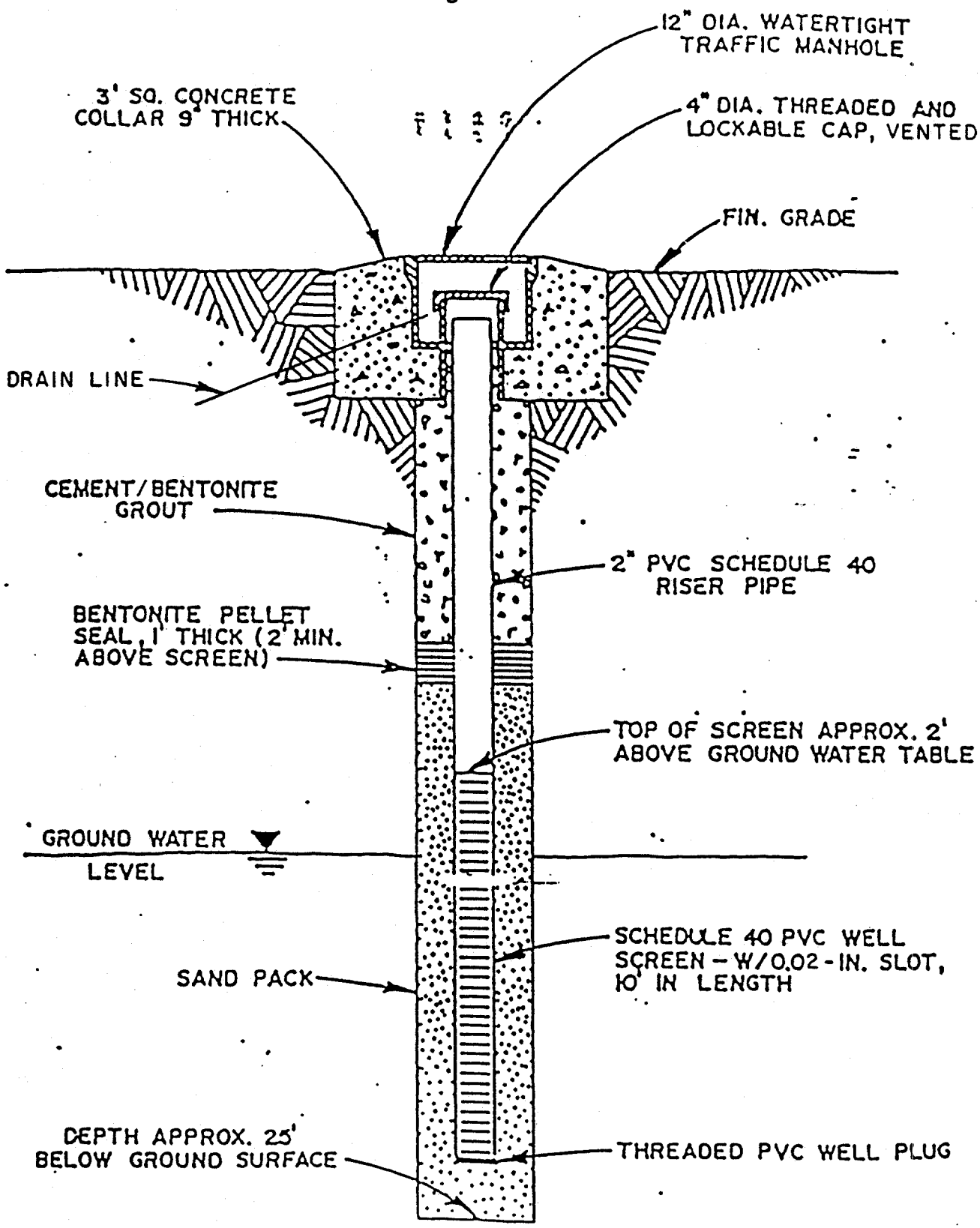
3. USEPA. RCRA Ground-Water Monitoring Technical Enforcement Guidance Document. September, 1986.

4. Aller, L. et al. Handbook of Suggested Practices for the Design and Installation of Ground Water Monitoring Wells. National Water Well Association. Dublin, Ohio. June, 1989.

ATTACHMENT A

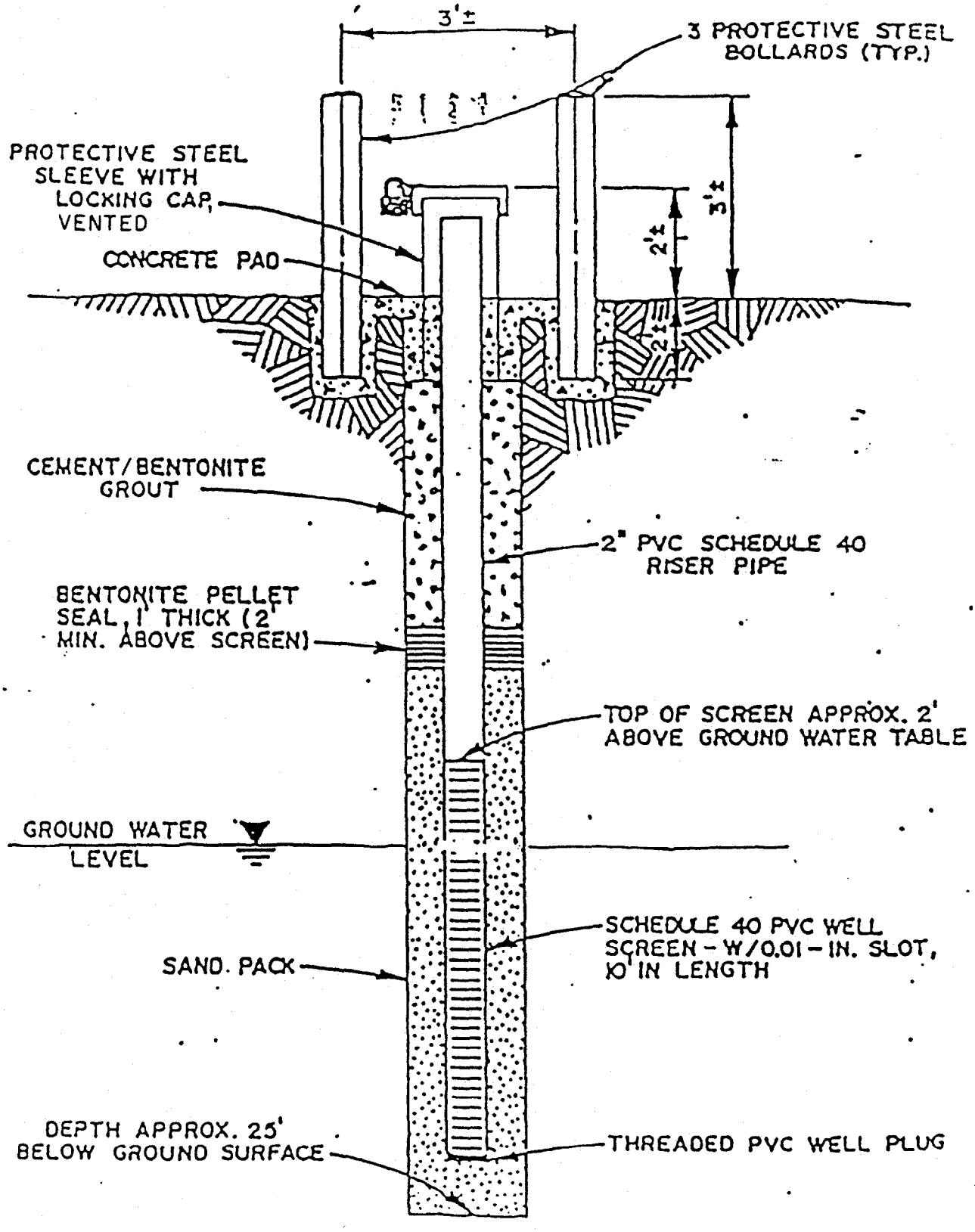
MONITORING WELL CONSTRUCTION

Figure A-1



MONITORING WELL CONSTRUCTION DETAIL
(TRAFFIC AREA)
NOT TO SCALE

Figure A-2



MONITORING WELL CONSTRUCTION DETAIL
(NON TRAFFIC AREA)
NOT TO SCALE

FIGURE A.3

FIELD WELL DEVELOPMENT RECORD

Baker

Baker Environmental, Inc.

PROJECT: _____

CTO NO.: _____ WELL NO.: _____

DATE: _____

GEOLOGIST/ENGINEER: _____

	DEVELOPMENT DATA						
	TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	COLOR AND TURBIDITY
TIME START							
TIME FINISH							
INITIAL WATER LEVEL (FT)							
TOTAL WELL DEPTH (TD)							
WELL DIAMETER (INCHES)							
CALCULATED WELL VOLUME							
BOREHOLE DIAMETER (INCHES)							
BOREHOLE VOLUME							
AMOUNT OF WATER ADDED DURING DRILLING							
DEVELOPMENT METHOD							
PUMP TYPE							
TOTAL TIME (A)							
AVERAGE FLOW (GPM)(B)							
TOTAL ESTIMATED WITHDRAWAL AxB=							
HNU/OVA READING							

OBSERVATIONS/NOTES

ATTACHMENT B

ALTERNATE WELL CASING MATERIAL JUSTIFICATION

ATTACHMENT B

ALTERNATE WELL CASING MATERIAL JUSTIFICATION

The following is EPA's minimum seven point information requirements to justify the use of PVC as an alternate casing material for groundwater monitoring wells. If requested by EPA (USEPA Region IV), justification of the use of PVC should be developed by addressing each of the following items.

1. The Data Quality Objectives (DQOs) for the samples to be collected from wells with PVC casing as per EPA/540/G-87/003, "Data Quality Objectives for Remedial Response Activities."

2. The anticipated compounds and their concentration ranges.

3. The anticipated residence time of the sample in the well and the aquifer's productivity.

4. The reasons for not using other casing materials.

5. Literature on the adsorption characteristics of the compounds and elements of interest for the type of PVC to be used.

6. Whether the wall thickness of the PVC casing would require a larger annular space when compared to other well construction materials.

7. The type of PVC to be used and, if available, the manufacturers specifications, and an assurance that the PVC to be used does not leach, mask, react or otherwise interfere with the contaminants being monitored within the limits of the DQOs.

ATTACHMENT C

FIELD TEST BORING RECORD AND
FIELD WELL CONSTRUCTION RECORD FORMS

Baker

Baker Environmental, Inc

TEST BORING AND WELL CONSTRUCTION RECORI

PROJECT: _____

S.O. NO.: _____ BORING NO.: _____

COORDINATES: EAST: _____ NORTH: _____

ELEVATION: SURFACE: _____ TOP OF PVC CASING: _____

RIG:	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)									
LENGTH									
TYPE									
HAMMER WT.									
FALL									
STICK UP									

REMARKS:

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

WELL INFORMATION	DIAM	TYPE	TOP DEPTH (FT)	BOTTOM DEPTH (FT)

Depth (Ft.)	Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	Lab. Class. or Pen. Rate	PID (ppm)	Visual Description	Well Installation Detail	Elevatic Ft. MSL
1								
2								
3								
4								
5								
6								
7								
8								
9								
10						Match to Sheet 2		

DRILLING CO.: _____ BAKER REP.: _____

DRILLER: _____ BORING NO.: _____ SHEET 1 OF

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: _____

S.O. NO.: _____ BORING NO.: _____

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab. Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab. Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	Lab. Class. or Pen. Rate	PID (ppm)	Visual Description	Well Installation Detail	Elevation Ft. MSL
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

DRILLING CO.: _____ BAKER REP.: _____

DRILLER: _____ BORING NO.: _____ SHEET 2 OF 2

SOP F104
Groundwater Sample Acquisition

GROUNDWATER SAMPLE ACQUISITION
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3.0 DEFINITIONS

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- 5.3 Evacuation of Static Water (Purging)
  - 5.3.1 Evacuation Devices
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  - 5.4.6 Sample Holding Times

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7.0 REFERENCES

GROUNDWATER SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this guideline is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This guideline provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methods.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and the Project Manager. The sampling personnel are responsible for the proper acquisition of groundwater samples.

5.0 PROCEDURES

To be useful and accurate, a groundwater sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained

from the time of sampling to the time of testing in order to minimize any changes in water quality parameters.

The groundwater sampling program should be developed with reference to ASTM D4448-85A, Standard Guide for Sampling Groundwater Monitoring Wells (Attachment A). This reference is not intended as a monitoring plan or procedure for a specific application, but rather is a review of methods. Specific methods shall be stated in the Sampling and Analysis Plan (SAP).

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain largely isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach should be followed during sample withdrawal:

1. All monitoring wells shall be pumped or bailed prior to withdrawing a sample. Evacuation of three to five volumes is recommended for a representative sample.

2. Wells that can be pumped or bailed to dryness with the sampling equipment being used, shall be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and time allows, evacuation of at least three well volumes of water is preferred; otherwise, a sample will be taken when enough water is available to fill the sample containers.

Stratification of contaminants may exist in the aquifer formation. This is from concentration gradients due to dispersion and diffusion processes in a homogeneous layer, and from separation of flow streams by physical division (for example, around clay lenses) or by contrasts in permeability (for example, between a layer of silty, fine sand and a layer of medium sand).

Purging rates and volumes for non-production wells during sampling development should be moderate; pumping rates for production wells should be maintained at the rate normal for that well. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, thus result in the collection of a non-representative sample. Water produced during purging shall be collected, stored or treated and discharged as allowed. Disposition of purge water is usually site-specific and must be addressed in the Sampling and Analysis Plan.

5.1 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with EPA regulations for the appropriate contaminants and to the specific Quality Assurance Project Plan.

The following list is an example of the type of equipment that generally must be on hand when sampling groundwater wells:

1. Sample packaging and shipping equipment: Coolers for sample shipping and cooling, chemical preservatives, and appropriate packing cartons and filler, labels and chain-of-custody documents.

2. Field tools and instrumentation: PID; Thermometer; pH meter; specific conductivity meter; appropriate keys (for locked wells) or bolt-cutter; tape measure; plastic sheeting; water-level indicator; calibrated buckets and, where applicable, flow meter.

3. Pumps

   a. Shallow-well pumps: Centrifugal, Packer Pumps, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing), as applicable.

   b. Deep-well pumps: Submersible pump and electrical power generating unit, bladder pump with compressed air source, or air-lift apparatus, as applicable.

4. Tubing: Sample tubing such as teflon, polyethylene, polypropylene, or PVC. Tubing type shall be selected based on specific site requirements and must be chemically inert to the groundwater being sampled.

5. Other Sampling Equipment: Bailers, Packer Pumps, teflon-coated wire, stainless steel single strand wire, and polypropylene monofilament line (not acceptable in EPA Region I) with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

6. Pails: Plastic, graduated.

7. Decontamination equipment and materials: discussed in SOP F501 and F502.

Ideally, sample withdrawal equipment should be completely inert, economical, easily cleaned, sterilized, and reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

5.2 Calculations of Well Volume for Purging

The volume of the cylinder of water in a well is given by:

Where: V =volume of standing water in well (in cubic feet)
r=well radius (in feet)
h=standing water in well (in feet)

To insure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well pipe or casing. The volume can be easily calculated by the following method. Calculations shall be entered in the field logbook:

1. Obtain all available information on well construction (location, casing, screens, etc.).

2. Determine well or casing diameter (D).

3. Measure and record static water level (DW-depth to water below ground level or top of casing reference point), using one of the methods described in Section 5.1 of SOP F202.

4. Determine the depth of the well (TD) to the nearest 0.01-foot by sounding using a clean, decontaminated weighted tape measure, referenced to the top of PVC casing or ground surface.

5. Calculate number of linear feet of static water (total well depth minus the depth to static water level).

6. Calculate the volume of water in the casing:

$$VW = R^2 (TD-DW)$$

$$V_{gal} = V_W \times 7.48 \text{ gallons/ft}^3$$

$$V_{purge} = Vgal \text{ (\# Well Vol)}$$

Where:

V_W	=	Volume of water standing in well in cubic feet (i.e., one well volume)
π	=	pi, 3.14
R	=	Well radius in feet (use D/12) if D is in inches)
TD	=	Total depth of well in feet (below ground surface or top of casing)
DW	=	Depth to water in feet (below ground surface or top of casing)

V_{gal} = Volume of water in well in gallons
V_{purge} = Volume of water to be purged from well in gallons
Well Vol. =Number of well volumes of water to be purged from the well (typically three to five)

7. Determine the minimum number of gallons to be evacuated before sampling. (Note: V_{purge} should be rounded to the next highest whole gallon. For example, 7.2 gallons should be rounded to 8 gallons.)

Table 5-1 lists gallons and cubic feet of water per standing foot of water for a variety of well diameters.

TABLE 5-1
WELL VOLUMES

Diameter of Casing or Hole (in.)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth
1	0.041	0.0055
2	0.163	0.0218
4	0.653	0.0873
6	1.469	0.1963
8	2.611	0.3491
10	4.080	0.5454

5.3 Evacuation of Static Water (Purging)

The amount of purging a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from a wide area. Generally, three to five well volumes are considered effective for purging a well.

An alternative method of purging a well, and one accepted in EPA Regions I and IV, is to purge a well continuously (usually using a low volume, low flow pump) while monitoring specific conductance, pH, and water temperature until the values stabilize. The well is considered properly purged when the values have stabilized.

If a well is dewatered before the required volume is purged, the sample should be collected from the well once as a sufficient volume of water has entered the well. In order to avoid stagnation, the well should not be allowed to fully recharge before the sample is collected. The field parameters (pH, conductance, and temperature) should be recorded when the well was dewatered.

The Project Manager shall define the objectives of the groundwater sampling program in the Sampling and Analysis Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.3.1 Evacuation Devices

The following discussion is limited to those devices which are commonly used at hazardous waste sites. Note that all of these techniques involve equipment which is portable and readily available.

Bailers - Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line (e.g., Teflon-coated) is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Inexpensive.
- Minimal outgassing of volatile organics while the sample is in the bailer.
- Relatively easy to decontaminate and use.

Limitations on the use of bailers include the following:

- Limited volume of sample.
- Time consuming to remove stagnant water using a bailer.
- Collection and transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.
- Unable to collect depth-discrete sample.

Suction Pumps - There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (generally not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 10 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps will cause significant loss of dissolved gases, including volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

Gas-Lift Samples - This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift pumps are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics. An inert gas such as nitrogen is generally used as a gas source.

Submersible Pumps - Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed air or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for two-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- Potentially low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

5.4 Sampling

The sampling approach consisting of the following, should be developed as part of the Sampling and Analysis Plan prior to the field work:

1. Background and objectives of sampling.

2. Brief description of area and waste characterization.

3. Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

4. Sampling equipment to be used.

5. Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these should be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

6. Sample preservation requirements.

7. Schedule.

8. List of team members.

9. Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.4.1 Sampling Methods

The collection of a groundwater sample includes the following steps:

1. First open the well cap and use volatile organic detection equipment (HNu or OVA) on the escaping gases at the well head to determine the need for respiratory protection. This task is usually performed by the Field Team Leader, Health and Safety Officer, or other designee.

2. When proper respiratory protection has been donned, measure the total depth and water level (with decontaminated equipment) and record these data in the field logbook. Calculate the fluid volume in the well according to Section 5.2 of this SOP.

3. Lower purging equipment or intake into the well to a distance just below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (e.g., DOT-approved 55-gallon drum).

4. Measure the rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters. Record the method of discharge measurement.

5. Observe peristaltic pump intake for degassing "bubbles" and all pump discharge lines. If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. The preferred method for collecting volatile organic samples and the accepted method by EPA Regions I through IV is with a bailer.

6. Purge a minimum of three to five well volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recharge as necessary, but preferably to 70 percent of the static water level, and then sample.

7. Record measurements of specific conductance, temperature, and pH during purging to ensure that the groundwater level has stabilized. Generally, these measurements are made after the removal of three, four, and five well volumes.

8. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to the sampling level before filling (this requires use of other than a "bucket-type" bailer). Purged water should be collected in a designated container and disposed of in an acceptable manner.

9. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers should always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

10. In the event that groundwater recovery time is very slow (e.g., 24 hours), sample collection can be delayed until the following day. However, it is preferred that such a well be bailed early in the morning so that sufficient volume of water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

11. Add preservative if required (see SOP F301). Label, tag, and number the sample bottle(s).

12. Volatile organics septum vials (40 ml) should be completely filled to prevent volatilization and extreme caution should be exercised when filling a vial to avoid turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure. If the second attempt still produces air bubbles, note on Chain-of-Custody form and in field notebook and submit sample to the laboratory.

    Fill the remaining sample containers in order of decreasing volatilability (semi-volatiles next, then pesticides, PCBs, inorganics, etc.).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping (see SOP F301). Attach custody seals to the shipping container. Make sure that Chain-of-Custody forms and Sample Analysis Request forms are properly filled out and enclosed or attached (see SOP F302).

15. Decontaminate all equipment.

5.4.2 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory. SOP F301 describes the required sampling containers for various analytes at various concentrations. Container requirements shall follow those given in NEESA 20.2 047B.

5.4.3 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. SOP F301 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Sample volume and preservation requirements shall follow those given in NEESA 20.2-047B.

5.4.4 Field Filtration

In general, preparation and preservation of water samples for dissolved inorganics involve some form of filtration. All filtration must occur in the field immediately upon collection. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) utilizing the pressure provided by the upstream pumping device for its operation.

In Region I, all inorganics are to be collected and preserved in the filtered form, including metals. In Region II, metals samples are to be analyzed as "total metals" and preserved unfiltered. In Regions III and IV, samples collected for metals analysis are also to be unfiltered. However, if metals analysis of groundwater is required, then both an unfiltered and filtered sample are to be collected, regardless of regulatory requirements. Filtration and preservation are to occur immediately in the field with the sample aliquot passing through a 0.45 micron filter. Samples for organic analyses shall never be filtered. Filters must be prerinsed with organic-free, deionized water.

5.4.5 Handling and Transporting Samples

After collection, samples should be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it should be double-bagged and steps taken to ensure that the melted ice does not cause sample

containers to be submerged, and thus possibly become cross-contaminated. All sample containers should be enclosed in plastic bags or cans to prevent cross-contamination. Samples should be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SOP F301.

5.4.6 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in NEESA 20.2-047B.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each sample that is collected. The following information will be recorded in the Field Logbook:

- Sample identification (site name, location, project no.; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method; volume of water purged prior to sampling; number of well volumes purged).
- Sample disposition (preservatives added; lab sent to; date and time).
- Additional remarks, as appropriate.

Proper chain-of-custody procedures play a crucial role in data gathering. SOP F302 describes the requirements for correctly completing a chain-of-custody form. Chain-of-custody forms (and sample analysis request forms) are considered quality assurance records.

7.0 REFERENCES

American Society of Testing and Materials. 1987. Standard Guide for Sampling Groundwater Monitoring Wells. Method D4448-85A, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

ATTACHMENT A

ASTM D4448-85A
STANDARD GUIDE FOR SAMPLING GROUNDWATER MONITORING WELLS

Designation: D 4448 – 85a

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St., Philadelphia, Pa. 19103
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Standard Guide for Sampling Groundwater Monitoring Wells[1]

This standard is issued under the fixed designation D 4448; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers procedures for obtaining valid, representative samples from groundwater monitoring wells. The scope is limited to sampling and "in the field" preservation and does not include well location, depth, well development, design and construction, screening, or analytical procedures.

1.2 This guide is only intended to provide a review of many of the most commonly used methods for sampling groundwater quality monitoring wells and is not intended to serve as a groundwater monitoring plan for any specific application. Because of the large and ever increasing number of options available, no single guide can be viewed as comprehensive. The practitioner must make every effort to ensure that the methods used, whether or not they are addressed in this guide, are adequate to satisfy the monitoring objectives at each site.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Guide

2.1 The equipment and procedures used for sampling a monitoring well depend on many factors. These include, but are not limited to, the design and construction of the well, rate of groundwater flow, and the chemical species of interest. Sampling procedures will be different if analyzing for trace organics, volatiles, oxidizable species, or trace metals is needed. This guide considers all of these factors by discussing equipment and procedure options at each stage of the sampling sequence. For ease of organization, the sampling process can be divided into three steps: well flushing, sample withdrawal, and field preparation of samples.

2.2 Monitoring wells must be flushed prior to sampling so that the groundwater is sampled, not the stagnant water in the well casing. If the well casing can be emptied, this may be done although it may be necessary to avoid oxygen contact with the groundwater. If the well cannot be emptied, procedures must be established to demonstrate that the sample represents groundwater. Monitoring an indicative parameter such as pH during flushing is desirable if such a parameter can be identified.

2.3 The types of species that are to be monitored as well as the concentration levels are prime factors for selecting sampling devices (**1**, **2**).[2] The sampling device and all materials and devices the water contacts must be constructed of materials that will not introduce contaminants or alter the analyte chemically in any way.

2.4 The method of sample withdrawal can vary with the parameters of interest. The ideal sampling scheme would employ a completely inert material, would not subject the sample to negative pressure and only moderate positive pressure, would not expose the sample to the atmosphere, or preferably, any other gaseous atmosphere before conveying it to the sample container or flow cell for on-site analysis.

2.5 The degree and type of effort and care that goes into a sampling program is always dependent on the chemical species of interest and the concentration levels of interest. As the concentration level of the chemical species of analytical interest decreases, the work and precautions necessary for sampling are increased. Therefore, the sampling objective must clearly be defined ahead of time. For example, to prepare equipment for sampling for mg/L (ppm) levels of Total Organic Carbon (TOC) in water is about an order of magnitude easier than preparing to sample for μg/L (ppb) levels of a trace organic like benzene. The specific precautions to be taken in preparing to sample for trace organics are different from those to be taken in sampling for trace metals. No final Environmental Protection Agency (EPA) protocol is available for sampling of trace organics. A short guidance manual, (**3**) and an EPA document (**4**) concerning monitoring well sampling, including considerations for trace organics are available.

2.6 Care must be taken not to cross contaminate samples or monitoring wells with sampling or pumping devices or materials. All samples, sampling devices, and containers must be protected from the environment when not in use. Water level measurements should be made before the well is flushed. Oxidation-reduction potential, pH, dissolved oxygen, and temperature measurements and filtration should all be performed on the sample in the field, if possible. All but temperature measurement must be done prior to any significant atmospheric exposure, if possible.

2.7 The sampling procedures must be well planned and all sample containers must be prepared and labeled prior to going to the field.

3. Significance and Use

3.1 The quality of groundwater has become an issue of national concern. Groundwater monitoring wells are one of

[1] This guide is under the jurisdiction of ASTM Committee D-34 on Waste Disposal and is the direct responsibility of Subcommittee D34.01 on Sampling and Monitoring.

Current edition approved Aug. 23 and Oct. 25, 1985. Published May 1986.

[2] The boldface numbers in parentheses refer to a list of references at the end of this guide.

TABLE 1 Typical Container and Preservation Requirements for a Ground-Water Monitoring Program

Sample and Measurement	Volume Required (mL)	Container P—Polyethylene G—Glass	Preservative	Maximum Holding Time
Metals As/Ba/Cd/Cr/Fe Pb/Se/Ag/Mn/Na	1000–2000	P/G (special acid cleaning)	high purity nitric acid to pH <2	6 months
Mercury	200–300	P/G (special acid cleaning)	high purity nitric acid to pH <2 +0.05 % $K_2Cr_2O_7$	28 days
Radioactivity alpha/beta/radium	4000	P/G (special acid cleaning)	high purity nitric acid to pH <2	6 months
Phenolics	500–1000	G	cool, 4°C H_2SO_4 to pH <2	28 days
Miscellaneous	1000–2000	P	cool, 4°C	28 days
Fluoride	300–500	P		28 days
Chloride	50–200	P/G		28 days
Sulfate	100–500	P/G		48 hours
Nitrate	100–250	P/G		6 h
Coliform	100	P/G		on site/24 h
Conductivity	100	P/G		on site/6 h
pH	100	P/G		48 h
Turbidity	100	P/G		
Total organic carbon (TOC)	25–100	P/G	cool, 4°C or cool, 4°C HCl or H_2SO_4 to pH <2	24 h 28 days
Pesticides, herbicides and total organic halogen (TOX)	1000–4000	G/TFE-fluorocarbon lined cap solvent rinsed	cool, 4°C	7 days/extraction +30 days/analysis
Extractable organics	1000–2000	G/TFE-fluorocarbon-lined cap solvent rinsed	cool, 4°C	7 days/extraction +30 days/analysis
Organic purgeables acrolein/acrylonitrile	25–120	G/vial TFE-fluorocarbon-lined septum	cool, 4°C	14 days 3 days

the more important tools for evaluating the quality of groundwater, delineating contamination plumes, and establishing the integrity of hazardous material management facilities.

3.2 The goal in sampling groundwater monitoring wells is to obtain samples that are truly representative of the aquifer or groundwater in question. This guide discusses the advantages and disadvantages of various well flushing, sample withdrawal, and sample preservation techniques. It reviews the parameters that need to be considered in developing a valid sampling plan.

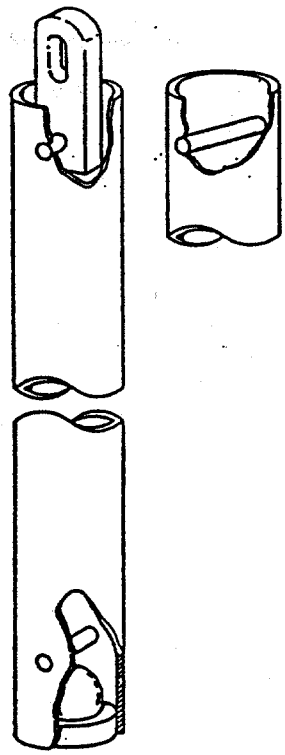
4. Well Flushing (Purging)

4.1 Water that stands within a monitoring well for a long period of time may become unrepresentative of formation water because chemical or biochemical change may cause water quality alterations and even if it is unchanged from the time it entered the well, the stored water may not be representative of formation water at the time of sampling, or both. Because the representativeness of stored water is questionable, it should be excluded from samples collected from a monitoring well.

4.2 The surest way of accomplishing this objective is to remove all stored water from the casing prior to sampling. Research with a tracer in a full scale model 2 in. PVC well (5) indicates that pumping 5 to 10 times the volume of the well via an inlet near the free water surface is sufficient to remove all the stored water in the casing. The volume of the well may be calculated to include the well screen and any gravel pack if natural flow through these is deemed insufficient to keep them flushed out.

4.3 In deep or large diameter wells having a volume of water so large as to make removal of all the water impractical, it may be feasible to lower a pump or pump inlet to some point well below the water surface, purge only the volume below that point then withdraw the sample from a deeper level. Research indicates this approach should avoid most contamination associated with stored water (5, 6, 7). Sealing the casing above the purge point with a packer may make this approach more dependable by preventing migration of stored water from above. But the packer must be above the top of the screened zone, or stagnant water from above the packer will flow into the purged zone through the well's gravel/sand pack.

4.4 In low yielding wells, the only practical way to remove all standing water may be to empty the casing. Since it is not always possible to remove all water, it may be advisable to let the well recover (refill) and empty it again at least once. If introduction of oxygen into the aquifer may be of concern, it would be best not to uncover the screen when performing the above procedures. The main disadvantage of methods designed to remove all the stored water is that large volumes may need to be pumped in certain instances. The main advantage is that the potential for contamination of samples with stored water is minimized.



NOTE—Taken from Ref (15).

FIG. 1 Single Check Valve Bailer

4.5 Another approach to well flushing is to monitor one or more indicator parameters such as pH, temperature, or conductivity and consider the well to be flushed when the indicator(s) no longer change. The advantage of this method is that pumping can be done from any location within the casing and the volume of stored water present has no direct bearing on the volume of water that must be pumped. Obviously, in a low yielding well, the well may be emptied before the parameters stabilize. A disadvantage of this approach is that there is no assurance in all situations that the stabilized parameters represent formation water. If significant drawdown has occurred, water from some distance away may be pulled into the screen causing a steady parameter reading but not a representative reading. Also, a suitable indicator parameter and means of continuously measuring it in the field must be available.

4.6 Gibb (4, 8) has described a time-drawdown approach using a knowledge of the well hydraulics to predict the percentage of stored water entering a pump inlet near the top of the screen at any time after flushing begins. Samples are taken when the percentage is acceptably low. As before, the advantage is that well volume has no direct effect in the duration of pumping. A current knowledge of the well's hydraulic characteristics is necessary to employ this approach. Downward migration of stored water due to effects other than drawdown (for example density differences) is not accounted for in this approach.

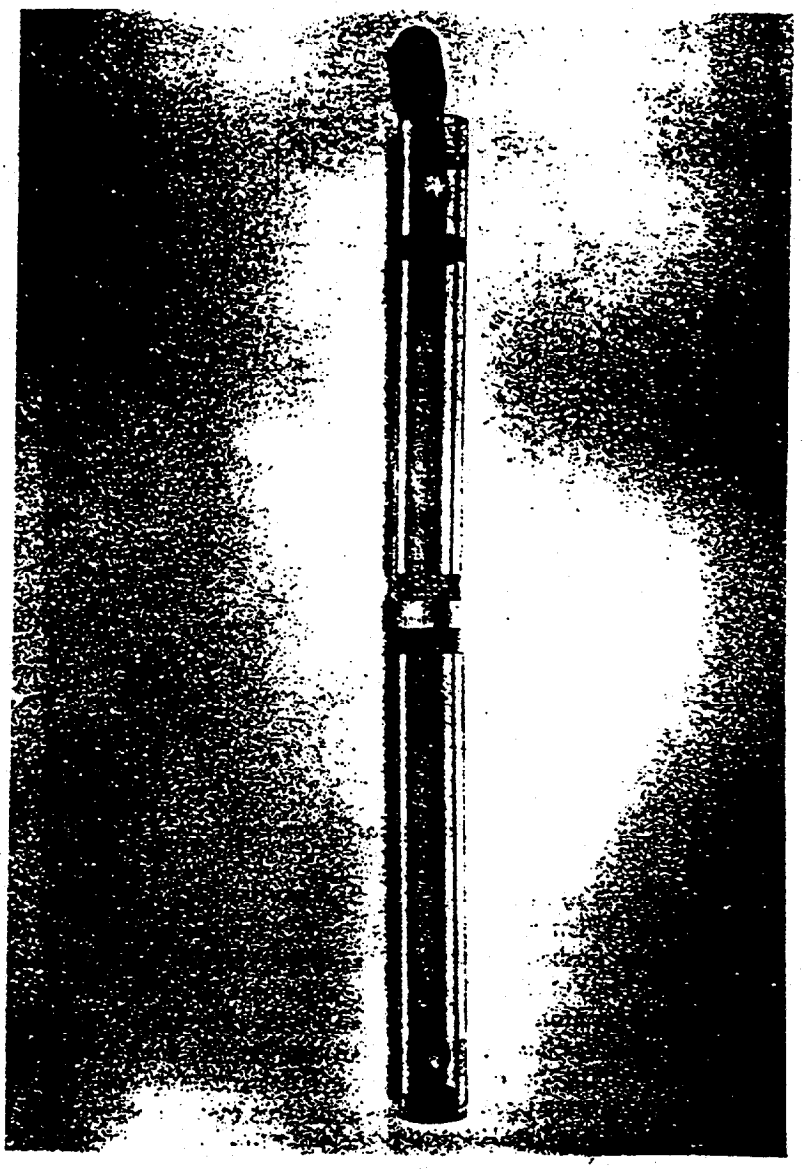
4.7 In any flushing approach, a withdrawal rate that minimizes drawdown while satisfying time constraints should be used. Excessive drawdown distorts the natural flow patterns around a well and can cause contaminants that were not present originally to be drawn into the well.

5. Materials and Manufacture

5.1 The choice of materials used in the construction of sampling devices should be based upon a knowledge of what compounds may be present in the sampling environment and how the sample materials may interact via leaching, adsorption, or catalysis. In some situations, PVC or some other plastic may be sufficient. In others, an all glass apparatus may be necessary.

5.2 Most analytical protocols suggest that the devices used in sampling and storing samples for trace organics analysis (µg/L levels) must be constructed of glass or TFE-fluorocarbon resin, or both. One suggestion advanced by the EPA is that the monitoring well be constructed so that only TFE-fluorocarbon tubing be used in that portion of the sampling well that extends from a few feet above the water table to the bottom of the borehole. (3, 5) Although this type of well casing is now commercially available, PVC well casings are currently the most popular. If adhesives are avoided, PVC well casings are acceptable in many cases although their use may still lead to some problems if trace organics are of concern. At present, the type of background presented by PVC and interactions occurring between PVC and groundwater are not well understood. Tin, in the form of an organotin stabilizer added to PVC, may enter samples taken from PVC casing. (9)

5.3 Since the most significant problem encountered in trace organics sampling, results from the use of PVC adhesives in monitoring well construction, threaded joints might avoid the problem (3, 5). Milligram per litre (parts per million) levels of compounds such as tetrahydrofuran, methyl-ethyl-ketone, and toluene are found to leach into



NOTE—Taken from Ref (17).

FIG. 2 Acrylic Point Source Bailer

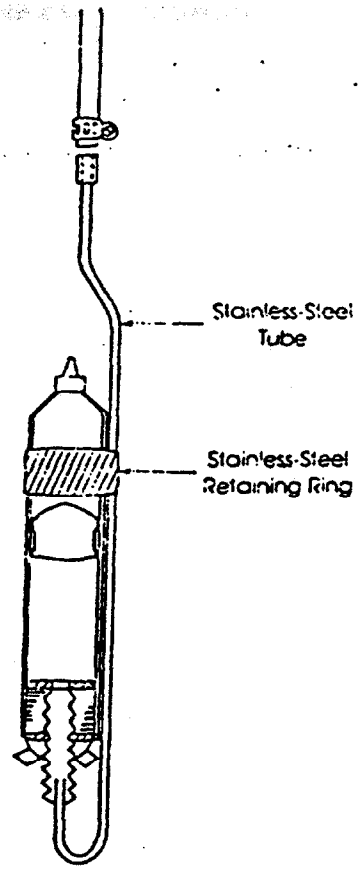
groundwater samples from monitoring well casings sealed with PVC solvent cement. Pollutant phthalate esters (8, 10) are often found in water samples at ppb levels; the EPA has found them on occasion at ppm levels in their samples. The ubiquitous presence of these phthalate esters is unexplained, except to say that they may be leached from plastic pipes, sampling devices, and containers.

5.4 TFE–fluorocarbon resins are highly inert and have sufficient mechanical strength to permit fabrication of sampling devices and well casings. Molded parts are exposed to high temperature during fabrication which destroys any organic contaminants. The evolution of fluorinated compounds can occur during fabrication, will cease rapidly, and does not occur afterwards unless the resin is heated to its melting point.

5.5 Extruded tubing of TFE-fluorocarbon for sampling may contain surface traces of an organic solvent extrusion aid. This can be removed easily by the fabricator and, once removed by flushing, should not affect the sample. TFE-fluorocarbon FEP and TFE-fluorocarbon PFA resins do not require this extrusion aid and may be suitable for sample tubing as well. Unsintered thread-sealant tape of TFE-fluorocarbon is available in an "oxygen service" grade and contains no extrusion aid and lubricant.

5.6 Louneman, et al. (11) alludes to problems caused by a lubricating oil used during TFE-fluorocarbon tubing extrusion. This reference also presents evidence that a fluorinated ethylene-propylene copolymer adsorbed acetone to a degree that later caused contamination of a gas sample.

5.7 Glass and stainless steel are two other materials generally considered inert in aqueous environments. Glass is probably among the best choices though it is not inconceivable it could adsorb some constituents as well as release other contaminants (for example, Na, silicate, and Fe). Of course glass sampling equipment must be handled carefully in the field. Stainless steel is strongly and easily machined to



NOTE—Taken from Ref (21).

FIG. 3 Schematic of the Inverted Syringe Sampler

fabricate equipment. Unfortunately, it is not totally immune to corrosion that could release metallic contaminants. Stainless steel contains various alloying metals, some of these (for example Ni) are commonly used as catalysts for various reactions. The alloyed constituents of some stainless steels can be solubilized by the pitting action of nonoxidizing anions such as chloride, fluoride, and in some instances sulfate, over a range of pH conditions. Aluminum, titanium, polyethylene, and other corrosion resistant materials have been proposed by some as acceptable materials, depending on groundwater quality and the constituents of interest.

5.8 Where temporarily installed sampling equipment is used, the sampling device that is chosen should be nonplastic (unless TFE-fluorocarbon), cleanable of trace organics, and must be cleaned between each monitoring well use in order to avoid cross-contamination of wells and samples. The only way to ensure that the device is indeed "clean" and acceptable is to analyze laboratory water blanks and field water blanks that have been soaked in and passed through the sampling device to check for the background levels that may result from the sampling materials or from field conditions. Thus, all samplings for trace materials should be accompanied by samples which represent the field background (if possible), the sampling equipment background, and the laboratory background.

5.9 Additional samples are often taken in the field and spiked (spiked-field samples) in order to verify that the sample handling procedures are valid. The American Chemical Society's committee on environmental improvement h published guidelines for data acquisition and data evaluati which should be useful in such environmental evaluatio (10, 12).

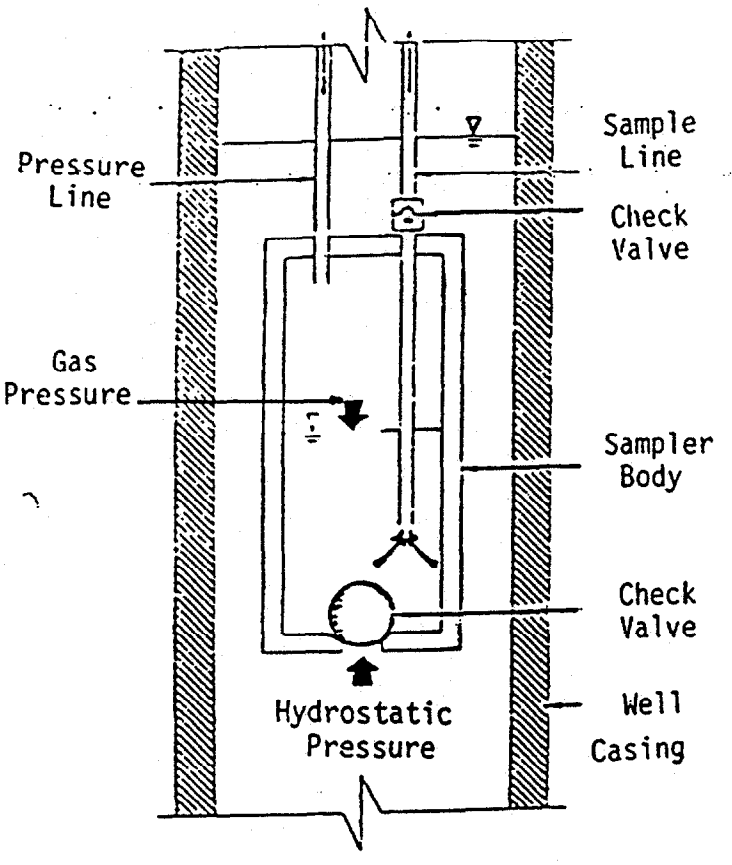
6. Sampling Equipment

6.1 There is a fairly large choice of equipment present available for groundwater sampling from single screen wells and well clusters. The sampling devices can be categ rized into the following eight basic types.

6.1.1 *Down-Hole Collection Devices:*

6.1.1.1 Bailers, messenger bailers, or thief samplers (1 14) are examples of down-hole devices that probably provi valid samples once the well has been flushed. They are n practical for removal of large volumes of water. The devices can be constructed in various shapes and sizes from variety of materials. They do not subject the sample t pressure extremes.

6.1.1.2 Bailers do expose part of the sample to th atmosphere during withdrawal. Bailers used for sampling volatile organic compounds should have a sample cock draft valve in or near the bottom of the sampler allowir withdrawal of a sample from the well below the expose surface of the water or the first few inches of the sampl should be discarded. Suspension lines for bailers and oth samplers should be kept off the ground and free of oth contaminating materials that could be carried into the wel Down-hole devices are not very practical for use in dee



NOTE—Taken from Ref (5).

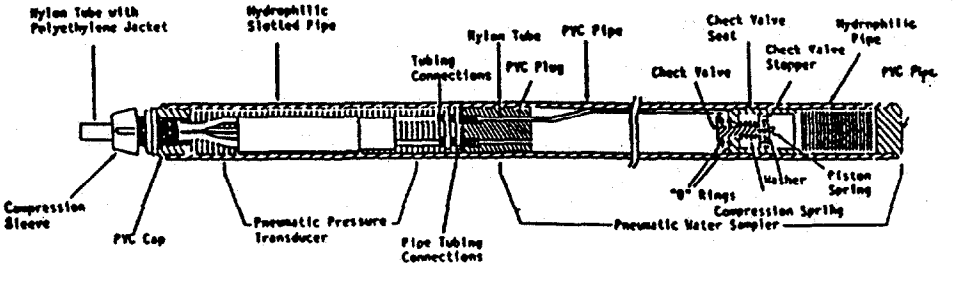
FIG. 4 The Principal of Gas Displacement Pumping

wells. However, potential sample oxidation during transfer of the sample into a collection vessel and time constraints for lowering and retrieval for deep sampling are the primary disadvantages.

6.1.1.3 Three down-hole devices are the single and double check valve bailers and thief samplers. A schematic of a single check valve unit is illustrated in Fig. 1. The bailer may be threaded in the middle so that additional lengths of blank casing may be added to increase the sampling volume. TFE-fluorocarbon or PVC are the most common materials used for construction (15).

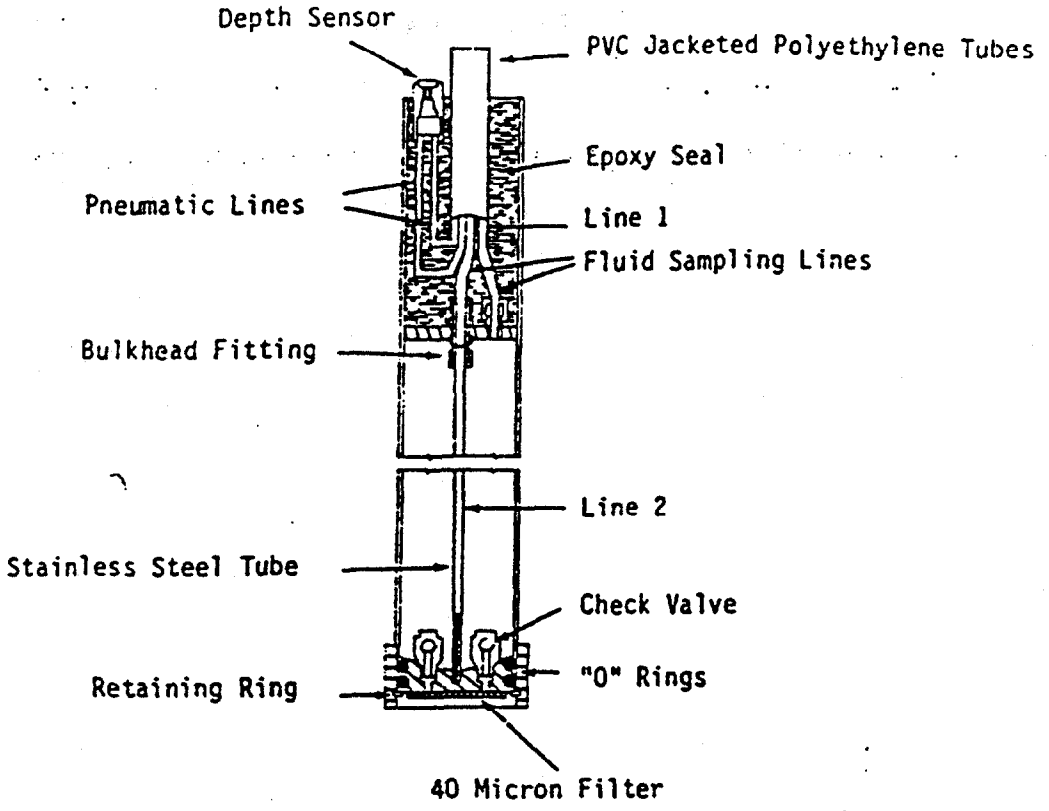
6.1.1.4 In operation, the single check valve bailer is lowered into the well, water enters the chamber through the bottom, and the weight of the water column closes the check valve upon bailer retrieval. The specific gravity of the ball should be about 1.4 to 2.0 so that the ball almost sits on the check valve seat during chamber filling. Upon bailer withdrawal, the ball will immediately seat without any samples loss through the check valve. A similar technique involves lowering a sealed sample container within a weighted bottle into the well. The stopper is then pulled from the bottle via a line and the entire assembly is retrieved upon filling of the container (14, 16).

6.1.1.5 A double check valve bailer allows point source sampling at a specific depth (15, 17). An example is shown in Fig. 2. In this double check valve design, water flows through the sample chamber as the unit is lowered. A venturi tapered inlet and outlet ensures that water passes freely through the



NOTE—Taken from Ref (41).

FIG. 5 Pneumatic Water Sampler With Internal Transducer



NOTE—Taken from Ref (42).

FIG. 6 Pneumatic Sampler With Externally Mounted Transducer

unit. When a depth where the sample is to be collected is reached, the unit is retrieved. Because the difference between each ball and check valve seat is maintained by a pin that blocks vertical movement of the check ball, both check valves close simultaneously upon retrieval. A drainage pin is placed into the bottom of the bailer to drain the sample directly into a collection vessel to reduce the possibility of air oxidation. The acrylic model in Fig. 2 is threaded at the midsection allowing the addition of threaded casing to increase the sampling volume.

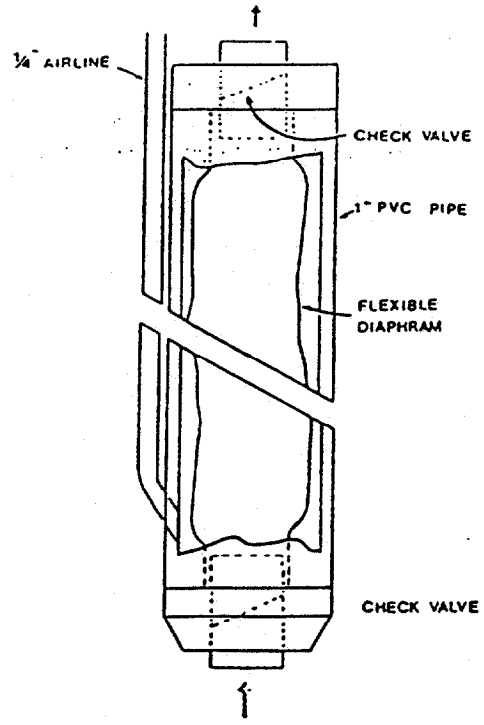
6.1.1.6 Another approach for obtaining point source samples employs a weighted messenger or pneumatic change to "trip" plugs at either end of an open tube (for example, tube water sampler or thief sampler) to close the chamber (18). Foerst, Kemmerer, and Bacon samplers are of this variety (14, 17, 19). A simple and inexpensive pneumatic sampler was recently described by Gillham (20). The device (Fig. 3) consists of a disposable 50 mL plastic syringe modified by sawing off the plunger and the finger grips. The syringe is then attached to a gas-line by means of a rubber stopper assembly. The gas-line extends to the surface, and is used to drive the stem-less plunger, and to raise and lower the syringe into the hole. When the gas-line is pressurized, the rubber plunger is held at the tip of the syringe. The sampler is then lowered into the installation, and when the desired depth is reached, the pressure in the gas-line is reduced to atmospheric (or slightly less) and water enters the syringe. The sampler is then retrieved from the installation and the syringe detached from the gas-line. After the tip is sealed, the syringe is used as a short-term storage container. A number of thief or messenger devices are available in various materials and shapes.

6.1.2 *Suction Lift Pumps:*

6.1.2.1 Three types of suction lift pumps are the direct line, centrifugal, and peristaltic. A major disadvantage of any suction pump is that it is limited in its ability to raise water by the head available from atmospheric pressure. Thus, if the surface of the water is more than about 25 ft below the pump, water may not be withdrawn. The theoretical suction limit is about 34 ft, but most suction pumps are capable of maintaining a water lift of only 25 ft or less.

6.1.2.2 Many suction pumps draw the water through some sort of volute in which impellers, pistons, or other devices operate to induce a vacuum. Such pumps are probably unacceptable for most sampling purposes because they are usually constructed of common materials such as brass or mild steel and may expose samples to lubricants. They often induce very low pressures around rotating vanes or other such parts such that degassing or even cavitation may occur. They can mix air with the sample via small leaks in the casing, and they are difficult to adequately clean between uses. Such pumps are acceptable for purging of wells, but should not generally be used for sampling.

6.1.2.3 One exception to the above statements is a peristaltic pump. A peristaltic pump is a self-priming, low volume suction pump which consists of a rotor with ball bearing rollers (21). Flexible tubing is inserted around the pump rotor and squeezed by heads as they revolve in a circular pattern around the rotor. One end of the tubing is placed into the well while the other end can be connected



NOTE—Taken from Ref (4).

FIG. 7 Bladder Pump

directly to a receiving vessel. As the rotor moves, a reduced pressure is created in the well tubing and an increased pressure (<40 psi) on the tube leaving the rotor head. A drive shaft connected to the rotor head can be extended so that multiple rotor heads can be attached to a single drive shaft.

6.1.2.4 The peristaltic pump moves the liquid totally within the sample tube. No part of the pump contacts the liquid. The sample may still be degassed (cavitation is unlikely) but the problems due to contact with the pump mechanism are eliminated. Peristaltic pumps do require a fairly flexible section of tubing within the pumphead itself. A section of silicone tubing is commonly used within the peristaltic pumphead, but other types of tubing can be used particularly for the sections extending into the well or from the pump to the receiving container. The National Council of the Paper Industry for Air and Stream Improvement (22) recommends using medical grade silicone tubing for organic sampling purposes as the standard grade uses an organic vulcanizing agent which has been shown to leach into samples. Medical grade silicone tube is, however, limited to use over a restricted range of ambient temperatures. Various manufacturers offer tubing lined with TFE-fluorocarbon or Viton[3] for use with their pumps. Gibb (1, 8) found little difference between samples withdrawn by a peristaltic pump and those taken by a bailer.

6.1.2.5 A direct method of collecting a sample by suction consists of lowering one end of a length of plastic tubing into the well or piezometer. The opposite end of the tubing is connected to a two way stopper bottle and a hand held or mechanical vacuum pump is attached to a second tubing leaving the bottle. A check valve is attached between the two lines to maintain a constant vacuum control. A sample can then be drawn directly into the collection vessel without contacting the pump mechanism (5, 23, 24).

6.1.2.6 A centrifugal pump can be attached to a length of plastic tubing that is lowered into the well. A foot valve is usually attached to the end of the well tubing to assist in priming the tube. The maximum lift is about 4.6 m (15 ft) for such an arrangement (23, 25, 26).

6.1.2.7 Suction pump approaches offer a simple sample retrieval method for shallow monitoring. The direct line method is extremely portable though considerable oxidation and mixing may occur during collection. A centrifugal pump will agitate the sample to an even greater degree although pumping rates of 19 to 151 Lpm (5 to 40 gpm) can be attained. A peristaltic pump provides a lower sampling rate with less agitation than the other two pumps. The withdrawal rate of peristaltic pumps can be carefully regulated by adjustment of the rotor head revolution.

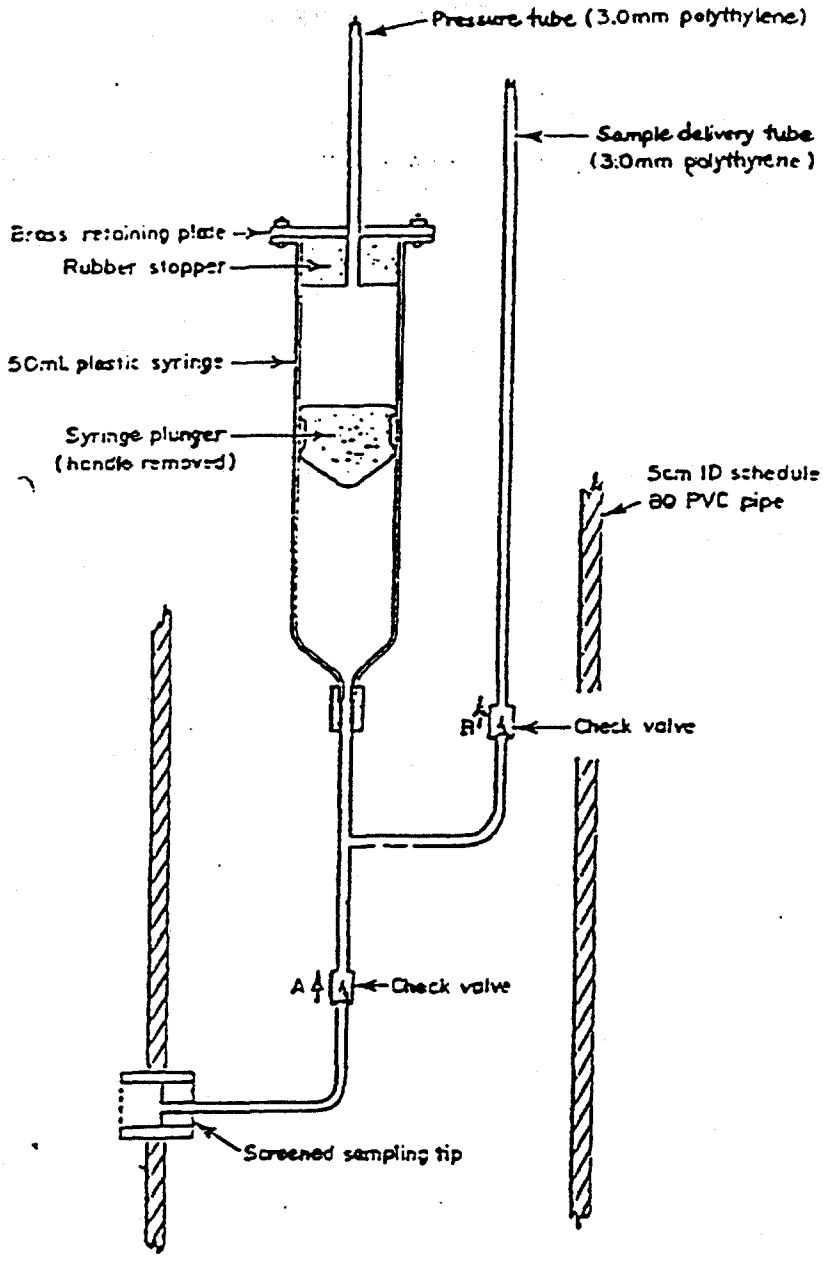
6.1.2.8 All three systems can be specially designed so that the water sample contacts only the TFE flourocarbon or silicone tubing prior to sample bottle entry. Separate tubing is recommended for each well or piezometer sampled.

