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Remedial Investigation/ Feasibility Study for Site 16 Naval Station Roosevelt Roads Puerto Rico

Prepared for

Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

Prepared by

Versar INC.

MAY 15, 1992

Versar INC

FINAL DRAFT

REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR THE OLD POWER PLANT (SITE 16) BUILDING 38, NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Prepared for:

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EXECUTIVE SUMMARY

Versar performed a Remedial Investigation (RI)/Feasibility Study (FS) to develop viable remedial alternatives for known polychlorinated biphenyl-contaminated (PCB-contaminated) soil and concrete at Site 16, the Old Power Plant, Building No. 38, Roosevelt Roads Naval Station, Puerto Rico. This RI/FS was performed according to criteria in the National Contingency Plan (NCP) and guidelines stipulated by the U.S. Environmental Protection Agency (USEPA) in RI/FS guidance documents.

The RI determined that concrete surfaces, and sediment and soil surrounding the immediate area of the Old Power Plant, and the transformer pads is contaminated with PCBs at concentrations exceeding ARARs. Additionally, surface water and wipe samples collected from the cooling water tunnel and underground storage tank (UST) manways clearly indicate that these areas are extensively contaminated with PCBs and require 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 prevents deeper sampling at this time. This RI/FS focuses on the soil/sediment operable unit. Any potential contamination of coral, ground-water or surface water pathways are to be further evaluated during the initial soil removal action proposed herein. An estimated 986 cubic yards of soil/sediment require remediation; 20,000 square feet of concrete 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 (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 and successful laboratory or pilot field tests to demonstrate viability.

The remedial technology recommended for Site 16 is Alternative B - soil excavation, shipment, and off-site landfill. There are no incineration or landfill facilities licensed to accept PCB wastes in Puerto Rico. The U.S. Ecology-Beaty, Nevada, facility is the nearest approved facility for disposal of PCB-bearing materials generated by remedial action at Site 16. The long-term potential liabilities associated with landfill disposal are higher than incineration, but are offset greatly by the low cost of landfill disposal. This process option was selected based on probable achievement of the nine CERCLA criteria for selecting remedial alternatives. The cost for this alternative at this site is estimated to be $1,785,219.

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1.0 INTRODUCTION

Versar, Inc., has been contracted (Navy Contract No. N62470-90-C-7645) by the U.S. Navy Facilities Engineering Command (NAVFACENGCOM), Atlantic Division (LANTDIV), to perform a follow-up Remedial Investigation and Feasibility Study (RI/FS) in order to complete the RI/FS efforts for the Old Power Plant, Building 38 (Site 16) identified in the Initial Assessment Study at Naval Station (NAVSTA) Roosevelt Roads, Puerto Rico. A Work Plan, Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and Health and Safety (HSP) were prepared to describe the available environmental information concerning the site, detail the tasks required to complete the RI/FS efforts, and the manner in which they were to be accomplished and managed. These work plans were subsequently reviewed and approved for use by NAVSTA Roosevelt Roads and LANTDIV environmental staff, and by the Naval Energy and Environmental Support Activity (NEESA) contractor, Martin Marietta for adherence to NEESA quality assurance requirements.

This RI/FS report has been prepared using the latest guidance (EPA, 1988a) and contains the results of the field investigation and sampling, a site characterization, risk assessment, and feasibility study for the site. All data collected during the May 1991 sampling activities were analyzed according to U.S. Environmental Protection Agency (EPA) Contract Laboratory, Program (CLP) methods developed for the EPA's Superfund Program. These data were then validated according to full EPA data validation procedures as specified in EPA (1988b). The chain of custody documents and data validation reports are contained in Appendix A. Previous data contained in the "Remedial Action Alternatives Analysis" for Site 16 (ESE, 1988) and Confirmation Study were not validated and are used for site characterization purposes only.

1.1 Purpose of the Report

The RI/FS report for Site 16, the Old Power Plant, Building 38 is intended to summarize existing site conditions, characterize the nature and extent of risks posed by the site, and provide the necessary and sufficient information for evaluating potential remedial options for contaminated media at the site. Ultimately, the goal of the RI/FS for this site is to select a remedy that is protective of human health and the environment, that maintains this protection over time, and that minimizes untreated wastes.

In order to speed the selection of an appropriated remedy for the site, this RI/FS focuses on the contaminated soil and sediment media at the site. The emphasis has been placed on the soil/sediment and building/concrete exterior operable units in consideration of the special characteristics of polychlorinated biphenyl (PCB) contaminants. PCBs have

applicable or relevant and appropriate requirements (ARARs) that are addressed by both TSCA and RCRA and whose remedial action levels are largely defined in terms of solid media owing to the relatively immobile nature of PCBs in aqueous media. Additionally, contamination of soil, sediment and exteriors of buildings or concrete structures are among the most clear and direct routes of human exposure present at the site.

1.2 Site Background

NAVSTA Roosevelt roads is located on the east coast of Puerto Rico in the municipality of Ceiba, approximately 33 miles southeast of the capital city of San Juan (Figure 1). It is bordered on all sides, but the west by the Caribbean Sea. Located to the southwest is agricultural land use and Bosque Estatal de Ceiba, a mangrove forest adjacent to the station's western border (Greenleaf/Telesca, 1984). Immediately to the west of the station and adjacent to its western border is the town of Ceiba. The nearest major town is Fajardo located 10 miles north of the station.

The town of Ceiba is located near the station's western boundary. It has the largest population in the vicinity of the station, with 15,000 people in an area of approximately 27.5 square miles.

This RI/FS report addresses the Old Power Plant, Building 38 (Site 16) on the base (Figure 2). A preliminary assessment (IAS under the Navy's older NACIP terminology) has been completed for NAVSTA Roosevelt Roads, including Building 38. A site investigation (called a confirmation study under the NACIP terminology) was also conducted. The preliminary assessment and site investigation (PA/SI) indicated PCBs present in soil at concentrations exceeding ARARs, and partially