6.1.3 *Electric Submersible Pumps:*

6.1.3.1 A submersible pump consists of a sealed electric motor that powers a piston or helical single thread worm at a high rpm. Water is brought to the surface through an access tube. Such pumps have been used in the water well industry for years and many designs exist (5, 26).

6.1.3.2 Submersible pumps provide relatively high discharge rates for water withdrawal at depths beyond suction

[3] Viton is a trademark of E. I. du Pont de Nemours & Co., Wilmington, DE 19898 and has been found suitable for this purpose.



NOTE—Taken from Ref (48).

FIG. 8 Positive Displacement Syringe Pump

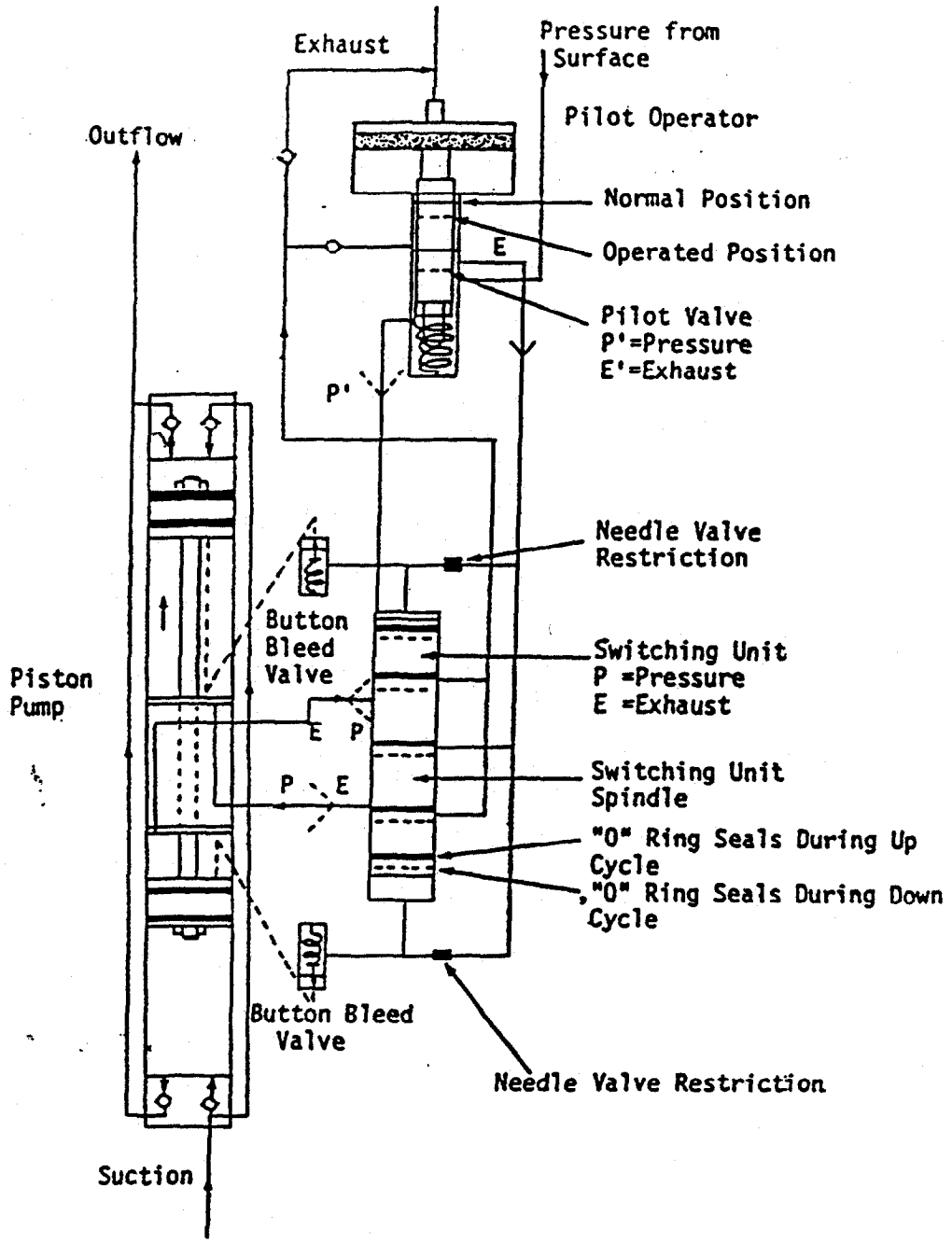
lift capabilities. A battery operated unit 3.6 cm (1.4 in.) in diameter and with a 4.5 Lpm (1.2 gpm) flow rate at 33.5 m (110 ft) has been developed (27). Another submersible pump has an outer diameter of 11.4 cm (4.5 in.) and can pump water from 91 m (300 ft). Pumping rates vary up to 53.0 Lpm (14 gpm) depending upon the depth of the pump (28).

6.1.3.3 A submersible pump provides higher extraction rates than many other methods. Considerable sample agitation results, however, in the well and in the collection tube during transport. The possibility of introducing trace metals into the sample from pump materials also exists. Steam cleaning of the unit followed by rinsing with unchlorinated, deionized water is suggested between sampling when analysis for organics in the parts per million (ppm) or parts per billion (ppb) range is required (29).

6.1.4 *Gas-Lift Pumps:*

6.1.4.1 Gas-lift pumps use compressed air to bring a water sample to the surface. Water is forced up an eductor pipe that may be the outer casing or a smaller diameter pipe inserted into the well annulus below the water level (30, 31).

6.1.4.2 A similar principle is used for a unit that consists of a small diameter plastic tube perforated in the lower end. This tube is placed within another tube of slightly larger diameter. Compressed air is injected into the inner tube; the air bubbles through the perforations, thereby lifting the water sample via the annulus between the outer and inner tubing (32). In practice, the eductor line should be submerged to a depth equal to 60 % of the total submerged eductor length during pumping (26). A 60 % ratio is considered optimal although a 30 % submergence ratio is adequate.



NOTE—Taken from Ref (49).

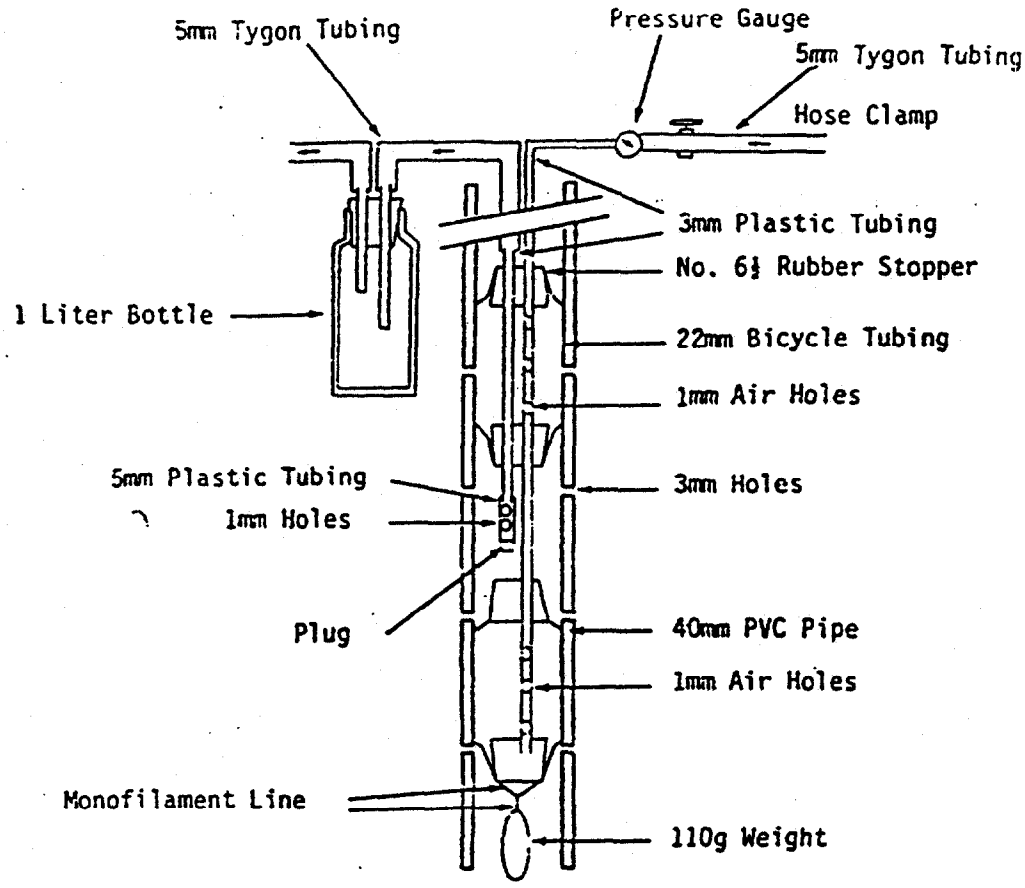
FIG. 9 Gas Driven Piston Pump

6.1.4.3 The source of compressed gas may be a hand pump for depths generally less than 7.6 m (25 ft). For greater depths, air compressors, pressurized air bottles, and air compressed from an automobile engine have been used.

6.1.4.4 As already mentioned, gas-lift methods result in considerable sample agitation and mixing within the well, and cannot be used for samples which will be tested for volatile organics. The eductor pipe or weighted plastic tubing is a potential source of sample contamination. In addition, Gibb (8) uncovered difficulties in sampling for inorganics. These difficulties were attributed to changes in redox, pH, and species transformation due to solubility constant changes resulting from stripping, oxidation, and pressure changes.

6.1.5 *Gas Displacement Pumps:*

6.1.5.1 Gas displacement or gas drive pumps are distinguished from gas-lift pumps by the method of sample transport. Gas displacement pumps force a discrete column of water to the surface via mechanical lift without extensive mixing of the pressurized gas and water as occurs with air-lift equipment. The principle is shown schematically in Fig. Water fills the chamber. A positive pressure is applied to the



NOTE—Taken from Ref (53).

FIG. 10 Packer Pump Arrangement

gas line closing the sampler check valve and forcing water up the sample line. By removing the pressure the cycle can be repeated. Vacuum can also be used in conjunction with the gas (30). The device can be permanently installed in the well (33, 34, 35) or lowered into the well (36, 37).

6.1.5.2 A more complicated two stage design constructed of glass with check valves made of TFE-fluorocarbon has been constructed (38, 39). The unit was designed specifically for sample testing for trace level organics. Continuous flow rates up to 2.3 Lpm (0.6 gpm) are possible with a 5.1 cm (2 in.) diameter unit.

6.1.5.3 Gas displacement pumps have also been developed with multiple functions. The water sample in Fig. 5 provides piezometric data measurements with an internally mounted transducer (40). A sample with its transducer exposed externally for piezometric measurements is illustrated in Fig. 6 (41). The sensor can activate the gas source at the surface to cause sample chamber pressurization at the predetermined depth. Another design can be used as a water sampler or as a tool for injecting brine or other tracers into a well (42).

6.1.5.4 Gas displacement pumps offer reasonable potential for preserving sample integrity because little of the driving gas comes in contact with the sample as the sample is conveyed to the surface by a positive pressure. There is, however, a potential loss of dissolved gasses or contamination from the driving gas and the housing materials.

6.1.6 *Bladder Pumps:*

6.1.6.1 Bladder pumps, also referred to as gas-operated squeeze pumps, consist of a flexible membrane enclosed by a rigid housing. Water enters the membrane through a check valve in the vessel bottom; compressed gas injected into the cavity between the housing and bladder forces the sample through a check valve at the top of the membrane and into a discharge line (Fig. 7). Water is prevented from re-entering the bladder by the top check valve. The process is repeated to cycle the water to the surface. Samples taken from depths of 30.5 m (100 ft) have been reported.

6.1.6.2 A variety of design modifications and materials are available (43, 44). Bladder materials include neoprene, rubber, ethylene propylene terpolymer (E.P.T.), nitrile, and the fluorocarbon Viton.[3] A bladder made of TFE-fluorocarbon is also under development (45). Automated sampling systems have been developed to control the time between pressurization cycles (46).

6.1.6.3 Bladder pumps provide an adaptable sampling tool due primarily to the number of bladder shapes that are feasible. These devices have a distinct advantage over gas displacement pumps in that there is no contact with the driving gas. Disadvantages include the large gas volumes required, low pumping rates, and potential contamination from many of the bladder materials, the rigid housing, or both.

6.1.7 *Gas Driven Piston Pumps:*

6.1.7.1 A simple and inexpensive example of a gas driven piston pump is a syringe pump (47). The pump (Fig. 8) is constructed from a 50 mL plastic syringe with plunger stem removed. The device is connected to a gas line to the surface and the sample passes through a check valve arrangement to a sampling container at the surface. By successively applying positive and negative pressure to the gas-line, the plunger is activated driving water to the surface.

6.1.7.2 A double piston pump powered by compressed air is illustrated in Fig. 9. Pressurized gas enters the chamber between the pistons; the alternating chamber pressurization activates the piston which allows water entry during the suction stroke of the piston and forces the sample to the surface during the pressure stroke (48). Pumping rates between 9.5 and 30.3 L/hr (2.5 to 8 gal/hr) have been reported from 30.5 m (100 ft). Depths in excess of 457 m (1500 ft) are possible.

6.1.7.3 The gas piston pump provides continuous sample withdrawal at depths greater than is possible with most other approaches. Nevertheless, contribution of trace elements from the stainless steel and brass is a potential problem and the quantity of gas used is significant.

6.1.8 *Packer Pump Arrangement:*

6.1.8.1 A packer pump arrangement provides a means by which two expandable "packers" isolate a sampling unit between two packers within a well. Since the hydraulic or pneumatic activated packers are wedged against the casing wall or screen, the sampling unit will obtain water samples only from the isolated well portion. The packers are deflated for vertical movement within the well and inflated when the desired depth is attained. Submersible, gas lift, and suction pumps can be used for sampling. The packers are usually constructed from some type of rubber or rubber compound (48, 49, 50, 51). A packer pump unit consisting of a vacuum sampler positioned between two packers is illustrated in Fig. 10 (52).

6.1.8.2 A packer assembly allows the isolation of discrete sampling points within a well. A number of different samplers can be situated between the packers depending upon the analytical specifications for sample testing. Vertical movement of water outside the well casing during sampling is possible with packer pumps but depends upon the pumping rate and subsequent disturbance. Deterioration of the expandable materials will occur with time with the increased possibility of undesirable organic contaminants contributing to the water sample.

7. Sample Containers and Preservation

7.1 Complete and unequivocal preservation of samples, whether domestic wastewater, industrial wastes, or natural waters, is practically impossible. At best, preservation techniques only retard the chemical and biological changes that inevitably continue after the sample is removed from the source. Therefore, insuring the timely analysis of a sample should be one of the forrmost considerations in the sampling plan schedule. Methods of preservation are somewhat limited and are intended to retard biological action, retard hydrolysis of chemical compounds and complexes, and reduce the volatility of constituents. Preservation methods are generally limited to pH control, chemical addition, refrigeration and freezing. For water samples, immediate refrigeration just above freezing (4°C in wet ice) is often the best preservation technique available, but it is not the only measure nor is it applicable in all cases. There may be special cases where it might be prudent to include a recording thermometer in the sample shipment to verify the maximum and minimum temperature to which the samples were exposed. Inexpensive devices for this purpose are available.

7.2 All bottles and containers must be specially precleaned, pre-labelled, and organized in ice-chests (isolating samples and sampling equipment from the environment) before one goes into the field. Otherwise, in any comprehensive program utter chaos usually develops in the field or laboratory. The time in the field is very valuable and should be spent on taking field notes, measurements, and in documenting samples, not on labelling and organizing samples. Therefore, the sampling plan should include clear instructions to the sampling personnel concerning the information required in the field data record logbook (notebook), the information needed on container labels for identification, the chain-of-custody protocols, and the methods for preparing field blanks and spiked samples. Example of detailed plans and documentation procedures have been published (14, 53).

7.3 The exact requirements for the volumes of sample needed and the number of containers to use may vary from laboratory to laboratory. This will depend on the specific analyses to be performed, the concentration levels of interest, and the individual laboratory protocols. The manager of the sampling program should make no assumptions about the laboratory analyses. He should discuss the analytical requirements of the sampling program in detail with the laboratory coordinator beforehand. This is especially the case since some analyses and preservation measures must be performed at the laboratory as soon as possible after the samples arrive. Thus, appropriate arrangements must be made.

7.4 There are a number of excellent references available which list the containers and preservation techniques appropriate for water and soils (13, 14, 50, 54, 55, 56). The "Handbook for Sampling and Sample Preservation of Water and Wastewater" is an excellent reference and perhaps the most comprehensive one (14). Some of this information is summarized in Table 1.

7.5 Sample containers for trace organic samples require special cleaning and handling considerations (57). The sample container for purgeable organics consist of a screw-cap vial (25 to 125 mL) fitted with a TFE-flourocarbon faced silicone septum. The vial is sealed in the laboratory immediately after cleaning and is only opened in the field just prior to pouring sample into it. The water sample then must be sealed into the vial headspace free (no air bubbles) and immediately cooled (4°C) for shipment. Multiple samples (usually about four taken from one large sample container) are taken because leakage of containers may cause losses, may allow air to enter the containers, and may cause erroneous analysis of some constituents. Also, some analyses are best conducted on independent protected samples.

7.6 The purgeable samples must be analyzed by the laboratory within 14 days after collection, unless they are to be analyzed for acrolein or acrylonitrile (in which case they are to be analyzed within 3 days). For samples for solvent extractions (extractable organics-base neutrals, acids and

pesticides), the sample bottles are narrow mouth, screw cap quart bottles or half-gallon bottles that have been precleaned, rinsed with the extracting organic solvent and oven dried at 105°C for at least 1 h. These bottles must be sealed with TFE-fluorocarbon lined caps (Note). Samples for organic extraction must be extracted within 7 days and analyzed within 30 days after extraction. Special pre-cleaned, solvent rinsed and oven-dried stainless steel beakers (one for each monitoring well) may be used for transferring samples from the sampling device to the sample containers.

NOTE—When collecting samples, the bottles should not be overfilled or prerinsed with sample before filling because oil and other materials may remain in the bottle. This can cause erroneously high results.

7.7 For a number of groundwater parameters, the most meaningful measurements are those made in the field at the time of sample collection or at least at an on-site laboratory. These include the water level in the well and parameters that sometimes can change rapidly with storage. A discussion of the various techniques for measuring the water level in the well is contained in a NCASI publication (5) and detailed procedures are outlined in a U.S. Geological Survey publication (58). Although a discussion of these techniques is beyond the scope of this guide, it is important to point out that accurate measurements must be made before a well is flushed or only after it has had sufficient time to recover. Parameters that can change rapidly with storage include specific conductance, pH, turbidity, redox potential, dissolved oxygen, and temperature. For some of the other parameters, the emphasis in groundwater monitoring is on the concentration of each specific dissolved component, not the total concentration of each. Samples for these types of measurements should be filtered through 0.45 µm membrane filters ideally in the field or possibly at an on-site laboratory as soon as possible. Analyses often requiring filtered samples include all metals, radioactivity parameters, total organic carbon, dissolved orthophosphate (if needed), and total dissolved phosphorous (if needed) (13, 14). If metals are to be analyzed, filter the sample prior to acid preservation. For TOC organics, the filter material should be tested to assure that it does not contribute to the TOC. The type or size of the filter to be used is not well understood. However, if results of metal, TOC or other parameters that could be effected by solids are to be compared, the same filtering procedure must be used in each case. Repeated analytical results should state whether the samples were filtered and how they were filtered.

7.8 Shipment and receipt of samples must be coordinated with the laboratory to minimize time in transit. All samples for organic analysis (and many other parameters), should arrive at the laboratory within one day after it is shipped and be maintained at about 4°C with wet ice. The best way to get them to the laboratory in good condition is to send them in sturdy insulated ice chests (coolers) equipped with bottle dividers. 24-h courier service is recommended, if personal delivery service is not practical.

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SOP F105
Surface Water and Sediment Sample Acquisition

SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION
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SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION

1.0 PURPOSE

This procedure describes methods and equipment commonly used for collecting environmental samples of surface water and aquatic sediment either for on-site examination and chemical testing or for laboratory analysis.

2.0 SCOPE

The information presented in this SOP is generally applicable to all environmental sampling of surface waters (Section 5.2) and aquatic sediments (Section 5.3), except where the analyte(s) may interact with the sampling equipment.

Specific sampling problems may require the adaptation of existing equipment or design of new equipment. Such innovations shall be documented and presented in the Sampling and Analysis Plan.

3.0 DEFINITIONS

Grab Sample - An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes.

Composite Sample - A sample collected over time that typically consists of a series of discrete samples which are combined or composited.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation for procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific surface water and/or sediment sampling techniques and equipment to be used, and

documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of surface water and sediment samples.

5.0 PROCEDURES

Collecting a representative sample from surface water or sediments is difficult due to water movement, stratification or patchiness. To collect representative samples, one must standardize sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important quality not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location, selection, and collection methods are important to ensure that a truly representative sample has been collected. Regardless of scrutiny and quality control applied during laboratory analyses, reported data are only as good as the confidence that can be placed on the representativeness of the samples.

5.1 Defining the Sampling Program

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives; accessibility; site topography; flow, mixing and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties (which effect adsorption/desorption). The sampling

plan must therefore reflect not only the mixing characteristics of streams and lakes, but also the role of fluvial-sediment transport, deposition, and chemical sorption.

5.1.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition are: (a) overland runoff; (b) leachate influx to the waterbody; (c) direct waste disposal (solid or liquid) into the water body; and (d) groundwater flow influx to the water body. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (when constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly nondetectable concentrations. Such dispersion does not, however, always readily occur throughout the entire body of water; the mixing may be limited to specific flow streams within the water body. For example, obtaining a representative sample of contamination from the center of a channel immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants which may accumulate

in low-energy environments while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb on particulate matter. Nitrogen, phosphorus, and the heavy metals also may be transported by particulates. Samples will be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

The first step in selecting sampling locations, therefore, is to review site history, define hydrologic boundaries and features of the site, and identify the sources, pathways and potential distribution of contamination based on these considerations. The numbers, types and general locations of required samples upgradient, on site and downgradient can then be identified.

5.1.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description of site conditions must be balanced against the costs of collection as controlled by accessibility. Wading or sampling from a stream bank often is sufficient for springs, seeps, and small streams. Bridges or piers are the first choice for locating a sampling station on a larger stream or small river; they provide ready access and also permit the sampling technician to sample any point across the stream or river. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment.

If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample. Use of boats or wading to collect samples requires the use of U. S. Coast Guard approved personal flotation devices (PFDs).

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance will apply.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data in association with contaminant concentration data are essential for estimating the total contaminant load carried by the stream. If a gaging station is not conveniently located on a selected stream, obtaining stream flow data by direct or indirect methods shall be explored.

5.1.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the Sampling and Analysis Plan. For single-event, site- or area-characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases it may be appropriate to sample only one phase, although this often is not recommended. If samples are collected primarily for monitoring purposes, consisting of repetitive, continuing measurements to define variations and trends at a given location, water samples shall be collected at established and consistent intervals, as specified in the Sampling and Analysis Plan (often monthly or quarterly), and during droughts and floods. Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water quality data shall be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program.

5.2 Surface Water Sample Collection

This section presents methods for collection of samples from various surface water bodies, as well as a description of types of surface water sampling equipment. The guidance in this section should be used to develop specific sampling procedures based on site conditions and investigation goals. A summary of sampling techniques and procedures is given in Section 5.2.5.

5.2.1 Streams, Rivers, Outfalls and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls and drainage features at a single point vary from the simplest of hand sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) method.

Samples from different depths or cross-sectional locations, collected during the same sampling episode, shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be collected depend on the river's width, depth, discharge, and amount of suspended sediment. With a greater number of individual points sampled, it is more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling location can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross-section.

For larger streams greater than three feet in depth, two samples at each station shall be taken from just below the surface, and just above the bottom.

5.2.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify according to physical or chemical differences than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling locations on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is conducted on each aliquot of the vertical composite. In naturally-formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical grab samples shall be composited to form a single sample. These vertical samples often are collected along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline which is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer which is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite sample consists of several vertical samples collected at various depths.

As it is likely that poor mixing may occur in lakes with irregular shape (with bays and coves that are protected from the wind), separate composite samples may be needed to adequately represent water quality. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements now are made in-situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

5.2.3 Estuaries

Estuarine areas are by definition among those zones where inland freshwaters (both surface and ground) mix with marine waters. Estuaries generally are categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations:

- Mixed estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Being well mixed, the sampling locations are not critical in this type of estuary.

- Salt wedge estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic estuary - characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shore line.

Sampling in estuarine areas normally is based upon the tidal phases, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements coupled with vertical dissolved oxygen and temperature profiles.

5.2.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type required. The most frequently used samplers are:

- Dip sampler
- Weighted bottle
- Kemmerer
- Depth-Integrating Sampler

The dip sampler and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include:

- Disposable and/or easily decontaminated
- Inexpensive (if the item is to be disposed of)
- Ease of operation
- Nonreactive/noncontaminating - Teflon-coating, glass, stainless steel or PVC sample chambers are preferred (in that order)

Each sample (grab or each aliquot collected for compositing) shall be measured for: specific conductance; temperature; pH; and dissolved oxygen (optional) as soon as it is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

5.2.4.1 Dip Sampling

Water often is sampled by filling a container, either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible it is recommended to augment dip samples with samples that represent both dissolved and suspended constituents, and both vertical and horizontal distributions. Dip sampling often is the most appropriate sampling method for springs, seeps, ditches, and small streams.

5.2.4.2 Weighted Bottle Sampling

A grab sample also can be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a stopped glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling is as follows:

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
- Pull out the stopper with a sharp jerk of the sampler line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
- Raise the sampler and cap the bottle.
- Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

5.2.4.3 Kemmerer

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. A "messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

5.2.5 Surface Water Sampling Techniques

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container directly in the body of water. The following suggestions are applicable to sampling springs, seeps, ditches, culverts, small streams and other relatively small bodies of water, and are presented to help ensure that the samples obtained are representative of site conditions:

- The most representative samples will likely be collected from near mid-stream, the center of flow in a culvert, etc.
- Downstream samples shall be collected first, with subsequent samples taken while moving upstream. Care shall be taken to minimize sediment disturbance while collecting surface water samples. If necessary, sediment samples shall be collected after the corresponding surface water sample.
- Samples may be collected either by immersing the approved sample container or a glass or nalgene beaker into the water. Sample bottles (or beakers) which do not contain preservatives shall be rinsed at least once with the water to be sampled prior to sample collection.
- Care shall be taken to avoid excessive agitation of the water which may result in the loss of volatile constituents. Additionally, samples for volatile organic analyses shall be collected first, followed by the samples for other constituents.
- Measurements for temperature, pH, specific conductance, or other field parameters, as appropriate, shall be collected immediately following sample collection for laboratory analyses.
- All samples shall be handled as described in SOP F301.
- The sampling location shall be marked via wooden stake placed at the nearest bank or shore. The sampling location number shall be marked with indelible ink on the stake.

- The following information shall be recorded in the field logbook:

  - Project location, date and time.
  - Weather.
  - Sample location number and sample identification number.
  - Flow conditions (i.e., high, low, in flood, etc.) and estimate of flow rate.
  - Visual description of water (i.e., clear, cloudy, muddy, etc.).
  - On-site water quality measurements.
  - Sketch of sampling location including boundaries of water body, sample location (and depth), relative position with respect to the site, location of wood identifier stake.
  - Names of sampling personnel.
  - Sampling technique, procedure, and equipment used.

General guidelines for collection of samples from larger streams, ponds or other water bodies are as follows:

- The most representative samples are obtained from mid-channel at mid- stream depth in a well-mixed stream.

- For sampling running water, it is suggested that the farthest downstream sample be obtained first and that subsequent samples be taken as one works upstream. Work may also proceed from zones suspected of low contamination to zones of high contamination.

- It is suggested that sample containers which do not contain preservative be rinsed at least once with the water to be sampled before the sample is taken.

- To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one composite sample, or several grids are selected at random.

- Care should be taken to avoid excessive agitation of the water that would result in the loss of volatile constituents.

- When obtaining samples in 40 ml septum vials for volatile organics analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner faces inward. The bottle can be turned upside down to check for air bubbles after the bottle is filled and capped.

- Do not sample at the surface unless sampling specifically for a known constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the mouth of the bottle facing upstream.

- Measurements for temperature, pH, specific conductance, or other field parameters, as appropriate shall be collected immediately following sample collection for laboratory analysis.

- All samples shall be handled as described in SOP F301.
- Items to be recorded in the field logbook are the same as those described above for small streams.

5.3 Sediment Sampling

Sediment samples usually are collected at the same locations as surface water samples. If only one sediment sample is to be collected, the sample location shall be approximately at the center of the water body. If, however, multiple samples are required, sediment samples should be collected along a cross-section to characterize the bed material. A common procedure for obtaining multiple samples is to sample at quarter points along the cross-section of flow. As with surface water samples, sediment samples should be collected from downstream to upstream.

5.3.1 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using on-shore or off-shore techniques.

When boats are used for sampling, U. S. Coast Guard approved personal flotation devices must be provided and two individuals must undertake the sampling. An additional person shall remain on-shore in visual contact at all times.

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers
- Bucket/hand auger
- Stainless steel spoon or trowel

5.3.1.1 Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping in the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

5.3.1.2 Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permits direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the chance of metal contamination from the frame of the device.

5.3.1.3 Bucket (Hand) Auger

Bucket (hand) augering is a viable method for collecting sediment samples in narrow, intermittent streams or tidal flats. Typically, a 4-inch auger bucket with a cutting head is pushed and twisted into the ground and removed as the bucket is filled. The auger hole is advanced one bucket at a time, to a depth specified in the project plans.

When a specific vertical sampling interval is required, one auger bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a new bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of sediment should be removed from the bucket to minimize the changes of cross-contamination of the sample from fall-in of material from the upper portions of the hole. The bucket auger should be decontaminated between samples as outlined in SOP F502.

5.3.1.4 Stainless Steel Spoon or Trowel

For loosely packed sediments, a stainless steel scoop or trowel can be used to collect a representative sample, in narrow intermittent streams or tidal flats.

Use the scoop or trowel to collect the sample from a desired depth. Remove heavy debris, rocks, and twigs before collecting the sample. Immediately transfer the sample to the appropriate sample container. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, chain-of-custody record, and other required forms.

5.3.2 Sediment Sampling Procedure

The following general procedure should be used, where applicable, for sampling sediment from springs, seeps, small streams, ditches, or other similar small bodies of water. Procedures sampling larger bodies of water (i.e., rivers, lakes, estuaries, etc.) should be developed on a project-specific basis, as needed.

- Sediment samples shall be collected only after the corresponding surface water sample has been collected, if one is to be collected.

- Sediment samples shall be collected from downstream locations to upstream locations.

- Samples shall be collected by excavating a sufficient amount of bottom material using a scoop, beaker, spoon, trowel, or auger. Samples should be collected with the sampling device facing upstream and the sample collected from downstream to upstream. Care should be taken to minimize the loss of fine-grained materials from the sample.

- The sample shall be transferred to the appropriate sample containers. Sampling personnel shall use judgment in removing large plant fragments to limit bias caused by bio-organic accumulation.

- All samples shall be handled as described in SOP F301.

- The sampling location shall be marked via a wooden stake placed at the nearest bank or shore. The sample location number shall be marked on the stake with indelible ink.

- The following information shall be recorded in the field logbook:

  - Project location, date and time.
  - Weather.
  - Sample location number and sample identification number.
  - Flow conditions.
  - Sketch of sampling location including boundaries of water body, sample location, water depth, sample collection depth, relative position with respect to the site, location of wooden identifier stake.
  - Chemical analyses to be performed.
  - Description of sediment (refer to SOP F001).

6.0 QUALITY ASSURANCE RECORDS

The description of the sampling event in the field logbook shall serve as a quality assurance record. Other records include chain-of-custody and sample analysis request forms as discussed in SOP F302.

7.0 REFERENCES

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SOP F106
Test Pit and Trench Excavation

TEST PIT AND TRENCH EXCAVATION
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TEST PIT AND TRENCH EXCAVATION

1.0 PURPOSE

The purpose of this procedure is to provide general reference information and technical guidance on the excavation of exploratory test pits and trenches.

2.0 SCOPE

These procedures provide overall technical guidance and may be modified by site-specific requirements for field exploratory trenches and test pits. Conditions which would make trench excavation difficult (such as a shallow water table), dangerous (presence of explosive materials or underground utilities) or likely to cause environmental problems (such as potential rupture of buried containerized wastes), will require modifications to the procedures presented herein and may prevent implementation of the exploratory excavation program. Furthermore, the costs and difficulties in disposing of potentially hazardous materials removed from the test pits may constrain their use to areas where contamination potential is low. Consequently, the techniques described herein are most applicable in areas of low apparent contamination and where potentially explosive materials are not expected to be present.

3.0 DEFINITIONS

Trench - Trench means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet. If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet or less (measured at the bottom of the excavation), the excavation is also considered to be a trench (definition from Federal Register, Vol. 54 No. 209, Tuesday, October 31, 1989, 29 CFR Part 1926 Occupational Safety and Health Standards - Excavations; Final Rule) (see Attachment A).

Test Pit - A test pit is a small excavation made below ground surface to characterize soil type and quality as well as determine the types of wastes buried. In general, a test pit is dug using a backhoe with dimensions measured as follows:

Width - Typically two to three backhoe buckets wide
Length - Typically five to 10 feet long
Depth - Typically to top of water table or one to two feet below base of fill material

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that field personnel responsible for trench and test pit excavation are familiar with these procedures. It also is the responsibility of the Project Manager to ensure that all appropriate documents (i.e., Test Pit Logs) have been completely and correctly filled out by the field inspector.

Field Team Leader - The Field Team Leader is responsible for the overall supervision of all test pit and trenching activities, and for ensuring that each test pit is properly and completely logged by the field inspector. It also is the responsibility of the Field Team Leader to ensure that all field inspectors have been briefed on these procedures.

Field Inspector - The Field Inspector is responsible for the direct supervision of test pit and trenching activities. It is the Field Inspector's responsibility to log each test pit, document subsurface conditions, complete appropriate forms, and to direct the test pit or trenching activities.

5.0 PROCEDURES

The procedures for test pit sizes, health and safety considerations, sampling, and backfilling are discussed in the following sections. Regulation for trench excavation, including trench sizes are given in the Tuesday October 31, 1989 edition of the Federal Register, 29 CFR Part 1926, "Occupation Safety and Health Standards - Excavations; Final Rule" (see Attachment A).

5.1 Test Pit Sizes

Test pits and trenches permit detailed exploration of the nature and contamination of in-situ materials, and the characteristics and stratification of near surface materials. The size of the excavation will depend on:

- Purpose and extent of the exploration.
- Space limitations imposed by site conditions (i.e., proximity to buildings, utilities, etc.).
- Contaminants present and the potential for release to the environment.
- Stability of the materials being excavated.
- Capabilities and limitations of the excavating equipment.

Test pits normally have a width ranging from two to ten feet or greater, depending on the objectives of the excavation and the equipment used. Test trenches are elongated test pits, usually three- to six-feet wide and extending for any desired length.

Standard equipment (i.e., backhoe) is readily available to excavate to depths of up to about 15 feet. However, larger and deeper excavations may be required. Standard equipment can be used to excavate deeper than their nominal limits by stepping or benching the excavation.

5.2 Health and Safety Considerations

Care must be taken by all on-site personnel during every phase of the test pit or trench excavation operation to avoid possible chemical and physical hazards. Chemical hazards may occur from direct exposure to excavated wastes or inhalation of volatilized materials. Physical hazards include the possible collapse of the trench or test pit, possible injury through violent contact with excavation equipment, or explosion or other forceful reaction upon contact with utilities exposed drums or other wastes.

All test pit and trench excavation activities must be carefully detailed in the site-specific Health and Safety Plan which will specify all precautions to be observed relative to possible chemical or physical hazards associated with these operations. Respiratory and personal protective equipment to be worn by all on-site personnel involved in excavation operations also will be specified in this document.

At locations where access is not restricted, a safety zone shall be established around the excavation. Additionally, personnel should, NOT under any circumstances, enter the excavation. Prior written approval and procedures documented in the Sampling and Analysis Plan and Health and Safety Plan, and approved by LANTDIV are required if entry into the excavation is to be considered. Additionally, a site Health and Safety Officer familiar with excavations shall be on site and shall direct the entry procedures.

5.3 Logging and Sampling

Test pits and/or trenches shall be logged and sampled by the Field Inspector. Soils shall be classified and described in accordance with the procedures given in SOP F101. Test Pit Records (see Figure 1) shall be legibly completed for all test pits. Samples shall only be collected from material in the equipment bucket, or from the pile of excavated materials. The excavation shall NOT be entered for the purpose of collecting samples.

5.4 Backfilling

Backfilling of trenches and test pits is a normally accepted practice to reduce immediate site hazards and minimize the potential for rainwater accumulation and subsequent contaminant migration.

After inspection and completion of the appropriate test pit logs, backfill material should be returned to the pit under the direction of the field inspector. Any hazardous and/or waste materials which are not returned to the excavation as backfill must be collected and properly disposed. If a low permeability layer is accidentally penetrated, or if a soil layer containing substantial quantities of contaminants is encountered, backfill material must consist of a soil-bentonite mix. The mix should be prepared in a proportion specified by the field inspector and should be covered by "clean" soil and graded to the original land contour. Where it is safe to do so, the backhoe bucket should be used to compact each one to two-foot layer of backfill as it is placed, to reduce settling and compaction. The test pit cover should be inspected and further regraded, if necessary after settling has occurred.

Figure 1

TEST PIT RECORD

Baker
Baker Environmental, Inc

PROJECT: _____
CTO NO.: _____ TEST PIT NO.: _____
COORDINATES: EAST _____ NORTH: _____
SURFACE ELEVATION: _____ WATER LEVEL: _____
WEATHER: _____ DATE: _____

REMARKS: _____

DEFINITIONS

HNU = Photo Ionization Detector Reading
OVA = Organic Vapor Analyzer Reading

Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	HNU (OVA) or ppm		Lab. Class.	Lab. Moist %	Soil Strat	Visual Description (Principal Constituents, Gradation, Color, Moisture Content, Organic Content, Plasticity, and Other Observations)	Elevation (MSL)
		Field	Head Space					
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

CONTRACTOR: _____ BAKER REP.: _____
EQUIPMENT: _____ TEST PIT NO.: _____ SHEET 1 OF 1

5.5 Test Pit Excavation Procedures

The following procedures apply to the excavation and backfilling of a typical test pit. Note that if a subcontractor is procured to perform the test pit operations, the subcontractor must provide both an equipment operator and a supervisor:

- The positions of the test pits shall be located in the field by the field team leader.
- Utility clearance shall be obtained for all test pit locations prior to excavation. Contact appropriate Base personnel as well as MISS Utility (VA, MD, DC) or ULOCO (NC).

MISS Utility (1-800-552-7001)
ULOCO (1-800-632-4949)

- Excavation equipment shall be thoroughly decontaminated prior to and after each test pit excavation.
- A safety zone shall be established around the test pit location prior to initiation of excavation activities.
- Excavation shall commence by removing lifts of no more than approximately 6 to 12 inches of soil.
- The field inspector shall log the test pit soils and record observations on a Test Pit Record (Figure 1). Additionally, the test pit cross-section shall be sketched in the Field Logbook with notable features identified.
- If applicable, soil or waste samples shall be collected either from the backhoe bucket or from the pile of excavated materials following all appropriate SOPs (i.e., F102).
- Test pit depths (and water levels) may be measured using an engineers rule (six foot) or a weighted measuring tape. Depths shall be measured from the ground surface.
- Upon completion, test pits shall be immediately backfilled as described in Section 5.4.
- Test pit locations shall be marked with five wooden stakes; one at each corner and one in the center. The test pit number shall be recorded on the centrally located stake.
- If applicable, the test pit will be surveyed by a registered land surveyor or measured and referenced to nearby permanent site structures (i.e., buildings, curbs, fences, etc.).

6.0 QUALITY ASSURANCE RECORDS

The Quality Assurance Records that should be prepared include Test Pit Records and the Field Logbook.

7.0 REFERENCES

OSHA , 1989. Occupational Safety and Health Standards - Excavations; Final Rule. 29 CFR Part 1926.

ATTACHMENT A

OSHA - EXCAVATIONS, FINAL RULE
29 CFR PART 1926

federal register

Tuesday
October 31, 1989

Part II

Department of Labor

Occupational Safety and Health Administration

29 CFR Part 1926

Occupational Safety and Health Standards—Excavations; Final Rule

PART 1926—[AMENDED]

Subpart M—[Amended]

1. By revising the authority citation for subpart M of part 1926 to read as follows:

Authority: Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12–71 (36 FR 8754), 8–76 (41 FR 25059), or 9–83 (48 FR 35736), as applicable, and 29 CFR part 1911.

2. By revising subpart P of part 1926 to read as follows:

Subpart P—Excavations

Sec.
1926.650 Scope, application, and definitions applicable to this subpart.
1926.651 General requirements.
1926.652 Requirements for protective systems.

Appendix A to Subpart P—Soil Classification

Appendix B to Subpart P—Sloping and Benching

Appendix C to Subpart P—Timber Shoring for Trenches

Appendix D to Subpart P—Aluminum Hydraulic Shoring for Trenches

Appendix E to Subpart P—Alternatives to Timber Shoring

Appendix F to Subpart P—Selection of Protective Systems

Subpart P—Excavations

Authority: Sec. 107, Contract Worker Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12–71 (36 FR 8754), 8–76 (41 FR 25059), or 9–83 (48 FR 35736), as applicable, and 29 CFR part 1911.

§ 1926.650 Scope, application, and definitions applicable to this subpart.

(a) *Scope and application.* This subpart applies to all open excavations made in the earth's surface. Excavations are defined to include trenches.

(b) *Definitions applicable to this subpart.*

Accepted engineering practices means those requirements which are compatible with standards of practice required by a registered professional engineer.

Aluminum Hydraulic Shoring means a pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such system is designed, specifically to support the sidewalls of an excavation and prevent cave-ins.

Bell-bottom pier hole means a type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (Benching system) means a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in means the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

Competent person means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Cross braces mean the horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

Excavation means any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces or *sides* means the vertical or inclined earth surfaces formed as a result of excavation work.

Failure means the breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere means an atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kickout means the accidental release or failure of a cross brace.

Protective system means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp means an inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting means the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system) means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with § 1926.652 (c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system) means a structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sides. See "Faces."

Sloping (Sloping system) means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Stable rock means natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp means a ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system means a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground

installation, or the sides of an excavation.

Tabulated data means tables and charts approved by a registered professional engineer and used to design and construct a protective system.

Trench (Trench excavation) means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box. See "Shield."

Trench shield. See "Shield."

Uprights means the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales means horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

§ 1926.651 General requirements.

(a) *Surface encumbrances.* All surface encumbrances that are located so as to create a hazard to employees shall be removed or supported, as necessary, to safeguard employees.

(b) *Underground installations.* (1) The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation.

(2) Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation. When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law), or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used.

(3) When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means.

(4) While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees.

(c) *Access and egress*—(1) *Structural ramps.* (i) Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

(ii) Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.

(iii) Structural members used for ramps and runways shall be of uniform thickness.

(iv) Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.

(v) Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

(2) *Means of egress from trench excavations.* A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

(d) *Exposure to vehicular traffic.* Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

(e) *Exposure to falling loads.* No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with § 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.

(f) *Warning system for mobile equipment.* When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

(g) *Hazardous atmospheres*—(1) *Testing and controls.* In addition to the requirements set forth in subparts D and E of this part (29 CFR 1926.50–1926.107) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:

(i) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.

(ii) Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with subparts D and E of this part respectively.

(iii) Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas.

(iv) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.

(2) *Emergency rescue equipment.* (i) Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

(ii) Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a life-line securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually

attended at all times while the employee wearing the lifeline is in the excavation.

(h) *Protection from hazards associated with water accumulation.* (1) Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

(2) If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.

(3) If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with paragraphs (h)(1) and (h)(2) of this section.

(i) *Stability of adjacent structures.* (1) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

(2) Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:

(i) A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or

(ii) The excavation is in stable rock; or

(iii) A registered professional engineer has approved the determination that the structure is sufficently removed from the excavation so as to be unaffected by the excavation activity; or

(iv) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

(3) Sidewalks, pavements, and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

(j) *Protection of employees from loose rock or soil.* (1) Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary on the face to stop and contain falling material; or other means that provide equivalent protection.

(2) Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet (.61 m) from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

(k) *Inspections.* (1) Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

(2) Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

(l) *Fall protection.* (1) Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails shall be provided.

(2) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

§ 1926.652 Requirements for protective systems.

(a) *Protection of employees in excavations.* (1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:

(i) Excavations are made entirely in stable rock; or

(ii) Excavations are less than 5 feet (1.52m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

(2) Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

(b) *Design of sloping and benching systems.* The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (b)(1); or, in the alternative, paragraph (b)(2); or, in the alternative, paragraph (b)(3), or, in the alternative, paragraph (b)(4), as follows:

(1) *Option (1)—Allowable configurations and slopes.* (i) Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

(ii) Slopes specified in paragraph (b)(1)(i) of this section, shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this subpart.

(2) *Option (2)—Determination of slopes and configurations using Appendices A and B.* Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be determined in accordance with the conditions and requirements set forth in appendices A and B to this subpart.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of sloping or benching systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and shall include all of the following:

(A) Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;

(B) Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under paragraph (b) of this section shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include at least the following:

(A) The magnitude of the slopes that were determined to be safe for the particular project;

(B) The configurations that were determined to be safe for the particular project; and

(C) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Secretary upon request.

(c) *Design of support systems, shield systems, and other protective systems.* Designs of support systems shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:

(1) *Option (1)—Designs using appendices A, C and D.* Designs for timber shoring in trenches shall be determined in accordance with the conditions and requirements set forth in appendices A and C to this subpart. Designs for aluminum hydraulic shoring shall be in accordance with paragraph (c)(2) of this section, but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with appendix D.

(2) *Option (2)—Designs Using Manufacturer's Tabulated Data.* (i) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

(ii) Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.

(iii) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Secretary upon request.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and include all of the following:

(A) Identification of the parameters that affect the selection of a protective system drawn from such data;

(B) Identification of the limits of use of the data;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include the following:

(A) A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

(B) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Secretary upon request.

(d) *Materials and equipment.* (1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.

(2) Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.

(e) *Installation and removal of support*—(1) *General.* (i) Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

(ii) Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.

(iii) Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.

(iv) Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.

(v) Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.

(vi) Backfilling shall progress together with the removal of support systems from excavations.

(2) *Additional requirements for support systems for trench excavations.* (i) Excavation of material to a level no greater than 2 feet (.61 m) below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.

(ii) Installation of a support system shall be closely coordinated with the excavation of trenches.

(f) *Sloping and benching systems.* Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.

(g) *Shield systems*—(1) *General.* (i) Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.

(ii) Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

(iii) Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

(iv) Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

(2) *Additional requirement for shield systems used in trench excavations.* Excavations of earth material to a level not greater than 2 feet (.61 m) below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

Appendix A to Subpart P

Soil Classification

(a) *Scope and application*—(1) *Scope.* This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

(2) *Application.* This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in § 1926.652(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in § 1926.652(c), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

(b) *Definitions.* The definitions and examples given below are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653–85 and D2488; The Unified Soils Classification System, The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS–121.

Cemented soil means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

Dry soil means soil that does not exhibit visible signs of moisture content.

Fissured means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular soil means gravel, sand, or silt, (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Layered system means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Saturated soil means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

Soil classification system means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.

Stable rock means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Submerged soil means soil which is underwater or is free seeping.

Type A means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:

(i) The soil is fissured; or

(ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or

(iii) The soil has been previously disturbed; or

(iv) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or

(v) The material is subject to other factors that would require it to be classified as a less stable material.

Type B means:

(i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or

(ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.

(iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.

(iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or

(v) Dry rock that is not stable; or

(vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C means:

(i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or

(ii) Granular soils including gravel, sand, and loamy sand; or

(iii) Submerged soil or soil from which water is freely seeping; or

(iv) Submerged rock that is not stable, or

(v) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

Unconfined compressive strength means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

(c) *Requirements*—(1) *Classification of soil and rock deposits.* Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) *Basis of classification.* The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses

shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods of soil classification and testing such as those adopted by the America Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) *Visual and manual analyses.* The visual and manual analyses, such as those methods being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) *Layered systems.* In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) *Reclassification.* If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) *Acceptable visual and manual tests.*—(1) *Visual tests.* Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(ii) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(iii) Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(iv) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(v) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(vi) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(vii) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) *Manual tests.* Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(i) *Plasticity.* Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as ⅛-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of ⅛-inch thread can be held on one end without tearing, the soil is cohesive.

(ii) *Dry strength.* If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

(iii) *Thumb penetration.* The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488—"Standard Recommended Practice for Description of Soils (Visual—Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) *Other strength tests.* Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shearvane.

(v) *Drying test.* The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

(A) If the sample develops cracks as it dries, significant fissures are indicated.

(B) Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as a unfissured cohesive material and the unconfined compressive strength should be determined.

(C) If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

Appendix B to Subpart P

Sloping and Benching

(a) *Scope and application.* This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in § 1926.652(b)(2).

(b) *Definitions.*

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and ravelling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) *Requirements*—(1) *Soil classification.* Soil and rock deposits shall be classified in accordance with appendix A to subpart P of part 1926.

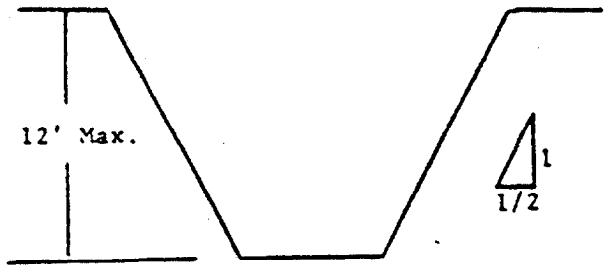
(2) *Maximum allowable slope.* The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.

(3) *Actual slope.* (i) The actual slope shall not be steeper than the maximum allowable slope.

(ii) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least ½ horizontal to one vertical (½H:1V) less steep than the maximum allowable slope.

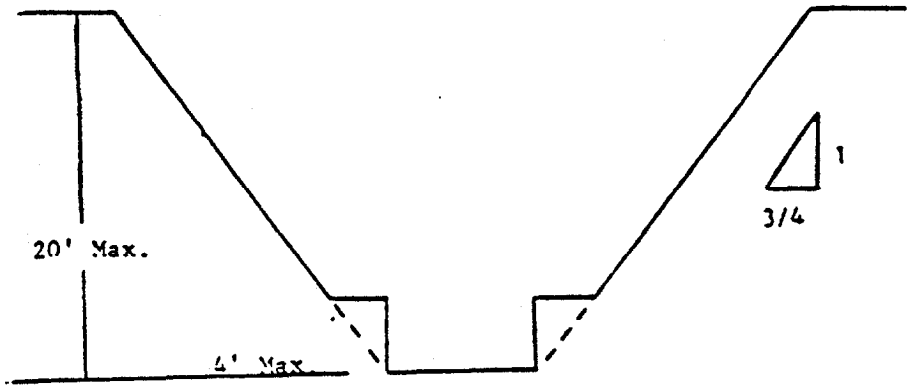
(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with § 1926.651(i).

(4) *Configurations.* Configurations of sloping and benching systems shall be in accordance with Figure B-1.

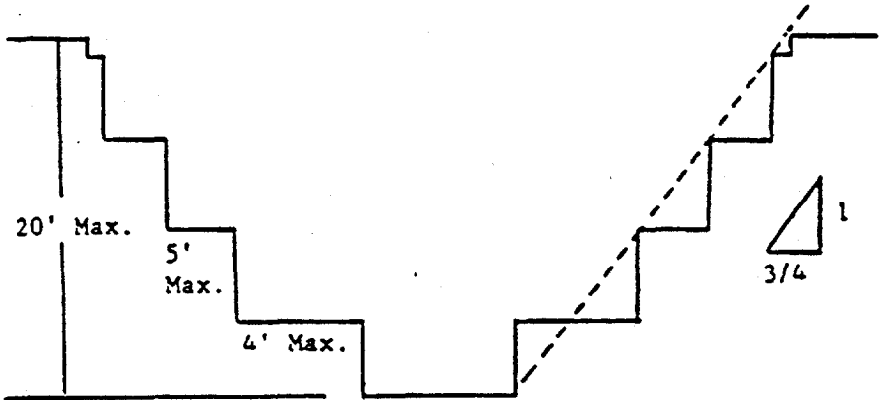


Simple Slope—Short Term

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of ¾ to 1 and maximum bench dimensions as follows:

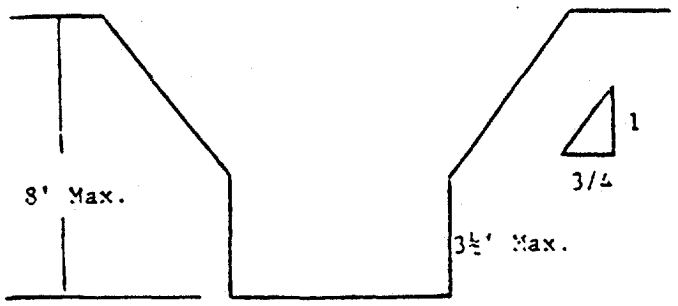


Simple Bench



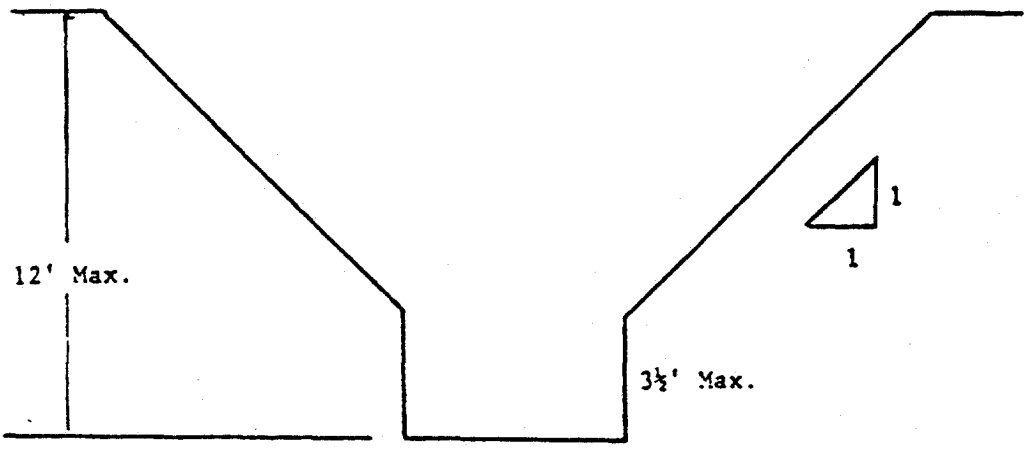
Multiple Bench

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 3½ feet.



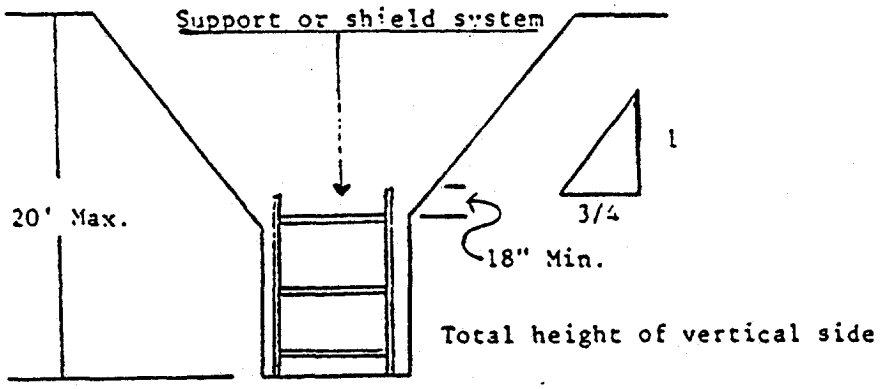
Unsupported Vertically Sided Lower Portion—Maximum 8 Feet in Depth

All excavations more than 8 feet but not more than 12 feet in depth which unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3½ feet.



Unsupported Vertically Sided Lower Portion—Maximum 12 Feet in Depth

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of ¾:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

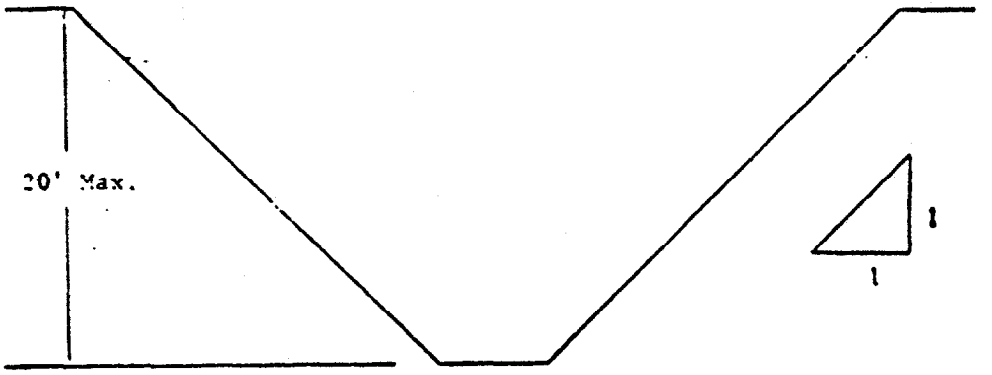


Suported or Shielded Vertically Sided Lower Portion

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under § 1926.652(b).

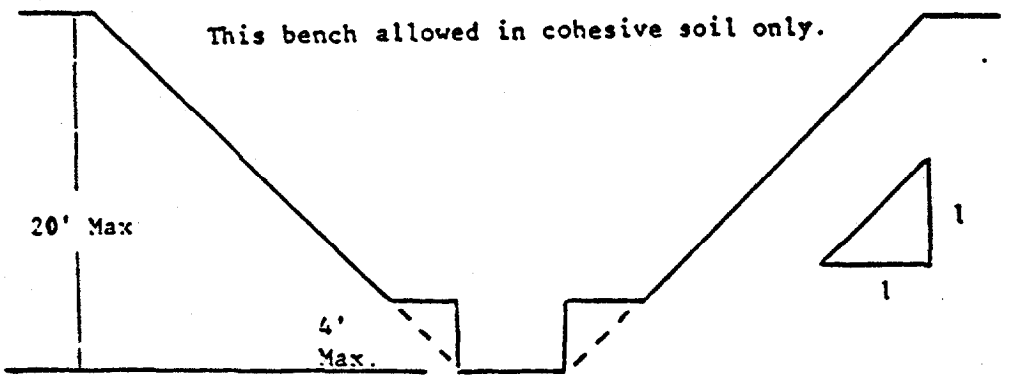
B–1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

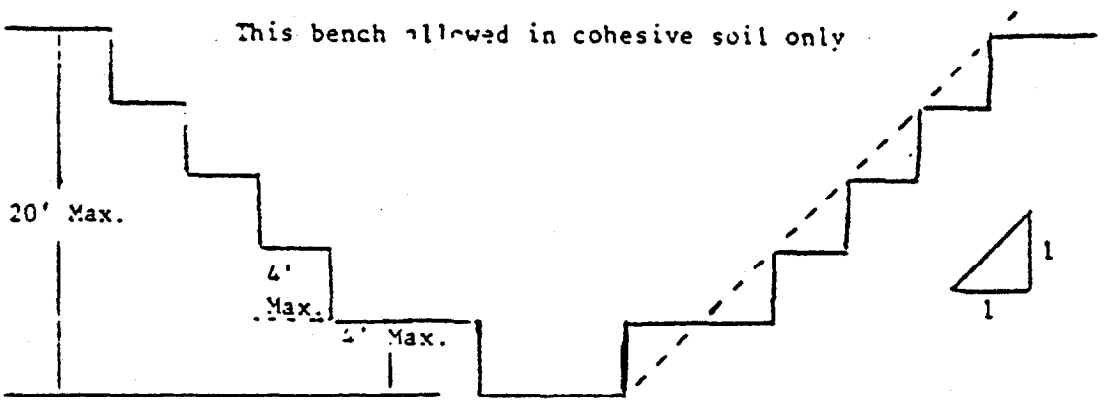


Simple Slope

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

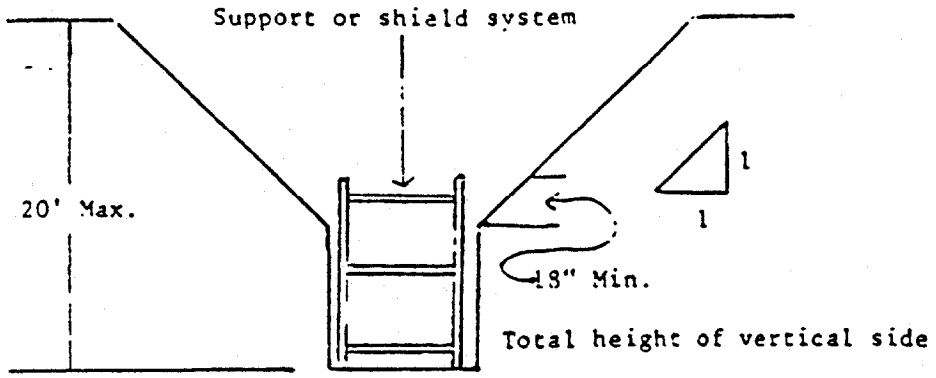


Single Bench



Multiple Bench

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

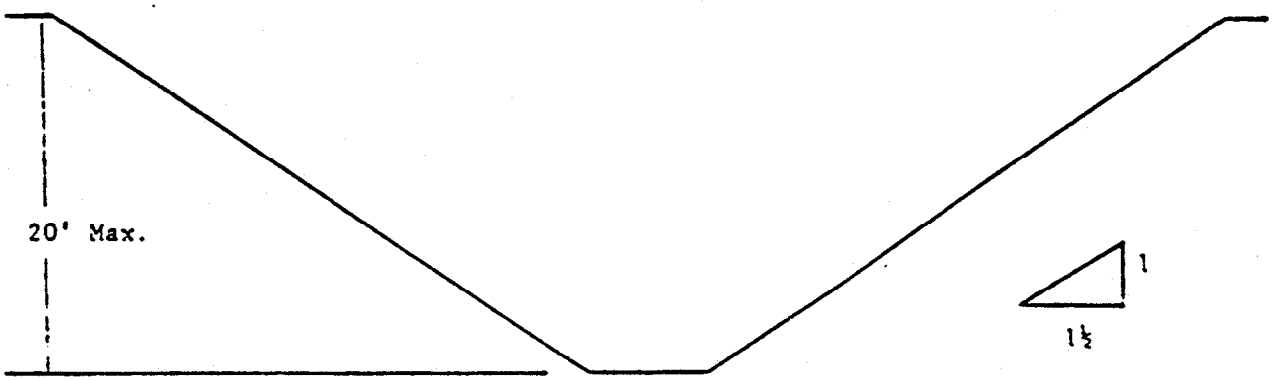


Vertically Sided Lower Portion

4. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

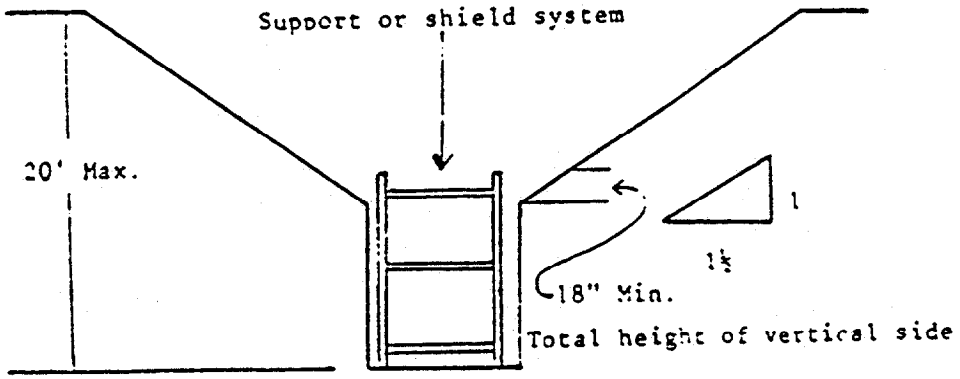
B–1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1½:1.



Simple Slope

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½:1.

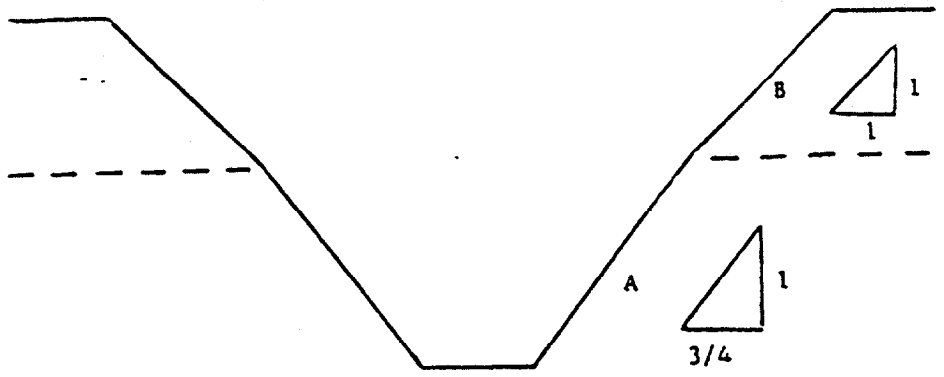


Vertical Sided Lower Portion

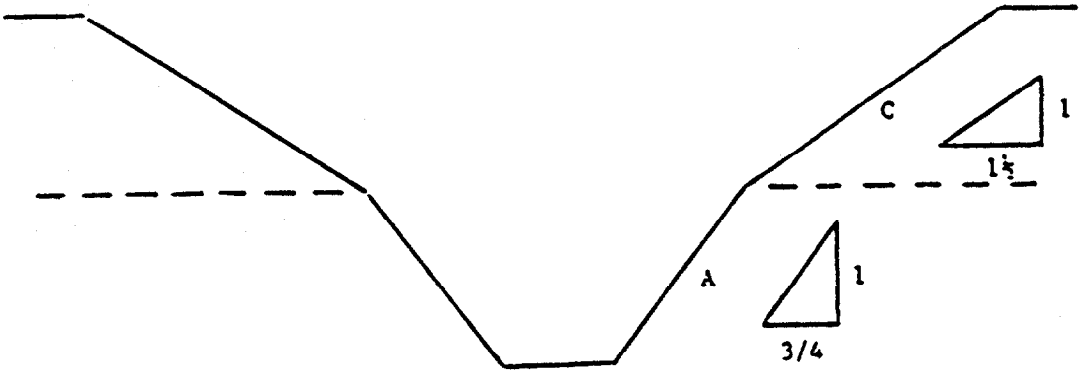
3. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

B–1.4 Excavations Made in Layered Soils

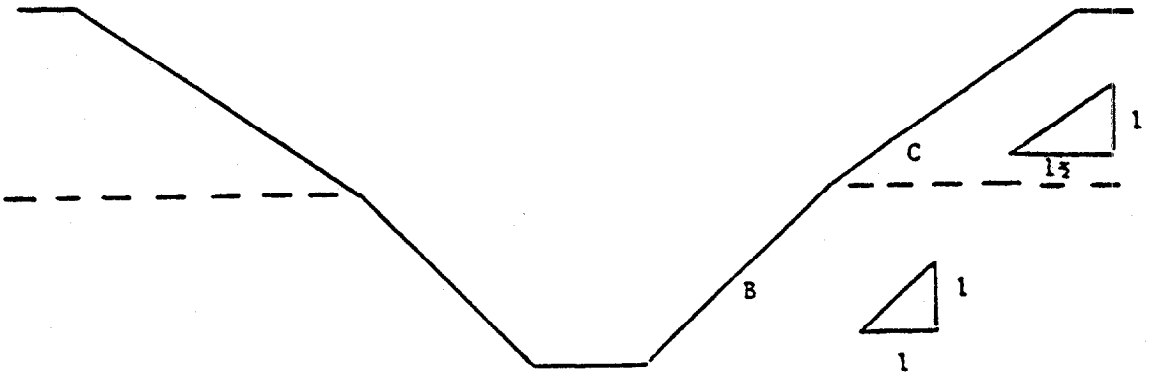
1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



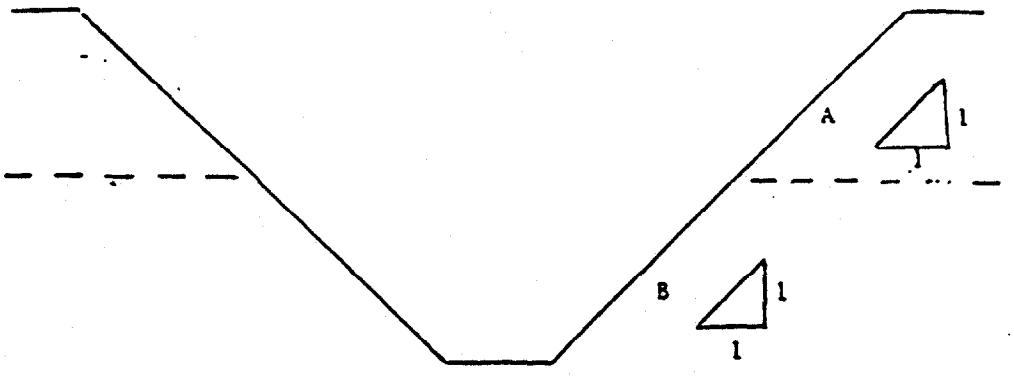
B OVER A



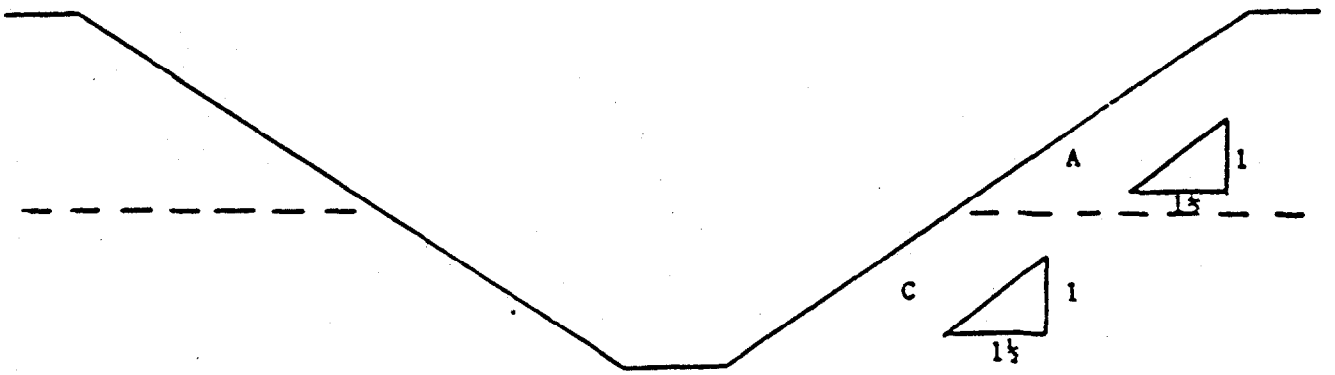
C OVER A



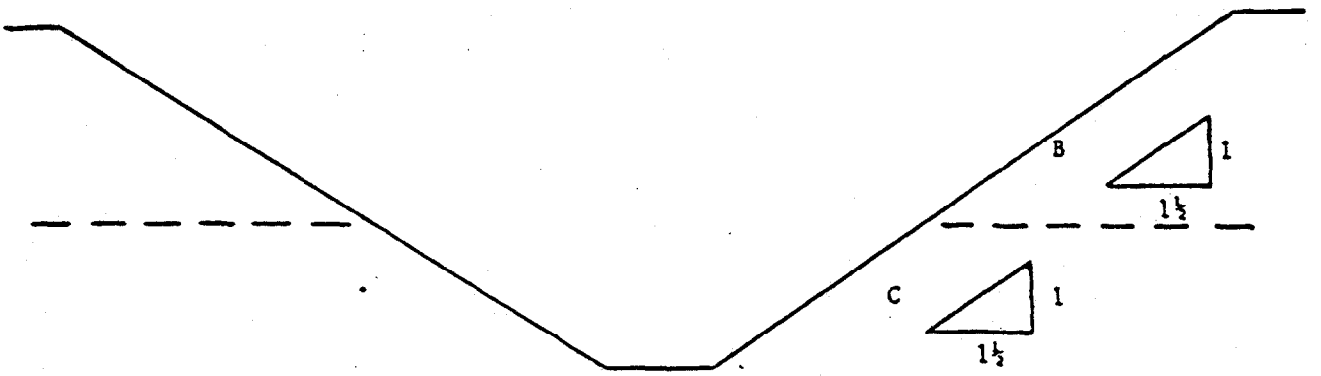
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

Appendix C to Subpart P

Timber Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with § 1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in § 1926.652(b) and § 1926.652(c).

(b) *Soil Classification.* In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil

classification method set forth in appendix A of subpart P of this part.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C-1.1, C-1.2, and C-1.3, and Tables C-2.1, C-2.2 and C-2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in paragraph (g) of this Appendix.

(d) *Basis and limitations of the data.*—(1) *Dimensions of timber members.* (i) The sizes of the timber members listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.

(ii) The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under § 1926.652(c)(3), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.

(2) *Limitation of application.* (i) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in § 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with § 1926.652.

(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables.* The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) *Examples to Illustrate the Use of Tables C-1.1 through C-1.3.*

(1) *Example 1.*

A trench dug in Type A soil is 13 feet deep and five feet wide.

From *Table C-1.1*, for acceptable arrangements of timber can be used.

Arrangement #1

Space 4×4 crossbraces at six feet horizontally and four feet vertically.

Wales are not required.

Space 3×8 uprights at six feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement #2

Space 4×6 crossbraces at eight feet horizontally and four feet vertically.

Space 8×8 wales at four feet vertically.

Space 2×6 uprights at four feet horizontally.

Arrangement #3

Space 6×6 crossbraces at 10 feet horizontally and four feet vertically.

Space 8×10 wales at four feet vertically.

Space 2×6 uprights at five feet horizontally.

Arrangement #4

Space 6×6 crossbraces at 12 feet horizontally and four feet vertically.

Space 10×10 wales at four feet vertically.

Spaces 3×8 uprights at six feet horizontally.

(2) *Example 2.*

A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement #1.

Space 6×6 crossbraces at six feet horizontally and five feet vertically.

Space 8×8 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #2

Space 6×8 crossbraces at eight feet horizontally and five feet vertically.

Space 10×10 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #3

Space 8×8 crossbraces at 10 feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Space 2×6 uprights at two feet vertically.

(3) *Example 3.*

A trench dug in Type C soil is 13 feet deep and five feet wide.

From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #1

Space 8×8 crossbraces at six feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Position 2×6 uprights as closely together as possible.

If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #2

Space 8×10 crossbraces at eight feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Position 2×6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) *Example 4.*

A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.

Space 8×10 crossbraces at six feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Use 3×6 tight sheeting.

Use of Tables C-2.1 through C-2.3 would follow the same procedures.

(g) *Notes for all Tables.*

1. Member sizes at spacings other than indicated are to be determined as specified in § 1926.652(c), "Design of Protective Systems."

2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.

3. All spacing indicated is measured center to center.

4. Wales to be installed with greater dimension horizontal.

5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.

6. Trench jacks may be used in lieu of or in combination with timber crossbraces.

7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

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TABLE C-1.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A $P_a = 25 \times H + 72$ psf (2 ft Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---				2X6	
	UP TO 8	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---					2X8
	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			2X6		
	UP TO 12	4X6	4X6	6X6	6X6	6X6	4	8X8	4				2X6	
10 TO 15	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---				3X8	
	UP TO 8	4X6	4X6	6X6	6X6	6X6	4	8X8	4		2X6			
	UP TO 10	6X6	6X5	6X6	6X8	6X8	4	8X10	4			2X6		
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	10X10	4				3X8	
15 TO 20	UP TO 6	6X6	6X6	6X6	6X8	6X8	4	6X8	4	3X6				
	UP TO 8	6X6	6X6	6X6	6X8	6X8	4	8X8	4	3X6				
	UP TO 10	8X8	8X8	8X8	8X8	8X10	4	8X10	4	3X6				
	UP TO 12	8X8	8X8	8X8	8X8	8X10	4	10X10	4	3X6				
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may by substituted for wood.

TABLE C-1.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B $P_a = 45 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**														
	CROSS BRACES							WALES		UPRIGHTS					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)					
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3			
5 TO 10	UP TO 6	4X6	4X6	6X6	6X6	6X6	5	6X8	5			2X6			
	UP TO 8	6X6	6X6	6X6	6X8	6X8	5	8X10	5			2X6			
	UP TO 10	6X6	6X6	6X6	6X8	6X8	5	10X10	5			2X6			
	See Note 1														
10 TO 15	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5		2X6				
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5		2X6				
	UP TO 10	8X8	8X8	8X8	8X8	8X10	5	10X12	5		2X6				
	See Note 1														
15 TO 20	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	3X6					
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	3X6					
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6					
	See Note 1														
OVER 20	SEE NOTE 1														

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may by substituted for wood.

TABLE C-1.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**														
	CROSS BRACES									UPRIGHTS					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET) (See Note 2)					
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE					
5 TO 10	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	2X6					
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6					
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6					
	See Note 1														
10 TO 15	UP TO 6	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6					
	UP TO 8	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6					
	See Note 1														
	See Note 1														
15 TO 20	UP TO 6	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6					
	See Note 1														
	See Note 1														
	See Note 1														
OVER 20	SEE NOTE 1														

* Mixed Oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A P_a = 25 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET) *	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X4	4X4	4X6	4	Not Req'd	Not Req'd				4X6	
	UP TO 8	4X4	4X4	4X4	4X6	4X6	4	Not Req'd	Not Req'd					4X8
	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			4X6		
	UP TO 12	4X6	4X6	4X6	6X6	6X6	4	8X8	4				4X6	
10 TO 15	UP TO 6	4X4	4X4	4X4	6X6	6X6	4	Not Req'd	Not Req'd				4X10	
	UP TO 8	4X6	4X6	4X6	6X6	6X6	4	6X8	4		4X6			
	UP TO 10	6X6	6X6	6X6	6X6	6X6	4	8X8	4			4X8		
	UP TO 12	6X6	6X6	6X6	6X6	6X6	4	8X10	4		4X6		4X10	
15 TO 20	UP TO 6	6X6	6X6	6X6	6X6	6X6	4	6X8	4	3X6				
	UP TO 8	6X6	6X6	6X6	6X6	6X6	4	8X8	4	3X6	4X12			
	UP TO 10	6X6	6X6	6X6	6X6	6X8	4	8X10	4	3X6				
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	8X12	4	3X6	4X12			
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B P_a = 45 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
5 TO 10	UP TO 6	4X6	4X6	4X6	6X6	6X6	5	6X8	5			3X12 4X8		4X12
	UP TO 8	4X6	4X6	6X6	6X6	6X6	5	8X8	5		3X8		4X8	
	UP TO 10	4X6	4X6	6X6	6X6	6X8	5	8X10	5			4X8		
	See Note 1													
10 TO 15	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5	3X6	4X10			
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5	3X6	4X10			
	UP TO 10	6X8	6X8	8X8	8X8	8X8	5	10X12	5	3X6	4X10			
	See Note 1													
15 TO 20	UP TO 6	6X8	6X8	6X8	6X8	8X8	5	8X10	5	4X6				
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X12	5	4X6				
	UP TO 10	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **														
	CROSS BRACES							WALES		UPRIGHTS					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)					
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE					
5 TO 10	UP TO 6	6X6	6X6	6X6	6X6	8X8	5	8X8	5	3X6					
	UP TO 8	6X6	6X6	6X6	8X8	8X8	5	10X10	5	3X6					
	UP TO 10	6X6	6X6	8X8	8X8	8X8	5	10X12	5	3X6					
	See Note 1														
10 TO 15	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	10X10	5	4X6					
	UP TO 8	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6					
	See Note 1														
	See Note 1														
15 TO 20	UP TO 6	8X8	8X8	8X8	8X10	8X10	5	10X12	5	4X6					
	See Note 1														
	See Note 1														
	See Note 1														
OVER 20	SEE NOTE 1														

* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

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Appendix D to Subpart P

Aluminum Hydraulic Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet (6.1m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with § 1926.652(c)(2).

(b) *Soil Classification.* In order to use data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of part 1926.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables D–1.1, D–1.2, D–1.3 and E–1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D–1.1 and D–1.2 are for vertical shores in Types A and B soil. Tables D–1.3 and D1.4 are for horizontal waler systems in Types B and C soil.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations (footnotes) regarding Table D–1.1 through D–1.4 are presented in paragraph (g) of this appendix.

(6) Figures, illustrating typical installations of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled "Aluminum Hydraulic Shoring; Typical Installations."

(d) *Basis and limitations of the data.*

(1) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D–1 Tables. Aluminum material is 6061–T6 or material of equivalent strength and properties.

(2) Hydraulic cylinders specifications. (i) 2-inch cylinders shall be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufaturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe working capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.

(3) Limitation of application.

(i) It is not intended that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in § 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with § 1926.652.

(A) When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.

(B) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(C) When only the lower portion or a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables D–1.1, D–1.2, D–1.3 and D–1.4.* The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D–1.1 and D–1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting are found in the horizontal wale Tables D–1.3 and D–1.4. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables the vertical spacing is held constant at four feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.

(f) *Example to Illustrate the Use of the Tables:*

(1) Example 1:

A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D–1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)

(2) Example 2:

A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D–1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)

(3) A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D–1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote #2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically, plywood (per footnote (g)(7) to the D–1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

(4) Example 4: A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D–1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) Example 5: A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D–1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(g) *Footnotes, and general notes, for Tables D–1.1, D–1.2, D–1.3, and D–1.4.*

(1) For applications other than those listed in the tables, refer to § 1926.652(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to § 1926.652(c)(2) and § 1926.652(c)(3).

(2) 2 inch diameter cylinders, at this width, shall have structural steel tube (3.5×3.5×0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.

(3) Hydraulic cylinders capacities. (i) 2 inch cylinders shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(4) All spacing indicated is measured center to center.

(5) Vertical shoring rails shall have a minimum section modulus of 0.40 inch.

(6) When vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

(7) Plywood shall be 1.125 in. thick softwood or 0.75 inch. thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores.

(8) See appendix C for timber specifications.

(9) Wales are calculated for simple span conditions.

(10) See appendix D, item (d), for basis and limitations of the data.

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ALUMINUM HYDRAULIC SHORING
TYPICAL INSTALLATIONS

FIGURE NO. 1
VERTICAL ALUMINUM HYDRAULIC SHORING (SPOT BRACING)

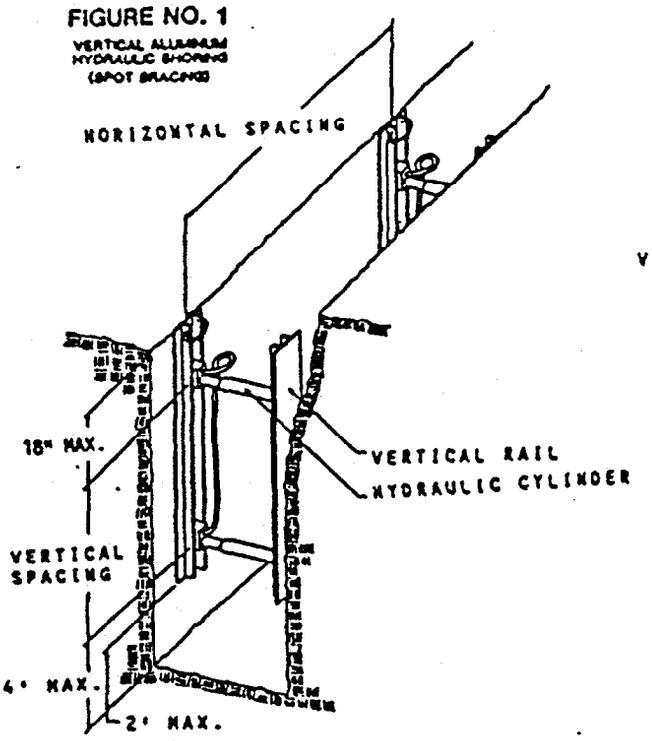


FIGURE NO. 2
VERTICAL ALUMINUM HYDRAULIC SHORING (WITH PLYWOOD)

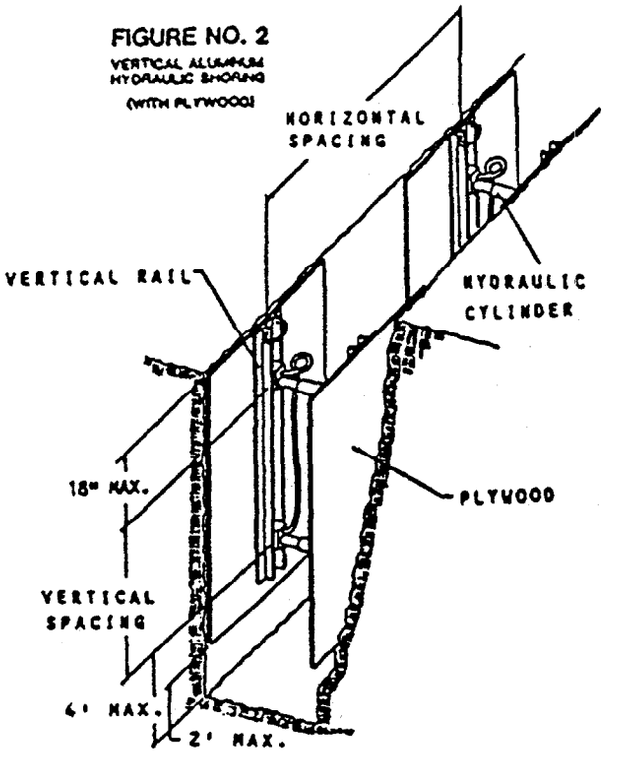


FIGURE NO. 3
VERTICAL ALUMINUM HYDRAULIC SHORING (STACKED)

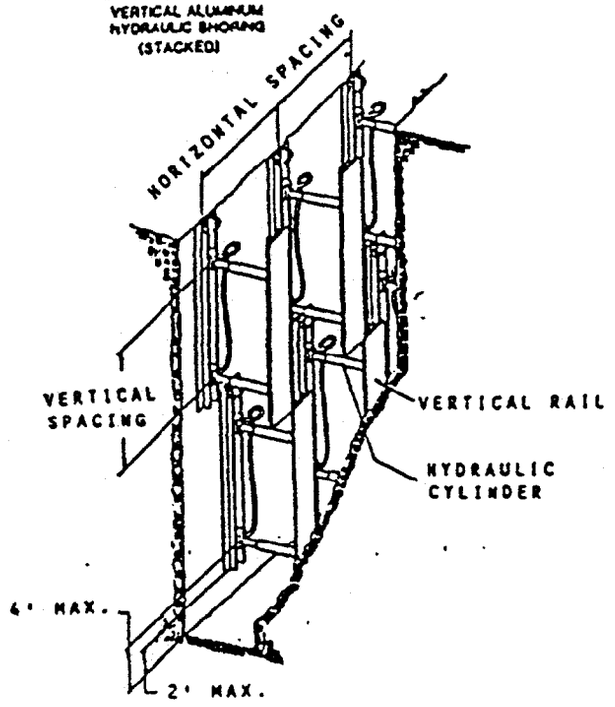


FIGURE NO. 4
ALUMINUM HYDRAULIC SHORING WALER SYSTEM (TYPICAL)

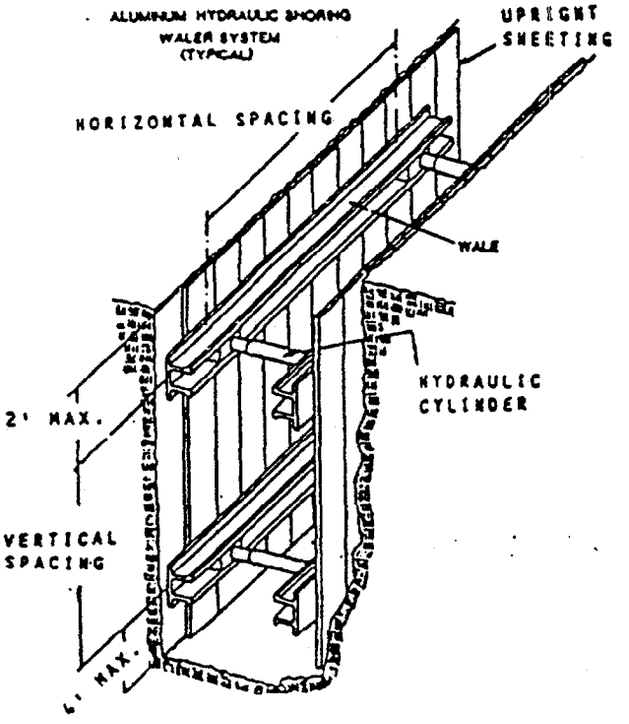


TABLE D - 1.1
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE A

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	8				
OVER 15 UP TO 20	7				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.2
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE B

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	6.5				
OVER 15 UP TO 20	5.5				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.3
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE B

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX.HORIZ.SPACING (ON CENTER)		
	VERTICAL SPACING (FEET)	* SECTION MODULUS (IN^3)	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO15		SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	8.0	2 IN	8.0	2 IN NOTE(2)	8.0	3 IN	—	—	3x12
		7.0	9.0	2 IN	9.0	2 IN NOTE(2)	9.0	3 IN			
		14.0	12.0	3 IN	12.0	3 IN	12.0	3 IN			
OVER 10 UP TO 15	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN	—	3x12	—
		7.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 15 UP TO 20	4	3.5	5.5	2 IN	5.5	2 IN NOTE(2)	5.5	3 IN	3x12	—	—
		7.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
		14.0	9.0	3 IN	9.0	3 IN	9.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g) (1)
Notes (2): See Appendix D, Item (g) (2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

TABLE D - 1.4
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE C

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX.HORIZ SPACING (ON CENTER)		
	VERTICAL SPACING (FEET)	SECTION MODULUS* (IN³)	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN	3x12	—	—
		7.0	6.5	2 IN	6.5	2 IN NOTE(2)	6.5	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 10 UP TO 15	4	3.5	4.0	2 IN	4.0	2 IN NOTE(2)	4.0	3 IN	3x12	—	—
		7.0	5.5	3 IN	5.5	3 IN	5.5	3 IN			
		14.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
OVER 15 UP TO 20	4	3.5	3.5	2 IN	3.5	2 IN NOTE(2)	3.5	3 IN	3x12	—	—
		7.0	5.0	3 IN	5.0	3 IN	5.0	3 IN			
		14.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)

Notes (1): See Appendix D, item (g) (1)

Notes (2): See Appendix D, Item (g) (2)

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

BILLING CODE 4510-26-C

Appendix E to Subpart P—Alternatives to Timber Shoring

Figure 1. Aluminum Hydraulic Shoring

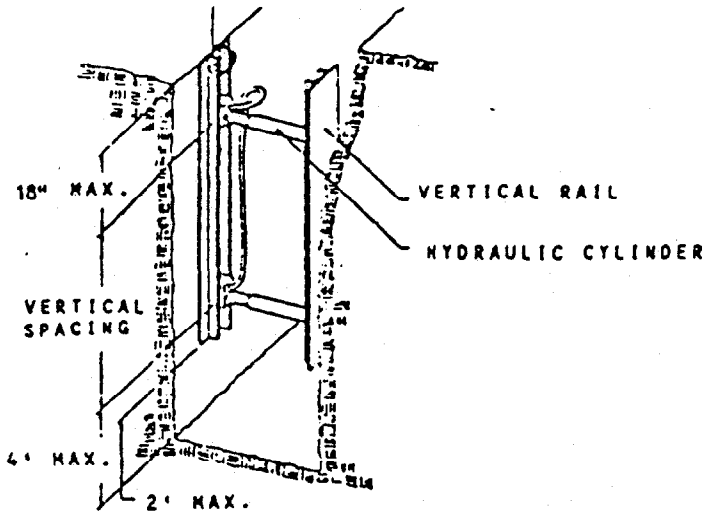
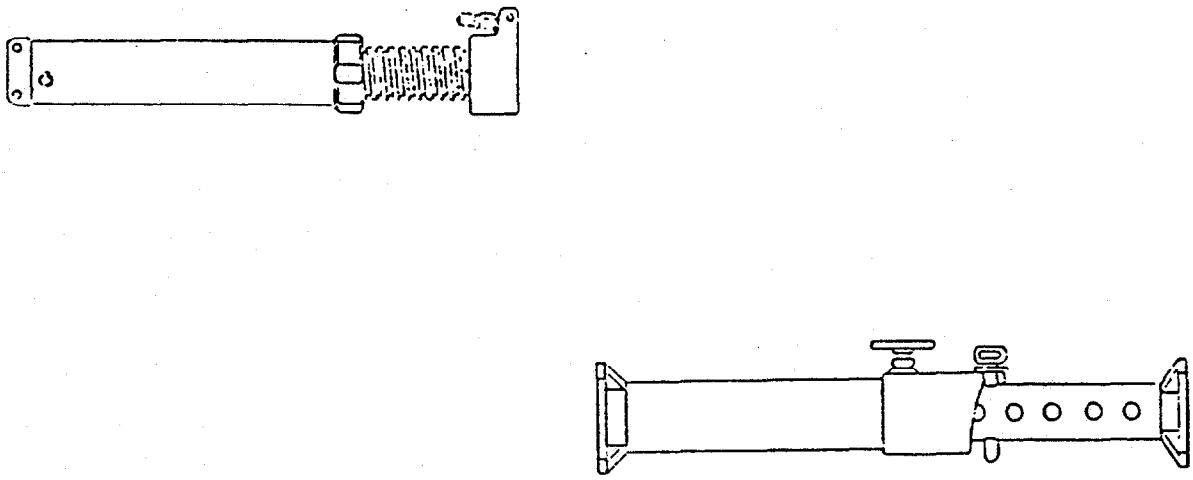


Figure 2. Pneumatic/hydraulic Shoring



BILLING CODE 4510-26-M

Figure 3. Trench Jacks (Screw Jacks)

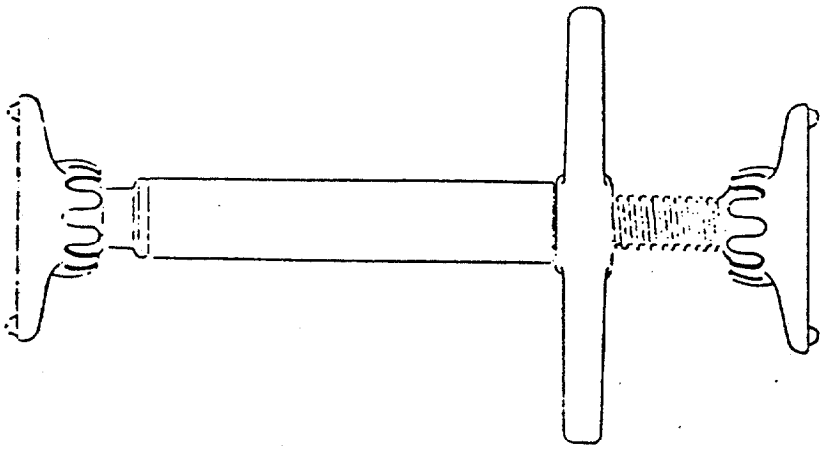
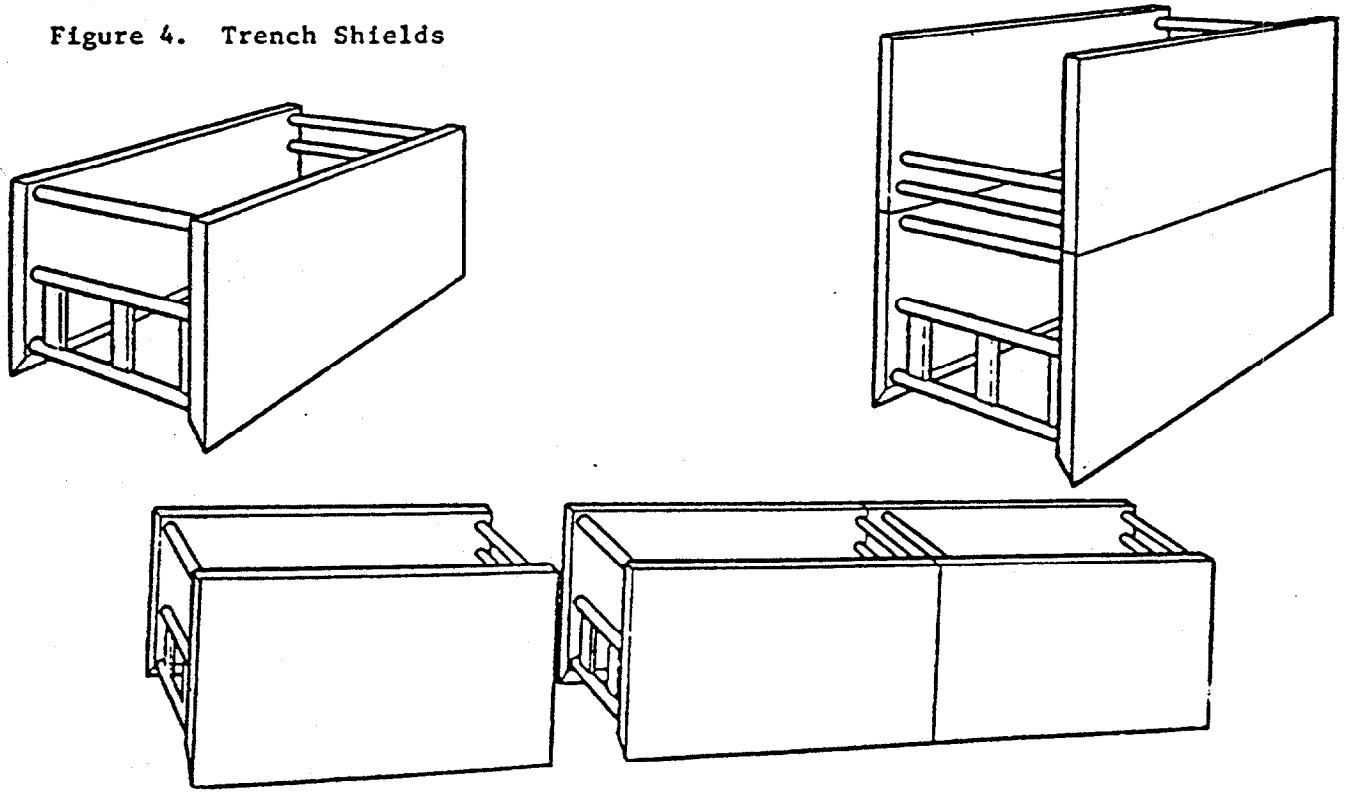


Figure 4. Trench Shields



BILLING CODE 4510-26-C

Appendix F to Subpart P—Selection of Protective Systems

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with § 1926.652 (b) and (c).

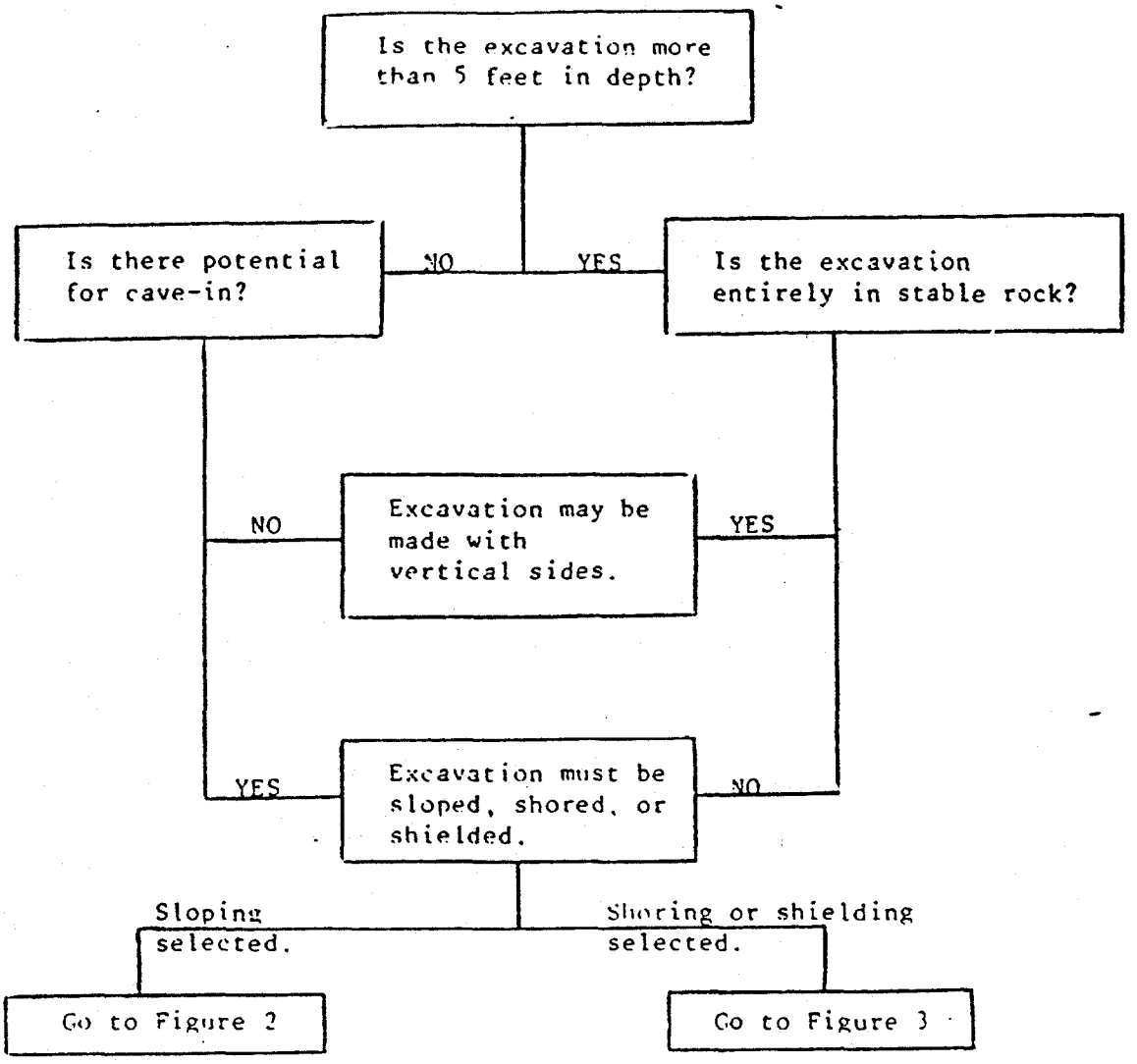


FIGURE 1 - PRELIMINARY DECISIONS

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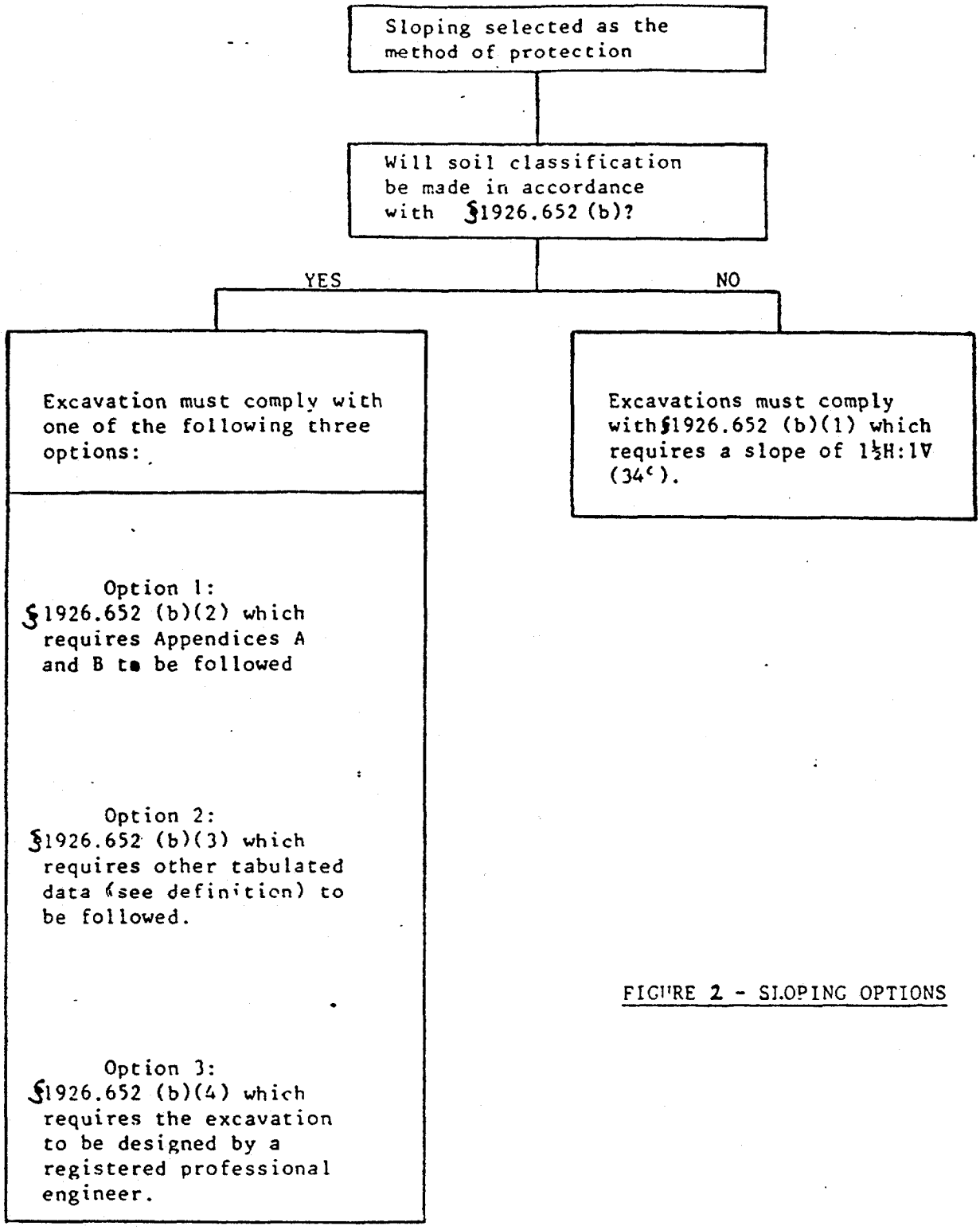

FIGURE 2 - SLOPING OPTIONS

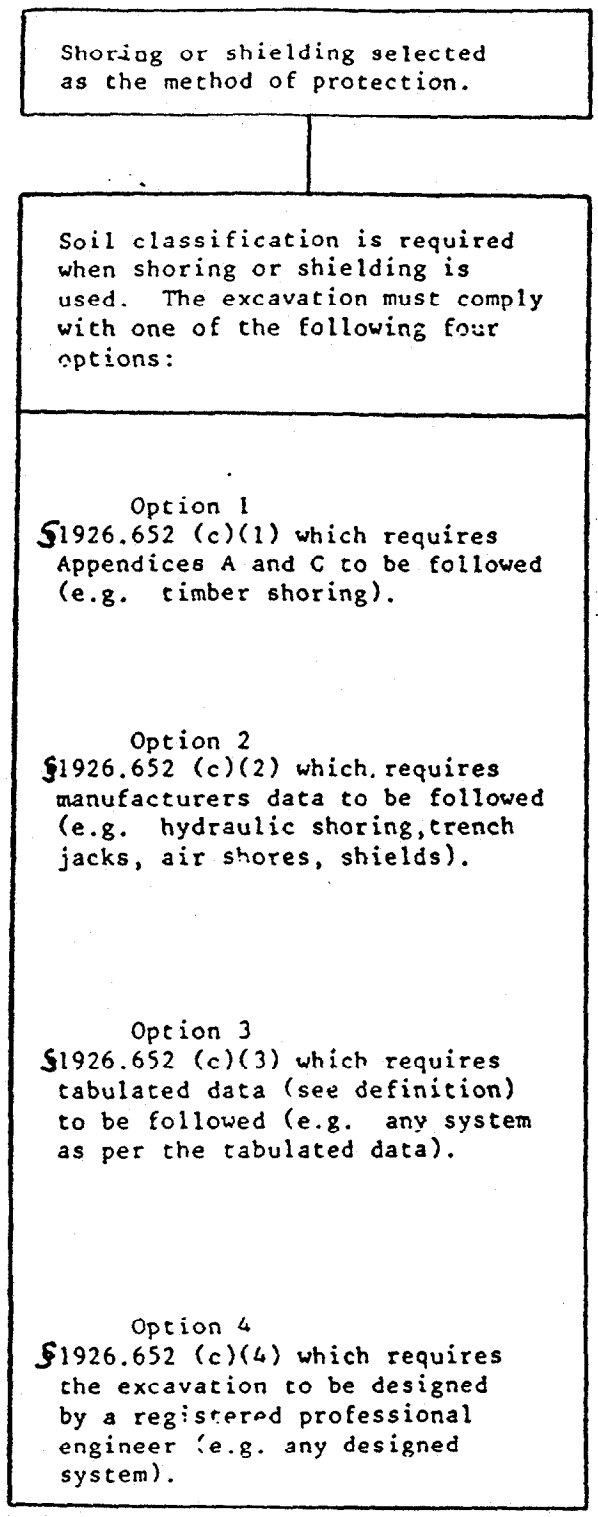

FIGURE 3 - SHORING AND SHIELDING OPTIONS

[FR Doc. 89-25217 Filed 10-30-89; 8:45 am]
BILLING CODE 4510-26-C

SOP F201
On-Site Water Quality Testing

ON-SITE WATER QUALITY TESTING
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ON-SITE WATER QUALITY TESTING (FIELD PARAMETERS)

1.0 PURPOSE

This SOP describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance (Sc)/Salinity
- Temperature (T)
- Dissolved Oxygen Concentration (DO)
- Turbidity (Secchi Disc)

The first three are the usual field parameters; dissolved oxygen may be used in particular applications according to project requirements.

2.0 SCOPE

These procedures are applicable for use in an on-site water quality monitoring program to be conducted during a Remedial Investigation or Site Investigation at a hazardous or nonhazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc.

This procedure provides generic information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

3.0 DEFINITIONS

Conductance - A measurement of water's capacity for conveying electrical current and is directly related to the concentrations of ionized substances in the water. The units of measurement for conductance (mhos) are the inverse of ohms, the unit commonly used to express resistance. Conductivity and specific conductance are used synonymously.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration. The range of pH is 0 to 14 standard units.

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's Law, $E = IR$, where E is the potential difference (in units of volts), I is the current (in units of Amperes), and R is the resistance (in units of ohms).

Secchi disc - A metal disc having four quadrants, two opposing ones painted black and the other two either white or unpainted. The Secchi disc is used to measure turbidity based on the depth of light penetration.

Turbidity - An optical property of water that causes light to be scattered or absorbed in the water, resulting in decrease in water transparency. It is a function of at least three variables: 1) dissolved chemicals, such as tannins, acids, or salts; 2) suspended particles, such as silt, clay, and organic matter; and, 3) density of microbial and planktonic life.

Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for determining which on-site water quality measurements shall be made, the data quality objectives (DQOs) for these measurements, and for ensuring that these measurements are made in accordance with project-specific plans.

Field Team Leader - The Field Team Leader is responsible for determining that these water quality measurement procedures are implemented in the field in accordance with this SOP, or in accordance with project-specific plans, and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures for collecting on-site water quality measurements including instrument calibration, quality control and recording of results, as well as care and maintenance of the instruments in the field.

5.0 PROCEDURES

The following sections provide general procedures for collecting pH, specific conductance/salinity, temperature, dissolved oxygen concentration and turbidity measurements.

5.1 Measurement of pH

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment, such as acid-base neutralization, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH also can be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis; specific measurement techniques for solids are not described here.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required; the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In most cases, use of a pH meter will be required.

5.1.1 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on the establishment of a potential difference across a glass or other type of membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

5.1.2 Equipment

The following equipment and reagents are needed for taking pH measurements:

- Portable pH meter, or pH indicator paper, such as Mydrion or Alkacid, to cover the pH range 2 through 12.

- Laboratory-prepared buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.1.3 Measurement Techniques for Field Determination of pH

A. pH Meter

Standardization, calibration, and operation and maintenance shall be performed according to the manufacturers instructions. The following procedure is used for measuring pH with a pH meter:

1. The batteries and instrument shall be checked and calibrated prior to initiation of the field effort.

2. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.

3. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.

4. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

5. Immerse the electrode(s) in a pH-7 buffer solution.

6. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). It is best to maintain the buffer solution at or near expected sample temperature before calibration, if possible.

7. Adjust the pH meter to read 7.0.

8. Remove the electrode(s) from the buffer and rinse well with distilled-deionized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.

9. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

10. After adjusting the temperature compensator to the sample temperature, read and record the pH of the solution. The pH value shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature. All measurements shall be recorded in the Field Logbook.

11. Upon completion of measurement and removal of the electrode from the sample, the electrode shall be thoroughly rinsed with deionized water.

12. The electrode(s) shall remain immersed in deionized water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution within the electrode, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted in the Field Logbook.

B. pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, or 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper.

5.2 Measurement of Specific Conductance/Salinity

Conductance provides a measure of dissolved ionic species in water and can be used to suggest the direction and extent of migration of contaminants in groundwater or surface water. Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants. One basic measure of salinity is the ability of water to conduct electric current, and, therefore, a measurement of specific conductance provides a measurement of salinity and the same instrument can be used. Salinity measurements are important in ecological field investigations because flora and fauna can be limited in their distribution based on the salinity of the sampled waters.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance and salinity measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.2.1 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions (cations) migrate toward the negative electrode (cathode), while the negatively charged ions (anions) migrate toward the positive electrode (anode). Most

inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell also may be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.2.2 Equipment

A portable conductivity meter, probe and thermometer are needed for taking specific conductance and salinity measurements. A variety of conductivity meters are available which also may be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirements of the sampling program.

5.2.3 Measurement Techniques for Specific Conductance/Salinity

Standardization, calibration, and operation and maintenance shall be performed according to manufacturers instructions. The steps involved in taking specific conductance and salinity measurements are listed below.

1. Check batteries and calibrate instrument before going into the field.

2. Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Calibration information shall be recorded in the field logbook.

3. Rinse the cell with one or more portions of the sample to be tested or with deionized water.

4. Immerse the electrode in the sample and measure the conductivity and salinity. If specified, adjust the temperature setting to the sample temperature.

5. Read and record the results on the Calibration Form (in the absence of the Calibration Form, the Field Logbook will be used).

6. If the meter does not compensate for temperature variations, the corrections given in Attachment A shall be applied.

7. On some meters, specific conductivity and salinity measurements may need to be reported with the associated temperature measurement. If the conductivity and salinity has been corrected, the measurements shall be reported as "corrected to 25°C." (See Attachment A)

   a. Do not take readings if the sample temperature is less than 10° C, because the calibration curve no longer follows a straight line below this temperature. If necessary, heat the sample in your vehicle to at least 10° C.

   b. Measure the sample temperature to the nearest 0.1° C to comply with SW-846.

   c. Only report results to the nearest two significant digits for the most circumstances, because of the inherent inacurracy in the test and conversion procedure.

      examples:

      - a calculated reading of 2353 umhos/cm @ 25° C should be reported as 2400 umhos/cm @ 25° C
      - a calculated reading of 2325 should be reported as 2300
      - a calculated reading of 337 should be reported as 340
      - etc.

5.3 Measurement of Temperature

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of

contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field prior to sample collection. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.3.1 Equipment

Temperature measurements may be taken with Thermistor, alcohol-toluene, mercury or bimetal thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature can be performed.

5.3.2 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.

- Record values in a Field Logbook to the nearest 0.5 or 0.1°C, depending on the measurement device used.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to the manufacturer's recommendations with an approved thermometer.

5.4 Measurement of Dissolved Oxygen Concentration

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms, as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time, if the sample is not adequately preserved.

The method discussed here is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible. DO meters also are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.1 Principles of Equipment Operation

Dissolved oxygen probes normally are electrochemical cells that have two solid metal electrodes of different potential immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of higher nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, but to leave the surface of the solution undisturbed.

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not easily depolarized from the indicating electrode. If gaseous interference is suspected, it shall be noted in the Field Logbook and checked if possible. Temperature variations also can cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation normally is provided by the manufacturer. Attachment B presents variations of DO in water as a fraction of temperature and salinity.

5.4.2 Equipment

The following, similar or equivalent, equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor (or equivalent).
- Dissolved oxygen/temperature probe.
- Sufficient cable to allow the probe to contact the sample.

5.4.3 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration.

1. Calibrate equipment and check batteries in the laboratory before going to the field.

2. The probe shall be conditioned in a water sample for as long as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

3. The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).

4. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers which are placed in wells should be moved up and down.

5. Record the dissolved oxygen content and temperature of the sample in a Field Logbook.

6. Recalibrate the probe when the membrane is replaced, or following similar maintenance, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This, however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or whether a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen dissolution and positive test interferences.

5.5 Measurement of Turbidity Using a Secchi Disc

In combination with other parameters, turbidity can be a useful indicator of the likelihood of biological action in a water body. It can be used to determine the depth of light penetration of surface water and the distribution and intensity of photosynthesis in the body of water. Turbidity measurements shall be taken in-situ with a Secchi disc.

5.5.1 Equipment

Turbidity measurements may be taken with a Secchi disc. In addition, turbidity may be measured using a colimeter or a spectrophotometer. These are ex-situ measurements conducted in a laboratory environment.

5.5.2 Measurement Techniques for Turbidity

Observations must be made through a shaded area of water surface.

- Standard conditions for the use of the Secchi disc are: 1) clear sky; (2) sun directly overhead; 3) shaded, protected side of boat or under a sun shade; 4) minimal waves or ripples; and, 5) any departure from these conditions should be specifically stated on field sheets.

- Rope accurately graduated in meters with 0.1 meter graduations for the first meter and 0.5 meters thereafter.

- Observer's eye should be 1 meter above the surface of the water.

- Observations should be made during the middle of the day.

- Lower the disc into the water, noting the depth at which it disappears, then lift the disc and note the depth at which it reappears. The average of the two readings is considered to be the limit of visibility and is recorded in a Field Logbook to the nearest 0.1 meter (first meter) or 0.5 meter, depending on the depth of visibility.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records for on-site water quality management consists principally of observations and measurements recorded in the Field Logbook. Records of instrument calibration, malfunction, repair, etc., shall be maintained in an Equipment Logbook as described in the Navy CLEAN Contractor Quality Control Plan.

7.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

ATTACHMENT A

SPECIFIC CONDUCTANCE CONVERSION TABLE

ATTACHMENT A
SPECIFIC CONDUCTANCE CONVERSION TABLE

Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier
10	1.402	12	1.330	14	1.266	16	1.208	20	1.106
10.1	1.398	12.1	1.327	14.1	1.263	16.1	1.205	20.1	1.103
10.2	1.394	12.2	1.324	14.2	1.260	16.2	1.202	20.2	1.101
10.3	1.390	12.3	1.320	14.3	1.257	16.3	1.199	20.3	1.099
10.4	1.387	12.4	1.317	14.4	1.254	16.4	1.197	20.4	1.096
10.5	1.383	12.5	1.314	14.5	1.251	16.5	1.194	20.5	1.094
10.6	1.379	12.6	1.310	14.6	1.248	16.6	1.191	20.6	1.092
10.7	1.376	12.7	1.307	14.7	1.245	16.7	1.188	20.7	1.089
10.8	1.372	12.8	1.304	14.8	1.242	16.8	1.186	20.8	1.087
10.9	1.369	12.9	1.301	14.9	1.239	16.9	1.183	20.9	1.085
11	1.365	13	1.297	15	1.236	17	1.180	21	1.083
11.1	1.361	13.1	1.294	15.1	1.233	17.1	1.178	21.1	1.080
11.2	1.358	13.2	1.291	15.2	1.230	17.2	1.175	21.2	1.078
11.3	1.354	13.3	1.288	15.3	1.227	17.3	1.172	21.3	1.076
11.4	1.351	13.4	1.285	15.4	1.225	17.4	1.170	21.4	1.074
11.5	1.347	13.5	1.281	15.5	1.222	17.5	1.167	21.5	1.072
11.6	1.344	13.6	1.278	15.6	1.219	17.6	1.165	21.6	1.069
11.7	1.341	13.7	1.275	15.7	1.216	17.7	1.162	21.7	1.067
11.8	1.337	13.8	1.272	15.8	1.213	17.8	1.159	21.8	1.065
11.9	1.334	13.9	1.269	15.9	1.210	17.9	1.157	21.9	1.063

Notes:

- Do not make specific conductance measurements at temperatures below 10° C.
- Measure temperature to the nearest 0.1° C.
- Report all conductivities at 25° C, to two significant digits.
- This conversion table is based on a temperature coefficient of 0.0191 (as per SW-846) and a cell constant of 1, where the ratio of conductivity at 25 C to the conductivity at temperature t° C equals $1/(1+0.0191[t-25])$.
- The temperature coefficient and cell constants are only approximate, actual values may differ.
- The more the temperature deviates from 25° C, the greater the uncertainty in applying the temperature correction.

ATTACHMENT A (Continued)
SPECIFIC CONDUCTANCE CONVERSION TABLE

Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier
22	1.061	24	1.019	26	0.981	28	0.946	30	0.913
22.1	1.059	24.1	1.017	26.1	0.979	28.1	0.944	30.1	0.911
22.2	1.057	24.2	1.016	26.2	0.978	28.2	0.942	30.2	0.910
22.3	1.054	24.3	1.014	26.3	0.976	28.3	0.941	30.3	0.908
22.4	1.052	24.4	1.012	26.4	0.974	28.4	0.939	30.4	0.907
22.5	1.050	24.5	1.010	26.5	0.972	28.5	0.937	30.5	0.905
22.6	1.048	24.6	1.008	26.6	0.970	28.6	0.936	30.6	0.903
22.7	1.046	24.7	1.006	26.7	0.969	28.7	0.934	30.7	0.902
22.8	1.044	24.8	1.004	26.8	0.967	28.8	0.932	30.8	0.900
22.9	1.042	24.9	1.002	26.9	0.965	28.9	0.931	30.9	0.899
23	1.040	25	1.000	27	0.963	29	0.929	31	0.897
23.1	1.038	25.1	0.998	27.1	0.961	29.1	0.927	31.1	0.896
23.2	1.036	25.2	0.996	27.2	0.960	29.2	0.926	31.2	0.894
23.3	1.034	25.3	0.994	27.3	0.958	29.3	0.924	31.3	0.893
23.4	1.032	25.4	0.992	27.4	0.956	29.4	0.922	31.4	0.891
23.5	1.029	25.5	0.991	27.5	0.954	29.5	0.921	31.5	0.890
23.6	1.027	25.6	0.989	27.6	0.953	29.6	0.919	31.6	0.888
23.7	1.025	25.7	0.987	27.7	0.951	29.7	0.918	31.7	0.887
23.8	1.023	25.8	0.985	27.8	0.949	29.8	0.916	31.8	0.885
23.9	1.021	25.9	0.983	27.9	0.948	29.9	0.914	31.9	0.884

Notes:

- Do not make specific conductance measurements at temperatures below 10° C.
- Measure temperature to the nearest 0.1° C.
- Report all conductivities at 25° C, to two significant digits.
- This conversion table is based on a temperature coefficient of 0.0191 (as per SW-846) and a cell constant of 1, where the ratio of conductivity at 25 C to the conductivity at temperature t° C equals $1/(1+0.0191[t-25])$.
- The temperature coefficient and cell constants are only approximate, actual values may differ.
- The more the temperature deviates from 25° C, the greater the uncertainty in applying the temperature correction.

ATTACHMENT B

VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

ATTACHMENT B

VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/ 100 mg chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.106
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

ATTACHMENT B
(Continued)
VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/ 100 mg chloride
	0	5,000	10,000	15,000	20,000	
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore used to correct measured D.O. concentration) using Attachment A.

SOP F202

Water Level, Water-Product Level Measurements, and Well Depth Measurements

WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND WELL DEPTH MEASUREMENTS
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WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND WELL DEPTH MEASUREMENTS

1.0 PURPOSE

The purpose of this procedure is to describe the method of determining various down-hole measurements: groundwater levels and product (or non-aqueous phase liquid, NAPL) levels, if present, and total depth of groundwater monitoring wells and piezometers.

2.0 SCOPE

The methods described in this SOP generally are applicable to the measurement of groundwater levels, product or NAPL levels, and well depths in monitoring wells and piezometers.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed.

Field Team Leader - The Field Team Leader is responsible for ensuring that these procedures are implemented in the field, and for ensuring that personnel performing these activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the sampling personnel to follow these procedures or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of down-hole measurements.

5.0 PROCEDURES

Calculations of groundwater elevations and product or NAPL interface level measurements collected from a monitoring well give an indication of:

- The horizontal hydraulic gradient and the direction of groundwater flow.
- The vertical hydraulic gradient, if well nests are used (i.e., the direction of groundwater flow in the vertical plane).

- Floating or sinking product thicknesses which are also known as Light Non-Aqueous Phase Liquids (LNAPLS) and Dense Non-Aqueous Phase Liquids (DNAPLS), respectively.

This information, when combined with other site specific information such as hydraulic conductivity or transmissivity, extent of contamination, and product density, may be used to estimate the rate of contaminant movement or source areas, etc.

Well depth is one of the factors used to determine the zone that a well monitors. Well depth also is used in the calculation of purge volumes as discussed in SOP F104, Groundwater Sample Acquisition.

The following sections briefly discuss the procedures for measuring groundwater levels, product or NAPL levels, and well depth. For all of the procedures discussed, it is assumed that the measurement will be taken from the top of the PVC or stainless steel casing (though other measuring points can be used), and that horizontal and vertical control is available for each well through a site survey, such that measurements may be converted to elevations above Mean Sea Level (MSL) or some other consistent datum. A permanent notch, placed on the inner PVC or stainless steel casing by the surveyor will facilitate consistent water level measurements.

The manufacturer's instructions for all equipment referenced herein should be read by the equipment operator(s) and accompany the equipment to the field.

5.1 Water Level Measurement

Water levels in groundwater monitoring wells shall be measured from the permanent point indicated at the top of the inner casing (they surveyed elevation point, as marked by the surveyor), unless otherwise specified in the project plans, using an electronic water level measuring device (water level indicator). The point of measurement will be documented in the field logbook if different from the top of the inner casing. The reason for deviating from the measurement point should also be noted.

Water levels are measured by lowering the probe into the well until the device indicates that water has been encountered, usually with either a constant buzz, or a light, or both. The water level is recorded to the nearest foot (0.01) using the graduated markings on the water level indicator cord. This measurement, when subtracted from the measuring point elevation, yields the groundwater elevation.

Groundwater levels shall always be measured to the nearest 0.01 foot. However, reporting of water level elevations depends on the accuracy of the vertical control (typically either 0.1 or 0.01 foot).

5.2 Product or NAPL Level Measurements

The procedure for product or NAPL and DNAPL level measurements is nearly identical to that for groundwater elevation measurements. The only differences are the use of an interface probe that detects both NAPLs, DNAPLs, and water, and the indication signal given by the measurement device. Typically, encountering NAPLs, and DNAPLs in a monitoring well is indicated by a constant sound. When water is encountered, the signal becomes an alternating on/off beeping sound. This allows for the collection of measurements for both the top of the NAPL layer in a well and the water/NAPL interface. DNAPL measurements are collected by lowering the interface probe to the bottom of the monitoring well.

The apparent water table elevation below the product level will be determined by subtracting the "depth to water" from the measuring point elevation. The corrected water table elevation will then be calculated using the following equation:

$$WTE_c = WTE_a + (\text{Free Product Thickness} \times 0.80)$$

Where:

WTE_c	=	Corrected water table elevation
WTE_a	=	Apparent water table elevation
0.80	=	Average value for the density of petroleum hydrocarbons. Site-specific data will be used where available.

5.3 Well Depth Measurements

Well depths typically are measured using a weighted measuring tape. A water level meter may also be used. The tape is lowered down the well until resistance is no longer felt, indicating that the weight has touched the bottom of the well. The weight should be moved in an up and down motion a few times so that obstructions, if present, may be bypassed. The slack in the tape then is collected until the tape is taut. The well depth measurement is read directly off of the measuring tape, at the top of the PVC or stainless steel casing, to the nearest 0.01-foot and recorded in the Field Logbook. If a water level indicator is used, add the distance from the bottom of the probe to the point where water levels are measured.

5.4 Decontamination of Measuring Devices

Water level indicators, interface probes and weighted measuring tapes that come in contact with groundwater must be decontaminated using the following steps after use in each well:

- Rinse with potable water
- Rinse with deionized water

- Rinse with:
  - Methanol or acetone (EPA Region I)
  - Methanol, hexane, or acetone (EPA Region II)
  - Methanol (EPA Region III)
  - Isopropanol (EPA Region IV)

- Rinse with deionized water

Portions of the water level indicators or other similar equipment that do not come into contact with groundwater, but may encounter incidental contact during use, need only undergo potable water and deionized water rinses.

6.0 QUALITY ASSURANCE RECORDS

The Field Logbook shall serve as the quality assurance record for water, product level or well depth measurements.

7.0 REFERENCE

U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

SOP F203
Photoionization Detector (PID)
HNu Models PI 101 and DL 101

PHOTOIONIZATION DETECTOR (PID)
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- 5.1 Calibration
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- 5.4 Maintenance

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

PHOTOIONIZATION DETECTOR (PID)
HNu MODELS PI 101 and DL 101

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for using the HNu Model PI 101 or DL 101 photoionization detector (PID), or an equivalent or similar instrument, in the field. Calibration and operation, along with field maintenance will be included in this SOP.

2.0 SCOPE

This procedure provides information on the field operation and general maintenance of the HNu (PID). Application of the information contained herein will ensure that this type of field monitoring equipment will be used properly. Review of the manufacturer's instruction manual is necessary for more complete information.

These procedures refer only to monitoring for health and safety. The methods are not directly applicable to surveillance of air quality for analytical purposes.

3.0 DEFINITIONS

Ionization Potential - In this case, a numeric equivalent that expresses the amount of energy needed to replace an electron with a photon. This energy is further defined in terms of electron volts (eV).

PID - Photoionization Detector

ppm - parts per million: parts of vapor or gas per million parts of air (directly proportional to calibration gas).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures

are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in both the Field Logbook and the daily Realtime Air Monitoring Log during each field investigation.

5.0 PROCEDURES

The HNu utilizes the principle of photoionization whereby contaminant molecules enter the ion chamber and electrons are displaced by ultraviolet photons producing positive ions. These displaced positive ions are in turn collected on a special electrode. As the positive ions collect on the electrode, they create an electrical current which is amplified and displayed on the meter as a concentration in parts per million (ppm).

The HNu is only effective for contaminants that have ionization potentials (IP) of less than or equal to the electron volt (eV) capacity of the lamp (i.e., methane, having an IP of 12.98 eV, will not be detected at a lamp potential of 11.7 eV). The standard lamp is 10.2 eV with optional lamps of 9.5 eV and 11.7 eV, respectively. For the PI 101 the span settings should be as

follows: 1.0 for 9.5 eV lamps; 9.8 for 10.2 eV lamps; and 5.0 for 11.7 eV lamps. During calibration, these span settings will be adjusted as necessary, using the span control knob.

The following subsections will discuss HNu calibration, operation, and maintenance. These sections, however, should not be used as a substitute for the manufacturer's instruction manual.

5.1 Calibration

For calibration purposes, the following items will be needed:

- *Gas cylinder containing 95 to 100 parts per million (ppm) of isobutylene, balance in air.
- A 0.30 liters per minute regulator.
- Connector tubing.
- Screwdriver set.
- Calibration Gas Humidifier (for high humidity environments).
- Photoionization Detector (PID) Calibration Form.

*Note: Do not rely on accuracy of rated cylinder concentration when content drops to <200 psi.

Prior to each use, make sure that the battery is fully charged, the ultraviolet lamp is working, and that the fan is operating and drawing air into the probe (fan operates at approximately 100-200 cc/minute for the PI 101 and 225 cc/minute for the DL 101). Procedures for completing these preliminary activities are given in the manufacturer's instruction manual.

PI 101

To calibrate the HNu PI 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 3-5 in the manufacturer's instruction manual. The HNu PI 101 should be calibrated on a daily basis.

- Turn the function control switch to the standby position and zero the instrument by turning the zero adjustment knob to align the indicator needle with zero on the readout meter.

- Set the range on the HNu and allow the instrument to warm up a few minutes before calibrating. Choices for range are 0-20, 0-200, and 0-2,000 ppm, respectively. Range choice must take into account the concentration of the calibration gas. For example, if you are using a concentration of 100 ppm isobutylene as the calibration gas, your

range should be set on the 0-200 scale. If you have to zero the instrument in the desired range, record background if present.

- Attach tubing to the regulator (use the Calibration Gas Humidifier in high humidity environments).

- Attach the free end of the tubing to the probe and turn on the calibration gas.

- Calibrate the PID to benzene equivalents. Using the 10.2 eV (lamp) probe and 100 ppm isobutylene, the meter should read 56 units. Using the 11.7 eV (lamp) probe and 100 ppm isobutylene, the meter should read 65 units. If the reading on the meter is not ±5 percent of the concentration of the calibration gas, adjust the span setting knob until the meter reads accordingly. If after adjusting the span setting knob the readout meter is still not responding, refer to the manufacturer's instruction manual. Also, when the HNu is calibrated it should respond to a minimum of 90 percent of the concentration of the calibration gas within three seconds after introduction of that gas. If proper calibration cannot be obtained, internal calibration may be required. Note, only qualified personnel should perform internal calibrations.

- Record the calibration on the "Photoionization Detector (PID) Calibration Form".

DL 101

To calibrate the HNu DL 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 4.4 in the manufacturer's instruction manual.

- Press and release the POWER button on the keypad and wait for the screen to stabilize then press the CALIBRATE key until "Calibrate?" appears. At this point press the ENTER key until "Elec_Zero? Yes" appears on the screen in which case you will press the ENTER key, again, to confirm the electronic zero.

- The display will now read "CE/ENT/EXIT Conc = ____ ppm" which requires the concentration of the calibration gas (noted on the side of the calibration gas bottle) to be entered on the keypad. The display will prompt you to "Attach gas to probe and /ENTER/" so attach tubing to probe (use the calibration gas humidifier in high humidity environments), open valve, and press ENTER key. Press ENTER again when "Press ENTER when Ready: xxx ppm" appears on screen. This will cause "Calibrating...Please Wait" to appear on screen.

Note: This calibration is effective when the instrument is in the Survey Mode, which is the default mode. For calibrations other the one described, or if proper calibration cannot be obtained, refer to the manufacturer's instruction manual.

- For calibrations using an alternate gas or span values, refer to Section 4.5 of the manufacturer's instruction manual.

- Record the calibration on the "Photoionization Detector (PID) Calibration Form" which accompanies each HNu.

5.2 Operation

PI 101

Note: IMPORTANT - The HNu should be "zeroed" in a fresh air environment if at all possible. If there is a background concentration, it must be documented and then zeroed out.

- Prior to each use of the HNu, check that the battery is fully charged by turning the dial to BATT and making sure that it is within range. Also make sure that the ultraviolet lamp and the fan are working properly.

- Select your desired range. HNu ranges consists of a 0-20, 0-200, and 0-2,000 ppm, respectively. Consult with the Field Team Leader for more information when choosing the appropriate range, however, in most instances the range will be set initially at 0-20.

- When HNu is used intermittently, turn knob to STANDBY to help in extending the life of the UV lamp when operating in a low humidity environment. Otherwise, leave the knob set to the range desired so that the UV lamp will "burn off" any accumulated moisture.

Note: When using the PI 101 HNu, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

DL 101

The DL 101 is designed to default to the survey mode when initially powered up, therefore once the calibration has been completed, the instrument is ready to go. Within the survey mode several options are available, briefly these options include:

1. The Site Function

The Site function assigns a number to a site that is being analyzed. Press the Site Key on the keypad to enter a specific site number, or press the gray button on the rear of the probe to increment a site number.

2. Logging Data

The Log function stores data in memory. To log data, press the Log key on the keypad or the Log button on the back of the probe. "Log" will appear in the upper right corner of the display when activated and disappears when not activated. To turn logging off, press either the Log key on the keypad or the red Log button on the rear of the probe.

- The DL 101 allows for the interchanging of different voltage lamps, however, refer to the manufacturer's instructions before attempting to change the lamp.

- The DL 101 also offers three other modes of operation, the Hazardous Waste Mode, the Industrial Hygiene Mode, and the Leak Detection Mode. Each of these modes increases the range of capabilities for this instrument which is covered in detail in the manufacturer's instruction manual.

Note: When using the DL 101 HNu, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

5.3 Interferences and Potential Problems

A number of factors can affect the response of the PI 101 HNu and DL 101 HNu.

- High humidity can cause lamp fogging and decreased sensitivity. This can be significant when soil moisture levels are high, or when monitoring a soil gas well that is accessible to groundwater.

- High concentrations of methane can cause a downscale deflection of the meter.

- High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpines in wooded areas, will also affect instrument response.

5.4 Maintenance

The best way to keep an HNu operating properly is to keep it as clean as possible. HNu's should be decontaminated and wiped down after each use.

Corrective Maintenance

- The ultraviolet lamp should be periodically cleaned using a special compound supplied by HNu Systems, Inc. for the 10.2 eV lamp, and a chlorinated solvent such as 1,1,1-trichloroethane for the 11.7eV lamp. Consult the manufacturer's instruction manual for specific cleaning instructions.
- The ionization chamber can be periodically cleaned with methyl alcohol and a swab.

Note: UV lamp and ion chamber cleaning is accomplished by following the procedures outlined in Section 5.2, however, this should only be performed by trained personnel.

- Documenting the HNu's observed symptoms and then referring to the manufacturer's instruction manual section on troubleshooting (Section 6.0) also can be employed. If this does not work, the Field Team Leader should be consulted for an appropriate course of action.

Repair and Warranty Repair - HNu's have different warranties for different parts, so documenting the problem and sending it into the manufacturer assists in expediting repair time and obtaining appropriate warranty service.

5.5 SHIPPING AND HANDLING

Following is information regarding the transport of the HNu meter and calibration gas.

- If HNu is to be carried on in aircraft, the calibration gas must be removed from the carrying case as cylinders of compressed gas are not permitted on passenger aircraft. The calibration gas should either be shipped to the site of its intended use, or purchased locally.

- Shipping of the calibration gas requires the completion of a form (specified by the shipping company) that identifies the package as a compressed gas. Compressed gas stickers must be affixed to the package.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc.) serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g., the HNu meter had wide range fluctuations during air monitoring activities).

7.0 REFERENCES

HNu Systems, Inc. Instruction Manual. Model PI 101, 1986.

HNu Systems, Inc. Operator's Manual. Model DL 101, 1991.

SOP F204
Flame Ionization Detector (FID)
Foxboro OVA 128

FLAME IONIZATION DETECTOR (FID)
FOXBORO OVA 128
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FLAME IONIZATION DETECTOR (FID)
FOXBORO OVA 128

1.0 PURPOSE

The purpose of this procedure is to provide general reference information for using the Foxboro OVA 128, Flame Ionization Detector (FID) or an equivalent or substitute device, in the field. Calibration, operation, and field maintenance will be included in this SOP. The OVA 128 is an intrinsically safe organic vapor monitor, but it cannot be used in atmospheres that are oxygen deficient and it is unable to detect inorganic compounds, including poisonous atmospheres.

2.0 SCOPE

This procedure provides information on the field operation and general maintenance of the Foxboro OVA 128 (FID). Application of the information contained herein will ensure that this type of field monitoring equipment will be properly operated. Review of the manufacturer's operating manual is a necessity for more detailed descriptions and operating information.

These procedures refer only to monitoring for health and safety. The methods are not directly applicable to surveillance of air quality for analytical purposes.

3.0 DEFINITIONS

FID - Flame Ionization Detector

ppm - parts per million: parts of vapor or gas per million parts of air (directly proportional to calibration gas).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer.. The Field Investigation Personnel are responsible for documenting all air monitoring results in both the Field Logbook during each field investigation.

5.0 PROCEDURES

The following subsections will discuss calibration, operation and maintenance of the OVA 128. These sections, however, should not be used as a substitute for the manufacturer's operating manual.

The OVA 128 utilizes the principle of flame ionization whereby molecules enter the detector chamber and are exposed to a hydrogen flame which ionizes the organic vapors. As the vapors are burned they leave positively-charged carbon-containing ions. These positive ions are driven by an electric field to a collecting electrode. As the positive ions collect on the electrode, a current is created. This current corresponds to the collection rate of the positive ions. The current is then measured with a linear electrometer preamplifier which produces a signal proportional to the ionization current. This signal is then amplified by a signal conditioning amplifier and sent to the readout assembly and the strip chart recorder (when attached) in parts per million (ppm). The FID responds to virtually all organic compounds, that is,

compounds that contain carbon-hydrogen or carbon-carbon bonds. The OVA can operate in two modes:

Survey Mode: During normal survey mode operation, a sample is drawn into the probe and transferred to the detector chamber by an internal pumping system. When the sample reaches the FID it is ionized as described above and the resulting signal is translated to the meter as a direct reading concentration for total organic vapors; or recorded as a quantifiable peak on a strip chart.

Gas Chromatography Mode: Gas Chromatography (GC) is a technique for separating components of a sample and qualitatively and quantitatively identifying them. This is possible when using the OVA128 GC Model. The sample to be separated is injected into a column packed with an inert solid. As the carrier gas (hydrogen) forces the sample through the column, the separated components of the sample are retained on the column for different periods of time. Each component will then be transferred to the detector chamber as described in the survey mode section. The response from each component will be recorded as a peak on the strip chart. The qualitative and quantitative results can then be determined only by qualified personnel.

5.1 Calibration

Primary calibration involves internal adjustments and should only be done by the manufacturer or an authorized equipment technician.

The following items will be needed for secondary calibration of the OVA 128:

- Calibration gas (usually methane but can be contaminant specific).
- Gas regulator.
- Tedlar bag (usually two to three liter capacity).
- Tubing.
- Screw driver set.
- Flame Ionization Detector (FID) Calibration Form.

Points to follow for "Single Sample Calibration:"

- Follow operation procedures up to "calibration" step.

- For methane calibration in the 90 to 100 ppm range, set scale to x10 and gas select control to 300.
- Use calibration adjustment knob to "zero" the meter. Care must be taken to document background readings before zeroing the instruments.
- Introduce methane sample of known concentration from Tedlar Bag and adjust gas select knob so that meter reading equals sample concentration. Withdraw methane sample, allow meter reading to stabilize and repeat. Discontinue calibration when meter reaction to sample introduction is consistent.
- If there is a problem with calibration, consult the manufacturer's operating manual or an experienced technician.
- Refer to manufacturer's operating manual for additional information.

Since the Foxboro OVA 128 uses flame ionization, it has a broad application in terms of which organic contaminants it can ionize. Note: the OVA 128 hydrogen flame ionization detector is more sensitive to hydrocarbons than any other class of organic compounds.

5.2 Operation

Review of the Startup Procedure Chapter of the manufacturer's operating manual (page 7), is critical prior to actual field operation.

Points to follow for startup of the OVA 128:

- After the OVA is assembled check that the battery level is sufficient for operation. A minimum, reading of 7.5 on the x1 scale should provide four hours of operation.
- Turn instrument switch on and allow a minimum of a five minute warmup before turning pump on.
- Turn the pump switch on. Pump operation is audible.
- Place the instrument panel in the vertical position and check the sample flow rate indicator. The normal range is 1.5 to 2.0 units. If less, filters may need to be changed, or the battery may need further charging or replacement.
- Ensure that an air-tight seal exists from the probe back to the instrument by placing your thumb over the end of the probe. Cover the probe long enough to shut the pump down (approximately 5-10 seconds). If the pump does not shut down, check all fittings and connections from the probe assembly back to the instrument. An air-tight seal is very important for obtaining an accurate reading. Readings obtained without an air-tight seal are diluted and not indicative of actual concentrations (survey mode) or concentrations and contaminants present (GC mode).

- Use calibrate adjust knob to set meter to predetermined level for activating audible alarm (if desired).

- Set to x1 scale and adjust meter reading to zero.

- Open hydrogen tank valve to be certain that there is enough hydrogen in the tank for operation approximately 1.5 to 2 full turns. The OVA will use approximately 150 psi/hour. Then open the hydrogen supply valve approximately 1.5 to 2 full turns noting that the gauge reading should be within the range of 8 to 12 psi.

Note: Caution must be used when filling the hydrogen tank to maintain safe operating pressures and temperatures. Only prepurified or zero grade hydrogen will be used. Use the hydrogen filling hose supplied by the manufacturer, and hydrogen tank with a rated pressure that does not exceed the capacity of the fill line.

- After approximately one minute depress the igniter button until the hydrogen has been ignited (needle on readout assembly should deflect to full-scale). DO NOT HOLD THE IGNITER BUTTON IN FOR MORE THAN FIVE SECONDS. If hydrogen does not light, wait two minutes and try again. If it still does not light, consult manufacturer's operating manual.

  Note: Hydrogen gas will not ignite if battery is too low.

- The instrument is now ready for calibration, if required.

Once the Foxboro OVA 128 has been running and stabilized for 15 minutes, it is ready for "Survey Mode" procedures. Set the calibrate switch to the desired range and the Foxboro OVA 128 is now ready for field operation.

Note: Care must be taken when operating the Foxboro OVA 128. Special areas of concern are the probe assembly and the analyzer. Do not stick the probe in water or soil; this will give erroneous readings and could possibly damage the pump. The analyzer unit must be kept clean and away from physical hazards, and the exhaust free from obstructions.

For shutdown and refueling, follow manufacturer's recommend procedures.

5.3 Maintenance

Preventive maintenance consists of keeping the Foxboro OVA 128 as clean as possible. The Foxboro OVA 128 must be decontaminated and wiped down with a damp cloth after each use.

The other type of maintenance is the manufacturer's scheduled maintenance which consists of the following:

- Check particle filters on a monthly basis.
- Check quad rings on a monthly basis or as needed.
- Clean burner chamber on a quarterly basis or as needed.
- Primary calibration and factory check on an annual basis or when non-operational.
- Secondary calibration on a daily or weekly basis depending on usage.

5.4 Shipping

Following is information regarding the transport of FID meters and calibration gas.

- Compressed gas cylinders (i.e., methane and hydrogen) may not be carried on aircraft. These cylinders should either be shipped to the jobsite, or purchased locally.

- Shipping of the gas cylinders requires completion of a form (specified by the shipping company), that identifies the container as compressed gas. Compressed gas stickers must be affixed to the package.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc.), serial number, time, resulting concentration, comments and identity of air monitoring personnel.

- Field observations - Appearance of sampled media (if definable).

- Additional remarks (e.g., the Foxboro OVA 128 meter had wide range fluctuations during air monitoring activities).

7.0 REFERENCES

Foxboro Model OVA 128 Century Organic Vapor Analyzer Instruction Manual, 1985.

SOP F208
Bacharach Combustible Gas/Oxygen Meter and Personal Gas Monitor

BACHARACH COMBUSTIBLE GAS/ OXYGEN METER PERSONAL GAS MONITOR TABLE OF CONTENTS

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6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

BACHARACH COMBUSTIBLE GAS/ OXYGEN METER AND PERSONAL GAS MONITOR

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for using the Bacharach Sentinel 4 and Bacharach Sniffer® 503-A meters in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

2.0 SCOPE

This procedure provides information into the field operation and general maintenance of the Sentinel 4 Sniffer and 503-A. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

3.0 DEFINITIONS

Carbon Monoxide Sensor - Expresses the Carbon Monoxide concentration in parts per million (ppm).

Combustible Gas - Combustible gas is expressed as a percent of the lower explosive limit (LEL).

Hydrogen Sulfide Sensor - Expresses the Hydrogen Sulfide concentration in parts per million (ppm).

Oxygen Sensor - Expresses the Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

Sentinel 4 - Combustible Gas/Oxygen/Hydrogen Sulfide/Carbon Monoxide meter.

Sniffer 503-A - portable Combustible Gas and Oxygen Alarm instrument.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project -specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in the Field Logbook during each field investigation.

5.0 PROCEDURES

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A utilize the principle of detecting sensors. The following four paragraphs discuss theory of operation as it applies to each functional sensor.

The combustible gas sensor uses two elements that are wound with a platinum wire. One of the elements is impregnated with a catalyst to oxidize combustible gases. The other element

is impregnated with material that will also oxidize combustible gases, but will respond to temperature and humidity conditions. When the meter is turned on, an electrical current is passed through the elements and wires. As a combustible gas enters the chamber the elements will oxidize the combustible gas, thus increasing the heat and resistance of the element. This change in resistance causes a system imbalance, which produces a measurable signal proportional to the combustible gas concentration.

The percent oxygen is measured utilizing an electrochemical sensor. As atmospheric oxygen enters the meter it diffuses into the sensor which converts the amount of oxygen in the sensor to a voltage signal. This voltage is directly proportional to percent oxygen in the atmosphere.

The concentration of hydrogen sulfide is measured utilizing an electrochemical sensor. As atmospheric hydrogen sulfide enters the meter it diffuses into the sensor which converts the amount of hydrogen sulfide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric hydrogen sulfide concentration.

The concentration of carbon monoxide as measured utilizing an electrochemical sensor. As atmospheric carbon monoxide enters the meter it diffuses into the sensor which converts the amount of carbon monoxide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric carbon monoxide concentration.

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A are intrinsically safe for use in Class I, Division 1, Groups A, B, C and D hazard areas. One fact that needs to be expressed is that this type of monitoring equipment utilizes internal oxidation of combustibles, if the meter is placed in an oxygen deficient atmosphere, the combustible reading may be affected. Review of each of the instruction manuals will aid in determining the percentage of oxygen that affects the combustible gas readings.

The following subsections will discuss Sentinel 4 and Sniffer 503-A calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

5.1 Calibration

Sentinel 4

Due to the numerous steps involved in calibration, it is recommended that you follow the calibration procedures (on a daily basis) as outlined in the instruction manual from pages 5-12 to 5-20.

NOTE: A calibration kit will be provided for each Sentinel 4. This kit contains a cylinder for the combustible gas sensor, one cylinder for the hydrogen sulfide sensor, and one cylinder for the carbon monoxide sensor. The oxygen sensor can be calibrated with (uncontaminated/fresh air environment) atmospheric air and does not need cylinder gas.

Note: When a single sensor doesn't zero, none of the sensors are zeroed.

Sniffer® 503-A

Oxygen Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if battery is in recharge zone instrument will need to be charged.

2. To zero the oxygen detector, turn function switch to "BATTERY TEST" position and press "TEST" switch and observe the O_2 meter indication. If indicator is zero, no further adjustment is necessary. If not, follow procedures in Section 5.4.1 of the Operations Manual.

3. To calibrate the oxygen detector, turn function switch to "BATTERY TEST" position. Unlock the "OXYGEN CALIB" knob and adjust it for an O2 meter indication of 21 or at the CAL mark. Relock "OXYGEN CALIB" knob. If using zero calibration gas, follow procedures in Section 5.4.2 of the Operator's Manual.

4. Record on Calibration Sheet.

% LEL Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if batter is in recharge zone, instrument will need to be charged. Allow 5 minutes for the instrument to warm up.

2. Turn function switch to the % LEL position.

   Note: To eliminate the annoyance of the audible alarm, cover the alarm with a hand or duct tape during calibration. The tape must be removed, prior to operation!!

3. Connect calibration gas (typically 30% of the LEL) and allow gas to flow for 1 minute.

   Note: If calibration gas has a concentration value, not a % LEL value, the % LEL can be calculated as follows:

   % calibration gas (i.e., methane) x 20% LEL (meter alarm setting) = % LEL calibration setting

   If meter indication is within ±5% of LEL calibration gas, no further adjustment is required. If not, follow procedures in Section 5.5.4 of Operator's Manual.

Sniffer® 503-A

1. Connect sample probe and tubing to the instrument's sample inlet (refer to Sections 8.4 and 8.5 for the Operator's Manual for available hoses and probes.

2. Check that battery is in Operational Range.

3. Turn instrument to % LEL range and allow to warm up for 1 minute.

4. Check in a fresh air environment that % LEL reads 0% and that O_2 indicator reads 21% (calibration mark).

5. Sample air/gas from area to be tested, allow 30 seconds for readings to stabilize. When finished, allow at least 10 seconds (longer if extension line is used) to purge sample line.

6. If instrument is operating erratically, refer to "TROUBLESHOOTING" Section (Table 5-2) in Operator's Manual.

5.2 Operation

Sentinel 4

Due to the Sentinel 4 having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 6-1 to 6-34. NOTE: Since the Sentinel 4 is capable of measuring four different parameters, an understanding of the alarm, error, and fault messages must be obtained. This can be done by reviewing the troubleshooting table found on pages 9-2 to 9-9.

5.3 Site Maintenance

After each use, the meters should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

5.4 Scheduled Maintenance

Function	Frequency
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, date, location, CTO number,activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.

- Field observations - Appearance of sampled media (if definable).

- Additional remarks (e.g., the Sentinel 4 or Sniffer 503-A had wide range fluctuations during air monitoring activities.)

  NOTE: The "Toxic Gas Meter Calibration Form" will be completed daily, prior to performing any air monitoring.

7.0 REFERENCES

Bacharach Installation, Operation, Maintenance Manual, Sentinel 4 Personal Gas Monitor, 1990.

Bacharach Installation, Operation, Maintenance Manual, Sniffer® 503-A, Rev. 3 - October 1990.

SOP F301
Sample Preservation and Handling

SAMPLE PRESERVATION AND HANDLING
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SAMPLE PRESERVATION AND HANDLING

1.0 PURPOSE

This SOP describes the appropriate containers for samples of particular matrices, and the steps necessary to preserve those samples when shipped off site for chemical analysis. It also identifies the qualifications for individuals responsible for the transportation of hazardous materials and samples and the regulations set forth by the Department of Transportation regarding the same.

2.0 SCOPE

Some chemicals react with sample containers made of certain materials; for example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the integrity of the sample prior to analysis.

Many water and soil samples are unstable and may change in chemical character during shipment. Therefore, preservation of the sample may be necessary when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s). While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that may occur after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/freezing. Their purposes are to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

Typical sample container and preservation requirements for the CLEAN Program are referenced in NEESA 20.2-047B and are provided in Attachment A of this SOP. Note that sample container requirements (i.e., volumes) may vary by laboratory.

The Department of Transportation, Code of Federal Regulations (CFR) Title 49 establishes regulations for all materials offered for transportation. The transportation of environmental

samples for analysis is regulated by Code of Federal Regulations Title 40 (Protection of the Environment), along with 49 CFR Part 172 Subpart H. The transportation of chemicals used as preservatives and samples identified as hazardous (as defined by 49 CFR Part 171.8) are regulated by 49 CFR Part 172.

3.0 DEFINITIONS

HCl - Hydrochloric Acid
H_2SO_4- Sulfuric Acid
HNO_3 - Nitric Acid
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalents per liter, where an equivalent is the amount of a substance containing one mole of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one mole of H, is "one-normal," while a one molar solution of H_2SO_4 containing two moles of H, is "two-normal."

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is also responsible for proper certification of individuals responsible for transportation of samples of hazardous substances.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures. The Field Team Leader is responsible to ensure all samples and/or hazardous substances are properly identified, labeled, and packaged prior to transportation.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate sample preservation and handling. It is also the responsibility of the field sampling personnel to understand and adhere to the requirements for proper transportation of samples and/or hazardous substances.

5.0 PROCEDURES

The following procedures discuss sample containerization and preservation techniques that are to be followed when collecting environmental samples for laboratory analysis.

5.1 Sample Containers

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be measured is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then glass or plastic containers may be used. Containers shall be kept out of direct sunlight (to minimize biological or photo-oxidation/photolysis of constituents) until they reach the analytical laboratory. The sample container shall have approximately five to ten percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (one liter of water at 4°C expands by 15 milliliters if heated to 130°F/55°C); however, head space for volatile organic analyses shall be omitted.

The analytical laboratory shall provide sample containers that have been certified clean according to USEPA procedures. Shipping containers for samples, consisting of sturdy ice chests, are to be provided by the laboratory.

Once opened, the sample container must be used at once for storage of a particular sample. Unused, but opened, containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing liners (if required for the container) shall be discarded.

General sample container, preservative, and holding time requirements are listed in Attachment A.

5.2 Preservation Techniques

The preservation techniques to be used for various analytes are listed in Attachment A. Reagents required for sample preservation will either be added to the sample containers by

laboratory prior to their shipment to the field or added in the field using laboratory supplied preservatives. Some of the more commonly used sample preservation techniques include storage of sample at a temperature of 4°C, acidification of water samples, and storage of samples in dark (i.e. amber) containers to prevent the samples from being exposed to light.

All samples shall be stored at a temperature of 4°C. Additional preservation techniques shall be applied to water samples as follows:

- Water samples to be analyzed for volatile organics shall be acidified.
- Water samples to be analyzed for semivolatile organics shall be stored in dark containers.
- Water samples to be analyzed for pesticides/PCBs shall be stored in dark containers.
- Water samples to be analyzed for inorganic compounds shall be acidified.

These preservation techniques generally apply to samples of low-level contamination. The preservation techniques utilized for samples may vary. However, unless documented otherwise in the project plans, all samples shall be considered low concentration. All samples preserved with chemicals shall be clearly identified by indicating on the sample label that the sample is preserved.

5.3 Sample Holding Times

The elapsed time between sample collection and initiation of laboratory analyses is considered the holding time and must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for routine sample collection are provided in Attachment A.

6.0 SAMPLE HANDLING AND TRANSPORTATION

After collection, the outside of all sample containers will be wiped clean with a damp paper towel; however sample handling should be minimized. Personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination and loss of sample labels. Sealable plastic bags, (zipper-type bags), should be used when glass sample containers are placed in ice chests to prevent cross-contamination, if breakage should occur.

Samples may be hand delivered to the laboratory or they may be shipped by common carrier. Relevant regulations for the storage and shipping of samples are contained in 40 CFR 261.4(d). Parallel state regulations may also be relevant. Shipment of dangerous goods by air cargo is also regulated by the United Nations/International Civil Aviation Organization (UN/ICAO). The Dangerous Goods Regulations promulgated by the International Air Transport Association (IATA) meet or exceed DOT and UN/ICAO requirements and should be used for shipment of dangerous goods via air cargo. Standard procedure for shipping environmental samples are given in Attachment B.

7.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

USEPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

USEPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. USEPA EMSL, Cincinnati, Ohio.

USEPA, Region IV, 1991. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia.

Protection of the Environment, Code of Federal Regulation, Title 40, Parts 260 to 299.

Transportation, Code of Federal Regulation, Title 49, Parts 100 to 177.

ATTACHMENT A

REQUIRED CONTAINER, PRESERVATION TECHNIQUES AND HOLDING TIMES

ATTACHMENT A

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time (1)	Analytical Method	Bottle Volume
Volatile Organic Compounds (VOA)	glass teflon lined cap	Cool to 4°C 1:1 HCl pH <2	10 days	CLP	2 x 40 ml
Semivolatile Organic Compounds (SVOA)	glass teflon lined cap	Cool to 4°C Dark	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
PCB/Pesticides	glass teflon lined cap	Cool to 4°C Dark	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
Cyanide	plastic/glass	NaOH to pH>12 Cool to 4°C	14 days	CLP EPA 335.2	1 x 1 liter
Metals (TAL)	plastic/glass	HNO_3 to pH <2	180 days except Mercury is 26 days	CLP	1 x 1 liter
Total Organic Carbon	glass, teflon lined cap	Cool to 4°C H_2SO_4 to pH <2	28 days	EPA 415.1	2 x 40 ml
Total Organic Halogen	plastic/glass	Cool to 4°C H_2SO_4 to pH <2	28 days	EPA 450.1	250 ml
Chloride	plastic/glass	none required	28 days	EPA 325.2/325.3	250 ml
Sulfate	plastic/glass	Cool to 4°C	28 days	EPA 375.4	250 ml
Alkalinity	plastic/glass	Cool to 4°C	14 days	EPA 310.1/310.2	250 ml
Gross alpha/gross beta	plastic/glass	HNO_3 to pH <2	6 months	9310	1 gallon
Chlorinated herbicides	glass, teflon lined cap	Cool to 4°C	14/28 days	EPA 515.1	1000 ml
Hardness	plastic/glass	HNO_3 to pH <2	6 months	EPA 130.2	150 ml

(1) Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991. Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

ATTACHMENT A (Continued)

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOIL SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time (1)	Analytical Method	Bottle Volume
Volatile Organic Compounds (VOA)	glass teflon lined cap	Cool to 4°C	10 days	CLP	1 x 50 gm
Semivolatile Organic Compounds (SVOA)	glass teflon lined cap	Cool to 4°C	Extraction within 10 days Analyze 40 days	CLP	1 x 250 gm
PCB/Pesticides	glass teflon lined cap	Cool to 4°C	Extraction within 10 days Analyze 40 days	CLP	1 x 50 gm
Metals (TAL)	plastic/glass	Cool to 4°C	Mercury is 26 days 180 days	CLP	1 x 50 gm
Cyanide	plastic/glass	Cool to 4°C	14 days	CLP EPA 335.2M	1 x 50 gm

(1) Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991.
Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

ATTACHMENT B

SAMPLE SHIPPING PROCEDURES

ATTACHMENT B

SAMPLE SHIPPING PROCEDURES

Introduction

Samples collected during field investigations or in response to a hazardous materials incident must be classified by the project leader, prior to shipping by air, as either environmental or hazardous substances. The guidance for complying with U.S. DOT regulations in shipping environmental laboratory samples is given in the "National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples."

Pertinent regulations for the shipping of environmental samples is given in 40 CFR 261.4(d). Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods/hazardous substance. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by the United Nations International Civil Aviation Organization (UN/ICAO),which is equivalent to IATA.

Individuals responsible for transportation of environmental samples or dangerous goods/hazardous substances must be tested and certified by their employer. This is required by 49 CFR Part 172 Subpart H Docket HM-126 to assure the required qualifications for individuals offering materials for transportation.

Environmental samples shall be packed prior to shipment by commercial air carrier using the following procedures:

1. Select a sturdy cooler in good repair. Secure and tape the drain plug (inside and outside) with fiber or duct tape. Line the cooler with a large heavy duty plastic bag. This practice keeps the inside of the cooler clean and minimizes cleanup at the laboratory after samples are removed.

2. Allow sufficient headspace (ullage) in all bottles (except VOAs) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).

3. Be sure the lids on all bottles are tight (will not leak). In many regions custody seals are also applied to sample container lids. The reason for this practice is two-fold: to maintain integrity of samples and keep lid on the container should the lid loosen during shipment. Check with the appropriate regional procedures prior to field work. In many cases, the laboratory manager of the analytical lot to be used on a particular project can also provide this information.

4. It is good practice to wrap all glass containers in bubblewrap or other suitable packing material prior to placing in plastic bags.

5. Place all bottles in separate and appropriately sized polyethylene bags and seal the bags with tape (preferably plastic electrical tape, unless the bag is a zipper-type bag). Up to three VOA bottles, separately wrapped in bubblewrap, may be packed in one plastic bag.

6. Optionally, place three to six VOA vials in a quart metal can and then fill the can with vermiculite.

7. Place two to four inches of vermiculite (ground corn cob, or other inert packing material) in the bottom of the cooler and then place the bottles and cans in the cooler with sufficient space to allow for the addition of more vermiculite between the bottles and cans.

8. Put frozen "blue ice" (or ice that has been placed in properly sealed, double-bagged, heavy duty polyethylene bags) on top of and between the samples. Fill all remaining space between the bottles or cans with packing material. Fold and securely fasten the top of the large heavy duty plastic bag with tape (preferably electrical or duct).

9. Place the Chain-of-Custody Record and the Request for Analysis Form (if applicable) into a plastic bag, tape the bag to the inner side of the cooler lid, and then close the cooler and securely tape (preferably with fiber tape) the top of the cooler unit. Wrap the tape three to four times around each side of the cooler unit. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

10. Each cooler (if multiple coolers) should have its own Chain-of-Custody Record reflecting the samples shipped in that cooler.

11. Label according to 40 CFR 261.4(d). The shipping containers should be marked "THIS END UP," and arrow labels which indicate the proper upward position of the container should be affixed to the container. A label containing the name and address of the shipper and laboratory shall be placed on the outside of the container. It is good practice to secure this label with clear plastic tape to prevent removal during shipment by blurring of important information should the label become wet. The commercial carrier is not required to sign the COC record as long as the custody seals remain intact and the COC record stays in the cooler. The only other documentation required is the completed airbill, which is secured to the top of the shipping container. Please note several coolers/shipping containers may be shipped under one airbill. However, each cooler must be labeled as "Cooler 1 of 3, Cooler 2 of 3, etc.", prior to shipping. Additionally it is good practice to label each COC form to correspond to each cooler (i.e., 1 of 3, 2 of 3, etc.).

SOP F302
Chain-of-Custody

CHAIN-OF-CUSTODY
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CHAIN-OF-CUSTODY

1.0 PURPOSE

The purpose of this SOP is to provide information on chain-of-custody procedures to be used to document sample handling.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters, SOP F101). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 DEFINITIONS

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is responsible for ensuring that chain-of-custody procedures are implemented. The Project Manager also is responsible for determining that custody procedures have been met by the analytical laboratory.

Field Team Leader - The Field Team Leader is responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper or laboratory. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate chain-of-custody procedures, and maintain custody of samples until they are relinquished to another custodian, the sample shipper, or to a common carrier.

5.0 PROCEDURES

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.1 Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s);
- CTO Number;
- Project Sample Number;
- Sample location or sampling station number;
- Date and time of sample collection and/or measurement;
- Field observations;
- Equipment used to collect samples and measurements; and,
- Calibration data for equipment used.

Measurements and observations shall be recorded using waterproof ink.

5.1.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project or Contract Task Order (CTO) Number.
- Station Location - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 12/21/85).
- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 am., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.

- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2 Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

5.2.1 Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographs will be stored in the project files. It is good practice to identify sample locations in photographs by including an easily read sign with the appropriate sample/location number.
- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.

5.2.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individual(s) relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below.

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method, grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).
- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening so that it would be broken if the container was to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other

documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

6.0 QUALITY ASSURANCE RECORDS

Once samples have been packaged and shipped, the COC copy and airbill receipt becomes part of the Quality Assurance Record.

7.0 REFERENCES

1. USEPA. User's Guide to the Contract Laboratory Program. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

ATTACHMENT A

EXAMPLE SAMPLE LABEL

ATTACHMENT A

EXAMPLE SAMPLE LABEL

Baker

Baker Environmental Inc.
Airport Office Park, Bldg. 3
420 Rouser Road
Coraopolis, PA 15108

Project: 19026-SRN CTO No.: 0026

Sample Description: Groundwater

Date: 09/17/92 Sampler: ABC

Time: 0944

Analysis: TAL Metals (CAP) Preservation: HNO_3

Project Sample No.: CAX-GW-04

Note: Typically, sample labels are provided by the analytical laboratory and may be used instead of the above. However, samplers should make sure all pertinent information can be affixed to the label used.

ATTACHMENT B

EXAMPLE CHAIN-OF-CUSTODY RECORD

Baker

Baker Environmental, Inc.
420 Rouser Road, AOP Building 3, Coraopolis, PA 15108

CHAIN-OF-CUSTODY RECORD

PROJECT NO.:

SITE NAME:

SAMPLERS (SIGNATURE):

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CON-TAINERS							REMARKS

RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE/TIME:	REMARKS:	

ATTACHMENT C

EXAMPLE CUSTODY SEAL

ATTACHMENT C

EXAMPLE CUSTODY SEAL

Baker _____/_____/_____ Date _____ Signature CUSTODY SEAL	Baker _____/_____/_____ Date _____ Signature CUSTODY SEAL

SOP F303
Field Logbook

FIELD LOGBOOK
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FIELD LOGBOOK

1.0 PURPOSE

This SOP describes the process for maintaining a field logbook.

2.0 SCOPE

The field logbook is a document which records all major on-site activities conducted during a field investigation. At a minimum, the following activities/events shall be recorded in the field logbook by each member of the field crew.

- Arrival/departure of site workers and visitors
- Arrival/departure of equipment
- Sample pickup (sample numbers, carrier, time)
- Sampling activities
- Start or completion of boreholes, monitoring wells, or sampling activities
- Health and safety issues

The field logbook is initiated upon arrival at the site for the start of the first on-site activity. Entries are made every day that on-site activities take place. At least one field logbook shall be maintained per site.

The field logbook becomes part of the permanent site file. Because information contained in the field logbook may be admitted as evidence in legal proceedings, it is critical that this document is properly maintained.

3.0 DEFINITIONS

Field logbook - The field logbook is a bound notebook with consecutively numbered pages. Upon entry of data, the logbook requires the signature of the responsible data/information recorder.

4.0 RESPONSIBILITIES

The Field Team Leader is responsible for maintaining a master field logbook for the duration of on-site activities. Each member of the sampling crew is responsible for maintaining a complete and accurate record of site activities for the duration of the project.

5.0 PROCEDURES

The following sections discuss some of the information which must be recorded in the field logbook. In general, a record of all events and activities, as well as other potentially important information shall be recorded by each member of the field team.

5.1 Cover

The inside cover or title page of each field logbook shall contain the following information:

- Contract Task Order Number
- Project name and location
- Name of Field Team Leader
- Baker's address and telephone number
- Start date
- If several logbooks are required, a sequential field logbook number

It is good practice to list important phone numbers and points of contact here.

5.2 Daily Entries

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded by each team member.

- Date
- Start time
- Weather
- All field personnel present
- All visitors present
- Other pertinent information (i.e., planned activities, schedule changes, expected visitors, and equipment changes)

During the day, an ongoing record of all site activities should be written in the logbook. The master logbook kept by the field team leader need not duplicate that recorded in other field logbooks, but should summarize the information in other books and, where appropriate, reference the page numbers of other logbooks where detailed information pertaining to a subject may be found.

Some specific information which must be recorded in the logbook includes:

- Equipment used, equipment numbers, calibration, field servicing
- Field measurements
- Sample numbers, media, bottle size, preservatives, collection methods, and time
- Test boring and monitoring well construction information, including boring/well number and location
- Sketches for each sample location including appropriate measurements if required.
- Photograph log
- Drum log
- Other pertinent information

All entries should be made in indelible ink; all pages numbered consecutively; and all pages must be signed or initialed and dated by the responsible field personnel completing the log. No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single line, initialed, and dated.

5.3 Photographs

If photographs are permitted at a site, the record shall be maintained in the field logbook. When movies, slides or photographs are taken of any site location, they are numbered or cross-referenced to correspond to logbook entries. The name of the photographer, date, time, site location, site description, direction of view and weather conditions are entered in the logbook as the photographs are taken. Special lenses, film, or other image-enhancement techniques also must be noted in the field logbook. Once processed, photographs shall be serially numbered and labeled corresponding to the field logbook entries. Note that it may not be permitted to take photographs at all Activities; permission must be obtained from the LANTDIV EIC and the Activity responsible individual.

6.0 QUALITY ASSURANCE RECORDS

Once on-site activities have been completed, the field logbook shall be considered a quality assurance record.

7.0 REFERENCES

None.

SOP F304
QA/QC Samples

QUALITY CONTROL SAMPLES
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QUALITY CONTROL SAMPLES

1.0 PURPOSE

The SOP describes the type and quantity of Quality Control (QC) samples to be collected for most field sampling operations.

2.0 SCOPE

QC samples are those samples (usually collected in the field) that are sent to the laboratory along with the environmental samples in order to evaluate site conditions and laboratory precision and accuracy. Evaluation of the results from the QC samples allows for the quality of the data to be assessed. There are five different type of QC samples: trip blanks, equipment rinsate blanks, field blanks, duplicates and matrix spike/matrix spike duplicate (MS/MSD) samples. The first three types of QC samples are used to assess field conditions during sampling and/or transport of the environmental samples. The latter two types of QC samples are used by the laboratory to help assess precision and accuracy. (The laboratory also has other internal samples and procedures to assess precision and accuracy.)

Depending on the Naval Energy and Environmental Support Activity (NEESA) Level of data quality required by the project, different amounts of QC samples are collected. These are described in detail below.

3.0 DEFINITIONS

Trip Blank - Trip blanks are 40-ml volatile organic analysis (VOA) vials of ASTM Type II water that are filled at the laboratory, transported to the sampling site, and returned to the laboratory with environmental VOA samples. Trip blanks are not opened in the field.

Equipment Rinsates - Equipment rinsates are samples of ASTM Type II water (provided by the laboratory) passed over decontaminated sampling equipment. They are used as a measure of the effectiveness of the decontamination procedure. The rinsate is analyzed for the same parameters as the environmental samples collected from the piece of equipment.

Field Blanks - Field blanks are samples of source water used for decontamination and steam cleaning. At a minimum there is one sample collected for each source of water used per sampling event. The field blank is analyzed for all the parameters tested during the sampling event.

Duplicates - Duplicates are collected to help assess laboratory reproducibility (precision). Solid matrix samples are homogenized before being split, except for VOAs, which are not homogenized because of potential volatile loss. Liquid matrix samples are collected simultaneously. For both solid and liquid matrices, double the normal volume is required. The same analyses are completed on the duplicate as on the environmental sample.

MS/MSD - MS/MSD samples are used by the laboratory (but collected in the field) to help determine both precision and accuracy of analysis. For liquid matrices, triple the volume of sample is required (that is, one volume for the environmental sample, one volume for the MS sample, and one volume for the MSD sample). For solid matrices, additional volume is usually not required (although this will depend upon the laboratory).

4.0 RESPONSIBILITIES

The Project Manager is responsible for estimating the number of QC samples required for any sampling event. The procedures for determining the number is described in Section 5.0 below. The Field Team Leader is responsible for making sure that the sampling team(s) are collecting the required number of QC samples. The Field Team member(s) are responsible for understanding the rationale and methods for QC sample collection and for coordinating QC sample collection as appropriate.

5.0 PROCEDURES

The procedures for QC sample collection and the frequency at which each type of sample should be collected is described below.

5.1 Trip Blanks

Trip blanks (one pair of 40 ml vials) are sent to the laboratory in each cooler which contains samples for volatile organic analyses. The trip blank should also be kept in the field, with the

volatile samples, during the period of sample collection. Analyses of the trip blank will determine if the sample containers were contaminated prior to sampling or during transport.

5.2 Equipment Rinsates

Equipment rinsates are collected by pouring analyte-free water (provided by the laboratory) over decontaminated sampling equipment and collecting the rinsate. These are collected at a frequency of once per day and are analyzed for the same parameters as are the samples collected from that equipment. If two (or more) different types of equipment are used to collect samples in the same day (say by two field teams, one collecting soil samples from split spoons and one collecting groundwater from bailers), then two separate rinsate samples may be collected. The rinsate blank is used to qualify data.

5.3 Field Blanks

One field blank per source of water used for decontamination per sampling event is collected for all the parameters analyzed during that sampling event. In general, two field blanks are collected - one from the potable water source used for steam cleaning and one from distilled water purchased at a local store for use in general decontamination. The field blank is collected by opening up the water source at the sampling locations and pouring the water directly into the appropriate sample bottles. Analysis of the sample will indicate whether contamination was introduced into the samples during the collection process.

5.4 Duplicates

Field duplicates are collected at a frequency of 10 percent (one duplicate or per 10 samples) for levels C and D analyses, and at 5 percent (or one duplicate per 20 samples) for Level E analyses. The samples are split as described above and in other SOPs related to sample collection procedures. The number of duplicates to collect for levels C and D analyses is determined as follows: 1-10 environmental samples, 1 duplicate; 11-20 environmental samples, 2 duplicates; 21-30 environmental samples, 3 duplicates, etc. Field duplicates are primarily used to check the precision and consistency of the sampling procedures used and as a check of laboratory accuracy.

5.5 MS/MSD

MS/MSD samples are collected in the same manner as for a duplicate sample, except that triple the volume is required for analysis (for liquids). Generally no additional volume is required by the laboratory for solid samples (CHECK WITH THE LAB). The frequency of collection is one MS/MSD pair (or two additional sample volumes) for each 20 environmental samples collected of similar matrix (e.g. groundwater, surface water, soil). The number of MS/MSD samples to collect is determined as follows: 1-20 environmental samples, one MS/MSD pair; 21-40 environmental samples, two MS/MSD pairs, etc. NEESA requires that one field duplicate be collected at the same location as the MS/MSD pair.

6.0 SAMPLE COLLECTION RECORDS AND EVALUATION

Records of collection of QC samples are kept in the field logbooks and on the Chain-of-Custody forms. Evaluation of the results from the QC samples is performed by the laboratory and through data validation for the MS/MSD samples. Results of the other QC samples are compared to analytical results from the sampling event to determine if any field procedures, or sample transportation/handling may have adversely affected the concentrations found in the environmental samples.

7.0 REFERENCES

Hazardous Waste Remedial Actions Program, 1990. Requirements for Quality Control of Analytical Data. DOE/HWP-65/R1, US Department of Energy, Oak Ridge, Tennessee.

Naval Energy and Environmental Support Activity, 1998. Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program. NEESA 20.2-047B, Port Hueneme, California.

USEPA, 1988. User's Guide to the Contract Laboratory Program. 9240.0-1, Office of Emergency and Remedial Response, Washington, D.C.

USEPA, 1990. Quality Assurance/Quality Control Guidance for Removal Activities - Sampling QA/QC Plan and Data Validation Procedures (Interim Final). EPA/540/G-90/004, Office of Emergency and Remedial Response, Washington, D.C.

SOP F402
Slug Testing

WELL-HEAD TESTING
(SLUG-TESTS)

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WELL-HEAD TESTING (SLUG-TESTS)

1.0 PURPOSE

This SOP provides a general description of the technical methods and field procedures of a representative suite of well-head testing (slug tests) to approximate part of the aquifer parameters. The well-head tests are to be considered at all times as a reconnaissance of the aquifer parameters across an area (the site under investigation); they are never reliable as definitive calculations of those parameters either at a point (an individual well) or across an area (the well-field). Aquifer testing (pump-tests) to calculate these parameters is discussed in SOP F401. The descriptions herein are general in nature and do not apply to a specific well, well-field or project. Prior to designing well-head tests as part of a site investigation and during execution of the tests, the Project Manager, Site Manager and Program Geohydrologist must consult on the appropriate procedures; these procedures must then be recorded in the project documents.

2.0 SCOPE

The procedures described here apply to tests for evaluation of the aquifer parameters at sites being investigated under both the Underground Storage Tank (UST) Program and the Installation Restoration (IR) Program of Navy CLEAN. The well-head tests apply both to consolidated and unconsolidated strata; and to confined, semiconfined and phreatic conditions. The aquifer parameters subject to evaluation and approximate calculation are the Coefficient of Transmissivity and the Hydraulic Conductivity.

3.0 DEFINITIONS

The following definitions are extracted or abstracted from standard references (Section 7); further discussions are available in those references.

Hydraulic Conductivity (K) - A medium has a hydraulic conductivity (K) of unit length per unit time (for example, feet per day [ft/d]) if it will transmit in unit time a unit volume of groundwater at the prevailing viscosity through a cross-section of unit area, measured at right angles to the direction of flow, under a hydraulic gradient of unit change in head through unit length of flow (Lohman 1979).

Coefficient of Transmissivity (T) - The transmissivity (T) is the rate (for example, in gallons per day per foot of drawdown [gpd/ft]) at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient (Lohman 1979). The transmissivity is mathematically equivalent to the hydraulic conductivity multiplied by the saturated thickness: $T = Kb$.

Saturated Thickness (b) - The saturated thickness (b) is the distance (for example, in feet [ft]) from the elevation of the upper groundwater surface in either a phreatic system (the water table) or a

confined or semiconfined system (the lower boundary of the upper confining or semiconfining layer, but not the potentiometric surface in a well) to the elevation of the upper boundary of the lower confining or semiconfining layer for the aquifer or water-bearing layer.

Drawdown (s) - The drawdown (s) in any well affected by a well-head test is the differential distance, usually in feet (ft), between the static (unstressed) water level in the well measured immediately prior to the test, and the (stressed) water level at the specified time during the test.

Falling-Head Test - The falling-head test is conducted where the static water level in the subject well is nearly instantaneously displaced vertically upward at the initiation of the test; the decay of this artificially impressed head is measured against time to provide data for the calculation of conductivity or transmissivity.

Rising-Head Test - The rising-head test is conducted where the static water level in the subject well is nearly instantaneously displaced vertically downward at the initiation of the test; the decay of this artificially depressed head is measured against time to provide data for the calculation of conductivity or transmissivity.

Confined Conditions - Confined conditions in a water-bearing layer are found where the groundwater is bounded vertically by opposed surfaces or layers that are impermeable to water, and where the total head of the system at the upper surface of the groundwater is greater than atmospheric pressure. For a confined system, when a well is drilled below the bottom of the upper confining layer, the water level in the well rises to an elevation (at least) within or (possibly) above the upper confining layer.

Unconfined (Phreatic) Conditions - Unconfined conditions in a water-bearing layer are found where the groundwater is bounded vertically only by a single surface or layer at the bottom of the water-bearing layer that is impermeable or semipermeable to water, and where the total head of the system at the upper surface of the groundwater is equal to atmospheric pressure. For an unconfined or phreatic or water-table system, when a well is drilled below the upper surface of the groundwater, the water level in the well does not rise to a significantly higher elevation.

Semiconfined Conditions - Semiconfined conditions in a water-bearing layer are found where the groundwater is bounded vertically by opposed surfaces or layers that are less permeable to water than the water-bearing layer itself, and where the total head of the system is greater than atmospheric pressure. For a semiconfined system, when a well is drilled below the bottom of the upper semiconfining layer, the water level in the well rises to an elevation within or above the upper semiconfining layer. However, one or both of the semiconfining layers will be, in some fashion, in hydraulic and hydrologic communication with the water-bearing layer, and may contribute water to or receive water from that layer.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation procedures which deviate from those presented herein.

Site Manager - It is the responsibility of the Site Manager to ensure that the procedures herein are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Field Geologist - Responsible for determining the need for hydrogeologic testing and has overall responsibility for the planning and implementation of the test. Evaluation and interpretation of the data is also the responsibility of the Field Geologist.

Program Geologist - Responsible for QA/QC oversight of the planning and implementation of the test, along with the evaluation of data generated by the test.

5.0 PROCEDURES

The procedures presented in this section concern the administration and execution of well-head tests; the technical content of a given test will be established by the project and program management for each instance according to experience and best professional practice.

5.1 Overview

The well-head test will conform to the objectives of the investigation and to standards of good practice common in geohydrologic investigations. Sufficient personnel, and sufficient standard and special equipment will be available for the intentions of the test. Data collection will conform to the practice described in SOP F202 (Water Level, Water/Product Level Measurements and Well Depth Measurements); additionally, time will be measured and recorded no less precisely than the nearest minute or half-minute, as appropriate, while conforming to the intent of the test. Containment and disposal of discharged liquids will conform to the practice described in SOP F504 (Handling of Site Investigation Wastes).

5.2 Applications

The well-head test will usually be divided into three stages:

1. Static measurement
2. Falling-head test
3. Rising-head test

Each stage will normally be run for no more than 30 minutes. The water level in the test well should recover to between 90 and 100 percent of static conditions before beginning the next stage. Should the recovery be less than acceptable after 30 minutes from the start of the first stage, or should other field conditions conspire adversely, the second stage will not be run. Measurements of recovery during the first stage may then be extended to 60 minutes.

5.2.1 Static Measurement

This stage of the well-head test provides the data on static conditions to be used in subsequent approximation of the aquifer parameters. The static water levels are to be measured no later than immediately prior to the first stage of the test, whether falling-head or rising-head. The levels should also have been measured once daily, if possible, for two or more days preceding the test; the optimal measurement program would provide continuous measurement and recording of levels in all wells to be used for a period of several weeks preceding well-head testing.

5.2.2 Falling-Head Test

The falling-head stage of the well-head test is usually conducted before the rising-head. This stage imposes a stress on the water-bearing layer by nearly instantaneously injecting water or introducing a solid slug of impermeable material at one point (the test well). This is usually repeated at a large number of the available wells in the well-field. The measurements, as recorded from the transducer, of the rate of recovery of the drawdown in the well provides data used in approximation of the aquifer parameters. The test should be planned to use between 50 and 75 percent of the available displacement in the well, but may use between 1 and 100 percent, at the discretion of the Site Manager. The use of a solid slug is favored by the program. The impressed head developed by this test must rise above the top of the well screen.

5.2.3 Rising-Head Test

The rising-head stage of the well-head test imposes a stress on the water-bearing layer by nearly instantaneously extracting water or removing a solid slug of impermeable material at one point (the test well). This is usually repeated at a large number of the available wells in the well-field. The measurements of the rate of recovery of the drawdown in the well provides data used in approximation of the aquifer parameters. The test should be planned to use between 50 and 75 percent of the available displacement in the well, but may use between 1 and 100 percent, at the discretion of the Site Manager. The use of a solid slug is favored by the program.

5.3 Measurements and Measurement Intervals

The measurement intervals for water levels in the test well during each stage will be modified from the following suggestions:

Time Since Start of Test (min)	Measurement Frequency (min)
0-5	0.5
5-10	1
10-20	2
20-60	5

The actual time and the test time for each reading will be recorded, with the water level measured to a precision of 0.01 ft.

The sequence of stations tested and the frequency of readings will be established by project and program management prior to the tests, and will be adjusted according to site conditions during the tests.

5.4 Calculation Methods

Calculation of the approximate values of the aquifer parameters will follow standard practice, with particular reference to the resources of Section 7, or as otherwise noted in the calculation sequence. A computer program, AQTESOLV (Duffield and Rambaugh) or similar or equivalent, may also be used; if the computer program is used, an example that has previously been verified by traditional calculation will be run as part of the data from the subject site.

6.0 QUALITY ASSURANCE RECORDS

The readings made during the well-head test may be recorded in field books or on separate forms, according to management decisions. The field books will be stored according to SOP F303, with photocopies of the specific pages with test data included in the file for each test. The file for each test will include the field data, the calculations and graphs, and summaries with references for calculations by computer program.

7.0 REFERENCES

Chow, V.T. 1964. Handbook of Applied Hydrology. McGraw-Hill, New York.

Lohman, S.W. 1979. Ground-Water Hydraulics. Geological Survey Professional Paper 708. U.S. Government Printing Office.

Freeze, R.A. and Cherry, J.A. 1979. Groundwater. Prentice-Hall, Englewood Cliffs.

Driscoll, F.G., ed. 1986. Groundwater and Wells, 2nd ed. Johnson Filtration Systems, St. Paul.

Duffield, G.M., Rambaugh, J. O. 1989. AQTESOLV. Aquifer Test Solvert, Version 1.00 Documentation.

SOP F501
Decontamination of Drilling Rigs and Monitoring Well Materials

DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

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DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

1.0 PURPOSE

The purpose of this SOP is to provide a general reference regarding the proper decontamination of drilling rigs and monitoring well materials used in the performance of field investigations.

2.0 SCOPE

This procedure addresses drilling equipment, test pit equipment (i.e. backhoe) and monitoring well material decontamination and should be consulted during the preparation of project-specific plans. This procedure does not pertain to personnel decontamination, or to chemical sampling or field analytical equipment decontamination.

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring the field personnel overseeing decontamination activities, and personnel conducting the activities have been briefed and trained to execute these procedures.

Drilling Inspector (Site Geologist, Rig Geologist etc.) - It is the responsibility of the drilling inspector to ensure that the drilling subcontractor follows these, or other project-specific procedures as directed by the Field Team Leader.

5.0 PROCEDURE

The various drilling equipment and materials involved with test boring, test pit excavation, subsurface soil sampling, and monitoring well construction must be properly decontaminated to ensure that chemical analysis results reflect actual concentrations present at sampling locations. These procedures will minimize the potential for cross contamination between sampling locations and the transfer of contamination off site.

5.1 Equipment

All drilling equipment involved in field sampling activities shall be decontaminated prior to drilling, excavation, or sampling activities. Such equipment includes drilling rigs, backhoes, augers, downhole tools, well casings, and screens. Split-spoon soil samplers and other similar soil sampling devices shall be decontaminated according to the procedures given in SOP F502.

5.2 Decontamination Procedures

Prior to drilling, or leaving the site, large equipment not directly utilized for sampling will be decontaminated by steam-cleaning in a designated area. The decontamination procedure consists of steam-cleaning the equipment, using potable water as the steam source, to remove visible signs of soils or wastes, and allowing the equipment to air dry. If necessary, the equipment may be cleaned with a scrub brush and alconox/liquinox-water solution prior to steam cleaning to remove visible signs of contamination.

The steam cleaning area will be designed to contain decontamination wastes and waste waters, and can be a lined, excavated pit or a bermed concrete or asphalt pad. For the latter, a floor-drain must be provided which is connected to a holding tank. A shallow, above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

At certain sites, due to the type of contaminants or proximity to residences, concerns may exist

about air emissions from steam cleaning operations. These concerns can be alleviated by utilizing one or more of the following practices:

- Locate the steam cleaning area on site to minimize potential impacts.

- Enclose steam cleaning operations. For example, augers and drilling rods can be steam cleaned in drums. Tarpaulins also can be placed around the steam cleaning area to control emissions.

For a given project, the location of the steam cleaning area will be identified in the Sampling and Analysis Plan.

Decontamination wastes will be collected and contained unless otherwise directed by LANTDIV. The eventual disposition of these wastes will be determined on a project-specific basis, but may include on-site treatment and/or transport off site to an approved treatment/disposal facility.

6.0 QUALITY ASSURANCE RECORDS

Rinsate samples may be collected from steam-cleaned equipment as quality assurance records. The frequency of rinsate samples from either drilling tools or well casings/screens shall be specified in the Sampling and Analysis and Quality Assurance Project Plans for a given project, as appropriate. Documentation in the field logbook also shall serve as a quality assurance record of decontamination activities.

7.0 REFERENCES

None.

SOP F502
Decontamination of Sampling and Monitoring Equipment

DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

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DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

1.0 PURPOSE

The purpose of this SOP is to provide a general methodology and protocol, and to reference information for the proper decontamination of field chemical sampling and analytical equipment.

2.0 SCOPE

This procedure applies to all field sampling equipment including, but not limited to, split-barrel soil samplers (split-spoons), bailers, beakers, trowels, filtering apparatus, and pumps. This procedure should be consulted when decontamination procedures are being developed as part of project-specific plans. Additionally, current USEPA regional procedures and decontamination guidance as well as state guidance should be reviewed.

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring field personnel performing decontamination activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader.

5.0 PROCEDURES

In order to ensure that chemical analysis results reflect actual concentrations present at sampling locations, sampling equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sampling locations) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sampling locations and the transfer of contamination off site.

Preferably, sampling equipment should be dedicated to a given sampling location. If this is not possible, equipment must be decontaminated between sampling locations. Sampling personnel also must use disposable gloves and change them between sampling locations.

5.1 Sampling Equipment Decontamination Procedures

Soil and sediment sampling equipment including, but not limited to trowels, beakers, dredges, etc., shall be decontaminated using the following USEPA Region procedures.

The following sections summarize decontamination procedures for USEPA Regions I through IV for overall comparison. Each region should be contacted prior to initiation of sampling activities to assure that the most recent, accepted decontamination procedures are used.

USEPA Region I

Prior to use, all sampling equipment should be carefully cleaned using the following procedure:

1. A dilute hydrochloric acid rinse
2. Deionized water rinse
3. Methanol or acetone rinse; and,
4. Distilled, organic-free water rinse.

For badly contaminated equipment, a hot water detergent wash may be needed prior to the rinse procedure. Additionally, a hexane rinse also may be needed, prior to the final distilled water rinse, when sampling for low-level organic pollutants.

USEPA Region II

Prior to use, all sampling equipment will be decontaminated using the following procedure:

1. Low-phosphate detergent wash (i.e., Alconox or Liquinox)
2. Tap water rinse
3. 10 percent nitric acid solution rinse
4. Tap water rinse
5. Methanol followed by a hexane or an acetone rinse
6. Analyte-free deionized water rinse
7. Air dry
8. Wrap in aluminum foil, shiny side out, for storage or transport

If the samples will not be analyzed for metals, then steps 3 and 4 may be omitted; if samples will not be analyzed for organics, then step 5 may be omitted. All solvents must be pesticide-grade.

USEPA Region III

Prior to use, all sampling equipment will be decontaminated using the following procedure:

1. Potable water rinse
2. Alconox or Liquinox detergent wash
3. Scrubbing, as necessary
4. Potable water rinse
5. 10 percent nitric acid rinse
6. Distilled-deionized water rinse
7. Methanol or hexane rinse
8. Distilled-deionized water rinse
9. Air dry

USEPA Region IV

The general decontamination procedure for Region IV is similar to that for Regions II and III. However, there may be some specialized procedures applicable to certain types of field equipment such as equipment used for the collection of samples for analysis of trace organic compounds, automatic wastewater sampling equipment, sampling tubing, and miscellaneous

equipment (i.e., pumps, hand augers, etc.). The most current version is "Standard Operating Procedures and Quality Assurance Manual," USEPA Region IV, Environmental Services Division, Environmental Compliance Branch (see Appendix B in February 1, 1991 version).

5.2 Field Analytical Equipment Decontamination

Field analytical equipment which may come in direct contact with the sample or sample media, including, but not limited to water level meters, water/product level meters, pH or specific ion probes, specific conductivity probes, thermometers, and/or borehole geophysical probes must be decontaminated before and after use, according to the procedures outlined in Section 5.1, unless manufacturers instructions indicate otherwise. Probes that contact water samples not used for laboratory analyses may be rinsed with distilled water. Probes which make no direct contact (e.g. HNu or OVA probes) will be wiped clean with clean paper towels or an alcohol-saturated cloth.

6.0 QUALITY ASSURANCE RECORDS

Decontamination procedures are monitored through the collection of equipment rinsate samples and field blanks. Collection of these samples shall be specified in the project-specific Sampling and Analysis and Quality Assurance Plans following the requirements of NEESA 20.2-047B. Documentation recorded in the field logbook also shall serve as a quality assurance record.

7.0 REFERENCES

NEESA 20.2-047B. Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program. Naval Energy and Environmental Support Activity. Port Hueneme, CA. June 1988.

U. S. EPA Office of Waste Program Enforcement. RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD). OSWER Directive 9950.1. 1986.

U. S. EPA. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA Environmental Services Division, Athens, Georgia. 1991.

Micham, J. T., R. Bellandi, E. C. Tifft, Jr. "Equipment Decontamination Procedures for Ground Water and Vadose Zone Monitoring Programs: Status and Prospects." in Ground Water Monitoring Review. Spring 1989.

SOP F504
Handling of Site Investigation Derived Waste

HANDLING OF SITE INVESTIGATION DERIVED WASTES
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6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

1.0 PURPOSE

The purpose of this SOP is to provide guidance for the disposal of investigation derived wastes (IDW) under the Navy CLEAN Installation Restoration (IR) Program.

2.0 SCOPE

This procedure describes the steps necessary to dispose of site investigation derived wastes that are generated during field investigations. These wastes may be either hazardous or nonhazardous in nature. The nature of the waste (hazardous or nonhazardous) will determine how the wastes will be handled during the field investigation. The sources of waste material depend on the site activities planned for a project. The following types of activities (or sources) that are typical of site investigations, may result in the generation of waste material which must be properly handled:

- Soil borings and monitoring well construction (drill cuttings)
- Mud rotary drilling (potentially contaminated mud)
- Monitoring well development (development water)
- Groundwater sampling (purge water)
- Heavy equipment decontamination (decontamination fluids)
- Sampling equipment decontamination (decontamination fluids)
- Personal protective equipment [PPE] (health and safety disposables)

3.0 DEFINITIONS

Investigation Derived Waste (IDW) - A waste (hazardous or nonhazardous) generated during a Navy-authorized field investigative task that has been properly labeled, stored, and containerized while awaiting final disposition. These wastes may include drilling muds, soil cuttings, and purge water from test pit and well installation; purge water, soil, and other materials from collection of samples; residues (e.g., ash, spent-carbon, well development purge water) from testing of treatment technologies and pump and treat systems; contaminated PPE; and solutions used to decontaminate non-disposable PPE and equipment (USEPA, April 1992, Guide to Management of Investigation-Derived Wastes).

4.0 RESPONSIBILITIES

LANTDIV - LANTDIV or the facility must ultimately be responsible for the final disposition of site wastes. As such, an Activity representative will usually prepare the disposal manifests in the event off-site disposal is required. However, it may be the responsibility of Baker, depending on the contingency discussions during execution of the investigation to provide assistance to the Activity in arranging for final disposition and preparing the manifests. The Activity representative will be required to sign all manifests.

Project Manager - It is the responsibility of the Project Manager to select investigation methods that minimize the generation of waste material, where possible, and to work with the Activity and LANTDIV NTR in determining the final disposition of site investigation wastes. The Project Manager will relay the results and implications of the chemical analysis of the waste or associated material, and advise on the regulatory requirements and prudent measures appropriate to the disposition of the material. The Project Manager also is responsible for ensuring that the site manager and/or field team leader for the site, is familiar with the procedures to be implemented in the field, and that all required field documentation has been completed.

Site Manager/Field Team Leader - The Site Manager or Field Team Leader is responsible for the on site supervision of the waste handling procedures during the site investigations. The Site Manager or Field Team Leader also is responsible for ensuring that all other field personnel are familiar with these procedures.

5.0 PROCEDURES

5.1 Preliminary Activities

Prior to the initiative of site activities the expected sources, media, and quantities should be estimated, and potential contaminants certified, as well as the method(s) of containerizing and staging of these materials.

5.2 Designation of Potentially Hazardous and Nonhazardous IDW

Wastes generated during the field investigation can be categorized as either potentially hazardous or nonhazardous in nature. The designation of such wastes will determine how the wastes will be handled. The criteria for determining the nature of the waste, and the subsequent handling, is described below for each type of investigative waste.

5.2.1 Drill Cuttings/Mud

Drill cuttings and mud generated during the augering of test (soil) borings and monitoring well installation boreholes, will be containerized in 55-gallon drums or in lined roll-off boxes. As the borehole is augered, and soil samples collected, the site geologist will monitor the cuttings/samples with an HNu photoionization (PID) unit for organic vapors. In addition, the site geologist will describe the soils in a field logbook. Upon completion, the soil borings will be backfilled with a cement-bentonite grout.

5.2.2 Monitoring Well Development and Purge Water

All site development and purge water shall be containerized in 55-gallon drums, tankers, or large (250-gallon) containers. 55-gallon drums will initially be strategically located at the site (i.e., next to each well).

5.2.3 Decontamination Fluids

Equipment and personal decontamination fluids shall be containerized in 55-gallon drums or tanks, if appropriate. The fluids shall be collected from each of the "decon"/wash pads on a daily basis. Decontamination fluids containing solvents and/or acids may be containerized separately.

5.2.4 Personal Protective Equipment

All personal protective equipment (e.g., tyvek, gloves, and other health and safety disposables) shall be double bagged and placed in a 55-gallon drum or a dump box, which will be provided by the Activity. The Activity will ultimately dispose of these materials.

5.3 Containerization

Waste materials should be segregated to minimize disposal quantities of hazardous materials. For instance, soils from a particular boring will be placed in a single set of containers for that boring. Development and purge water from a given well may be placed in the same set of containers; however, water from different wells should be placed in different containers unless otherwise stipulated by the Project Plans.

Polyethylene or other suitably compatible liners will be used in roll-off boxes for solids. The containers are to remain closed except when filling, emptying or sampling. The container lid shall be securely attached at the end of each work day or when the container is completely empty.

5.4 Labeling

When 55-gallon drums are used to containerize IDWs, the containers will be closed, numbered and labeled by the field team during the site investigation. Labeling shall be performed using spray paint and a stencil kit. Information shall be recorded both on the container lid and its side. Container labels shall include, as a minimum:

- Date
- Site number
- CTO number
- Boring or well number
- Matrix (liquid, solid)
- Contents (dev. water, decon fluids, etc.)
- Contaminant of concern (PCBs, solvents, metals, etc.)

If laboratory analysis reveals that containerized materials are hazardous or contain PCBs, additional labeling of containers may be required. The project management will assist LANTDIV in additional labeling procedures, if necessary, after departure of the field team from the facility. These additional labeling procedures will be based upon the identification of material present; EPA regulations applicable to labeling hazardous and PCB wastes are contained in 40 CFR Parts 261, 262 and 761.

5.5 Container Storage

Containers of site investigation wastes shall be stored in a designated and secure area that is managed initially by Baker and subsequently by the Environmental Management Division (EMD) of the facility until disposition is determined. All containers shall be covered with plastic sheeting to provide protection from weather.

If the laboratory analysis reveals that the containers hold hazardous or PCB waste, additional storage and/or security measures may be implemented; in the absence of the investigation team, this will be the responsibility of LANTDIV or the facility, as confirmed by the contingency discussions.

Baker will assist LANTDIV in devising the storage requirements, which may include the drums being staged for easy access or on wooden pallets or other structures to prevent contact with the ground. Weekly inspections of the temporary storage area by facility personnel may also be required. These inspections may assess the structural integrity of the containers and proper container labeling. Also, precipitation that may accumulate in the storage area may need to be removed. These weekly inspections and precipitation removal events, shall be recorded in the site logbook.

5.6 Container Disposition

The disposition of containers of site investigation generated wastes shall be determined by LANTDIV, the Activity, and regulatory personnel with the assistance of Baker, as necessary. Container disposition shall be based on quantity of materials, types of materials, and analytical results. If necessary, specific samples of contained materials may be collected identify further characteristics which may affect disposition. Typically, container disposition will not be addressed until after receipt of applicable analytical results; these results are usually not available until long after completion of the field investigation at the facility.

5.7 Disposal of Contaminated Materials

Actual disposal methods for contaminated materials disturbed during a site investigation are the same as for other PCB or hazardous substances: incineration, landfilling, treatment, and

so forth. The responsibility for disposal must be determined and agreed upon by all involved parties during negotiations addressing this contingency.

The usual course will be a contractor specialist retained to conduct the disposal. However, regardless of the mechanism used, all applicable Federal, state and local regulations shall be observed. EPA regulations applicable to generating, storing and transporting PCB or hazardous wastes are contained in 40 CFR Parts 262, 263 and 761.

Another consideration in selecting the method of disposal of contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable on-site disposal or treatment structure is expected, contaminated materials generated during the site investigation may be stored at the site for treatment/disposal with other site materials. In this case, the initial containment (i.e., drums or other containers) shall be evaluated for use as long-term storage. Also, other site conditions, such as drainage control, security and soil types must be considered in order to provide proper storage.

6.0 QUALITY ASSURANCE RECORDS

A container log shall be maintained in the site log book. The container log shall contain the same information as the container label plus any additional remarks or information. Such additional information may include the identification number of a representative laboratory sample. Weekly inspections of the drum or dump box storage areas will be performed and documented in the site log.

7.0 REFERENCES

Federal Register 40 CFR Parts 261, 263 and 761.

SOP F703
Geophysics - Ground Penetrating Radar

GEOPHYSICS: GROUND PENETRATING RADAR (GPR)
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GEOPHYSICS: GROUND PENETRATING RADAR (GPR)

1.0 PURPOSE

The purpose of this SOP is to provide general reference information and technical guidance on the methods and techniques of ground penetrating radar (GPR).

2.0 SCOPE

These procedures provide overall technical guidance.

3.0 DEFINITIONS

Bistatic Antenna - An antenna system in which transmitting and receiver coils are housed in separate antenna units.

Deconvolution - A computer processing method. The process of undoing the effect of another filter (in this instance the "earth"). A process that removes ringing, multiples, ghosts, and some background noise (Sheriff, 1973).

Dielectric Permittivity - (Also known as the relative dielectric permittivity): 1. A complex number consisting of a real and imaginary part, which uniquely describes the propagation and attenuation of electromagnetic energy in every material. The real dielectric permittivity (dielectric constant) characterizes the propagation and reflection of electromagnetic (EM) waves, while the imaginary part (dielectric loss) characterizes the attenuation of EM signal (Kutrubes and Olhoeft, 1987). 2. A measure of the capacity of a material to store charge when an electric field is applied (Sheriff, 1973).

Electromagnetic Waves - One of the waves that are propagated by simultaneous periodic variations of electric and magnetic field intensity and that include radio waves, infrared, visible light, ultraviolet, X-rays and gamma rays (Webster's New Collegiate Dictionary. 1979).

Migration - here velocity varies laterally, data will migrate (relative to the time versus antenna distance plot), and ray tracing is used to determine migrated positions (Sheriff, 1973).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that the project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for ensuring that the personnel operating and interpreting the geophysical data are trained, skilled in that endeavor, so far as to receiving documentation on the training and experience of the operating personnel.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the geophysical technique and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the field investigation personnel performing the activities have been briefed and trained to execute these procedures.

5.0 PROCEDURES

5.1 Overview

Ground penetrating radar (GPR) is an active geophysical system which transmits high frequency electromagnetic (EM) waves into the ground and detects the energy reflected back to the surface. GPR operates on a similar principle as seismic reflection, except, instead of acoustic waves, electromagnetic waves of radio and microwave frequencies (80 MHz to 1,000 MHz) are utilized. Electromagnetic signals are reflected back to the surface from interfaces with differing electrical properties, such as dielectric permittivity and conductivity. The greater the contrast in the real dielectric permittivity (dielectric constant) between two materials, the more energy is reflected to the surface. Reflections typically occur at lithologic changes, subsurface discontinuities, and internal soil structures such as:

- Top of bedrock surfaces
- Soil and rock stratification
- Water table
- Seepage and leachate zones
- Buried metal objects such as drums and utilities
- Open and water filled voids

- Bedrock fractures
- Archaeological structures

The depth of penetration of GPR is site specific, being limited by the attenuation of the electromagnetic energy. Signal attenuation is controlled by four different mechanisms listed below, any or all of which may be present at a site.

- Scattering losses
- Conduction losses
- Water losses
- Clay losses

Energy losses due to scattering occur when signals are dispersed in random directions, away from the receiving antenna, by large irregularly shaped objects, such as boulders and tree stumps.

Signal attenuation due to conduction is a function of the conductivity of a material, which varies with mineral composition, the amount of water, and the total dissolved solids (salt, heavy metals) within the water. The greater the electrical conductivity values of materials at a site, the more signal attenuation (hence less penetration) there will be.

Energy losses attributed to water occur when water molecules polarize in the presence of the applied electromagnetic field. Electromagnetic energy is lost to the radar system when it is converted to kinetic and thermal energy as a result of the rotation of water molecules.

Signal attenuation due to clay losses occurs when electrochemically charged ions polarize along clay surfaces in the presence of the electromagnetic field induced by the radar system. The migration and subsequent collision of these charged particles causes electromagnetic energy to be converted to kinetic and thermal energy, which is lost to the radar system.

Signal penetration is also dependent on the frequency of the transmitting antenna used in the radar system. Higher frequency antennas produce waves with shorter wave lengths, which are attenuated more rapidly with depth, but give better resolution. Specially designed 2 MHz antennas have been used to detect the ice-rock boundary of a 2 km thick glacier. Penetration of up to 75 feet has been reported for water saturated, clean sands in a Massachusetts glacial delta using a commercial antenna. Signal penetration in saturated clays, on the other hand, is on the order of magnitude of a few inches. Olhoeft (1986a) determined that even 5% clay

added to a clean sand and gravel will cause a decrease in penetration by a factor of 20. Salt water is also a high loss substance, as signal penetration in sea water is less than a foot. It is important to note that in a layered medium a single, highly reflective layer alone can limit signal penetration by preventing the propagation of energy through it. In this instance the apparent loss of energy is caused by reflection rather than by signal attenuation.

5.2 Applications and Uses

Ground penetrating radar (GPR) is a shallow penetrating geophysical profiling system used where rapid and accurate surveys are desired. GPR can be used for both area and source detection studies. GPR has been used to locate underground pipes, buried drums, foundations, voids in rock and concrete, lithologic contacts, determine stratigraphy, depth to the water table, and depth to bedrock, locate buried archaeological artifacts, excavations, filled pits and lagoons, and numerous other site specific applications. GPR has been used successfully to delineate the lateral extent of plumes. Haeni et al. (1985) used GPR to investigate the thickness, type, and extent of sediments beneath a frozen lake with a 80 MHz antenna. The information acquired with GPR was used to help map the lateral extent of an aquiclude, and better estimate inputs to the mass balance equation for water budget calculations.

A GPR system can be used to determine depths to reflecting discontinuities by conducting a depth calibration. Typically, calibration is performed by moving the radar antenna over a metal target of known depth, such as a buried metal plate. Also, if transmitting and receiving antennas are housed in different units, designated as a bistatic antenna system, a common depth point (CDP) survey, identical to surveys conducted with seismic reflection, can be used to calculate the velocity of the medium, and hence depth to the reflector. Sakayama and others (1988) describe another method to calculate velocity from bistatic antennas where the receiving antenna is continually moved away from the stationary transmitting antenna. The velocities of the direct arrival and the first strong reflector are recalculated from the inverse slope of the time-distance display (antenna separation) on the GPR record in a similar manner as seismic refraction.

To verify GPR results, other geophysical or ground truth methods can be utilized. Haeni et al. (1985) utilized seismic refraction to correlate calculated depths of stratigraphic horizons and water tables with radar reflections. Magnetometry and electromagnetic induction methods have been utilized to verify the presence of buried drums and fuel tanks. Electromagnetic

induction and electrical resistivity have been utilized to verify the lateral extent of conductive plumes. The depth to a particular reflector or target can also be verified by boreholes and/or test pit excavation.

5.3 Equipment

A ground penetrating radar system, shown on Figure 1, consists of:

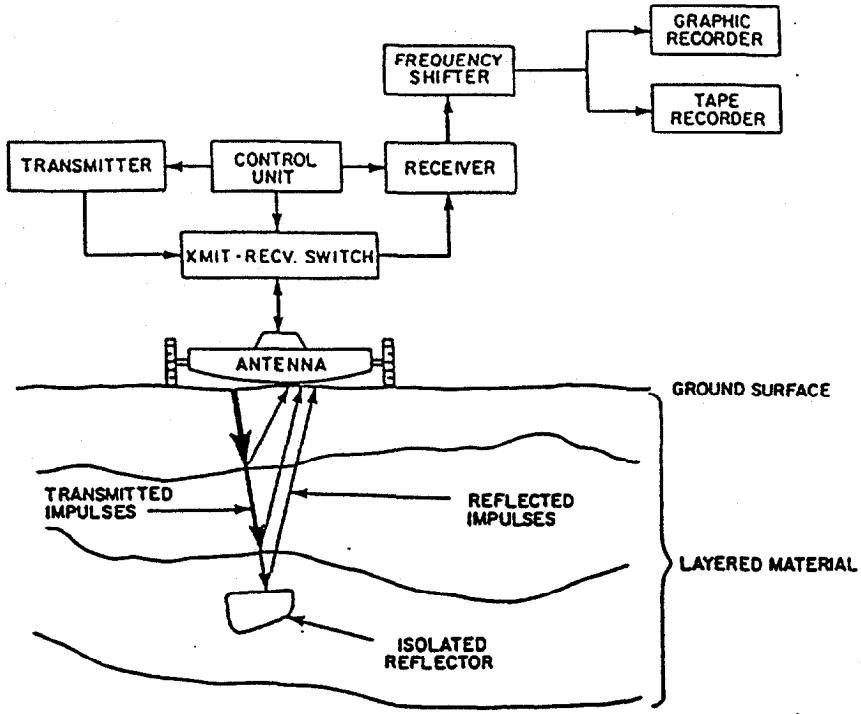
- AC/DC power supply
- Control unit (pulse transmitter)
- Antenna(s)
- Graphic recorder
- Digital recorder (optional)
- Magnetic tape recorder (optional)
- Coaxial cable which connects the control unit to the antenna

Typically, radar antennas contain both the transmitter and receiver within one fiberglass unit. Once a radar impulse is transmitted, the antenna switches to the receiver mode and records reflected radar impulses. The pulse receiver contains an amplifier which increase the amplitude of reflected signals. Bistatic antennas (transmitter-receiver are separate) allow the coverage of larger areas with one pass, and multi-receiver combinations allow the "stacking" of radar data which increases the signal to noise ratio.

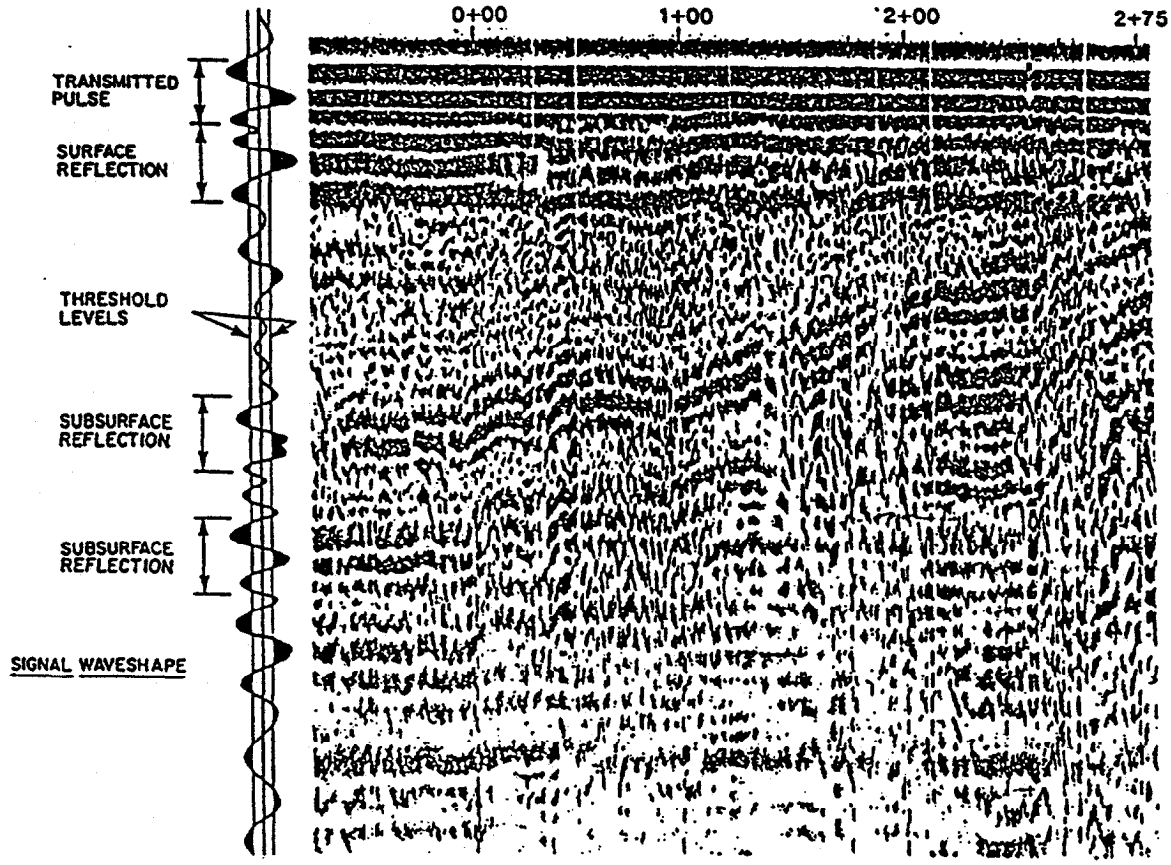
Field data are generally printed by a graphic recorder and simultaneously can be stored on magnetic tape or diskette. The graphic recorder produces a continuous time (vertical) versus distance (horizontal) profile of the subsurface for field quality control and qualitative interpretations. Radar impulses are synchronized with the swept-stylus type graphic recorder, producing a dark band proportional to the amplitude of reflected radar signal. Because the antenna is moving, each pass of the stylus represents a slightly different antenna position. Gradually, as the recorder paper advances under the moving stylus, a pattern of reflective interfaces emerges.

Storage of data on diskette or magnetic tape allows opportunity of additional printing and/or computer processing for the refinement of data. Deconvolution of stored data enhances stratigraphic reflections from the water table and soil structures (Olhoeft, 1988). Migration of data allows easier resolution of metallic targets, such as buried drums, and delineation of excavations and sinkholes (Hogan, 1988).

FIGURE 1



RADAR SYSTEM BLOCK DIAGRAM



TYPICAL RADAR RECORD

GROUND PENETRATING RADAR SET-UP

Radar systems are designed to use antennas of various electrical characteristics. Selection of the antenna is dictated by the requirements of the survey. If high resolution, near-surface data are desired, a small, high frequency antenna is used; if the survey requires deeper probing, a larger, lower frequency antenna is used (80, 120, 250, 300, 400, 500, 900, and 1,000 MHz antennas are commercially available). The drawback of using the lower frequency antennas is that resolution of data is sacrificed for penetration. Also, the low frequency antennas (less than 250 MHz) are generally not shielded, making them susceptible to overhead power line noise and spurious reflections from passing cars. The 900 and 1,000 MHz antennas are used almost exclusively for short penetration projects such as the detection of rebar in concrete, as their penetration is generally limited to 2 to 3 feet.

5.4 Field Procedures

The majority of time involved with any GPR survey is spent establishing survey lines in the area of investigation so that detected anomalies can be easily located and excavated. Survey lines should be set to maximize coverage, while maintaining a grid spacing proportional to the presumed target dimensions. A minimum survey line spacing of 10 feet is desired when looking for a 1,000 gallon fuel tank, while a larger spacing of 50 feet or more may be used to define the lateral extent of a conductive plume.

At the onset of any GPR survey the radar control unit should be adjusted for the anticipated depth of penetration. Adjustments of the time window of exploration should be made by estimating the velocity of the medium and desired depth of penetration. Most surveys can be effectively conducted with a minimum time window of 50 nanoseconds.

Accurate determination of the depth to any layer requires calibration of the radar system. The easiest way of calibrating the GPR system to specific settings is by burying a plate at a measured depth, and moving the antenna slowly along the survey line. The plate will produce on the GPR record a thick, dark band, parabolic or flat in shape, with many multiple reflections beneath it. Once a certain confidence level is attained from depth calibration, the survey is conducted by slowly pulling the antenna along survey lines. A slow walking pace increases the horizontal resolution as radar signals are propagated in a 15 to 45 degree cone from the bottom of the antenna. A slow walking pace is recommended for hazardous waste investigations as targets are better defined and easier to resolve. On the other hand, the radar

antenna can be towed from the back of a car or truck at speeds up to 10 miles an hour if the "target" is a continuous reflector, such as the water table.

5.5 Interpretation

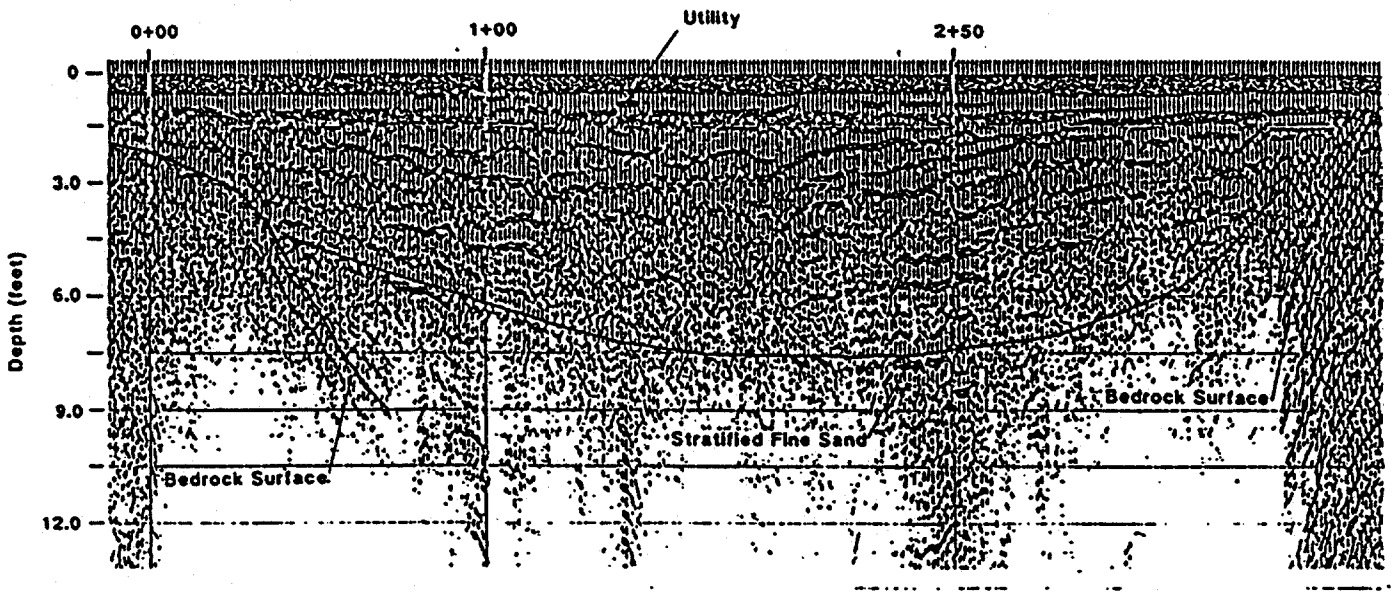
A typical GPR record is shown on Figure 1. A representation of a single GPR signal pulse is shown along the side of the record. The horizontal scale of the record is maintained by marking on the record the locations of survey stations as they are reached by the antenna. Accurate determination of the vertical scale (i.e., conversion of a time into a depth) requires calibration of the radar system. If the depth to a known reflector can not be determined through calibration or verification using boreholes and test pits, the velocity of the medium can be approximated from relationships involving the velocity of the medium, and the dielectric constant (real dielectric permittivity) of the medium. Values of the dielectric constant can be found in GSSI (1974), and Kutrubes (1986). It is important to note that the relationship is no longer valid when signal losses are great. The depth to the reflector can be calculated from time and velocity values.

Interpretation of GPR data is subjective, even among experienced interpreters. The strength of a reflected signal and/or the continuity of that reflector across the record may be indicative of a stratigraphic contact. The water table in an unconfined sand and gravel aquifer may also produce a similar signature on the GPR record. The strong continuous reflector shown in Figure 2 delineates the contact between bedrock and unconsolidated materials. Point targets, such as buried drums, pipes, boulders, tree stumps, etc., create a distinctive parabolic feature on GPR records. Positive identification of point targets are subjective, as the GPR signature of a pipe is similar to that of a large boulder.

Figure 3 shows the characteristic parabolic signal created by a point target, underground storage tanks in this instance, which are situated in a clean sand and gravel deposit. Metallic objects, such as buried drums and pipes, also produce a characteristic parabolic signal on the record, and sometimes produces a "ringing" noise, denoted by the heavy, dark banding, as shown in Figure 3.

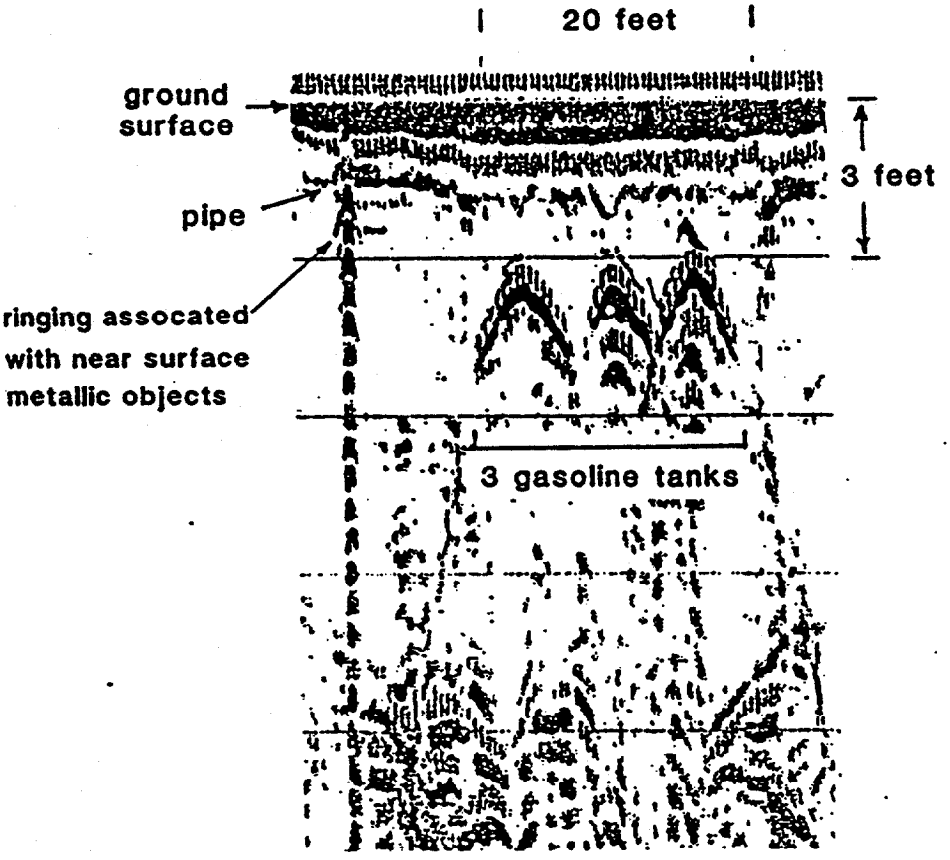
Recorded data from diskettes or magnetic tapes can be enhanced using numerous computer processing methods to remove constant noise problems, such as ringing, or to sharpen up geologic contact features and point target boundaries. Such methods are described in detail by

FIGURE 2



GROUND PENETRATING RADAR RECORD
OF A BURIED RIVER CHANNEL

FIGURE 3



GROUND PENETRATING RADAR RECORD OF BURIED FUEL TANKS

Hogan (1988) and Olhoeft (1988). Computer processing is costly and generally not necessary in most instances.

5.6 Advantages/Disadvantages

Advantages of ground penetrating radar systems include:

- Rapid coverage of an area
- GPR is a non-destructive technique
- Portable equipment
- Provides high vertical resolution profiles in the field for immediate interpretation

Ground penetrating radar provides a cost effective way of evaluating a large site in a short amount of time. One day of work coverage completed by GPR may be equivalent to four or five days of work with seismic refraction or electrical resistivity. The GPR method is "non-destructive" in that it does not require any excavation or probing of the overburden materials, although verification of anomalies should be conducted.

Equipment can be easily loaded in the back of a truck as most pieces comprising the radar system weigh under 40 pounds. The 80 MHz antenna weighs about 100 pounds and is less portable as it is approximately 4 feet wide.

Limitations of radar systems include:

- Survey lines must be cleared to ground level
- Multiple receiver antennas are generally required to stack and process radar data
- Penetration is site specific, requiring data corroboration using alternative geophysical methods and/or verification
- Interpretations are subjective

To maximize resolution and minimize scattering losses, survey lines must be as level as possible to prevent the bouncing and jarring of the radar antenna. Survey lines cleared of debris also allow the antenna to be pulled at an even, continuous pace, permitting the easy determination of horizontal scale.

Application of GPR to a site is limited by soil type and presence of high loss materials. In New England, the presence of glacial tills, and lacustrine and marine clays limit the depth of penetration. Delineation of buried drums beneath a conductive plume also may not be

possible. The unpredictability of radar effectiveness requires that site investigations be conducted with alternative geophysical methods, such as electromagnetic induction, seismic refraction, magnetometry, and/or electrical resistivity.

6.0 QUALITY ASSURANCE RECORDS

All data will be recorded in field log books with the following information: date, location, personnel on site, start and finish times (in military time), instrument gain and time settings, and Contract Task Order number.

7.0 REFERENCES

Benson, R.C., and Glaccum, R.A., 1979, Remote Assessment of Pollutants in Soil and Ground Water, in the Proceedings of the 1979 Conference on Hazardous Material Risk Assessment, Disposal and Management: Information Transfer Inc., Miami Beach, April 25-27, p. 188-194.

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Kutrubes, D.L., 1986, Dielectric Permittivity Measurements of Soils Saturated with Hazardous Fluids: H.Sc. Thesis, Colorado School of Mines, Golden, CO, 300 p.

Olhoeft, G.R., 1988, Applications and Limitations of Computer-Processed Ground Penetrating Radar Data, in Abstracts for the Second International Symposium on Geotechnical Applications of Ground Penetrating Radar: West Gainesville, Florida, March 6-10, sponsored by the U.S. Dept. of Agriculture, Washington, DC, p. 37.

Olhoeft, G.R., 1986a, Electrical Properties From 103 to 109 Hz-Physics and Chemistry, in Proceedings of the Second International Symposium on the Physics and Chemistry of Porous Media: Houston, Texas, Schlumberger-Doll, October, 18 p.

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Sheriff, R.E., 1973, Encyclopedic Dictionary of Exploration Geophysicists: Tulsa, OK, Society of Exploration Geophysicists, 266 p.

SOP A008
Filing

FILING
TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

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- 5.2 Outgoing Correspondence

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7.0 REFERENCES

FILING

1.0 PURPOSE

The purpose of this SOP is to provide direction for the distribution and filing of incoming and outgoing correspondence.

2.0 SCOPE

This SOP outlines the procedures for ensuring that all Navy CLEAN correspondence, incoming and outgoing, is distributed properly, and to ensure that the files are complete and easily accessible.

3.0 DEFINITIONS

Central File - A file located at the office in Beaver, Pennsylvania. When applicable (see "Distribution"), the correspondence should be routed first to the president of Baker Environmental (APPajak), then to Central File as follows: APPajak/CF.

Copying Bin - A bin where incoming or outgoing correspondence is placed for subsequent copying and distribution. The bin is usually located behind the group secretary's work station.

CTO File - A file within the Program File that contains correspondence specific to a CTO. The CTO file is divided into a number of subfiles for organizational purposes and easy access of information.

Daily File - A chronological file which contains copies of all outgoing Baker correspondence. A bin for the Daily File is located on top of the main SRN mail boxes.

Distribution - A listing of personnel who will receive copies of specific incoming or outgoing correspondence. Distribution includes those individuals identified on the "cc" (carbon copy) or "bcc" (blind carbon copy) listing. The "Program File" (PROG F) will always be included on the "bcc" distribution list. The Central File (CF) will be listed on the "bcc" at the discretion of the author of the outgoing correspondence or the receiver of the incoming correspondence. The CF must be included on the "bcc" for Final deliverables and contractual correspondence.

File Bin - A bin where incoming correspondence is placed for subsequent filing in the Program Files. The Filing Bin is located behind the group secretary's work station.

Incoming Correspondence - Includes all letters, reports, data, contractual documents, photographs, invoices, or other information forwarded to Baker from LANTDIV, subcontractors, or other parties associated with the Navy CLEAN Program.

Navy CLEAN Stamp - A stamp that will be placed on incoming correspondence so that the correspondence is properly distributed and placed in the appropriate file. See Exhibit A.

Outgoing Correspondence - Includes all letters, deliverables, data, contractual documents, or other information generated by Baker and forwarded to LANTDIV, subcontractors, or other parties associated with the Navy CLEAN Program.

Program File - A centrally located file that will contain all correspondence pertaining to the Navy CLEAN Program.

Project File - A file that is kept by the Project Manager for the specific CTO. There are no specific formats or requirements for the Project File. The filing of information in the Project File is at the discretion of the Project Manager or person who generated or received correspondence.

Subfile - A breakdown of common information within a CTO File. Attachment A provides a listing of Subfiles for the Program Management CTO (i.e., CTO-0001/19493) and Attachment B provides a listing of standardized Subfiles applicable to all other CTOs.

4.0 RESPONSIBILITIES

Addressee - The person receiving the correspondence is responsible for stamping the correspondence and filling out the information on the stamp and then placing the correspondence in the "copying bin" for subsequent copying, distribution, and filing by the reproduction clerk.

Reproduction Technician/File Clerk - He/she is responsible for ensuring that all information on the stamp or "bcc" attachment is completely filled out by the addressee or sender before making copies and filing.

Author - The person generating the outgoing correspondence (i.e., Project Managers, Program Manager, Technical Staff, etc.) is responsible for identifying the "cc" listing, the "bcc" listing, the correct Service Order Number, and the Subfile Number on the correspondence.

Secretary - The person responsible for ensuring that the Service Order Number and File Number are included on all outgoing correspondence. Both the Service Order Number and the File Number will be placed below the "bcc" distribution list.

5.0 PROCEDURES

5.1 Incoming Correspondence

5.1.1 STEP ONE: The Addressee stamps relevant incoming correspondence with the Navy CLEAN Stamp.

In cases of Express Mail, the person receiving the Express Mail package is responsible for stamping the original. Stamps will be located near each secretary/word processing station, and also in the copy room. Exhibit A shows this stamp.

EXHIBIT A

NAVY CLEAN FILING STAMP

Date Received: _____
Project Manager: _____
CTO Number: _____
bcc: _____
_____
Subfile No.: _____

5.1.2 STEP TWO: Fill out the filing stamp information.

The stamp will contain the following information to be filled out by the person (addressee) receiving the incoming correspondence:

Date Received: Self-explanatory in most cases. If you are out of the office for an extended period of time, it may be more difficult to know the exact date that the mail was received by Baker. However, in most cases, all incoming mail is opened in the mail room and is stamped on the back with the date received.

Project Manager: Identify the Project Manager's initial, even if the letter is addressed to you and you are not the Project Manager.

CTO Number: Use only the first 5 digits (e.g., 19002, 19024, etc.)

bcc: identify who should be copied. For incoming mail, the following persons should ALWAYS be included:

> WDTrimbath/JWMentz/PROG F(original); the remaining names are to the addressee's discretion

For contractual documents, APPajak/CF and the CLEAN Contracts Administrator should also be included.

Subfile No. : The person filling out the stamp must decide what category or subfile (within a CTO file) the document should be filed. Attachment A provides a listing of subfiles for CTO-0001/19493 (Program Management) and Attachment B provides a listing of subfiles for all other CTOs. This listing should be placed somewhere in your office for easy access (e.g., on your wall).

5.1.3 STEP THREE: After you have filled out the information on the stamp, place it in the "copy bin" located near the Secretarial work station.

5.2 Outgoing Correspondence

All letters, reports, etc. will contain a line under the "bcc" that identifies the subfile number. This line will be included on all outgoing correspondence. This line must be filled out by the person authoring the letter. An example is given below:

bcc: APPajak/CF; WDTrimbath/JWMentz/PROG F;
DPBlack(ck)/RPWattras/PF; Daily File
S.O. #19003-62-SVZ
Subfile No.: 4

The letter will then be filed under the "First Tier Subcontracts - Other" category under CTO 19003.

6.0 QUALITY ASSURANCE RECORDS

None.

7.0 REFERENCES

Reviewed by Contract Administrator, August 1993.

ATTACHMENT A

NAVY CLEAN SUBFILE NUMBERS FOR CTO-0001/19493 ONLY

SUBFILE NO.	DESCRIPTION
1.	MONTHLY PROGRESS REPORTS
2.	PERSONNEL ACQUISITION A. PERFORMANCE B. ACQUISITION
3.	CORRESPONDENCE A. PROGRAM B. MISCELLANEOUS C. MEETING MINUTES
4.	PROJECT SCOPING/SITE VISITS/NEGOTIATIONS
5.	ADP SYSTEM
6.	QA/QC A. CONTRACT MGMT. PLAN (CMP) B. CONTRACTOR QUALITY CONTROL PLAN (CQCP) C. SOPs D. AUDITS
7.	CONTRACT ADMINISTRATION (LANTDIV)
8.	FIRST TIER SUBCONTRACT ADMINISTRATION (RFW)
9.	FIRST TIER SUBCONTRACT ADMINISTRATION (FWE)
10.	FIRST TIER SUBCONTRACT ADMINISTRATION (BOAs) A. LABS-IRP B. LABS-UST C. DRILLER D. SURVEYORS E. CH2M HILL F. OTHERS
11.	MINORITY AND SMALL DISADVANTAGED BUSINESSES
12.	PROGRAM TRAVEL
13.	INVOICES TO LANTDIV A. INVOICES B. CONTRACT PERFORMANCE STATEMENTS

ATTACHMENT A (CONTINUED)

NAVY CLEAN SUBFILE NUMBERS FOR CTO-0001/19493 ONLY

SUBFILE NO.	DESCRIPTION
14.	BAKER PMS REPORTS
15.	INTERNAL SOPs/POLICIES/PROCUREMENT MANUAL
16.	MISC. TECHNICAL SUPPORT
17.	MISCELLANEOUS A. FIELD SUPPLY PURCHASES B. DASH #/BUDGET INFORMATION
18.	AWARD FEE

ATTACHMENT B

NAVY CLEAN SUBFILE NUMBERS FOR CTO-0002 through 9999

SUBFILE NO.	DESCRIPTION
1.	BACKGROUND/HISTORICAL INFORMATION (reports or correspondence associated with previous investigations)
2.	NAVY CONTRACT DOCUMENTS (implementation plans/fee proposals; contract modifications; etc.)
3.	FIRST TIER SUBCONTRACTS (Contract documents pertaining to RFW or FWE)
4.	FIRST TIER SUBCONTRACTS - OTHER (Contract documents or specifications pertaining to drillers, data validation, laboratories, etc.)
5.	REPORTS (all reports prepared by Baker under this CTO)
6.	DATA (field-generated data, boring logs, field notebooks, data received from laboratories, etc.)
7.	PHONE REPORTS/SITE VISIT REPORTS/MEETING MINUTES
8.	CORRESPONDENCE (letters, internal correspondence)
9.	INVOICES (drilling, analytical, surveying, vendors)
10.	QA/QC (validation reports, audit reports)
11.	MISCELLANEOUS (Photographs,etc.)

Appendix C
Geophysical Report
SWMUs 11/45

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2.2	Ground Penetrating Radar	C-2-1
2.3	Electromagnetic Terrain Conductivity	C-2-4
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ATTACHMENTS

C1 EM and Magnetic Profiles

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2-2	EM, Magnetic, and GPR Surveys Associated With the East and West Tunnels	2-3

1.0 INTRODUCTION AND INVESTIGATION OBJECTIVES

A surface geophysical survey was conducted from October 28 to November 1, 1993, at Solid Waste Management Units (SWMUs) 11 and 45 at Naval Station, Roosevelt Roads in Puerto Rico. These SWMUs comprise Installation Restoration (IR) Site 16. The survey objectives were to characterize subsurface conditions by delineating suspected tunnels leading to Building 38, verifying the location of underground storage tanks, and detecting buried utilities adjacent to Building 38.

2.0 METHODS OF INVESTIGATION

2.1 Survey Control

Geophysical data obtained in the immediate vicinity of Building 38 were referenced to a survey grid established on site. The east side of the building served as a baseline and a 10 by 10-foot grid was set with a tape measure over the (concrete pad) area suspected of covering the USTs. The survey grid was extended to include an open area between the building and the road where three access ways to the east tunnel were observed. Geophysical data acquired away from Building 38, in an attempt to detect the east and west tunnels, were referenced to surface features, such as roads and fences.

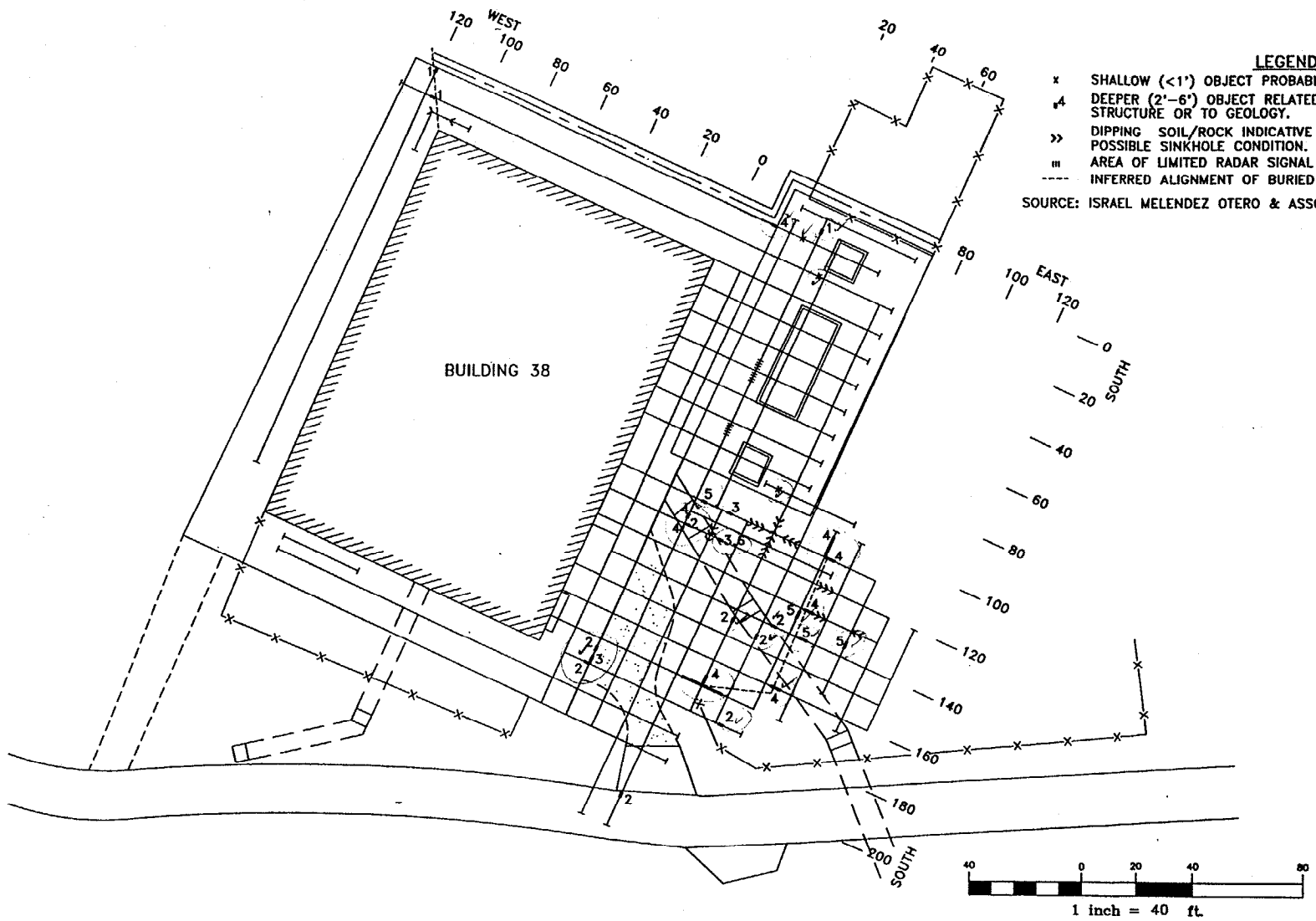
A licensed land surveyor was used to develop an accurate site map of physical features as shown in Figures 2-1 and 2-2. The geophysical survey grid and lines of coverage near Building 38 and across the tunnels have been superimposed for reference.

2.2 Ground Penetrating Radar

Ground penetrating radar (GPR) is an electromagnetic survey technique that reveals a graphic cross-sectional view of subsurface stratigraphy and buried objects (i.e., drums, pipelines, tanks, boulders, etc.). Data acquisition is continuous along lines of coverage and a graphic recorder provides an immediate view of the data, yielding both horizontal (lateral) and vertical (depth) control information. Penetration (typically 2 to 8 feet) and resolution are determined by the frequency of the antenna, but the overall effectiveness of GPR can be limited by highly reflective materials such as water-saturated clay, salt, slag, or highly conductive materials.

GPR profiling was completed with analog instrumentation that consisted of a GSSI SIR-7 mainframe, Adtek graphic recorder, and 500 megahertz antenna. This antenna was selected to provide high-resolution recordings of buried objects.

GPR profiles were obtained in an effort to detect USTs, the east and west tunnels and associated access ways, and buried utilities. The overall effectiveness of GPR was limited due to steel reinforcing in the concrete tank pad and to the high conductivity of subsurface materials. Penetration of the radar signal on the tank pad was 1 to 2 feet and on ground surface a maximum depth of 5 feet was achieved.



LEGEND

- x SHALLOW (<1') OBJECT PROBABLY METALLIC.
- 4 DEEPER (2'–6') OBJECT RELATED TO A BURIED UTILITY/ STRUCTURE OR TO GEOLOGY.
- >> DIPPING SOIL/ROCK INDICATIVE OF EXCAVATION/BACKFILL OR POSSIBLE SINKHOLE CONDITION.
- ||| AREA OF LIMITED RADAR SIGNAL PENETRATION.
- ---- INFERRED ALIGNMENT OF BURIED UTILITY/STRUCTURE.

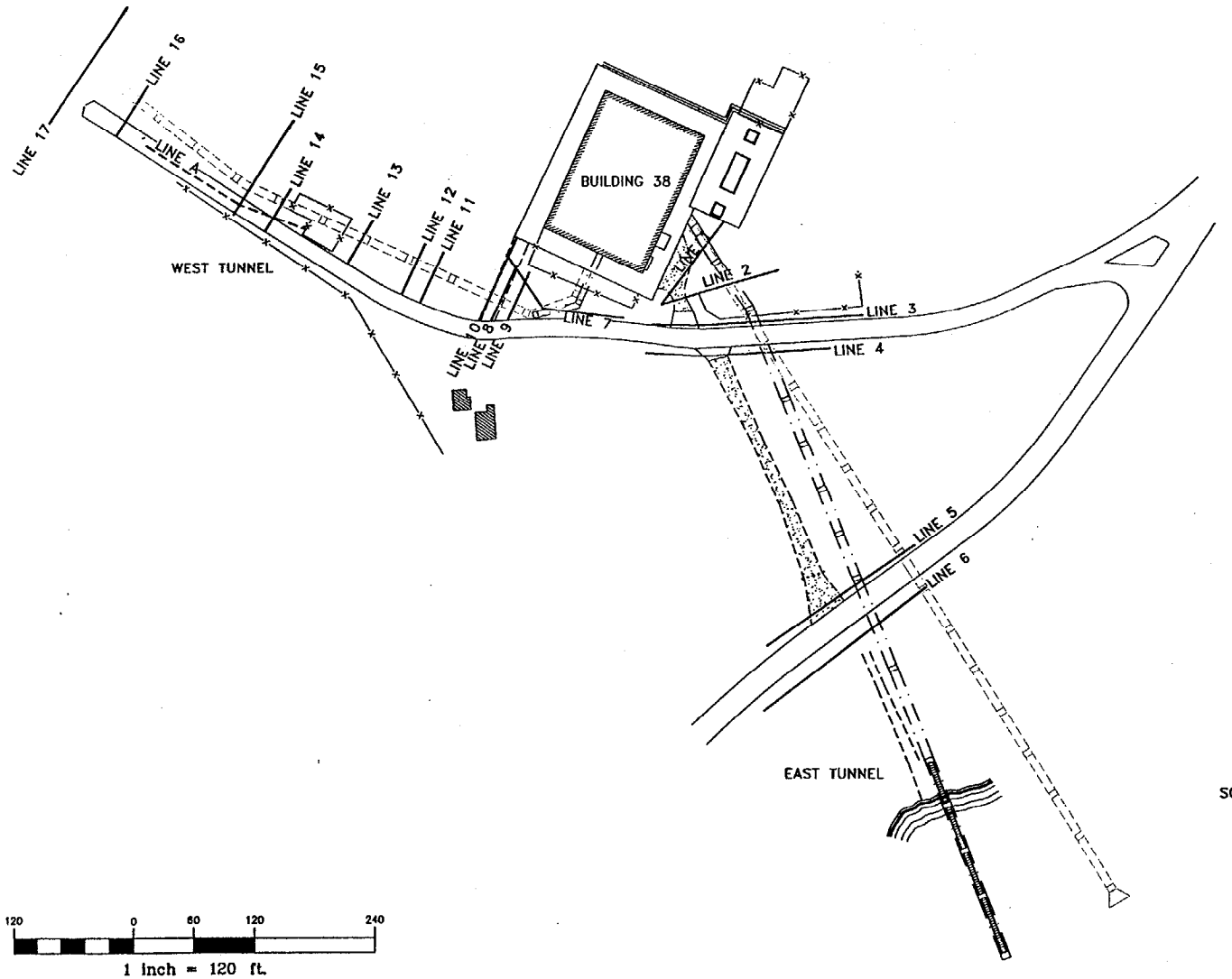
SOURCE: ISRAEL MELENDEZ OTERO & ASSOC.

REVISIONS			
WESTON GEOPHYSICAL CORP. IS A WHOLLY OWNED SUBSIDIARY OF BAKER ENVIRONMENTAL, INC.	DATE FEB. 1994 SCALE 1"= 40' DRAWN REL REVIEWED MJN S.O.# 19173–22–SRN CADD# 173102GP	GEOPHYSICAL INVESTIGATION NAVAL STATION ROOSEVELT ROADS PUERTO RICO WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.

SWMUs 11 AND 45
(IR SITE 16)
GROUND PENETRATING RADAR SURVEY RESULTS

SCALE 1"= 40' DATE FEBRUARY 1994

FIGURE NO. 2–1



LEGEND

- GEOPHYSICAL SURVEY LINE EM (LINES 4 AND 5 MAG)
- GEOPHYSICAL SURVEY LINE GPR
- TUNNEL ALIGNMENTS FROM P.W. DRAWING No. 1959

SOURCE: ISRAEL MELENDEZ OTERO & ASSOC.

120 0 60 120 240

1 inch = 120 ft.

REVISIONS				
WESTON GEOPHYSICAL CORP. IS A WHOLLY OWNED SUBSIDIARY OF BAKER ENVIRONMENTAL, INC.	DATE FEB. 1994 SCALE 1"= 120' DRAWN REL REVIEWED MJN S.O.# 19173-22-SRN CADD# 173103GP	GEOPHYSICAL INVESTIGATION NAVAL STATION ROOSEVELT ROADS PUERTO RICO WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	SWMUs 11 AND 45 (IR SITE 16) EM, MAG, AND GPR SURVEYS ASSOCIATED WITH THE EAST AND WEST TUNNELS SCALE 1"= 120' DATE FEBRUARY 1994	FIGURE NO. 2-2

2.3 Electromagnetic Terrain Conductivity

The conductivity of subsurface materials is determined by measuring the response of the ground to an induced magnetic field. Factors affecting in-situ conductivity include porosity, moisture content, clay content, and the conductivity of subsurface fluids and materials. Hydrogeologic conditions in Puerto Rico, such as a shallow saline water table and near surface volcanic rocks rich in magnetite, would yield relatively high levels of conductivity.

Former excavations or landfill boundaries may be detected through measurement of lateral variations in natural soil/fill material conductivity. This method may also be used to infer the presence of buried metal objects, such as drums, tanks, or utilities.

Electromagnetic (EM) terrain conductivity profiling was performed to measure anticipated lateral variations in subsurface conductivity due to the presence of the tunnels. Instrumentation utilized for this survey included a Geonics model EM-31, with an effective penetration depth of approximately 15 feet when operated in the vertical dipole mode (VDM).

Both the quadrature-phase (terrain conductivity) and in-phase components of the EM field were measured in the vertical dipole mode. The quadrature-phase mode provides a measurement of soil conductivity, while the in-phase mode is responsive to the effects of highly conductive, buried metallic objects. Terrain conductivity is measured in millimhos/meter (mmhos/m) and the in-phase component is measured in parts per thousand (ppt) of the primary magnetic field.

EM-31 data were acquired at five-foot intervals along selected geophysical traverses crossing both the east and west tunnel alignments. Profile characteristics obtained across known tunnel locations were used in an attempt to develop a standard to identify the tunnel at other unknown locations. The conductivity and in-phase measurements were recorded using a digital data logger then downloaded to a portable computer for data processing and interpretation.

2.4 Magnetometry

Magnetic profiling was performed in an attempt to delineate the tunnels by measuring small perturbations to the ambient magnetic field which could be attributed to the steel reinforcing

used in construction of the tunnels. A digital proton precession magnetometer (Geometrics model G-856X) was utilized along two traverses crossing the east tunnel at known locations. A "magnetic signature" of the tunnel could not be discerned and it was therefore decided not to continue the magnetometer survey in an area where the location of the west tunnel was unknown and where existing surface structures would be potential sources of interference, further complicating the magnetic profile and interpretation.

3.0 RESULTS

3.1 Site Conditions

The geophysical investigation for USTs and buried utilities covered the vicinity immediately around Building 38, which was fairly open and easily accessible. Much of the outerlying areas, i.e., between Building 38 and the shore, were densely vegetated and access was limited.

With the aid of a (recently obtained) drawing of the plant and facilities, access ways along the east tunnel were visually detected in the field and could be used to trace the tunnel from the shore to Building 38. Similarly, two access ways closest to the building were detected along the west tunnel. (These access ways were later located by the surveyors and included on the site map.)

The remaining alignment of the west tunnel, as depicted by the old drawing, continued through a stretch of dense vegetation, crossed beneath a power line and an old incinerator, and then paralleled the road leading to the landfill, as shown on Figure 2-2.

3.2 Subsurface Characterization

A combination of geophysical techniques were used to locate USTs, buried utilities, and the tunnels associated with Building 38 as discussed in the following subsections.

3.2.1 Underground Storage Tanks

It had been reported that two USTs were located near the northeast corner of Building 38. GPR was conducted in this area which is covered by a concrete pad measuring approximately 50 by 100 feet. Figure 2-1 shows the location of the pad and GPR traverses.

The radar records showed the concrete pad to be heavily reinforced with steel bars. The tight spacing of the reinforcing bars limited penetration of the radar signal to approximately one foot. Therefore, it was not possible to verify the presence/absence of the tanks beneath the concrete pad.

3.2.2 Buried Utilities

GPR coverage was extended south of the tank pad and included a traverse on each side of Building 38 in order to detect buried utilities, i.e., primarily drain pipes on site. The lines of coverage and the interpreted results are provided on Figure 2-1.

Penetration of the radar signal was significantly greater off the concrete. Subsurface geology and buried objects were discernible to a depth of five to six feet. Of most significance is a linear feature trending mostly north-south across the site at a depth of 4 to 5 feet. The inferred trend of the suspected utility is shown on Figure 2-1.

Small, discrete objects, which could include inorganic debris or soil/rock aggregates, were detected mostly near the access ways.

Subsurface conditions on site appear to be inhomogeneous and disturbed, characteristic of previous excavation activities and placement of backfill materials. Soil and/or bedrock structure was observed on some of the radar records, most noticeably at coordinates 60E/110S, where dipping structure has been interpreted as a bedrock low and possibly associated with a sinkhole condition.

GPR traverses along the perimeter of the building located a possible shallow buried pipe off the northeast corner of the plant.

3.2.3 East/West Tunnels

A combination of EM terrain conductivity, magnetometry, and GPR techniques were utilized in an attempt to detect the tunnels. Several geophysical traverses crossing the east tunnel at known locations, as shown on Figures 2-1 and 2-2, were unsuccessful in developing a consistent signature or pattern in the data which could be attributed to the presence of the tunnel and used to verify its location.

Several traverses (Lines 7 - 19) were obtained across the suspected alignment of the west tunnel (obtained from an old drawing of the plant). There was no correlation between the EM data and the suspected location of the tunnel. (EM and magnetic data profiles are provided in Attachment C1.)

Similarly, radar coverage obtained along a portion of the west tunnel between the old incinerator and the landfill, did not detect the tunnel. Although several small, shallow objects were detected, they appear to be unrelated to the tunnel or access way structures.

4.0 SUMMARY AND CONCLUSIONS

Electromagnetic terrain conductivity (EM), magnetometry, and ground penetrating radar (GPR) were utilized in a geophysical investigation to characterize subsurface conditions near Building 38 by verifying the location of underground storage tanks, by detecting buried utilities adjacent to the building, and by delineating two tunnels.

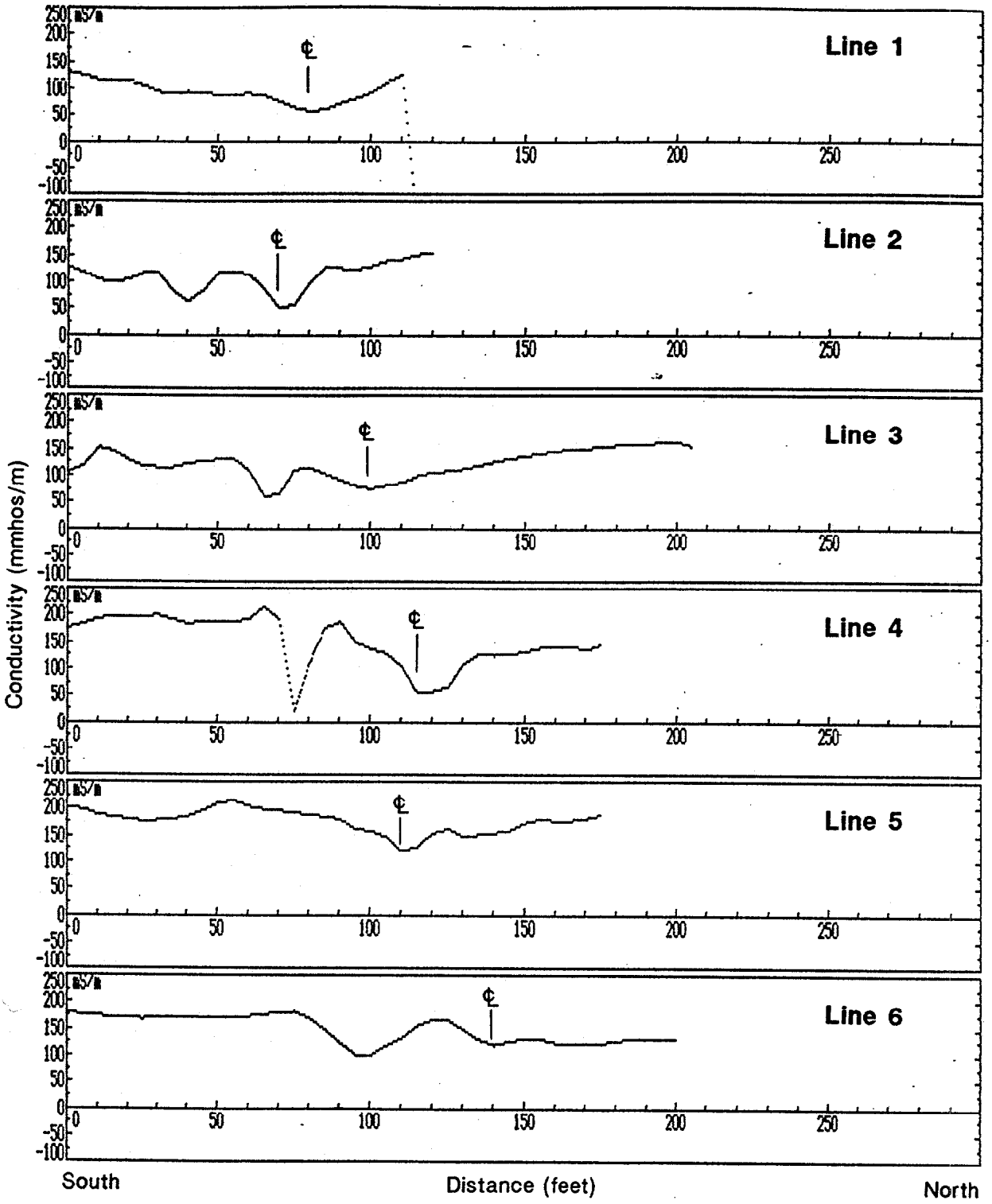
GPR records indicated that the concrete tank pad is heavily reinforced with steel bars, thereby minimizing penetration of the radar signal and masking identification of deeper structures. Delineation of tanks beneath the pad, either individual metallic tanks or tanks which might be integral with the concrete pad, proved to be unsuccessful.

Radar coverage in other areas identified a potential near-surface drain off the northwest corner of Building 38 and a linear feature extending southeast of the concrete tank pad, interpreted to be a buried utility at a depth of 4 to 5 feet.

Geophysical techniques were unsuccessful in developing a consistent instrument response at known locations over the east tunnel, which was traced in the field by visually locating all the access ways along the alignment. Similarly, no unique data signature or pattern attributable to a tunnel was observed along the suspected alignment of the west tunnel. However, neither the presence nor the absence of the west tunnel can be confirmed based on the geophysical data.

Measured levels of conductivity were high in the vicinity of Building 38, along the east tunnel alignment, and on the landfill, averaging 100 to 200 mmhos/m. Levels averaging 50 to 100 mmhos/m were encountered along the suspected alignment of the west tunnel between Building 38 and the landfill. Site history and present surface conditions do not explain the two-fold variation in conductivity levels observed between the east and west sides of Building 38.

Attachment C1
EM and Magnetic Profiles



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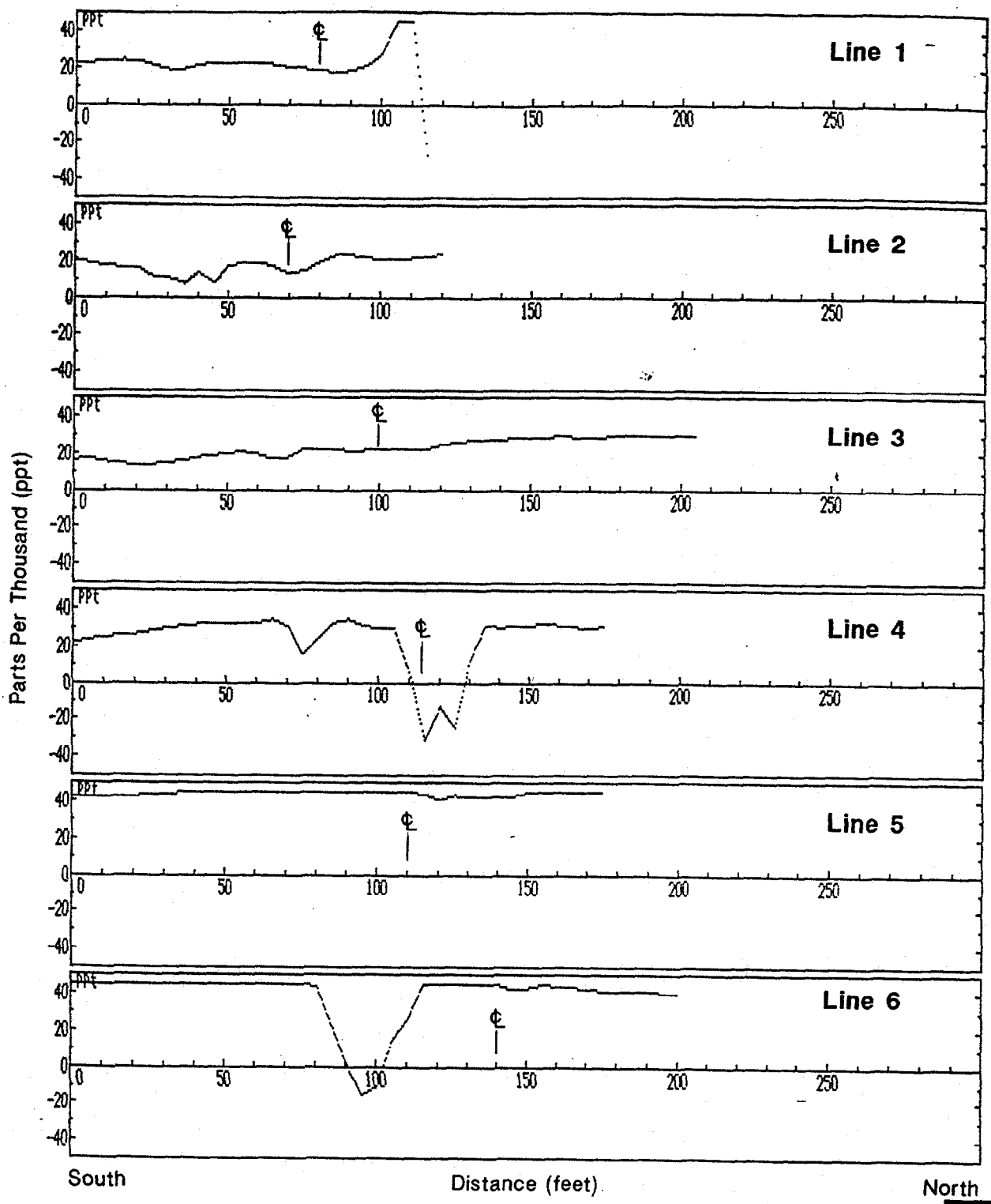
Geophysical Investigation
Site 16
Naval Station, Roosevelt Roads
Puerto Rico

EM Conductivity Profiles (VDM)
Across Intake Tunnel
Lines 1 through 6

WESTON GEOPHYSICAL CORP.
Coraopolis, Pennsylvania

Date Nov. 1993

Figure No.



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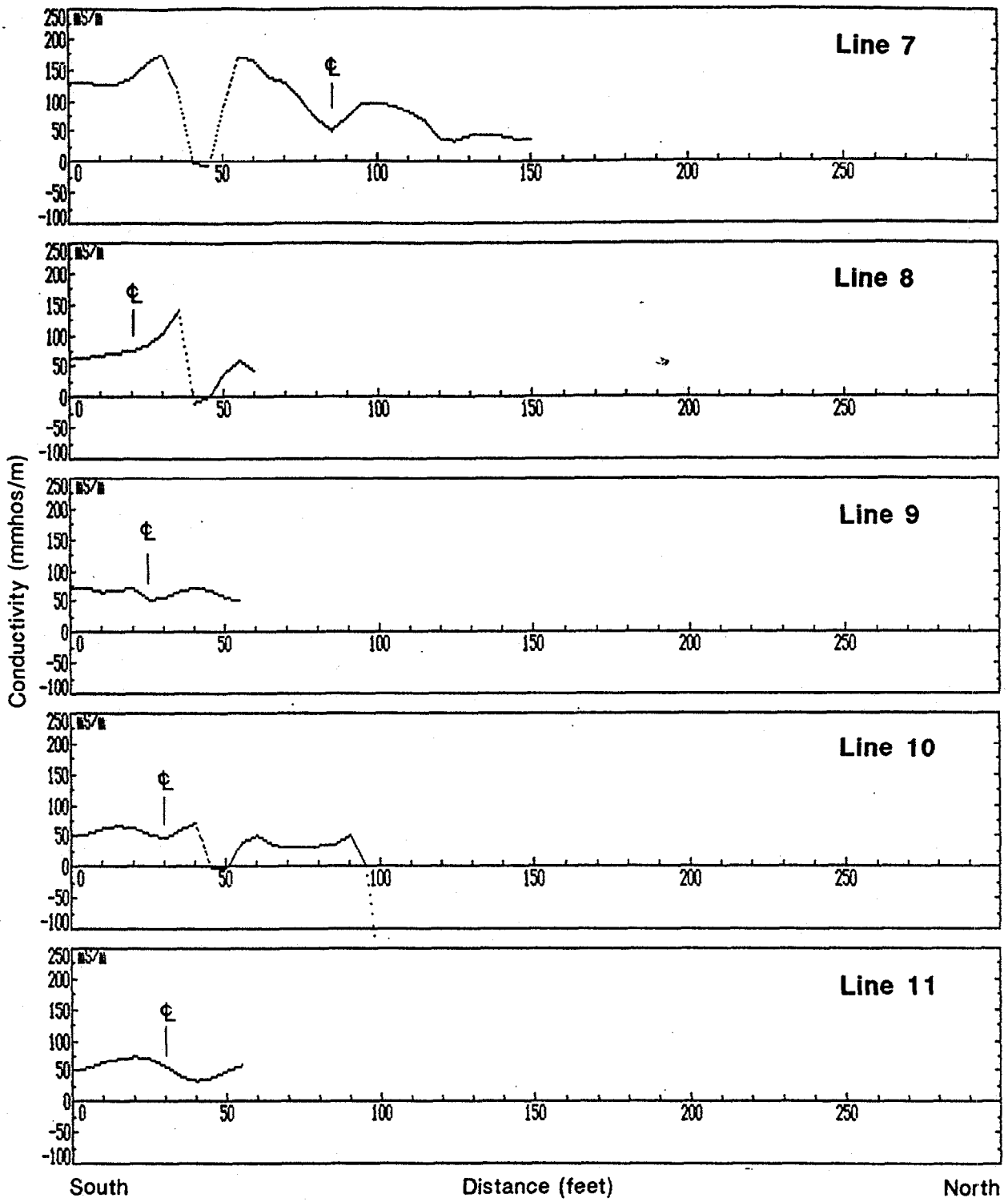
Baker Environmental, Inc.

Geophysical Investigation **Site 16** **Naval Station, Roosevelt Roads** **Puerto Rico**	**EM In-Phase Profiles** **Across Intake Tunnel** **Lines 1 through 6**
WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Date Nov. 1993 / Figure No.



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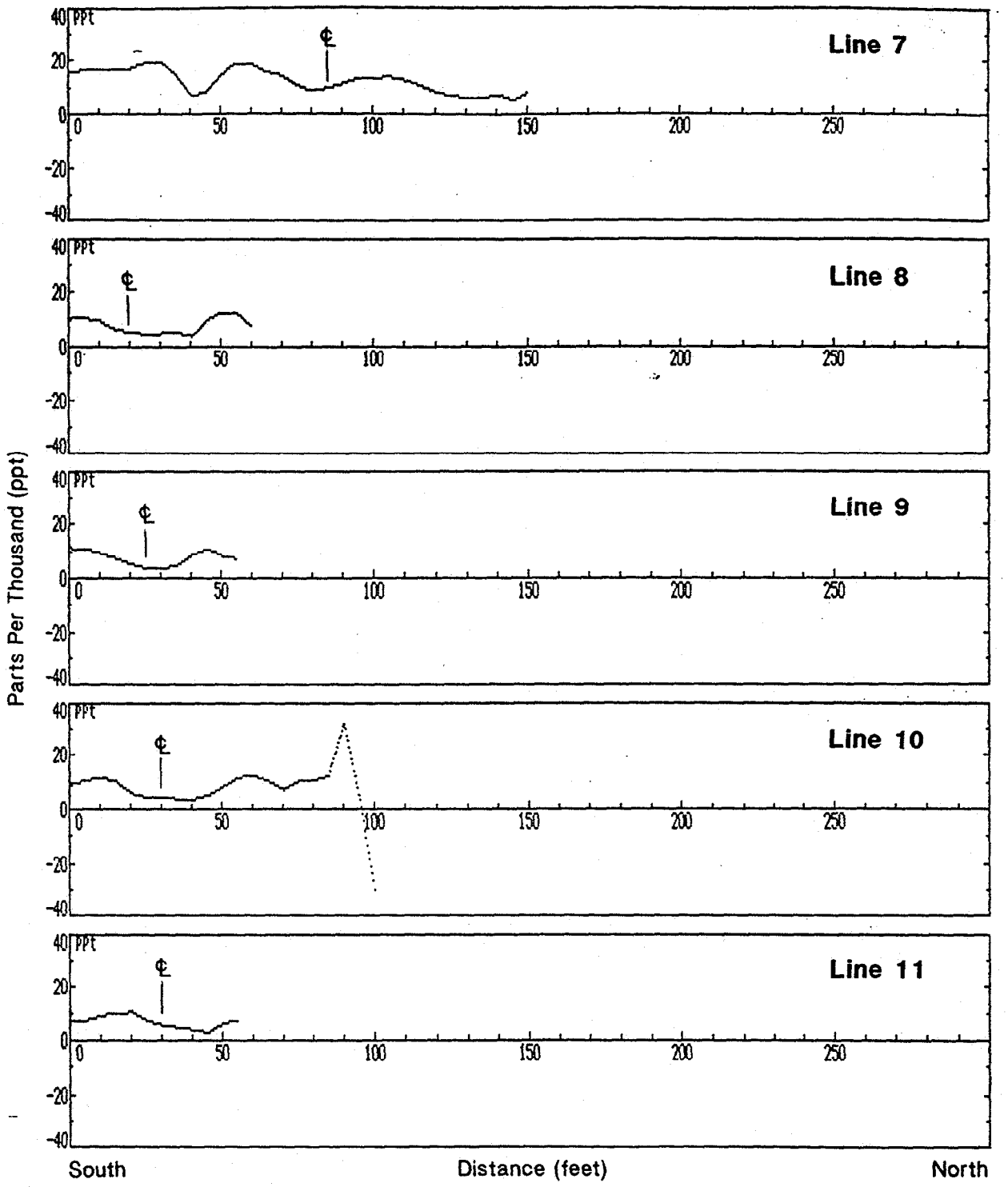
Geophysical Investigation **Site 16** **Naval Station, Roosevelt Roads** **Puerto Rico**	**EM Conductivity Profiles (VDM)** **Across Discharge Tunnel** **Lines 7 through 11**
WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Date Nov. 1993 / Figure No.



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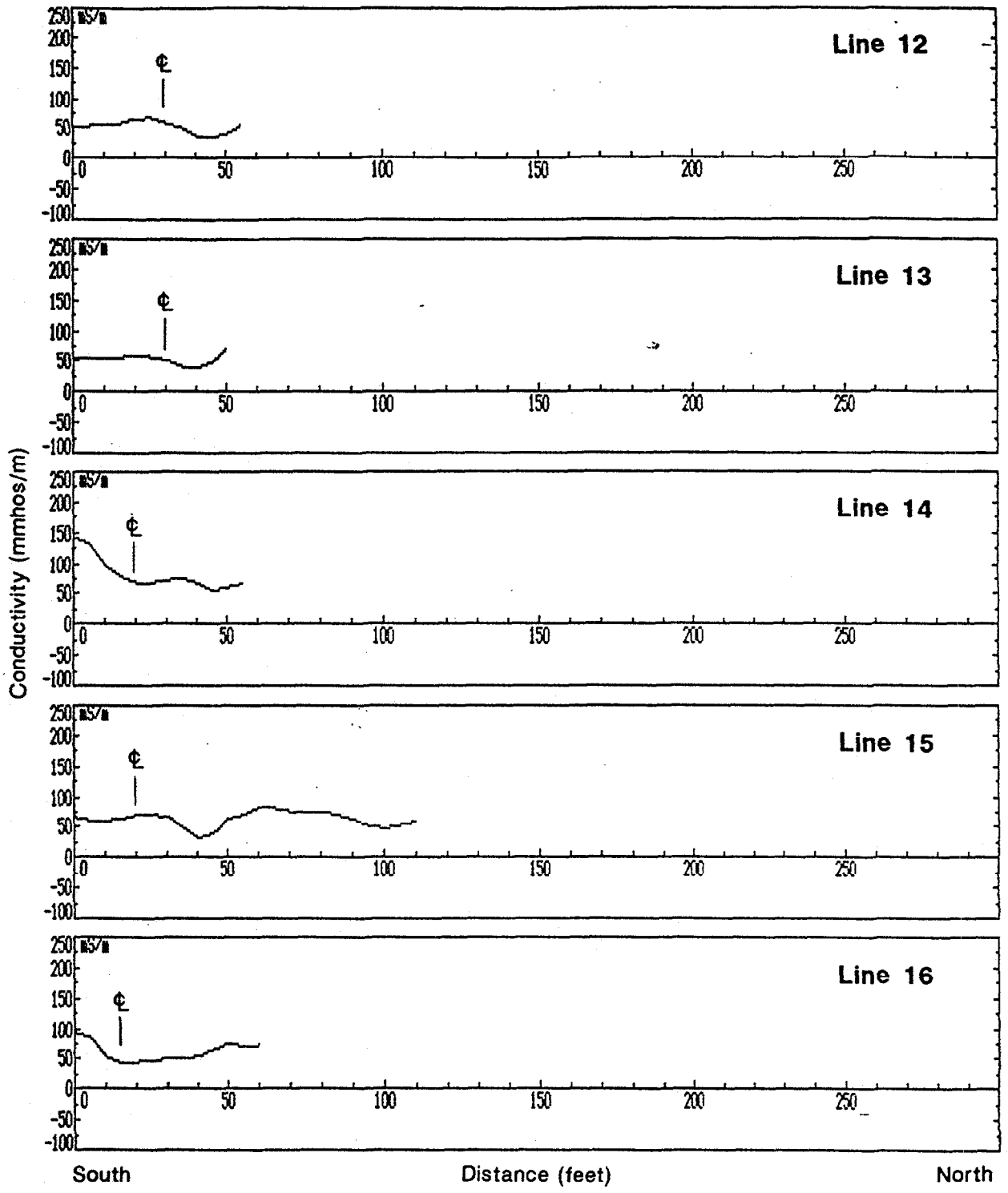
Geophysical Investigation Site 16 Naval Station, Roosevelt Roads Puerto Rico	EM In-Phase Profiles Across Discharge Tunnel Lines 7 through 11
WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Date Nov. 1993 / Figure No.



Baker
Baker Environmental, Inc.

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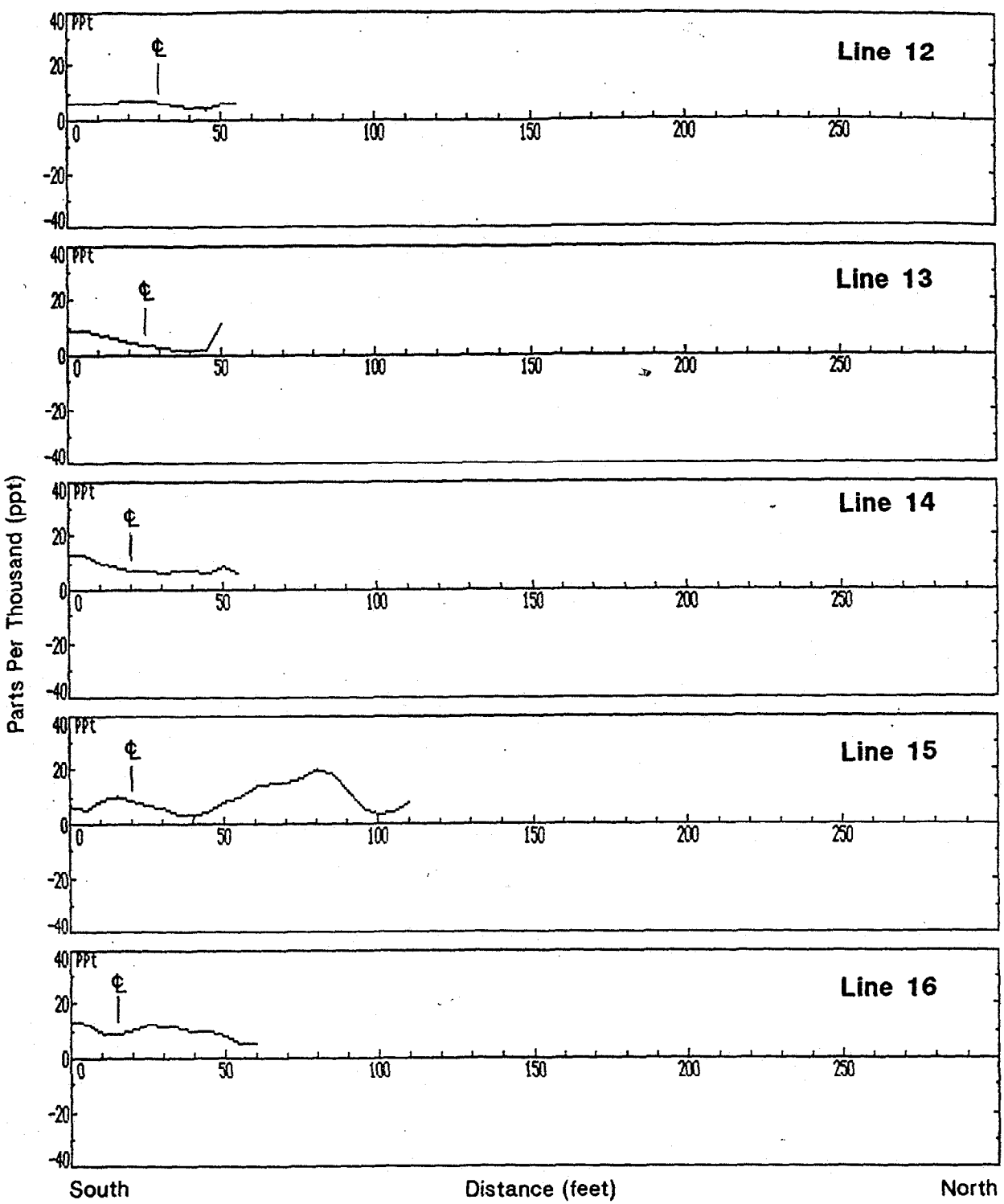
Geophysical Investigation **Site 16** **Naval Station, Roosevelt Roads** **Puerto Rico**	**EM Conductivity Profiles (VDM)** **Across Discharge Tunnel** **Lines 12 through 16**
WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Date Nov. 1993 / Figure No.



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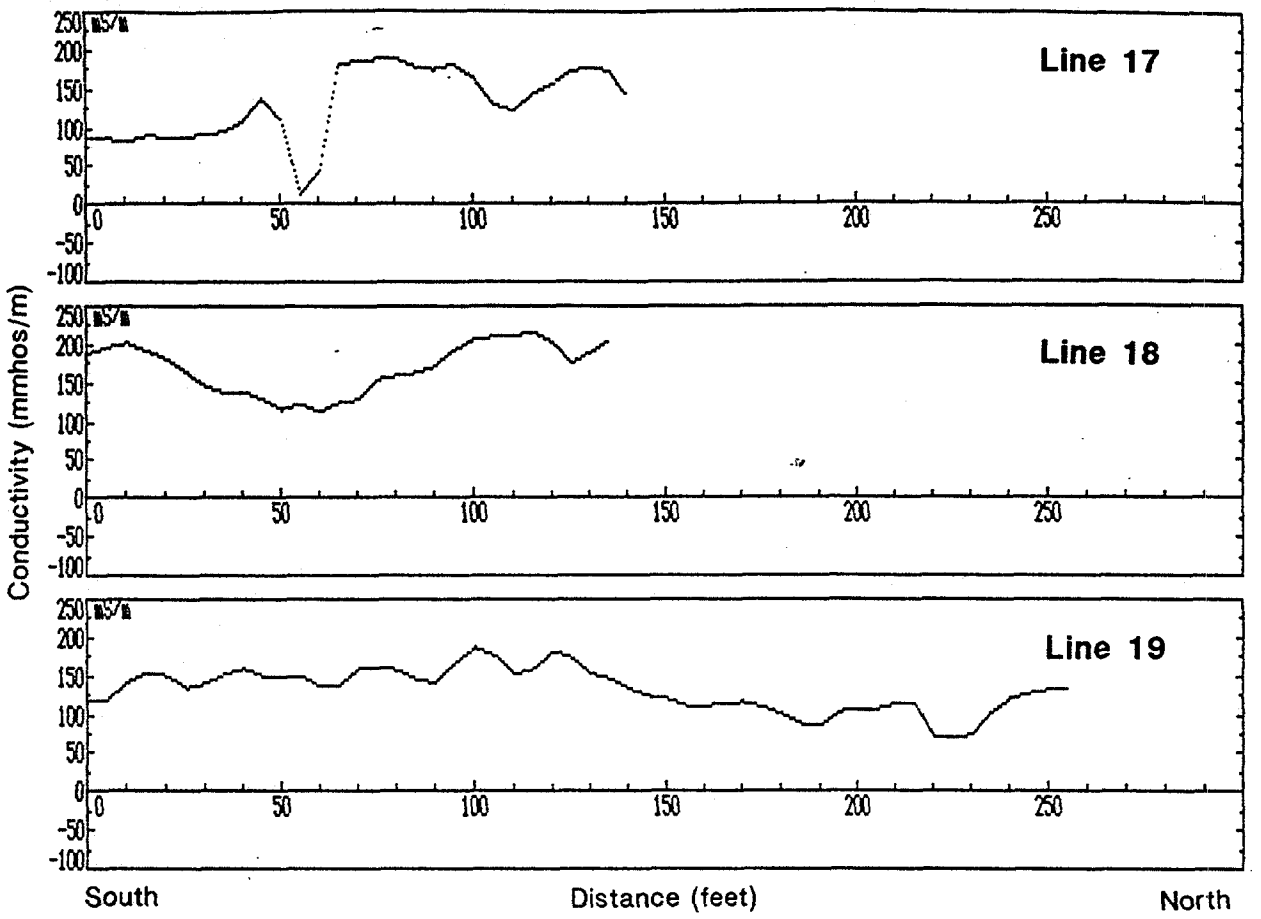
Geophysical Investigation Site 16 Naval Station, Roosevelt Roads Puerto Rico	EM In-Phase Profiles Across Discharge Tunnel Lines 12 through 16
WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Date Nov. 1993 / Figure No.



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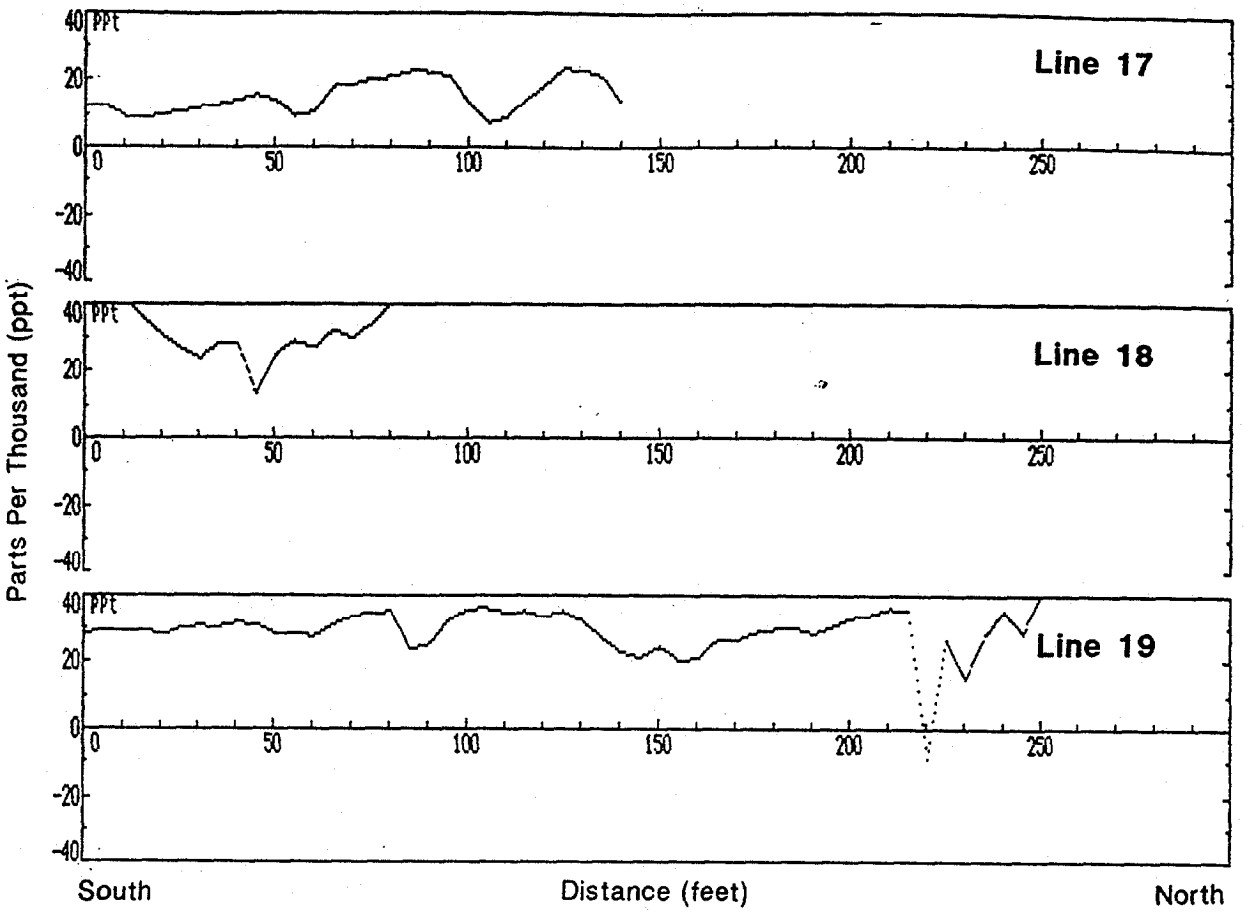
Baker
Baker Environmental, Inc.

Geophysical Investigation **Site 16** **Naval Station, Roosevelt Roads** **Puerto Rico**	**EM Conductivity Profiles (VDM)** **Across Discharge Tunnel** **Lines 17 through 19**
WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Date Nov. 1993 / Figure No.



Baker
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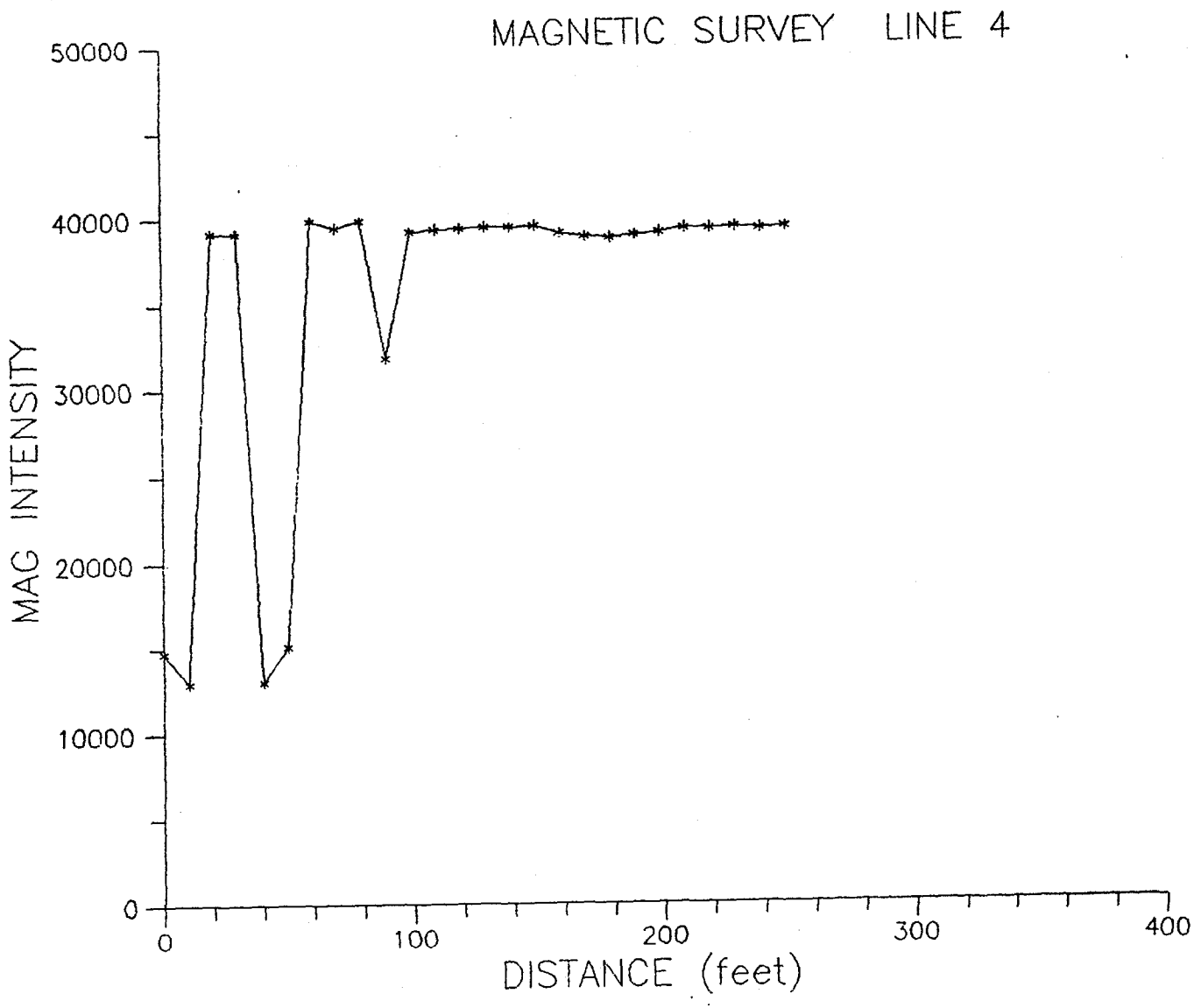
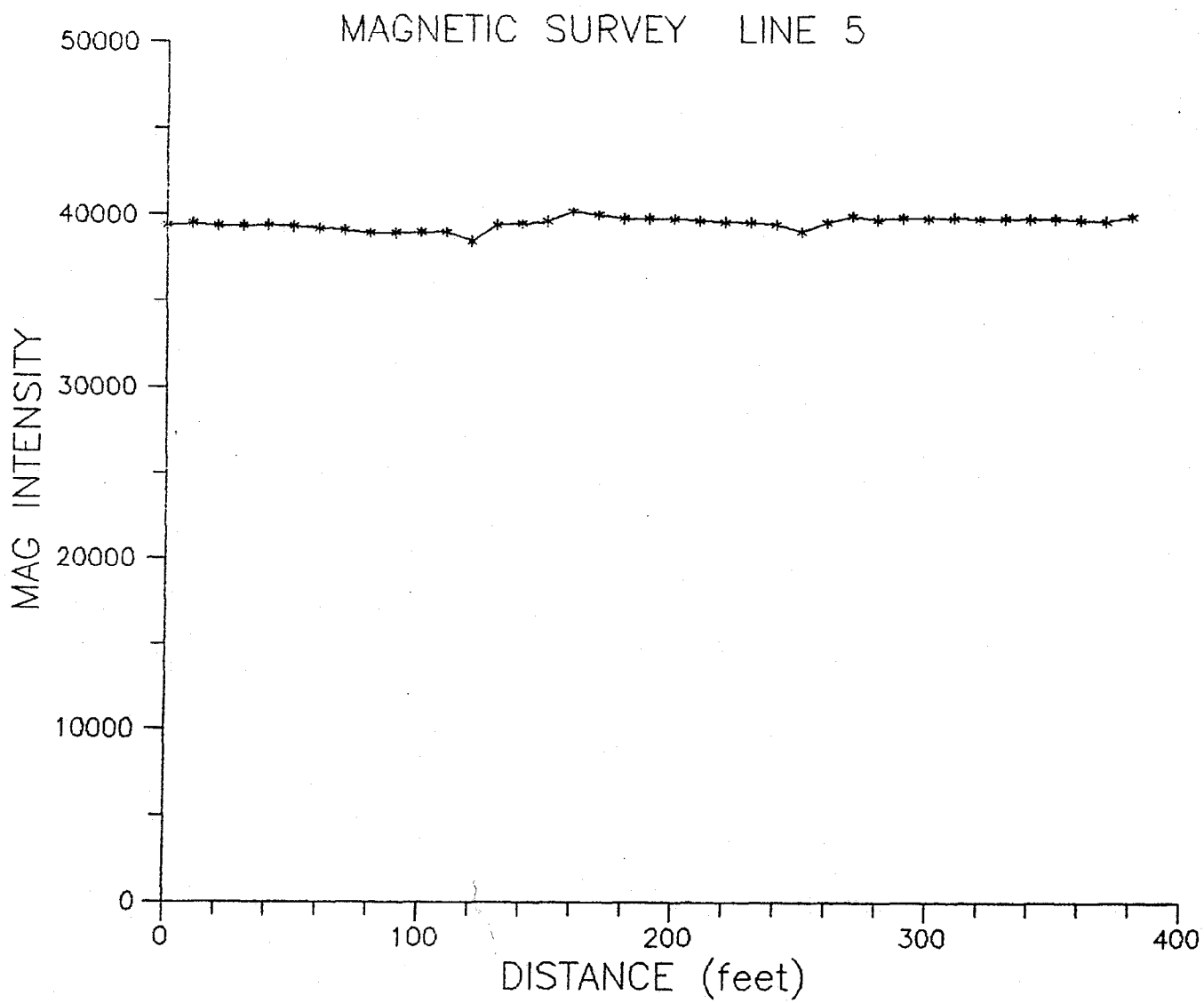
Geophysical Investigation **Site 16** **Naval Station, Roosevelt Roads** **Puerto Rico**	**EM In-Phase Profiles** **Across Discharge Tunnel** **Lines 17 through 19**
WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania	Date Nov. 1993 / Figure No.


MAGNETIC SURVEY LINE 4
MAG INTENSITY
50000
40000
30000
20000
10000
0
0
100
200
300
400
DISTANCE (feet)


MAGNETIC SURVEY LINE 5
MAG INTENSITY
50000
40000
30000
20000
10000
0
0
100
200
300
400
DISTANCE (feet)

APPENDIX D
DATA VALIDATION METHODOLOGIES

APPENDIX D

DATA VALIDATION METHODOLOGIES

This appendix provides the detailed data validation methodologies to be followed for the NSRR RFI. The following analytical methods are addressed:

- SW-846 Methods 6010, 7000 Series and 9010;
- SW-846 Method 8080;
- SW-846 Method 8140;
- SW-846 Method 8150;
- SW-846 Method 8240;
- SW-846 Method 8270; and
- SW-846 Method 8330

Methods which are not standard SW-846 will be validated as appropriate to the analysis using the CLP, the National Functional Guidelines and best professional judgement of the independent, third part, data validator (Heartland Environmental Services, Inc.)

GUIDELINES FOR INORGANIC DATA REVIEW
SW-846 METHODS 6010, 7000 SERIES, 9010
DQO LEVEL IV DATA PACKAGES

Data Deliverables Required:

- Case Narrative
- Chain of Custody
- Form 1s
- Form 2A - Calibration Standards Data
- Form 3 - Calibration and Preparation Blank Data
- Form 4 - Interference Check Standard Data
- Form 5 - Matrix Spike/Matrix Spike Duplicate Data
- Form 6 - Duplicate Data
- Form 7 - Laboratory Control Standard Data
- Form 8 - Standard Addition Data
- Form 9 - Serial Dilution Data
- Form 10 - 13 - Quarterly Required Data (Documentation only)
- Form 14 - Runlog Data

(Equivalent Forms are acceptable providing all of the required information is presented)

Review Requirements:

- Raw Data Verification
- Holding Times
- Initial and Continuing Calibration percent recoveries
- Method and Calibration Blank contamination and sample associations
- MS/MSD recoveries and RPDs
- Laboratory Control Standard recoveries
- Post-digestion results for GFAA
- Serial Dilution RPDs
- Samples results

Holding Times

Review items: Form Is and Sample Chain of Custody

Criteria: Verify the sample holding time based on the time of collection to the time of analysis.

Holding Times - continued

Technical holding times for water and soils samples are as follows:

Metals:	180 days
Mercury:	28 days
Cyanide:	14 days

All samples must be preserved.

Action: If the samples holding times were exceeded, qualify/reject the samples based on the following guidance:

Mercury and Cyanide

1) 1 Day - 5 Days

   a) Positive and non detect results are qualified as estimated, J/UJ.

2) >5 Days

   a) Positive results are qualified as estimated, J, and non-detect results are rejected, R.

TAL Metals

1) >1 Day

   a) Positive and non detect results are qualified as estimated, J/UJ.

Calibration Standards Results

Review items: Form IIA

Criteria: Verify the initial and calibration standards are acceptable.

6010	90% - 110%
7000 series	80% - 120%
Cyanide	85% - 115%

Calibration Standards Results - continued

Action: 6010

1) If the percent recovery is greater than 125%:

   a) Reject, R, the positive results for the non compliant element.

2) If the percent recovery is greater than the upper control limit, but less than 125%:

   a) Qualify all positive results for the non compliant element as estimated, J.

3) If the percent recovery is below the lower control limit, but greater than 75%:

   a) Qualify all positive and non detect results for the non compliant element as estimated, J/UJ.

4) If the percent recovery is less than 75%:

   a) Reject, R, the positive and non detect results for the non compliant element.

7000 series

1) If the percent recovery is greater than 140%:

   a) Reject, R, the positive results for the non compliant element.

2) If the percent recovery is greater than the upper control limit, but less than 140%:

   a) Qualify all positive results for the non compliant element as estimated, J.

Calibration Standards Results - continued

3) If the percent recovery is less than the lower control limit, but greater than 60%:

   a) Qualify all positive and non detect results for the non compliant element as estimated, J/UJ.

4) If the percent recovery is less than 60%:

   a) Reject (R) the positive and non detect results for the non compliant element.

9010 - Cyanide

1) If the percent recovery is greater than 135%:

   a) Reject, R, the positive results for the non compliant element.

2) If the percent recovery is greater than the upper control limit, but less than 135%:

   a) Qualify all positive results for the non compliant element as estimated, J.

3) If the percent recovery is below the lower control limit, but greater than 65%:

   a) Qualify all positive and non detect results for the non compliant element as estimated, J/UJ.

4) If the percent recovery is less than 65%:

   a) Reject, R, the positive and non detect results for the non compliant element.

Blanks (Method, Field QA, and Calibration)

Review items: Form III

Blanks (Method, Field QA, and Calibration) - continued

Criteria: Verify that a method blank has been analyzed for sample extraction lot. All method blanks should be free of contamination. If a problem exists with <u>any</u> blank, all associated samples must be evaluated to determine whether there is inherent variability in the data or if the problem is an isolated occurrence not affecting other data.

Action:

1. If an analyte is found in the blank but not in the associated sample(s), no action is required.

2. Any analyte result that is detected at a concentration greater than the IDL but less than five times (5X) the concentration detected in any blank will be qualified as non-detect, U. Any positive analyte result that is found at a concentration greater than five times (5X) the concentration detected in any blank will not be qualified.

3. The reviewer should take note that the blank analysis may not involve the same weights, volumes, or dilution factors such as associated samples. These factors must be taken into consideration when applying the 5X blank criteria.

4. The validator must review the field QA blank, including trip, rinseate, and field blanks and all associated samples. Apply the same data validation guidelines used in assessing the method blanks.

5. Qualification/Action Codes for Blanks:

   U: The sample result is greater than the IDL and less than five times (5X) the blank value. Qualify the sample result as non detect, U.

   No Action: The sample result is greater than the IDL and greater than five times (5X) the blank value

Matrix Spike/ Matrix Spike Duplicate Results

Review items: Form V

Criteria: Spike recovery must be within the recovery limits of 75% to 125%. Spike recovery limits do not apply when sample concentration exceeds the spike concentration by a factor of 4 time or more (>4X).

Action:

1) If the percent recovery is greater than the upper control limit (125%):

   a) Qualify all positive results for the non compliant element as estimated, J.

2) If the percent recovery is less than the lower control limit, but greater than 30%:

   a) Qualify all positive and non detect results for the non compliant element as estimated, J/UJ.

3) If the percent reconvey is than 30%:

   a) Reject, R, the non detect results for the non compliant element and qualify positive results as estimated, J.

Duplicate Results

Review items: Form VI

Criteria: If the reported samples results are greater than five times (5X) the CRDL: the Duplicate RPD must be less than 20% for water samples and 35% for soils.

If the reported sample results are less than five times (5X) the CRDL: the Duplicate RPD must be less than the CRDL for water samples and two times (2X) the CRDL for soils samples.

Action: All positive results for the elements are qualified as estimated, J, when the RPD criteria has been exceeded.

Laboratory Control Standards Results

Review items: Form VII

Criteria: Water Samples:

LCS recovery must be within the recovery limits of 80% to 120%.

Soil Samples:

LCS recovery must be within the EPA soil control limits (vary element to element).

Action: Water Samples

1) If the percent recovery is greater than the upper control limit, 120%:

   a) Qualify all positive results for the non compliant element as estimated, J.

2) If the percent recoveries are below the lower control limits, but greater than 50%:

   a) Qualify all positive and non detect results for the non compliant element as estimated, J/UJ.

3) If the percent recovery is less than 50%:

   a) Reject, R, the positive and non detect results for the non compliant element.

Soil Samples

1) If the percent recovery is greater than the upper control limit:

   a) Qualify all positive results for the non compliant element as estimated, J.

Laboratory Control Standards Results - continued

2) If the percent recovery is below the lower control limits

a) Qualify all positive and non detect results for the non compliant element as estimated, J/UJ.

Interference Check Standard Results

Review items: Form IV

Criteria: All Samples:

The interference check standard recovery must be within the recovery limits of 80% to 120%.

Action: All Samples

1) If the percent recovery is greater than the upper control limit, 120%:

a) Qualify all positive results for the non compliant element as estimated, J.

2) If the percent recoveries are below the lower control limits, 80%:

a) Qualify all positive and non detect results for the non compliant element as estimated, J/UJ.

Serial Dilution Results

Review items: Form IX

Criteria: All Samples:

Serial Dilution RPDs must be within the recovery limits of ±10%.

Serial Dilution Results - continued

Action: All Samples

1) If the RPD is greater than 10%:

   a) Qualify all positive results for the non compliant element as estimated, J.

Raw Data Verification

Review items: Form 1, Form 14, and raw data

Criteria: All Samples:

Verify that the results reported on the Form Is reflect the results as reported in the raw data.

Action: All Samples

1) If the raw data does reflect what has been reported on the FormIs, notify the contractor and the laboratory for immediate correction.

Post Digestion Spike Results

Review items: Form VIII and raw GFAA Data

Criteria: Verify that a post-digestion Spiking was performed for all GFAA elements.

7000 series 85% - 115%

Action: 7000

1) If the percent recovery is greater than 115%:

   a) Qualify, J, the positive results for the non compliant element.

Post Digestion Spike Results - continued

2) If the percent recovery is below 85%:

   a) Qualify all positive and non detect results for the non compliant element as estimated, J/UJ.

GUIDELINES FOR ORGANIC DATA REVIEW
SW-846 METHOD 8080
DQO LEVEL IV DATA PACKAGES

Data Deliverables Required:

- Case Narrative
- Chain of Custody
- Form 2 - Surrogate Recovery Summary
- Form 3 - MS/MSD results
- Form 3A - QC Check Sample results (LCS)
- Form 4 - Method Blank Summary
- Form 1s with chromatograms and quantitation pages
- Form 6 - %RSDs and Calibration Factors with raw data
- Form 7 - %Ds and Calibration Factors with raw data
- Form 7D - %Breakdown for 4,4'-DDT and Endrin with raw data
- Form 1s - Method Blank raw data
- Form 1s - MS/MSD, LCS raw data

(Equivalent Forms are acceptable providing all of the required information is presented)

Review Requirements:

- Holding Times
- Surrogate Recoveries
- MS/MSD recoveries and RPDs
- LCS recoveries
- Method Blank contamination and sample associations
- Initial Calibration %RSDs, calibration factors, and raw data
- Continuing Calibration %Ds, calibration factors, and raw data
- Sample results, CRQLs, and raw data

Holding Times

Review Items: Form I, Sample Chain of Custody

Criteria: Verify the sample holding time based on the time of <u>collection</u> to the time of extraction and the time of extraction to the time of analysis.

Holding Times - continued

Technical holding times for water samples are as follows:

Water Samples cooled to 4°C (±2°C): 7 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Technical extraction holding times for soil samples are as follows:

Soil samples cooled to 4°C (±2°C): 14 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Action:

1. If the samples were properly preserved and the sample holding times were exceeded, qualify the positive and non detect sample results as defined by Table 1.

2. If the samples were not properly preserved and the temperature of the samples exceeded 4°C (±2°C), reject (R) all sample results.

Table 1 - Holding Time Qualifications

Sample Results	1 Day - 5 Days	6 Days - 15 Days	> 15 Days
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Surrogates

Review Items: Form IIs, chromatograms and quantitation pages.

Criteria: Verify the sample surrogate recoveries are within the QA/QC limits established by the laboratory. Verify that surrogate recoveries were calculated correctly.

Recoveries for the surrogate compound(s) in the samples and method blanks must be within QA/QC criteria.

Surrogates - continued

Action:

1. If the surrogate recovery is greater than the upper control limit (UL):

   a) Qualify all positive results as estimated, J (Table 2).

2. If the surrogate recovery is less than the lower control limit (LL), but is greater than 10%:

   a) Qualify all positive and non detect results as estimated, J/UJ (Table 2).

3. If the surrogate recovery is less than 10%:

   a) Qualify all positive results as estimated, J, and reject, R, all non detect results (Table 2).

Table 2 - Surrogate Recovery Qualifications

Sample Results	< 10%	>10%<LL	> UL
Positive Results	J	J	J
Non Detect Results	R	UJ	No Quals.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Review Items: Form III, chromatograms and quantitation pages.

Criteria: Verify the MS/MSD recoveries and RPDs are within the advisory limits established by the laboratory. MS/MSDs are analyzed at a frequency of one MS/MSD per twenty (20) samples of similar matrix.

Verify that MS/MSD recoveries were calculated correctly.

Action: No action is taken on the MS/MSD alone. However, the data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data.

QC Check Sample (Laboratory Control Sample)

Review Items: Form IIIA, chromatograms and quantitation pages.

Criteria: Verify the LCS recoveries are within the advisory limits establishedby the laboratory. LCS' are analyzed at a frequency of one (1) LCS per Sample Delivery Group (SDG).

Verify that LCS recoveries were calculated correctly.

Action: The data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data .

If a compound exhibits a 0% recovery:

a) Qualify the positive results for the compound as estimated, J, and reject, R, non detect results.

Blanks (Method and Field QA Blanks)

Review Items: Form I, Form IV, chromatograms and quantitation pages.

Criteria: Verify that a method blank has been analyzed for each sample matrix analyzed with each analytical sequence. All method blanks should be free of contamination. If a problem exists with <u>any</u> blank, all associated samples must be evaluated to determine whether there is inherent variability in the data or if the problem is an isolated occurrence not affecting other data.

Action:

1. If a compound is found in the blank but not in the associated sample(s), no action is required.

2. Any compound detected in the sample, which was also detected in the associated blank, must be qualified by elevating the limit of detection or adjusting the limit of detection to the reported sample result, when the sample concentration is less than five (5) times the blank concentration.

Blanks (Method and Field QA Blanks) - continued

3. The reviewer should take note that the blank analysis may not involve the same weights, volumes, or dilution factors such as associated samples. These factors must be taken into consideration when applying the 5X blank criteria.

4. The validator must review the field QA blank, including trip, rinseate, and field blanks and all associated samples. Apply the same data validation guidelines used in assessing the method blanks.

5. Qualification/Action Codes for Blanks:

   CRQL: The sample result is less than the CRQL and less than five times (5x) the blank value. Reject (R) the sample result and the "B" qualifier flag and report the result as non detect at the CRQL.

   U: The sample result is greater than the CRQL and less than five times (5X) the blank value. Cross out the "B" qualifier flag and qualify the sample result as non detect, U.

   No Action: The sample result is greater than the CRQL and greater than five times (5X) the blank value. Cross out the "B" qualifier flag.

Initial Calibration

Review Items: Form VI's, chromatograms and quantitation pages.

Criteria: Verify the initial calibration is linear for all compounds (20% RSD) and that all of the calibration factors are acceptable.

Verify that the calibration factors and %RSDs were calculated correctly.

Initial Calibrations - continued

Action:

1. If the initial calibration is not linear for a compound(s), >20% RSD, but is less than 90% RSD (Table 3):

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J.

2. If the initial calibration is not linear for a compound(s), >90% RSD (Table 3):

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results.

Table 3 - Initial Calibration Qualifications

Sample Results	>30%≤90%	>90%
Positive Results	J	J
Non Detect Results	No Quals.	R

Continuing Calibration

Review Items: Form VII, chromatograms and quantitation pages.

Criteria: Verify the continuing calibration is capable of producing acceptable qualitative and quantitative data (15% D) and that all of the calibration factors are acceptable.

Verify that the %D calculations were performed correctly.

Action:

1. If the continuing calibration is not acceptable for a compound(s), >15% D, but is less than 50% D (Table 4):

Continuing Calibrations - continued

a) For the samples analyzed after the continuing calibration, qualify all positive results for the non compliant compound(s) as estimated, J.

2. If the continuing calibration is not acceptable for a compound(s), >50% D, but is less than 90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive and non detect results for the non compliant compound(s) as estimated, J/UJ.

3. If the continuing calibration is not acceptable for a compound(s), >90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results

Table 4 - Continuing Calibration Qualifications

Sample Results	>15%≤ 50%	>50%≤ 90%	> 90%
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Breakdown Standard

Review Items: Form VIID, chromatograms and quantitation pages.

Criteria: Verify the %breakdowns for 4,4'-DDT and Endrin are < 20% and that combined breakdown is less than 30%.

Verify that the breakdown calculations were performed properly.

Breakdown Standard - continued

Action:

1. If the breakdown for either compound is greater than 20%:

   a) All positive results for 4,4'-DDT or endrin are qualified as estimated, J.

   b) If 4,4'-DDT or endrin were not detected but the breakdown products were detected, then the non-detect results for 4,4'-DDT or endrin are rejected (R), and all positive results for the breakdown products are qualified as presumptively present at an estimated concentration, NJ.

2. If the combined breakdown for either compound is greater than 30%:

   a) All positive results for 4,4-DDT and endrin are qualified as estimated,

   b) If 4,4'-DDT or endrin were not detected but the breakdown products were detected, then the non-detect results for 4,4'-DDT or endrin are rejected (R), and all positive results for the breakdown products are qualified as presumptively present at an estimated concentration, NJ.

Compound Quantitation and Reported CRQLs

Review Items: Form Is, Form Xs, Sample Chromatograms and quantitation pages

Criteria: Verify the reported CRQLs are accurate and have been adjusted appropriately based on dilutions, concentrations, etc. Review the chromatograms and quantitation pages to ensure that required dilutions are performed, sample matrix interference does not suppress the detection of target compounds, and that false positives or false negatives were not reported. Verify that reported compounds are within the RTWs on both columns. Verify sample quantitation calculations.

Compound Quantitation and Reported CRQLs - continued

Action:

1) If the CRQLs are incorrect based on sample dilutions or percent moisture:

   a) Reject (R) the reported CRQLs and report the correct CRQLs.

2) If qualitative criteria is not met; i.e. the reported results are not with the RTWs on one or both columns or matrix interferences are present:

   a) the reported results should be rejected, R, and amended to non-detect. The reviewer may need to use professional judgement to assign an appropriate quantitation limit, considering any interferences which could be affecting the accurate identification of target compounds. If interferences preclude the identification of a target compound on one of the analytical columns then the result should be rejected, R.

3) If false negative results are noted; i.e. a compound with peaks which fall within the RTW on both columns but was not reported:

   a) the reviewer should use professional judgement to determine whether the result should be reported. A detailed discussion of decisions should be included in the case narrative.

4) For the multi-component compounds, if marginal pattern matching quality is noted:

   a) the reviewer should use professional judgement to determine if weathering has occurred. If the identification is uncertain but the presence of the aroclor, toxaphene, or chlordane is highly suspected (if pattern is good on one (1) column and marginal on the other column) then the result should be reported and qualified as presumptively present, N.

GUIDELINES FOR ORGANIC DATA REVIEW
SW-846 METHOD 8140
DQO LEVEL IV DATA PACKAGES

Data Deliverables Required:

- Case Narrative
- Chain of Custody
- Form 2 - Surrogate Recovery Summary
- Form 3 - MS/MSD results
- Form 3A - QC Check Sample results (LCS)
- Form 4 - Method Blank Summary
- Form 1s with chromatograms and quantitation pages
- Form 6 - %RSDs and Calibration Factors with raw data
- Form 7 - %Ds and Calibration Factors with raw data
- Form 1s - Method Blank raw data
- Form 1s - MS/MSDs, LCS raw data

(Equivalent Forms are acceptable providing all of the required information is presented)

Review Requirements:

- Holding Times
- Surrogate Recoveries
- MS/MSD recoveries and RPDs
- LCS recoveries
- Method Blank contamination and sample associations
- Initial Calibration %RSDs, calibration factors and raw data
- Continuing Calibration %Ds, calibration factors and raw data
- Sample results, CRQLs, chromatograms and quantitation pages

Holding Times

Review Items: Form I, Sample Chain of Custody

Criteria: Verify the sample holding time based on the time of <u>collection</u> to the time of extraction and the time of extraction to the time of analysis.

Holding Times - continued

Technical holding times for water samples are as follows:

Water Samples cooled to 4°C (±2°C): 7 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Technical holding times for soil samples are as follows:

Soil samples cooled to 4°C (±2°C): 14 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Action:

1. If the samples were properly preserved and the holding times were exceeded, qualify the positive and non detect sample results as defined by Table 1.

2. If the samples were not properly preserved and the temperature of the samples exceeded 4°C (±2°C), reject (R) all sample results.

Table 1 - Holding Time Qualifications

Sample Results	1 Day - 5 Days	6 Days - 15 Days	> 15 Days
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Surrogates

Review Items: Form II, chromatograms and quantitation pages.

Criteria: Verify the sample surrogate recoveries are within the QA/QC limits established by the laboratory.

Verify that surrogate recoveries were calculated correctly.

Recoveries for the surrogate compound(s) in the samples and method blanks must be within QA/QC criteria.

Surrogates - continued

Action:

1. If the surrogate recovery is greater than the upper control limit (UL):

   a) Qualify all positive results as estimated, J (Table 2).

2. If the surrogate recovery is less than the lower control limit (LL), but is greater than 10%:

   a) Qualify all positive and non detect results as estimated, J/UJ (Table 2).

3. If the surrogate recovery is less than 10%:

   a) Qualify all positive results as estimated, J, and reject, R, all non detect results (Table 2).

Table 2 - Surrogate Recovery Qualifications

Sample Results	< 10%	>10%<LL	> UL
Positive Results	J	J	J
Non Detect Results	R	UJ	No Quals.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Review Items: Form III, chromatograms and quantitation pages.

Criteria: Verify the MS/MSD recoveries and RPDs are within the advisory limits established by the laboratory. MS/MSDs are analyzed at a frequency of one MS/MSD per twenty (20) samples of similar matrix.

Verify that MS/MSD recoveries were calculated correctly.

Action: No action is taken on the MS/MSD alone. However, the data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data.

QC Check Sample (Laboratory Control Sample)

Review Items: Form IIIA, chromatograms and quantitation pages.

Criteria: Verify the LCS recoveries are within the advisory limits established by the laboratory. LCS' are analyzed at a frequency of one (1) LCS per Sample Delivery Group (SDG).

Verify that LCS recoveries were calculated correctly.

Action: The data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data .

If a compound exhibits a 0% recovery:

a) Qualify the positive results for the compound as estimated, J, and reject, R, non detect results.

Blanks (Method and Field QA Blanks)

Review Items: Form I, Form IV, chromatograms and quantitation pages.

Criteria: Verify that a method blank has been analyzed for each sample matrix analyzed with each analytical sequence. All method blanks should be free of contamination. If a problem exists with <u>any</u> blank, all associated samples must be evaluated to determine whether there is inherent variability in the data or if the problem is an isolated occurrence not affecting other data.

Action:

1. If a compound is found in the blank but not in the associated sample(s), no action is required.

2. Any compound detected in the sample, which was also detected in the associated blank, must be qualified by elevating the limit of detection or adjusting the limit of detection to the reported sample result, when the sample concentration is less than five (5) times the blank concentration.

Blanks (Method and Field QA Blanks) - continued

3. The reviewer should take note that the blank analysis may not involve the same weights, volumes, or dilution factors such as associated samples. These factors must be taken into consideration when applying the 5X blank criteria.

4. The validator must review the field QA blank, including trip, rinseate, and field blanks and all associated samples. Apply the same data validation guidelines used in assessing the method blanks.

5. Qualification/Action Codes for Blanks:

   CRQL: The sample result is less than the CRQL and less than five times (5x) the blank value. Reject (R) the sample result and the "B" qualifier flag and report the result as non detect at the CRQL.

   U: The sample result is greater than the CRQL and less than five times (5X) the blank value. Cross out the "B" qualifier flag and qualify the sample result as non detect, U.

   No Action: The sample result is greater than the CRQL and greater than five times (5X) the blank value. Cross out the "B" qualifier flag.

Initial Calibration

Review Items: Form VI, chromatograms and quantitation pages.

Criteria: Verify the initial calibration is linear for all compounds (20% RSD) and that all of the calibration factors are acceptable.

Verify that the calibration factors and %RSDs were calculated correctly.

Action:

1. If the initial calibration is not linear for a compound(s), >20% RSD, but is less than 90% RSD (Table 3):

Initial Calibration - continued

a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J.

2. If the initial calibration is not linear for a compound(s), >90% RSD (Table 3):

a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results.

Table 3 - Initial Calibration Qualifications

Sample Results	>30%≤90%	>90%
Positive Results	J	J
Non Detect Results	No Quals.	R

Continuing Calibration

Review Items: Form VII, chromatograms and quantitation pages.

Criteria: Verify the continuing calibration is capable of producing acceptable qualitative and quantitative data (15% D) and that all of the calibration factors are acceptable.

Verify that the calibration factors and %Ds were calculated correctly.

Action:

1. If the continuing calibration is not acceptable for a compound(s), >15% D, but is less than 50% D (Table 4):

a) For the samples analyzed after the continuing calibration, qualify all positive results for the non compliant compound(s) as estimated, J.

Continuing Calibrations - continued

2. If the continuing calibration is not acceptable for a compound(s), >50% D, but is less than 90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive and non detect results for the non compliant compound(s) as estimated, J/UJ.

3. If the continuing calibration is not acceptable for a compound(s), >90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results

Table 4 - Continuing Calibration Qualifications

Sample Results	>15%≤ 50%	>50%≤ 90%	> 90%
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Compound Quantitation and Reported CRQLs

Review Items: Form Is, Sample Chromatograms and quantitation pages

Criteria: Verify the reported CRQLs are accurate and have been adjusted appropriately based on dilutions, concentrations, etc. Review the chromatograms and quantitation pages to ensure that required dilutions are performed, sample matrix interference does not suppress the detection of target compounds, and that false positives or false negatives were not reported. Verify that reported compounds are within the RTWs on both columns. Verify sample quantitation calculations.

Compound Quantitation and Reported CRQLs - continued

Action:

1) If the CRQLs are incorrect based on sample dilutions or percent moisture:

   a) Reject (R) the reported CRQLs and report the correct CRQLs.

2) If qualitative criteria is not met; i.e. the reported results are not with the RTWs on one or both columns or matrix interferences are present:

   a) the reported results should be rejected, R, and amended to non-detect. The reviewer may need to use professional judgement to assign an appropriate quantitation limit, considering any interferences which could be affecting the accurate identification of target compounds. If interferences preclude the identification of a target compound on one of the analytical columns then the result should be rejected, R.

3) If false negative results are noted; i.e. a compound with peaks which fall within the RTW on both columns but was not reported:

   a) the reviewer should use professional judgement to determine whether the result should be reported. A detailed discussion of decisions should be included in the case narrative.

GUIDELINES FOR ORGANIC DATA REVIEW
SW-846 METHOD 8150
DQO LEVEL IV DATA PACKAGES

Data Deliverables Required:

- Case Narrative
- Chain of Custody
- Form 2 - Surrogate Recovery Summary
- Form 3 - MS/MSD results
- Form 3A - QC Check Sample results (LCS)
- Form 4 - Method Blank Summary
- Form 1s with chromatograms and quantitation pages
- Form 6 - %RSDs and Calibration Factors with raw data
- Form 7 - %Ds and Calibration Factors with raw data
- Form 1s - Method Blank results

(Equivalent Forms are acceptable providing all of the required information is presented)

Review Requirements:

- Holding Times
- Surrogate Recoveries
- MS/MSD recoveries and RPDs
- LCS recoveries
- Method Blank contamination and sample associations
- Initial Calibration %RSDs, calibration factors and raw data
- Continuing Calibration %Ds, calibration factors and raw data
- Sample results, CRQLs, chromatograms and quantitation pages

Holding Times

Review Items: Form I, Sample Chain of Custody

Criteria: Verify the sample holding time based on the time of <u>collection</u> to the time of extraction and the time of extraction to the time of analysis.

Holding Times - continued

Technical holding times for water samples are as follows:

Water Samples cooled to 4°C (±2°C): 7 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Technical extraction holding times for soil samples are as follows:

Soil samples cooled to 4°C (±2°C): 14 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Action:

1. If the samples were properly preserved and the sample holding times were exceeded, qualify the positive and non detect sample results as defined by Table 1.

2. If the samples were not properly preserved and the temperature of the samples exceeded 4°C (±2°C), reject (R) all sample results.

Table 1 - Holding Time Qualifications

Sample Results	1 Day - 5 Days	6 Days - 15 Days	> 15 Days
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Surrogates

Review Items: Form II, chromatograms and quantitation pages.

Criteria: Verify the sample surrogate recoveries are within the QA/QC limits established by the laboratory.

Verify that surrogate recoveries were calculated correctly.

Recoveries for the surrogate compound(s) in the samples and method blanks must be within QA/QC criteria.

Surrogates - continued

Action:

1. If the surrogate recovery is greater than the upper control limit (UL):

   a) Qualify all positive results as estimated, J (Table 2).

2. If the surrogate recovery is less than the lower control limit (LL), but is greater than 10%:

   a) Qualify all positive and non detect results as estimated, J/UJ (Table 2).

3. If the surrogate recovery is less than 10%:

   a) Qualify all positive results as estimated, J, and reject, R, all non detect results (Table 2).

Table 2 - Surrogate Recovery Qualifications

Sample Results	< 10%	>10%<LL	> UL
Positive Results	J	J	J
Non Detect Results	R	UJ	No Quals.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Review Items: Form III, chromatograms and quantitation pages.

Criteria: Verify the MS/MSD recoveries and RPDs are within the advisory limits established by the laboratory. MS/MSDs are analyzed at a frequency of one MS/MSD per twenty (20) samples of similar matrix.

Verify that MS/MSD recoveries were calculated correctly.

Action: No action is taken on the MS/MSD alone. However, the data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data.

QC Check Sample (Laboratory Control Sample)

Review Items: Form IIIA, chromatograms and quantitation pages.

Criteria: Verify the LCS recoveries are within the advisory limits established by the laboratory. LCS' are analyzed at a frequency of one (1) LCS per Sample Delivery Group (SDG).

Verify that LCS recoveries were calculated correctly.

Action: The data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data .

If a compound exhibits a 0% recovery:

a) Qualify the positive results for the compound as estimated, J, and reject, R, non detect results.

Blanks (Method and Field QA Blanks)

Review Items: Form I, Form IV, chromatograms and quantitation pages.

Criteria: Verify that a method blank has been analyzed for each sample matrix analyzed with each analytical sequence. All method blanks should be free of contamination. If a problem exists with <u>any</u> blank, all associated samples must be evaluated to determine whether there is inherent variability in the data or if the problem is an isolated occurrence not affecting other data.

Action:

1. If a compound is found in the blank but not in the associated sample(s), no action is required.

2. Any compound detected in the sample, which was also detected in the associated blank, must be qualified by elevating the limit of detection or adjusting the limit of detection to the reported sample result, when the sample concentration is less than five (5) times the blank concentration.

3. The reviewer should take note that the blank analysis may

Blanks (Method and Field QA Blanks) - continued

not involve the same weights, volumes, or dilution factors such as associated samples. These factors must be taken into consideration when applying the 5X blank criteria.

4. The validator must review the field QA blank, including trip, rinseate, and field blanks and all associated samples. Apply the same data validation guidelines used in assessing the method blanks.

5. Qualification/Action Codes for Blanks:

   CRQL: The sample result is less than the CRQL and less than five times (5x) the blank value. Reject (R) the sample result and the "B" qualifier flag and report the result as non detect at the CRQL.

   U: The sample result is greater than the CRQL and less than five times (5X) the blank value. Cross out the "B" qualifier flag and qualify the sample result as non detect, U.

   No Action: The sample result is greater than the CRQL and greater than five times (5X) the blank value. Cross out the "B" qualifier flag.

Initial Calibration

Review Items: Form VI, chromatograms and quantitation pages.

Criteria: Verify the initial calibration is linear for all compounds (20% RSD) and that all of the calibration factors are acceptable.

Verify that the calibration factors and %RSDs were calculated correctly.

Action:

1. If the initial calibration is not linear for a compound(s), >20% RSD, but is less than 90% RSD (Table 3):

Initial Calibration - continued

a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J.

2. If the initial calibration is not linear for a compound(s), >90% RSD (Table 3):

a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results.

Table 3 - Initial Calibration Qualifications

Sample Results	>30%≤90%	>90%
Positive Results	J	J
Non Detect Results	No Quals.	R

Continuing Calibration

Review Items: Form VII, chromatograms and quantitation pages.

Criteria: Verify the continuing calibration is capable of producing acceptable qualitative and quantitative data (15% D) and that all of the calibration factors are acceptable.

Verify that the calibration factors and %RSDs were calculated correctly.

Action:

1. If the continuing calibration is not acceptable for a compound(s), >15% D, but is less than 50% D (Table 4):

a) For the samples analyzed after the continuing calibration, qualify all positive results for the non compliant compound(s) as estimated, J.

Continuing Calibrations - continued

2. If the continuing calibration is not acceptable for a compound(s), >50% D, but is less than 90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive and non detect results for the non compliant compound(s) as estimated, J/UJ.

3. If the continuing calibration is not acceptable for a compound(s), >90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results

Table 4 - Continuing Calibration Qualifications

Sample Results	>15%≤ 50%	>50%≤ 90%	> 90%
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Compound Quantitation and Reported CRQLs

Review Items: Form Is, Sample Chromatograms and quantitation pages

Criteria: Verify the reported CRQLs are accurate and have been adjusted appropriately based on dilutions, concentrations, etc. Review the chromatograms and quantitation pages to ensure that required dilutions are performed, sample matrix interference does not suppress the detection of target compounds, and that false positives or false negatives were not reported. Verify that reported compounds are within the RTWs on both columns. Verify sample quantitation calculations.

Compound Quantitation and Reported CRQLs, continued

Action:

1) If the CRQLs are incorrect based on sample dilutions or percent moisture:

   a) Reject (R) the reported CRQLs and report the correct CRQLs.

2) If qualitative criteria is not met; i.e. the reported results are not with the RTWs on one or both columns or matrix interferences are present:

   a) the reported results should be rejected, R, and amended to non-detect. The reviewer may need to use professional judgement to assign an appropriate quantitation limit, considering any interferences which could be affecting the accurate identification of target compounds. If interferences preclude the identification of a target compound on one of the analytical columns then the result should be rejected, R.

3) If false negative results are noted; i.e. a compound with peaks which fall within the RTW on both columns but was not reported:

   a) the reviewer should use professional judgement to determine whether the result should be reported. A detailed discussion of decisions should be included in the case narrative.

GUIDELINES FOR ORGANIC DATA REVIEW
SW-846 METHOD 8240
DQO LEVEL IV DATA PACKAGES

Data Deliverables Required:

- Case Narrative
- Chain of Custody
- Form 2 - Surrogate Recovery Summary
- Form 3 - MS/MSD results
- Form 3A - QC Check Sample results (LCS)
- Form 4 - Method Blank Summary
- Form 5 - Instrument Performance Check Summary with raw data
- Form 8 - Internal Standard EICP Area Summary
- Form 1s with chromatograms
- Form 6 - %RSDs, Relative Response Factors, and raw data
- Form 7 - %Ds, Relative Response Factors, and raw data
- Form 1s - Method Blank raw data
- Form 1s - MS/MSD, LCS raw data

(Equivalent Forms are acceptable providing all of the required information is presented)

Review Requirements:

- Holding Times
- Surrogate Recoveries
- MS/MSD recoveries and RPDs
- LCS recoveries
- Method Blank contamination and sample associations
- BFB Tuning
- Initial Calibration %RSDs and calibration factors
- Continuing Calibration %Ds and calibration factors
- Sample results, CRQLs, chromatograms, and spectra

Holding Times

Review Items: Form I, Sample Chain of Custody

Criteria: Verify the sample holding time based on the time of <u>collection</u> to the time of analysis.

Holding Times - continued

Technical holding times for water samples are as follows:

Unpreserved Water Samples cooled to 4°C (±2°C): 7 Days
Preserved Water Samples cooled to 4°C (±2°C): 14 Days

Water samples that have not been maintained at 4°C (±2°C) and have been preserved to a pH of 2 or below must be analyzed within seven (7) days.

Technical holding times for soil samples are as follows:

Soil samples cooled to 4°C (±2°C): 14 Days

Action:

1. If the samples were properly preserved and the holding times were exceeded, qualify the positive and non detect sample results as defined by Table 1.

2. If the samples were not properly preserved and the temperature of the samples exceeded 4°C (±2°C), reject (R) all sample results.

Table 1 - Holding Time Qualifications

Sample Results	1 Day - 5 Days	6 Days - 15 Days	> 15 Days
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Surrogates

Review Items: Form II, chromatograms, and quantitation pages

Criteria: Verify the sample surrogate recoveries are within the QA/QC limits established by the laboratory. Verify that the surrogate recoveries were calculated correctly.

Recoveries for the surrogate compound(s) in the samples and method blanks must be within QA/QC criteria.

Surrogates - continued

Action:

1. If the surrogate recovery is greater than the upper control limit (UL):

   a) Qualify all positive results as estimated, J (Table 2).

2. If the surrogate recovery is less than the lower control limit (LL), but is greater than 10%:

   a) Qualify all positive and non detect results as estimated, J/UJ (Table 2).

3. If the surrogate recovery is less than 10%:

   a) Qualify all positive results as estimated, J, and reject, R, all non detect results (Table 2).

Table 2 - Surrogate Recovery Qualifications

Sample Results	< 10%	>10%<LL	> UL
Positive Results	J	J	J
Non Detect Results	R	UJ	No Quals.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Review Items: Form III, chromatograms, quantitation pages, and spectra

Criteria: Verify the MS/MSD recoveries and RPDs are within the advisory limits established by the laboratory. MS/MSDs are analyzed at a frequency of one MS/MSD per twenty (20) samples of similar matrix. Verify that the MS/MSD percent recoveries and the RPDs were calculated correctly.

Action: No action is taken on the MS/MSD alone. However, the data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data.

QC Check Sample (Laboratory Control Sample)

Review Items: Form IIIA, chromatograms, and quantitation pages

Criteria: Verify the LCS recoveries are within the advisory limits established by the laboratory. LCS' are analyzed at a frequency of one (1) LCS per Sample Delivery Group (SDG).

Action: The data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data .

If a compound exhibits a 0% recovery:

a) Qualify the positive results for the compound as estimated, J, and reject, R, non detect results.

Blanks (Method and Field QA Blanks)

Review Items: Form I, Form IV, chromatograms, quantitation pages, and spectra

Criteria: Verify that a method blank has been analyzed for each sample matrix analyzed with each analytical sequence. All method blanks should be free of contamination. If a problem exists with <u>any</u> blank, all associated samples must be evaluated to determine whether there is inherent variability in the data or if the problem is an isolated occurrence not affecting other data.

Action:

1. If a compound is found in the blank but not in the associated sample(s), no action is required.

2. Any compound (other than acetone, 2-butanone, and toluene) detected in the sample, which was also detected in the associated blank, must be qualified by elevating the limit of detection or adjusting the limit of detection to the reported sample result, when the sample concentration is less than five (5) times the blank concentration. For acetone, 2-butanone, and toluene, common laboratory contaminants, the results are qualified by elevating the limit of detection or adjusting the limit of detection to the reported sample result, when the

sample concentration is less than ten (10) times the blank concentration.

3. The reviewer should take note that the blank analysis may not involve the same weights, volumes, or dilution factors such as associated samples. These factors must be taken into consideration when applying the 5X and 10X blank criteria.

4. The validator must review the field QA blank, including trip, rinseate, and field blanks and all associated samples. Apply the same data validation guidelines used in assessing the method blanks.

5. Qualification/Action Codes for Blanks:

   CRQL: The sample result is less than the CRQL and less than five times (5x) (ten times (10X) for common laboratory contaminants) the blank value. Reject (R) the sample result and the "B" qualifier flag and report the result as non detect at the CRQL.

   U: The sample result is greater than the CRQL and less than five times (5X) (ten times (10X) for common laboratory contaminants) the blank value. Cross out the "B" qualifier flag and qualify the sample result as non detect, U.

   No Action: The sample result is greater than the CRQL and greater than five times (5X) (ten times (10X) for common laboratory contaminants) the blank value. Cross out the "B" qualifier flag.

Tuning

Review Items: Form V and raw tuning data

Criteria: Verify the BFB tune is performed every twelve (12) hours at the beginning of each analytical sequence to ensure mass resolution, mass identification, and sensitivity. The BFB tune must meet the ion abundance criteria.

Bromofluorobenzene (BFB) Ion Abundance Criteria

m/z	Ion Abundance Criteria
50	15.0% - 40.0% of m/z 95
75	30.0% - 60.0% of m/z 95
95	Base peak, 100.0% relative abundance
96	5.0% - 9.0% of m/z 95
173	less than 2.0% of m/z 174
174	greater than 50.0% of m/z 95
175	greater than 95.0% but less than 101.0% of m/z 174
177	5.0% - 9.0% of m/z 176

Action:

1. If a mass assignment is in error, reject (R) all of the associated data.

2. If ion abundance criteria are not met, professional judgement may be used to determine useability of the data.

3. If samples are analyzed after the expiration of the twelve (12) hour tuning period, reject (R) all associated data for those samples.

Internal Standards

Review Items: Form VIII and sample quantitation pages

Criteria: Verify the internal standard performance for GC/MS sensitivity and stability (-50% or +100% of the internal standard area for the associated standard and ± 30 seconds of the retention time of the internal standard for the associated standard).

Internal Standards - continued

Action:

1. If an internal standard area for a sample or blank is greater than +100%:

   a) For the compounds associated with the non compliant internal standard, qualify all positive results as estimated, J.

2. If an internal standard area for a sample or blank is less than - 50%:

   a) For the compounds associated with the non compliant internal standard, qualify all positive and non detect results as estimated, J/UJ.

3. If an extremely low area counts are reported or performance exhibits a major abrupt drop-off:

   a) For the compounds associated with the non compliant internal standard, qualify all positive results as estimated, J, and reject, R, all non detect results.

4. If an internal standard retention time shifts by more than 30 seconds:

   a) Professional judgement may be used to determine useability of the data.

Initial Calibration

Review Items: Form VI, chromatograms, and quantitation pages

Criteria: Verify the initial calibration is linear for all compounds (30% RSD) and that all of the relative response factors (RRFs) are acceptable (>0./05). Separate calibrations must be performed for water samples and medium level soil samples, non-heated purge, and for soil samples, heated purge.

Initial Calibration - continued

Action:

1. If the initial calibration is not linear for a compound(s), >30% RSD, but is less than 90% RSD (Table 3):

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J.

2. If the initial calibration is not linear for a compound(s), >90% RSD (Table 3):

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results.

Table 3 - Initial Calibration Qualifications

Sample Results	>30%≤90%	>90%
Positive Results	J	J
Non Detect Results	No Quals.	R

3. If the average RRF for a compound(s) is less than 0.05:

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non compliant compound(s) as estimated, J, and reject, R, non detect results.

Continuing Calibration

Review Items: Form VII, chromatograms, and quantitation pages

Criteria: Verify the continuing calibration is capable of producing acceptable qualitative and quantitative data (25% D) and that all of the relative response factors (RRFs) are acceptable. Separate calibrations must be performed for water samples and medium level soil samples, non-heated purge, and for soil samples, heated purge.

Continuing Calibration - continued

Action:

1. If the continuing calibration is not acceptable for a compound(s), >25% D, but is less than 50% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non compliant compound(s) as estimated, J.

2. If the continuing calibration is not acceptable for a compound(s), >50% D, but is less than 90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive and non detect results for the non compliant compound(s) as estimated, J/UJ.

3. If the continuing calibration is not acceptable for a compound(s), >90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results

Table 4 - Continuing Calibration Qualifications

Sample Results	>25%≤50%	>50%≤90%	>90%
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

4. If the average RRF for a compound(s) is less than 0.05:

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non compliant compound(s) as estimated, J, and reject, R, non detect results.

Compound Quantitation and Reported CRQLs

Review Items: Form I, sample chromatograms, quantitation pages, and positive spectra

Criteria: Verify the reported CRQLs are accurate. Review the chromatograms to ensure dilutions are required and sample matrix interference does not suppress the detection of target compounds. Review the sample quantitation to ensure the proper internal standards have been used for quantitation and the RRFs have been updated from the appropriate daily standard. Review spectra to ensure correct positive identification of compounds and/or potential false positives.

Action:

1) If the CRQLs are incorrect based on sample dilutions or percent moisture:

   a) Reject (R) the reported CRQLs and report the correct CRQLs.

2) If the sample chromatograms exhibit sample matrix interference:

   a) For the compounds that elute in the region of the interference, qualify positive results as estimated, J, and reject (R) non detect results.

3) If the RRT of the reported compounds are not within ±0.06 RRT units of the associated standard RRT:

   a) Professional judgement must be used to determine the cause and impact of the non compliance.

4) If the correct identification of the mass spectra were not made:

   a) Professional judgement should be used to qualify the data as non detect, U, or unusable, R.

GUIDELINES FOR ORGANIC DATA REVIEW
SW-846 METHOD 8270
DQO LEVEL IV DATA PACKAGES

Data Deliverables Required:

- Case Narrative
- Chain of Custody
- Form 2 - Surrogate Recovery Summary
- Form 3 - MS/MSD results
- Form 3A - QC Check Sample results (LCS)
- Form 4 - Method Blank Summary
- Form 5 - Instrument Performance Check Summary with raw data
- Form 8 - Internal Standard EICP Area Summary
- Form 1s with chromatograms and quantitation pages
- Form 6 - %RSDs, Relative Response Factors, and raw data
- Form 7 - %Ds, Relative Response Factors, and raw data
- Form 1s - Method Blank raw data
- Form 1s - MS/MSD, LCS raw data

(Equivalent Forms are acceptable providing all of the required information is presented)

Review Requirements:

- Holding Times
- Surrogate Recoveries
- MS/MSD recoveries and RPDs
- LCS recoveries
- Method Blank contamination and sample associations
- DFTPP Tuning
- Initial Calibration %RSDs and calibration factors
- Continuing Calibration %Ds and calibration factors
- Sample results, CRQLs, and chromatograms

Holding Times

Review Items: Form I, Sample Chain of Custody

Holding Times - continued

Criteria: Verify the sample holding time based on the time of collection to the time of extraction and the time of extraction to the time of analysis.

Technical holding times for water samples are as follows:

Water Samples cooled to 4°C (±2°C): 7 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Technical extraction holding times for soil samples are as follows:

Soil samples cooled to 4°C (±2°C): 14 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Action:

1. If the samples were properly preserved and the sample holding times were exceeded, qualify the positive and non detect sample results as defined by Table 1.

2. If the samples were not properly preserved and the temperature of the samples exceeded 4°C (±2°C), reject (R) all sample results.

Table 1 - Holding Time Qualifications

Sample Results	1 Day - 5 Days	6 Days - 15 Days	> 15 Days
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Surrogates

Review Items: Form II, chromatograms and quantitation pages

Surrogates - continued

Criteria: Verify the sample surrogate recoveries are within the QA/QC limits established by the laboratory. Up to one (1) surrogate per fraction may be outside the QA/QC limits, as long as the percent recovery is greater than 10%. Verify that the surrogate recoveries were calculated correctly.

Recoveries for the surrogate compound(s) in the samples and method blanks must be within QA/QC criteria.

Action:

1. If two (2) surrogate recoveries in either fraction are greater than the upper control limit (UL):

   a) Qualify all positive results for that fraction as estimated, J (Table 2).

2. If two (2) surrogate recoveries in either fraction are less than the lower control limit (LL), but is greater than 10%:

   a) Qualify all positive and non detect results for that fraction as estimated, J/UJ (Table 2).

3. If a surrogate recovery in either fraction is less than 10%:

   a) Qualify all positive results as estimated, J, and reject, R, all non detect results for that fraction (Table 2).

Table 2 - Surrogate Recovery Qualifications

Sample Results	< 10%	>10%<LL	> UL
Positive Results	J	J	J
Non Detect Results	R	UJ	No Quals.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Review Items: Form III, chromatograms, and raw data

Matrix Spike/Matrix Spike Duplicate (MS/MSD) - continued

Criteria: Verify the MS/MSD recoveries and RPDs are within the advisory limits established by the laboratory. MS/MSDs are analyzed at a frequency of one MS/MSD per twenty (20) samples of similar matrix.

Verify that the MS/MSD recoveries and RPDs were calculated correctly.

Action: No action is taken on the MS/MSD alone. However, the data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data.

QC Check Sample (Laboratory Control Sample)

Review Items: Form IIIA, chromatograms and quantitation pages

Criteria: Verify the LCS recoveries are within the advisory limits established by the laboratory. LCS' are analyzed at a frequency of one (1) LCS per Sample Delivery Group (SDG).

Verify that the LCS recoveries were calculated correctly.

Action: The data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data .

If a compound exhibits a 0% recovery:

a) Qualify the positive results for the compound as estimated, J, and reject, R, non detect results.

Blanks (Method and Field QA Blanks)

Review Items: Form I, Form IV, chromatograms, and quantitation pages

Blanks (Method and Field QA Blanks) - continued

Criteria: Verify that a method blank has been analyzed for each sample matrix analyzed with each analytical sequence. All method blanks should be free of contamination. If a problem exists with <u>any</u> blank, all associated samples must be evaluated to determine whether there is inherent variability in the data or if the problem is an isolated occurrence not affecting other data.

Action:

1. If a compound is found in the blank but not in the associated sample(s), no action is required.

2. Any compound (other than phthalates) detected in the sample, which was also detected in the associated blank, must be qualified by elevating the limit of detection or adjusting the limit of detection to the reported sample result, when the sample concentration is less than five (5) times the blank concentration. For phthalates, common laboratory contaminants, the results are qualified by elevating the limit of detection or adjusting the limit of detection to the reported sample result, when the sample concentration is less than ten (10) times the blank concentration.

3. The reviewer should take note that the blank analysis may not involve the same weights, volumes, or dilution factors such as associated samples. These factors must be taken into consideration when applying the 5X and 10X blank criteria.

4. The validator must review the field QA blank, including trip, rinseate, and field blanks and all associated samples. Apply the same data validation guidelines used in assessing the method blanks.

Blanks (Method and Field QA Blanks) - continued

5. Qualification/Action Codes for Blanks:

CRQL: The sample result is less than the CRQL and less than five times (5x) (ten times (10X) for phthalates) the blank value. Reject (R) the sample result and the "B" qualifier flag and report the result as non detect at the CRQL.

U: The sample result is greater than the CRQL and less than five times (5X) (ten times (10X) for phthalates) the blank value. Cross out the "B" qualifier flag and qualify the sample result as non detect, U.

No Action: The sample result is greater than the CRQL and greater than five times (5X) (ten times (10X) for toluene) the blank value. Cross out the "B" qualifier flag.

Tuning

Review Items: Form V and raw tuning data

Criteria: Verify the DFTPP tune is performed every twelve (12) hours at the beginning of each analytical sequence to ensure mass resolution, mass identification, and sensitivity. The DFTPP tune must meet the ion abundance criteria.

Tuning - continued

Decafluorotriphenylphosphine (DFTPP) Ion Abundance Criteria

m/z	Ion Abundance Criteria
51	30.0% - 80.0% of m/z 198
68	less than 2.0% of m/z 69
69	present
70	less than 2.0% of m/z 69
127	25.0% - 75.0% of m/z 198
197	less than 1.0% of m/z 198
198	base peak, 100% relative abundance
199	5.0% - 9.0% of m/z 198
275	10.0% - 30.0% of m/z 198
365	greater than 0.75% of m/z 198
441	present, but less than m/z 443
442	40.0% - 110.0% of m/z 198
443	15.0% - 24.0% of m/z 442

Action:

1. If a mass assignment is in error, reject (R) all of the associated data.

2. If ion abundance criteria are not met, professional judgement may be used to determine useability of the data.

3. If samples are analyzed after the expiration of the twelve (12) hour tuning period, reject (R) all associated data for those samples.

Internal Standards

Review Items: Form VIII and sample quantitation pages

Criteria: Verify the internal standard performance for GC/MS sensitivity and stability (-50% or +100% of the internal standard area for the associated standard and ± 30 seconds of the retention time of the internal standard for the associated standard).

Internal Standards - continued

Action:

1. If an internal standard area for a sample or blank is greater than +100%:

   a) For the compounds associated with the non compliant internal standard, qualify all positive results as estimated, J.

2. If an internal standard area for a sample or blank is less than - 50%:

   a) For the compounds associated with the non compliant internal standard, qualify all positive and non detect results as estimated, J/UJ.

3. If an extremely low area counts are reported or performance exhibits a major abrupt drop-off:

   a) For the compounds associated with the non compliant internal standard, qualify all positive results as estimated, J, and reject, R, all non detect results.

4. If an internal standard retention time shifts by more than 30 seconds:

   a) Professional judgement may be used to determine useability of the data.

Initial Calibration

Review Items: Form VI, chromatograms, and quantitation pages

Criteria: Verify the initial calibration is linear for all compounds (30% RSD) and that all of the relative response factors (RRFs) are acceptable (>0./05). Separate calibrations must be performed for water samples and medium level soil samples, non-heated purge, and for soil samples, heated purge.

Initial Calibration - continued

Action:

1. If the initial calibration is not linear for a compound(s), >30% RSD, but is less than 90% RSD (Table 3):

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J.

2. If the initial calibration is not linear for a compound(s), >90% RSD (Table 3):

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results.

Table 3 - Initial Calibration Qualifications

Sample Results	>30%≤90%	>90%
Positive Results	J	J
Non Detect Results	No Quals.	R

3. If the average RRF for a compound(s) is less than 0.05:

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non compliant compound(s) as estimated, J, and reject, R, non detect results.

Continuing Calibration

Review Items: Form VII, chromatograms, and quantitation pages

Criteria: Verify the continuing calibration is capable of producing acceptable qualitative and quantitative data (25% D) and that all of the relative response factors (RRFs) are acceptable. Separate calibrations must be performed for water samples and medium level soil samples, non-heated purge, and for soil samples, heated purge.

Continuing Calibration - continued

Action:

1. If the continuing calibration is not acceptable for a compound(s), >25% D, but is less than 50% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non compliant compound(s) as estimated, J.

2. If the continuing calibration is not acceptable for a compound(s), >50% D, but is less than 90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive and non detect results for the non compliant compound(s) as estimated, J/UJ.

3. If the continuing calibration is not acceptable for a compound(s), >90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results

Table 4 - Continuing Calibration Qualifications

Sample Results	>25%≤50%	>50%≤90%	>90%
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

4. If the average RRF for a compound(s) is less than 0.05:

   a) For the samples analyzed after the initial calibration, qualify all positive results for the non compliant compound(s) as estimated, J, and reject, R, non detect results.

Compound Quantitation and Reported CRQLs

Review Items: Form I, sample chromatograms, quantitation pages, and positive spectra

Criteria: Verify the reported CRQLs are accurate. Review the chromatograms to ensure dilutions are required and sample matrix interference does not suppress the detection of target compounds. Review the sample quantitation to ensure the proper internal standards have been used for quantitation and the RRFs have been updated from the appropriate daily standard. Review spectra to ensure correct positive identification of compounds and/or potential false positives.

Action:

1) If the CRQLs are incorrect based on sample dilutions or percent moisture:

   a) Reject (R) the reported CRQLs and report the correct CRQLs.

2) If the sample chromatograms exhibit sample matrix interference:

   a) For the compounds that elute in the region of the interference, qualify positive results as estimated, J, and reject (R) non detect results.

3) If the RRT of the reported compounds are not within ±0.06 RRT units of the associated standard RRT:

   a) Professional judgement must be used to determine the cause and impact of the non compliance.

4) If the correct identification of the mass spectra were not made:

   a) Professional judgement should be used to qualify the data as non detect, U, or unusable, R.

GUIDELINES FOR ORGANIC DATA REVIEW
SW-846 METHOD 8330
DQO LEVEL IV DATA PACKAGES

Data Deliverables Required:

- Case Narrative
- Chain of Custody
- Form 2 - Surrogate Recovery Summary if reported
- Form 3 - MS/MSD results if reported
- Form 3A - QC Check Sample results (LCS)
- Form 4 - Method Blank Summary
- Form 1s with chromatograms and quantitation pages
- Form 6 - %RSDs and Calibration Factors with raw data
- Form 7 - %Ds and Calibration Factors with raw data
- Form 1s - Method Blank raw data
- Form 1s - MS/MSD, LCS raw data

(Equivalent Forms are acceptable providing all of the required information is presented)

Review Requirements:

- Holding Times
- Surrogate Recoveries
- MS/MSD recoveries and RPDs
- LCS recoveries
- Method Blank contamination and sample associations
- Initial Calibration %RSDs, calibration factors and raw data
- Continuing Calibration %Ds, calibration factors and raw data
- Sample results, CRQLs, chromatograms and quantitation pages

Holding Times

Review Items: Form I, Sample Chain of Custody

Criteria: Verify the sample holding time based on the time of <u>collection</u> to the time of extraction and the time of extraction to the time of analysis.

Holding Times - continued

Technical holding times for water samples are as follows:

Water Samples cooled to 4°C (±2°C): 7 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Technical holding times for soil samples are as follows:

Soil samples cooled to 4°C (±2°C): 14 days from sample collection to sample extraction and 40 days from sample extraction to sample analysis.

Action:

1. If the samples were properly preserved and the holding times were exceeded, qualify the positive and non detect sample results as defined by Table 1.

2. If the samples were not properly preserved and the temperature of the samples exceeded 4°C (±2°C), reject (R) all sample results.

Table 1 - Holding Time Qualifications

Sample Results	1 Day - 5 Days	6 Days - 15 Days	> 15 Days
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Surrogates (if reported by laboratory)

Review Items: Form II, chromatograms and quantitation pages.

Criteria: Verify the sample surrogate recoveries are within the QA/QC limits established by the laboratory.

Verify that surrogate recoveries were calculated correctly.

Recoveries for the surrogate compound(s) in the samples and method blanks must be within QA/QC criteria.

Surrogates - continued

Action:

1. If the surrogate recovery is greater than the upper control limit (UL):

   a) Qualify all positive results as estimated, J (Table 2).

2. If the surrogate recovery is less than the lower control limit (LL), but is greater than 10%:

   a) Qualify all positive and non detect results as estimated, J/UJ (Table 2).

3. If the surrogate recovery is less than 10%:

   a) Qualify all positive results as estimated, J, and reject, R, all non detect results (Table 2).

Table 2 - Surrogate Recovery Qualifications

Sample Results	< 10%	>10%<LL	> UL
Positive Results	J	J	J
Non Detect Results	R	UJ	No Quals.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) (if reported by laboratory)

Review Items: Form III, chromatograms and quantitation pages.

Criteria: Verify the MS/MSD recoveries and RPDs are within the advisory limits established by the laboratory. MS/MSDs are analyzed at a frequency of one MS/MSD per twenty (20) samples of similar matrix.

Verify that MS/MSD recoveries were calculated correctly.

Action: No action is taken on the MS/MSD alone. However, the data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data.

QC Check Sample (Laboratory Control Sample)

Review Items: Form IIIA, chromatograms and quantitation pages.

Criteria: Verify the LCS recoveries are within the advisory limits established by the laboratory. LCS' are analyzed at a frequency of one (1) LCS per Sample Delivery Group (SDG).

Verify that LCS recoveries were calculated correctly.

Action: The data reviewer may use professional judgement in conjunction with other QA/QC criteria to determine the need for qualification of the data .

If a compound exhibits a 0% recovery:

a) Qualify the positive results for the compound as estimated, J, and reject, R, non detect results.

Blanks (Method and Field QA Blanks)

Review Items: Form I, Form IV, chromatograms and quantitation pages.

Criteria: Verify that a method blank has been analyzed for each sample matrix analyzed with each analytical sequence. All method blanks should be free of contamination. If a problem exists with <u>any</u> blank, all associated samples must be evaluated to determine whether there is inherent variability in the data or if the problem is an isolated occurrence not affecting other data.

Action:

1. If a compound is found in the blank but not in the associated sample(s), no action is required.

2. Any compound detected in the sample, which was also detected in the associated blank, must be qualified by elevating the limit of detection or adjusting the limit of detection to the reported sample result, when the sample concentration is less than five (5) times the blank concentration.

Blanks (Method and Field QA Blanks) - continued

3. The reviewer should take note that the blank analysis may not involve the same weights, volumes, or dilution factors such as associated samples. These factors must be taken into consideration when applying the 5X blank criteria.

4. The validator must review the field QA blank, including trip, rinseate, and field blanks and all associated samples. Apply the same data validation guidelines used in assessing the method blanks.

5. Qualification/Action Codes for Blanks:

   CRQL: The sample result is less than the CRQL and less than five times (5x) the blank value. Reject (R) the sample result and the "B" qualifier flag and report the result as non detect at the CRQL.

   U: The sample result is greater than the CRQL and less than five times (5X) the blank value. Cross out the "B" qualifier flag and qualify the sample result as non detect, U.

   No Action: The sample result is greater than the CRQL and greater than five times (5X) the blank value. Cross out the "B" qualifier flag.

Initial Calibration

Review Items: Form VI, chromatograms and quantitation pages.

Criteria: Verify that the laboratory analyzed the calibration standards in triplicate. Verify the initial calibration curve is linear with zero intercept. Verify that the calibration curves were plotted correctly.

Action:

1. If the initial calibration is not linear for a compound(s), >0.995 (Table 3):

Initial Calibration - continued

a) For the samples analyzed after the initial calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non-detect results.

Table 3 - Initial Calibration Qualifications

Sample Results	<0.995
Positive Results	J
Non Detect Results	R

Continuing Calibration

Review Items: Form VII, chromatograms and quantitation pages.

Criteria: Verify that the laboratory analyzed the continuing calibrations at appropriate intervals in the sequence. Verify the continuing calibration is capable of producing acceptable qualitative and quantitative data (20% D). Verify that the %D calculations were calculated correctly.

Action:

1. If the continuing calibration is not acceptable for a compound(s), >20% D, but is less than 50% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non compliant compound(s) as estimated, J.

2. If the continuing calibration is not acceptable for a compound(s), >50% D, but is less than 90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive and non detect results for the non compliant compound(s) as estimated, J/UJ.

Continuing Calibrations - continued

3. If the continuing calibration is not acceptable for a compound(s), >90% D (Table 4):

   a) For the samples analyzed after the continuing calibration, qualify all positive results for the non linear compound(s) as estimated, J and reject, R, non detect results

Table 4 - Continuing Calibration Qualifications

Sample Results	>20%≤ 50%	>50%≤ 90%	> 90%
Positive Results	J	J	J
Non Detect Results	No Quals.	UJ	R

Compound Quantitation and Reported CRQLs

Review Items: Form Is, Sample Chromatograms and quantitation pages

Criteria: Verify the reported CRQLs are accurate and have been adjusted appropriately based on dilutions, concentrations, etc. Review the chromatograms and quantitation pages to ensure that required dilutions are performed, sample matrix interference does not suppress the detection of target compounds, and that false positives or false negatives were not reported. Verify that reported compounds are within the RTWs on both columns. Verify that target compounds did not co-elute. Verify sample quantitation calculations.

Action:

1) If the CRQLs are incorrect based on sample dilutions or percent moisture:

   a) Reject (R) the reported CRQLs and report the correct CRQLs.

2) If qualitative criteria is not met; i.e. the reported results are not with the RTWs on one or both columns or matrix interferences are present:

Compound Quantitation and Reported CRQLs - continued

a) the reported results should be rejected, R, and amended to non-detect. The reviewer may need to use professional judgement to assign an appropriate quantitation limit, considering any interferences which could be affecting the accurate identification of target compounds. If interferences preclude the identification of a target compound on one of the analytical columns then the result should be rejected, R.

3) If false negative results are noted; i.e. a compound with peaks which fall within the RTW on both columns but was not reported:

a) the reviewer should use professional judgement to determine whether the result should be reported. A detailed discussion of decisions should be included in the case narrative.

DRAFT

DATA MANAGEMENT PLAN

RCRA FACILITY INVESTIGATION

NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CONTRACT TASK ORDER 0223

SEPTEMBER 14, 1995

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

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1.0 INTRODUCTION

This document provides the Data Management Plan (DMP) for Selected Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico. This has been prepared by Baker Environmental, Inc. (Baker) under the Naval Facilities Engineering Command (NAVFACENGCOM), Atlantic Division (LANTDIV) Contract Number 62470-89-4814, Contract Task Order 0223 (CTO-0223). This CTO includes conducting a RCRA Facilities Investigation and the preparation of a Corrective Measures Study (CMS) Evaluation Report.

The SWMUs and AOCs evaluated are those that require investigation under the RCRA Corrective Action Permit. A complete list of these SWMUs/AOCs are provided in Table 1-1.

The DMP presents the program that will be used to document and track investigation samples, data and results. This plan identifies and establishes data documentation materials and procedures, project file requirements, and project-related progress reporting and documents. This plan also provides the format to be used to present the raw data and conclusions of the investigation.

This DMP is one of five project plans associated with the RFI. Other RFI project plans include:

- Project Management Plan
- Data Collection Quality Assurance Plan (DCQAP)
- Health and Safety Plan (HASP)
- Community Relations Plan (CRP)

The Draft Corrective Action Permit (Module III, Appendix A, Section V) specifies the items to be included in the DMP. The DMP has been designed to satisfy these requirements. The items included in the permit are addressed specifically in Section 4.0 of this DMP. The additional sections of the DMP are included to provide background on data management procedures and reporting.

Table 1-2 serves as a cross reference between the material presented in this DMP and the material required by the Corrective Action Permit (Module III, Appendix A, Section V). Table 1-2 is designed to allow the reader of this DMP to quickly retrieve selected information from the text.

2.0 DATA DOCUMENTATION AND PROCEDURES

There are four general categories of data that will be generated during the RFI at NSRR. They are listed below:

- Physical and chemical analytical results, including but not limited to:
  - Soil (geologic and geotechnical), water (surface and ground), sediment, and wipe samples
  - Laboratory data, including laboratory identifiers, analytical methodologies, analytical results, quantitation limits, and qualifiers
- Field data, including but not limited to:
  - Field records and observations, including unique sample identifiers, geologic, spatial, geotechnical characteristics, and field methods and procedures for samples collected
- Documents, including but not limited to:
  - Contracts, reports, and field manuals
- Communications, including but not limited to:
  - Records of telephone conversations, letters, facsimile transmissions, memoranda, and meeting notes

Documentation procedures and more specific examples of documentation/data formatting are provided in the Baker Standard Operating Procedures (SOPs) contained in Appendix B of the DCQAP. In terms of data documentation and procedures, the following SOPs are pertinent:

- A008 - Filing
- F101 - Borehole and Sample Logging
- F103 - Monitoring Well Installation
- F302 - Chain-of-Custody
- F303 - Field Logbook

The following sections describe the project data flow, data management organization, and project documentation materials for this project. Forms provided in the above-cited SOPs, as well as project-specific forms that will be used, are outlined in this discussion.

2.1 Data Management Organization and Responsibilities

The four categories of data described above will be handled by the following organizations: the analytical laboratory and data validation subcontractors; Baker; LANTDIV; and USEPA. Each organization has a specific role in this process:

- Laboratory Subcontractor

  The laboratory subcontractor will accept field samples from Baker for analysis, and will assign laboratory identifiers to each sample. Also, the laboratory subcontractor will provide a hardcopy of the data as well as an electronic data deliverable. These deliverables will be provided to Baker for data reduction and reporting.

- Data Validation Subcontractor

  The laboratory analytical results will be submitted to an independent third party for data validation. Note that 100 percent of the analytical data will be validated.

- Baker

  Baker will collect field samples and submit them to the laboratory subcontractor and validated data for analysis. Baker also will record all field data including all geological, geotechnical, and procedural notes regarding sample collection and

conditions in the field. Unique identifiers will be assigned to all samples collected in the field, and chain-of-custody forms will be completed for all samples shipped from the site for analysis. Samples collected in the field will be analyzed using NEESA Level C quality control.

Baker will accept raw analytical results and reduce the data for the RFI report. Baker also will provide storage of the data hardcopy and the electronic data deliverables.

Within Baker, four separate position titles that will have primary responsibility for the management of project data are listed below.

- Project Manager - Responsible for documenting project communications and the flow of information into and out of the project files. The Project Manager is also responsible for arranging the final storage of data collected as part of the RFI.

- Site Manager - Overall responsibility for coordinating field activities conducted as part of the RFI. This individual will be on site for field investigation work and will oversee proper collection and recording of data as well as provide the first review for completeness of all data collected in the field.

- Data Management Coordinator - Responsible for coordinating the submission of samples to and the receipt of data deliverables from the laboratory and data validation subcontractors. Also responsible for overseeing the preparation of the raw data and data summary tables by the Database Manager (See Section 4.0 for a description of the tables to be prepared for the RFI).

- Database Technician - Responsible for the flow of all data into and out of Baker's database management system. The Database Technician also prepares the raw data tables and data summary tables required for the report.

2.2 RFI Data Flow

Prior to sampling a given SWMU or AOC, the Data Management Coordinator prepares a sampling summary. This summary contains a map of the SWMU or AOC depicting the sampling locations, sample designations, a list of the analyses to be collected, sample containers required for collection, and QA/QC requirements. This sampling summary will be provided to the Site Manager. The Data Management Coordinator also forwards the sample container requirements to the subcontract laboratory and arranges the shipment of the sample containers to the site. RFI data flow is illustrated in Figure 2-1.

After the sampling for the SWMU or AOC is completed, the Site Manager telecopies the chain-of-custody forms to the Data Management Coordinator. Subsequently, the Site Manager forwards the chain-of-custody form along with the samples to the laboratory subcontractor. Prior to receipt of the samples by the laboratory subcontractor, the Data Management Coordinator reviews the chain-of-custody forms to confirm that the required samples were collected and the appropriate analyses (including QA/QC) were requested. Subsequent to this review, the Data Management Coordinator contacts the laboratory subcontractor to confirm that the chain-of-custody form has been completed correctly or to provide corrections to the requested analyses.

Following sample analysis and receipt of the data deliverable by Baker, the Data Management Coordinator confirms that the analyses requested have been received. This is accomplished using the data summary forms shown in Figure 2-2. From the information collected by this form, the data quality indicator of completeness can be calculated. If the form indicates that a discrepancy exists between the analyses requested and those received, the Data Management Coordinator will contact the laboratory in order to resolve the discrepancy.

The laboratory analytical results will be submitted to an independent third party data validation firm for data validation. Validated data will be returned to the Data Management Coordinator for review and incorporation into the sample database.

2.3 Project Documentation Materials

Standardized project forms and formats have been developed for the collection of field data and observations as well as for recording laboratory information. Standardized field record forms are included in the SOPs cited previously in this section. These standardized forms (and their associated SOPs) are as follows:

- F101 - Boring and Sample Logging
- F103 - Monitoring Well Installation
- F302 - Chain-of-Custody including sample label and custody seals

In addition to these standardized forms, a standard procedure for completing the field logbook is also provided in F303 - Field Logbook.

These SOPs are presented in Appendix B of the DCQAP.

3.0 PROJECT FILES

Files for the project will be maintained as described in the following SOP:

- A008 - Filing

This SOP is given in Appendix B of the DCQAP. It provides directions for the distribution and filing of incoming and outgoing correspondence. The procedures given in the SOPs ensure that project files are maintained in a manner that allows easy retrieval of project materials.

4.0 DATA RECORD AND PRESENTATION

4.1 Data Record

A record of the investigation data and results collected during the RFI will be established. For the field and laboratory analyses, this record will include the following:

- Unique sample or field measurement code
- Sampling or field measurement location and sample or measurement type
- Sampling or field measurement raw data
- Laboratory analysis ID number
- Property or component measured
- Result of analysis (e.g., concentration)

4.2 Tabular Displays

For the RFI report, the following data will be presented in tables:

- Unsorted (raw) data
- Results for each medium or for each constituent monitored
- Data reduction for statistical analysis
- Sorting of data by potential stratification factors
  (e.g., location, soil layer, and topography)
- Summary data

Examples of these tables are provided in Tables 4-1 through 4-5.

4.3 Graphical Displays

In addition to data tables, data shall be presented in figures which may include bar graphs, line graphs, area or plan maps, isopleth plots, cross-sectional plots or transects, and three-dimensional graphs. As warranted, the following types of data will be displayed in figures:

- Sampling locations and sampling grids
- Boundaries of sampling areas, and areas where more data is required
- Levels of contamination at each sampling area
- Contamination levels, averages, and maxima
- Changes in concentration in relation to distance from the source, time, depth, or other parameters
- Features affecting intramedia transport and potential receptors

4.4 Sample Designation

In order to identify and accurately track the various samples, all samples collected during this investigation, including QA/QC samples, will be designated with a unique number. The number will serve to identify the investigation, the SWMU/AOC, the area within the SWMU/AOC, the sample media, sampling location, the depth (soil) or round (groundwater) of sample, and QA/QC qualifiers.

The sample designation format is as follows:

SWMU/AOC # - Location - Media/Station # or QA/QC - Depth/Round

An explanation of each of these identifiers is given below.

SWMU/AOC#	This investigation includes SWMUs/AOC listed on Table 1-1.		
Location	The location designation will refer to a surface feature (e.g., PL = Parking Lot) or grid (e.g., LA = Lawn Area)		
Media	SB	=	Soil Boring (soil sample from a boring)
	GW	=	Groundwater
	SW	=	Surface Water
	SD	=	Sediment
	WT	=	Waste

Station #	Each soil test boring or monitoring well will be identified with a unique identification number.		
QA/QC	(FB)	=	Field Blank
	(D)	=	Duplicate Sample (preceding depth/round)
	(TB)	=	Trip Blank
	(ER)	=	Equipment Rinsate
Depth/Round	Depth indicators will be used for soil samples. The number will refer to the depth of the top of the sampled interval. For example:		
	00	=	top of sample at ground surface
	01	=	top of sample is 1 foot below surface
	02	=	top of sample 3 feet below ground surface
	03	=	top of sample is 5 feet below ground surface
	Round indicator will be used for groundwater samples (round one and round two). For example:		
	01	=	Round 1
	02	=	Round 2

Under this sample designation format the sample number 11-GW03DW-01D refers to:

11-GW03DW-01D	SWMU 11
11-GW03DW-01D	Groundwater sample
11-GW03DW-01D	Monitoring well #3
11-GW03DW-01D	Deep well
11-GW03DW-01D	Round 1
11-GW03DW-01D	Duplicate (QA/QC) sample

The sample designation 12-LA-SB06-03D refers to:

12-LA-SB06-03D	SWMU 12
12-LA-SB06-03D	Lawn Area
12-LA-SB06-03D	Soil boring
12-LA-SB06-03D	Test boring #6
12-LA-SB06-03D	Sampling depth interval 5' to 7'
12-LA-SB06-03D	Duplicate

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

4.5 Data Reduction

4.5.1 Reporting of Outliers

Values outside the expected range of values will be included in the data summary tables in the RFI report. These outliers will be flagged with data qualifiers in the summary tables. These data qualifiers reported by the laboratory and/or data validator will indicate the reliability of the data and the source of variability (i.e., field or laboratory).

5.0 DATABASE MANAGEMENT

Analytical and appropriate field data collected during the RFI will be entered, stored, and evaluated using computerized databases. The database system will be established and tested for integrity and compatibility prior to the commencement of the major portions of field work. The principle intent of this system will be to provide rapid access to the results of the field activities and to allow evaluations and comparisons to be made from a variety of references. If requested, USEPA will be provided data files transmitted on diskettes and hard copy, or other electronic media (e.g., modem).

5.1 Field Data

Field personnel will record, on a daily basis, information concerning conditions and features observed during the field activities in the field logbook and field forms. Copies of these logs will be provided to data management personnel on a weekly basis, and suitable data will be extracted and entered into the database system. These data will include sample identifiers, sampling methodologies, conditions during sampling, and sample identification information as detailed in Section 4.2. These data will be merged in the database with analytical results obtained from the laboratory to create a unified data set describing the results of the investigations. Once filled, original logbooks will be maintained in the project files for future comparison and QA/QC review.

5.2 Analytical Laboratory/Validation Data Deliverables

Analytical data will be reported by the laboratory in two formats: data files on diskette and hard copy reports. The database system will be designed to allow direct input of the data files from the diskettes in order to limit the potential for data entry errors. If data is not submitted by diskette, the data will be double key entered from hard copies to the database system. The hard copy reports will be logged into, and maintained in, the project files for future comparison and QA/QC review. In addition, hard copies and electronic copies of laboratory analytical data will be provided to the data validator for ease of management and tracking purposes.

5.3 Reporting

The database system will be developed to provide an interface with various spreadsheets, allowing direct translation of the data for presentation. Various tabular formats for the presentation of data are described in Section 4.0. The database system will allow for other presentation formats as desired, including (but not limited to) tabular, graphical, and geographical displays.

6.0 REPORTING

Based on Condition B.8 (a) of Module III of the Permit, LANTDIV will provide USEPA with signed, quarterly monitoring reports. These reports will contain:

- A description of the work completed.
- Summaries of all findings made during the reporting period, including summaries of laboratory data.
- Summaries of all changes made during the reporting period.
- Summaries of all contacts made with representatives of the local community and public interest groups during the reporting period.
- Summaries of all problems or potential problems encountered during the reporting period and actions taken to rectify the problems.
- Changes in personnel conducting or managing the corrective action activities during the reporting period.
- Projected work for the next reporting period.
- Copies of daily reports, inspection reports, laboratory and monitoring data, and other correspondence generated during the reporting period.

Upon USEPA's request, copies of other reports (e.g., inspection reports, drilling logs, and laboratory data) not provided in the quarterly report may be made available to USEPA.

TABLES

TABLE 1-1

SWMUs/AOC MEDIA SUBJECT TO CORRECTIVE ACTION REQUIREMENTS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

SWMU/AOCs	Ground-water	Soil	Surface Water/ Sediment	RFI Type
#1 Former Cremator Disposal Site	Yes	Yes	Yes	Full(1)
#2 Langley Drive Disposal Site	Yes	Yes	Yes	Full
#3 Base Landfill	Yes	Yes	Yes	Full
#6 Building 145	No	Yes	No	First Phase(2)
#7 Tow Way Fuel Farm	Yes	Yes	No	Full
#8 Tow Way Fuel Farm - Disposal Pits	Yes	Yes	No	Full
#9 Tank 212-217 Sludge Burial Pits	Yes	Yes	Contingent(3)	Full
#10 Substation 2/Bldg. 90	No	Yes	No	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
#30 Former Incinerator	Yes	No	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
AOC #D/Ensenada Honda Sediments	No	No	Yes	First Phase

Notes: (1) Full RFIs are conducted where releases were established during previous investigations. The purpose of the full RFI is to determine the nature, rate, direction, and extent of hazardous waste or hazardous constituents.

(2) The purpose of the first phase RFI is to confirm any releases from these SWMUs and/or AOCs.

(3) Contingent requirements are pending results of ongoing investigation or closure activities.

TABLE 1-2

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
B. Data Collection Quality Assurance Plan The Permittee shall prepare a plan to document all monitoring procedures: sampling, field measurements, and sample analysis performed during the investigation to characterize the environmental setting, source, and contamination, so as to ensure that all information, data and resulting decisions are technically sound, statistically valid, and properly documented. 1. Data Collection Strategy The strategy section of the Data Collection Quality Assurance Plan shall include but not be limited to the following:	
a. Description of the intended uses for the data, and the necessary level of precision and accuracy for these intended uses	4.1.1 and 4.1.2.2
b. Description of methods and procedures to be used to assess the precision, accuracy and completeness of the measurement data	4.1.2.1
c. Description of the rationale used to assure that the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition or an environmental condition. Examples of factors which shall be considered and discussed include:	
(i) Environmental conditions at the time of sampling	3.0
(ii) Number of sampling points	4.1.4
(iii) Representativeness of selected media	4.1.3
(iv) Representativeness of selected analytical parameters	4.2 and 9.0
d. Description of the measures to be taken to assure that the following data sets can be compared to each other	
(i) RFI data generated by the Permittee over some time period	4.1.5
(ii) RFI data generated by an outside laboratory or consultant versus data generated by the Permittee	4.1.5
(iii) Data generated by separate consultants or laboratories	4.1.5
(iv) Data generated by an outside consultant or laboratory over some time period	4.1.5

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 1-2 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
e. Details relating to the schedule and information to be provided in quality assurance reports. The reports should include but not be limited to:	
(i) Periodic assessment of measurement data accuracy, precision, and completeness	10.3
(ii) Results of performance audits	10.3 and 12.0
(iii) Results of system audits	10.3 and 12.0
(iv) Significant quality assurance problems and recommended solutions	10.3
(v) Resolutions of previously stated problems	10.3
2. Sampling The Sampling section of the Data Collection Quality Assurance Plan shall discuss	
a. Selecting appropriate sampling locations, depths, etc.	4.2
b. Providing a statistically sufficient number of sampling sites	4.1.4 and 4.2
c. Measuring all necessary ancillary data	4.2
d. Determining conditions under which sampling should be conducted	5.0 and SOPs F101, F102, F104, and F105
e. Determining which media are to be sampled (e.g., groundwater, air, soil, sediment, etc.)	4.1.3
f. Determining which parameters are to be measured and where	4.2
g. Selecting the frequency of sampling and length of sampling period	4.2
h. Selecting the types of sample (e.g., composites versus grabs) and number of samples to be collected	4.1.4 and 4.2
i. Measures to be taken to prevent contamination of the sampling equipment and cross-contamination between sampling points	5.0 and SOPs F501 and F502
j. Documenting field sampling operations and procedures, including	

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 1-2 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
(i) Documentation of procedures for preparation of reagents or supplies which become an integral part of the sample (e.g., filters and adsorbing reagents)	SOP F301
(ii) Procedures and forms for recording the exact location and specific considerations associated with sample acquisition	SOPs F302 and F303
(iii) Documentation of specific sample preservation method	7.0 and SOPs F301 and F303
(iv) Calibration of field devices	8.1 and SOPs F202, F203, F204, and F208
(v) Collection of replicate samples	11.2 and SOPs F302 and F303
(vi) Submission of field-biased blanks, where appropriate	11.2 and SOPs F302 and F303
(vii) Potential interferences present at the facility	SOP F303
(viii) Construction materials and techniques, associated with monitoring wells and piezometers	SOPs F103 and F303
(ix) Field equipment listing and sample containers	SOPs F101, F102, F104, F105, F301, and F303
(x) Sample order	SOPs F101, F102, F104, and F105
(xi) Decontamination procedures	SOPs F501 and F502
k. Selecting appropriate sample containers	7.0 and SOP F301
l. Sample preservation	7.0 and SOP F301
m. Chain-of-custody, including	
(i) Standardized field tracking reporting forms to establish sample custody in the field prior to and during shipment	7.0 and SOP F302
(ii) Pre-prepared sample labels containing all information necessary for effective sample tracking	7.0 and SOP F302

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 1-2 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
3. Field Measurements The Field Measurements section of the Data Collection Quality Assurance Plan shall discuss:	
a. Selecting appropriate field measurement locations, depths, etc.	4.2
b. Providing a statistically sufficient number of field measurements	4.1.4 and 4.2
c. Measuring all necessary ancillary data	4.2
d. Determining conditions under which field measurements should be conducted	5.0 and SOPs F101, F102, F104, and F105
e. Determining which media are to be addressed by appropriate field measurements (e.g., groundwater, air, soil, sediment, etc.)	4.1.3
f. Determining which parameters are to be measured and where	4.2
g. Selecting the frequency of field measurement and length of field measurements period	4.2
h. Documenting field measurement operations and procedures, including	
(i) Procedures and forms for recording raw data and the exact location , time, and facility-specific considerations associated with the data acquisition	SOP F303
(ii) Calibration of field devices	8.0 and SOPs F202, F203, F204, and F208
(iii) Collection of replicate measurements	11.2 and SOPs F302 and F303
(iv) Submission of field-biased blanks, where appropriate	11.2 and SOPs F302 and F303
(v) Potential interferences present at the facility	SOP F303
(vi) Construction materials and techniques associated with monitoring wells and piezometers used to collect field data	SOPs F301 and F303
(vii) Field equipment listing	SOPs F301 and F303
(viii) Order in which field measurements were made	SOPs F101, F102, F104, F105, F201, and F402

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 1-2 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
(ix) Decontamination procedures	SOPs F501 and F502
4. Sample Analysis The Sample Analysis section of the Data Collection Quality Assurance Plan shall specify the following:	
a. Chain-of-custody procedures, including	
(i) Identification of a responsible party to act as sample custodian at the laboratory facility authorized to sign for incoming field samples, obtain documents of shipment, and verify the data entered onto the sample custody records	7.0 and SOP F302
(ii) Provision for a laboratory sample custody log consisting of serially numbered standard lab-tracking report sheets	7.0 and SOP F302
(iii) Specification of laboratory sample custody procedures for sample handling, storage, and dispersement for analysis	7.0 and SOP F302
b. Sample storage procedures and storage times	7.0 and SOP F301
c. Sample preparation methods	7.0 and SOP F301
d. Analytical procedures, including	
(i) Scope and application of the procedure	9.2
(ii) Sample matrix	9.2
(iii) Potential interferences	9.2
(iv) Precision and accuracy of the methodology	9.2
(v) Method detection limits	9.2
e. Calibration procedures and frequency	8.0
f. Data reduction, validation and reporting	10.0
g. Internal quality control checks, laboratory performance and systems audits and frequency, including	
(i) Method blank(s)	11.2 and 11.3
(ii) Laboratory control sample(s)	11.2 and 11.3
(iii) Calibration check sample(s)	11.2 and 11.3
(iv) Replicate sample(s)	11.2 and 11.3

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 1-2 (Continued)

CROSS-REFERENCE TABLE FOR PERMIT REQUIREMENTS AND DATA COLLECTION QUALITY ASSURANCE PLAN MATERIAL

Material to be included in the DCQAP, per Draft Corrective Action Permit Module III, Appendix A, Section V	Section of DCQAP that Covers This Material
(v) Matrix-spiked sample(s)	11.2 and 11.3
(vi) "Blind" quality control sample(s)	11.2 and 11.3
(vii) Control charts	11.2 and 11.3
(viii) Surrogate samples	11.2 and 11.3
(ix) Zero and span gases	11.2 and 11.3
(x) Reagent quality control checks	11.2 and 11.3
h. Preventive maintenance procedures and schedules	13.0 and SOPs F202, F203, F204, and F208
i. Corrective action (for laboratory problems)	11.3
j. Turnaround time	4.2

Note: SOPs referenced here appear in Appendix B of this document.

TABLE 4-1
EXAMPLE
SEDIMENT DATA AND FREQUENCY SUMMARY RAW DATA
ORGANIC CHEMICALS

PESTICIDES/PCBS

SAMPLE NO.	2-RRSD10-06	2-RRSD10-612	2-RRSD11-06	2-RRSD11-612	2-RRSD12-06	2-RRSD12-612
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
ALPHA-BHC	2.5 UJ	2.4 UJ	1.9 UJ	1.9 UJ	21 UJ	21 UJ
BETA-BHC	2.5 UJ	2.4 UJ	1.9 UJ	1.9 UJ	21 UJ	21 UJ
DELTA-BHC	2.5 UJ	2.4 UJ	1.9 UJ	1.9 UJ	21 UJ	21 UJ
GAMMA-BHC	2.5 UJ	2.4 UJ	1.9 UJ	1.9 UJ	21 UJ	21 UJ
HEPTACHLOR	2.5 UJ	2.4 UJ	1.9 UJ	1.9 UJ	21 UJ	21 UJ
ALDRIN	2.5 UJ	2.4 UJ	1.9 UJ	1.9 UJ	21 UJ	21 UJ
HEPTACHLOR EPOXIDE	2.5 UJ	2.4 UJ	1.9 UJ	1.9 UJ	21 UJ	21 UJ
ENDOSULFAN I	2.5 UJ	2.4 UJ	1.9 UJ	1.9 UJ	21 UJ	21 UJ
DIELDRIN	4.8 UJ	4.6 UJ	7.5 J	12 J	41 UJ	41 UJ
4,4'-DDE	51 J	10 J	83	78	170 J	190 J
ENDRIN	4.8 UJ	4.6 UJ	3.7 UJ	3.7 UJ	41 UJ	41 UJ
ENDOSULFAN II	4.8 UJ	4.6 UJ	3.7 UJ	3.7 UJ	41 UJ	41 UJ
4,4'-DDD	50 J	17 J	16 J	11 J	900	3600 J
ENDOSULFAN SULFATE	4.8 UJ	4.6 UJ	3.7 UJ	3.7 UJ	41 UJ	41 UJ
4,4'-DDT	35 J	6 J	120	98	740	4500 J
METHOXYCHLOR	25 UJ	24 UJ	19 UJ	19 UJ	210 UJ	210 UJ
ENDRIN KETONE	4.8 UJ	4.6 UJ	3.7 UJ	3.7 UJ	41 UJ	41 UJ
ENDRIN ALDEHYDE	4.8 UJ	4.6 UJ	3.7 UJ	3.7 UJ	41 UJ	41 UJ
ALPHA-CHLORDANE	14 J	3.5 J	3.5 J	1.9 UJ	21 UJ	44 J
GAMMA-CHLORDANE	15 J	2.9 J	2.8 J	1.9 UJ	21 UJ	49 J
TOXAPHENE	250 UJ	240 UJ	190 UJ	190 UJ	2100 UJ	2100 UJ
AROCLOR-1016	48 UJ	46 UJ	37 UJ	37 UJ	410 UJ	410 UJ
AROCLOR-1221	97 UJ	94 UJ	74 UJ	76 UJ	840 UJ	830 UJ
AROCLOR-1232	48 UJ	46 UJ	37 UJ	37 UJ	410 UJ	410 UJ
AROCLOR-1242	48 UJ	46 UJ	37 UJ	37 UJ	410 UJ	410 UJ
AROCLOR-1248	48 UJ	46 UJ	37 UJ	37 UJ	410 UJ	410 UJ
AROCLOR-1254	48 UJ	46 UJ	37 UJ	37 UJ	410 UJ	410 UJ
AROCLOR-1260	48 UJ	46 UJ	37 UJ	37 UJ	410 UJ	410 UJ

HERBICIDES

SAMPLE ID	2-RRSD10-06	2-RRSD10-612	2-RRSD11-06	2-RRSD11-612	2-RRSD12-06	2-RRSD12-612
UNITS	UG/KG	UG/KG	UG/KG	UG/KG		
Silvex	290 U	700 U	220 U	230 U		
2,4-D	290 U	700 U	220 U	230 U		

TABLE 4-2
EXAMPLE
SURFACE WATER POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS

VOLATILES

SAMPLE NO.	2-OC-SW01	2-OC-SW03	2-RR-SW06
UNITS	UG/L	UG/L	UG/L
CHLOROMETHANE			
BROMOMETHANE			
VINYL CHLORIDE			
CHLOROETHANE			
METHYLENE CHLORIDE			
ACETONE			4 J
CARBON DISULFIDE	7 J		
1,1-DICHLOROETHENE			
1,1-DICHLOROETHANE			
1,2-DICHLOROETHENE (total)			
CHLOROFORM	6 J	5 J	
1,2-DICHLOROETHANE			
2-BUTANONE			
1,1,1-TRICHLOROETHANE			
CARBON TETRACHLORIDE			
BROMODICHLOROMETHANE			
1,2-DICHLOROPROPANE			
CIS-1,3-DICHLOROPROPENE			
TRICHLOROETHENE			
DIBROMOCHLOROMETHANE			
1,1,2-TRICHLOROETHANE			
BENZENE			
TRANS-1,3-TRICHLOROPROPENE			
BROMOFORM			
4-METHYL-2-PENTANONE			
2-HEXANONE			
TETRACHLOROETHENE			
1,1,2,2-TETRACHLOROETHANE			
TOLUENE			
CHLOROBENZENE			
ETHYLBENZENE			
STYRENE			
XYLENES (total)			

TABLE 4-3
EXAMPLE
SEDIMENT STATISTICAL SUMMARY
TAL METALS AND CYANIDE

	MAXIMUM DETECTED MG/KG	NORMAL ARITHMETIC MEAN	NORMAL STANDARD DEVIATION	NORMAL UPPER 95 % CONFIDENCE INTERVAL	LOG-NORMAL UPPER 95 % CONFIDENCE INTERVAL
ALUMINUM	9780	4208.5	2636.2	5227.7	5735.9
ANTIMONY	1.8 J	1.0	0.3	1.1	1.1
ARSENIC	1.4 J	0.6	0.4	0.7	0.8
BARIUM	114	18.7	24.4	28.2	29.3
BERYLLIUM	0.86 B	0.2	0.2	0.3	0.3
CADMIUM	ND	NA	NA	NA	NA
CALCIUM	247000	16554.6	54653.3	37684.5	63971.0
CHROMIUM	10.3 J	5	3	6	6.9
COBALT	ND	NA	NA	NA	NA
COPPER	6.6 J	2.4	1.9	3.1	4.0
IRON	14900	2151.1	3096.8	3348.3	2935.3
LEAD	51.4 J	11	11	16	16.1
MAGNESIUM	2540	305.8	542.7	515.6	602.2
MANGANESE	203	18	44	35	27.9
MERCURY	ND	NA	NA	NA	NA
NICKEL	ND	NA	NA	NA	NA
POTASSIUM	440 J	144.9	114.8	189.3	237.2
SELENIUM	2.1 J	0.30	0.50	0.60	0.47
SILVER	ND	NA	NA	NA	NA
SODIUM	171 B	57.8	33.5	70.8	70.2
THALLIUM	0.31 J	0.10	0.10	0.20	0.16
VANADIUM	14 J	6.3	3.4	7.6	8.2
ZINC	120 J	26.0	31.1	38.0	77.4
CYANIDE	NA	NA	NA	NA	NA

TABLE 4 - 4
EXAMPLE
SUBSURFACE SOIL POSITIVE DETECTION SUMMARY
ORGANIC CHEMICALS

SAMPLE NO.	2-LA-SB02-01	2-LA-SB04-02	2-LA-SB06-02	2-LA-SB07-01	2-LA-SB08-02	2-LA-SB09-02
DEPTH	2 - 4'	4 - 6'	4 - 6'	2 - 4'	4 - 6'	4 - 6'
UNITS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
PESTICIDES						
HEPTACHLOR						
4,4'-DDE		9.4		4.7	24	14
4,4'-DDD			4.2 J		4.9 J	9
ENDOSULFAN SULFATE						
4,4'-DDT		4.8			11	6.8
ALPHA-CHLORDANE						2.9 J
GAMMA-CHLORDANE						2.4
VOLATILES						
METHYLENE CHLORIDE	10 J					28
ACETONE						
2-BUTANONE						
4-METHYL-2-PENTANONE	12 J					
XYLENES (total)	5 J					
SEMIVOLATILES						
NAPHTHALENE						
2-METHYLNAPHTHALENE						
ACENAPHTHENE						
FLUORENE						
N-NITROSODIPHENYLAMINE						
PHENANTHRENE						
ANTHRACENE						
DI-N-BUTYL PHTHALATE						
FLUORANTHENE						
PYRENE						
BIS(2-ETHYLHEXYL)PHTHALATE		140 J		200 J		

Notes:
UG/KG - microgram per kilogram
J - value [illegible]imated

TABLE 4-5
EXAMPLE
SURFACE WATER DATA AND FREQUENCY SUMMARY
ORGANIC CHEMICALS

VOLATILES

	MINIMUM NONDETECTED UG/L	MAXIMUM NONDETECTED UG/L	MINIMUM DETECTED UG/L	MAXIMUM DETECTED UG/L	LOCATION OF MAXIMUM DETECTED	FREQUENCY OF DETECTION
CHLOROMETHANE	10 U	10 U	ND	ND	ND	0 / 3
BROMOMETHANE	10 U	10 U	ND	ND	ND	0 / 3
VINYL CHLORIDE	10 U	10 U	ND	ND	ND	0 / 3
CHLOROETHANE	10 U	10 U	ND	ND	ND	0 / 3
METHYLENE CHLORIDE	10 U	10 U	ND	ND	ND	0 / 3
ACETONE	10 U	10 U	4 J	4 J	2-RR-SW06	1 / 3
CARBON DISULFIDE	10 U	10 U	7 J	7 J	2-OC-SW01	1 / 3
1,1-DICHLOROETHENE	10 U	10 U	ND	ND	ND	0 / 3
1,1-DICHLOROETHANE	10 U	10 U	ND	ND	ND	0 / 3
1,2-DICHLOROETHENE (total)	10 U	10 U	ND	ND	ND	0 / 3
CHLOROFORM	10 U	10 U	5 J	6 J	2-OC-SW01	2 / 3
1,2-DICHLOROETHANE	10 U	10 U	ND	ND	ND	0 / 3
2-BUTANONE	10 U	10 U	ND	ND	ND	0 / 3
1,1,1-TRICHLOROETHANE	10 U	10 U	ND	ND	ND	0 / 3
CARBON TETRACHLORIDE	10 U	10 U	ND	ND	ND	0 / 3
BROMODICHLOROMETHANE	10 U	10 U	ND	ND	ND	0 / 3
1,2-DICHLOROPROPANE	10 U	10 U	ND	ND	ND	0 / 3
CIS-1,3-DICHLOROPROPENE	10 U	10 U	ND	ND	ND	0 / 3
TRICHLOROETHENE	10 U	10 U	ND	ND	ND	0 / 3
DIBROMOCHLOROMETHANE	10 U	10 U	ND	ND	ND	0 / 3
1,1,2-TRICHLOROETHANE	10 U	10 U	ND	ND	ND	0 / 3
BENZENE	10 U	10 U	ND	ND	ND	0 / 3
TRANS-1,3-TRICHLOROPROPENE	10 U	10 U	ND	ND	ND	0 / 3
BROMOFORM	10 U	10 U	ND	ND	ND	0 / 3
4-METHYL-2-PENTANONE	10 U	10 U	ND	ND	ND	0 / 3
2-HEXANONE	10 U	10 U	ND	ND	ND	0 / 3
TETRACHLOROETHENE	10 U	10 U	ND	ND	ND	0 / 3
1,1,2,2-TETRACHLOROETHANE	10 U	10 U	ND	ND	ND	0 / 3
TOLUENE	10 U	10 U	ND	ND	ND	0 / 3
CHLOROBENZENE	10 U	10 U	ND	ND	ND	0 / 3
ETHYLBENZENE	10 U	10 U	ND	ND	ND	0 / 3
STYRENE	10 U	10 U	ND	ND	ND	0 / 3
XYLENES (total)	10 U	10 U	ND	ND	ND	0 / 3

FIGURES

FIGURE 2-1

RFI DATA FLOW

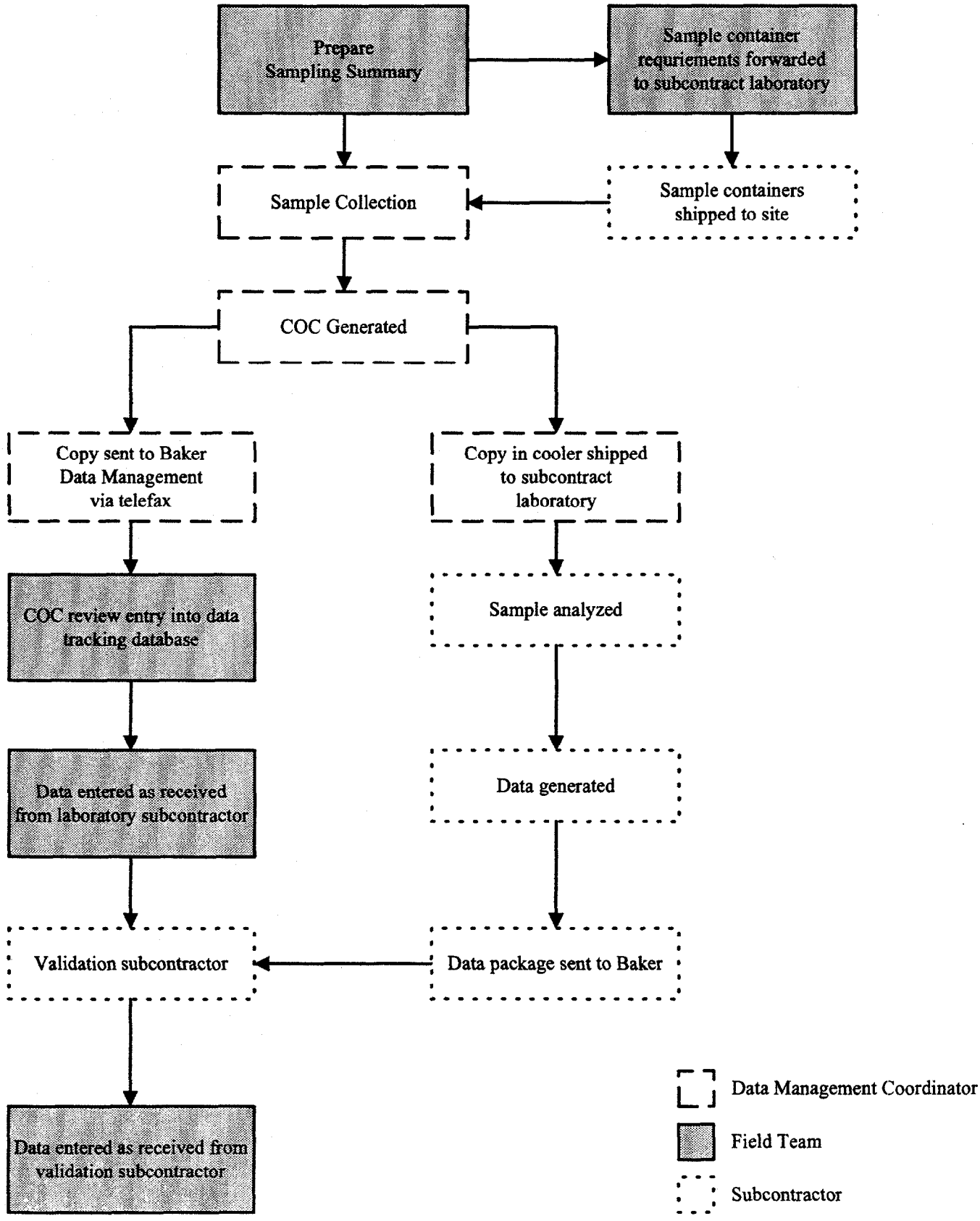

FIGURE 2-2
DATA SUMMARY FORM

DATE SHIPPED	SAMPLE ID	Analysis Requested	Analysis Received	DATE RECEIVED	TURNAROUND TIME	SDG NO.	COMMENTS
					0		
COUNT		0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0				

1 - Date Shipped - Date shipped from field

2 - Sample ID - Sample identification assigned in field

3 - Requested analysis that laboratory is to complete

4 - Analyses that laboratory completed

5 - Date Received - Date received from laboratory

6 - Turnaround Time - Date deliverables

7 - SDG Number - Sample Delivery Group in which sample is associated

8 - Comments

9 - Count - Counts the number of samples taken under the given media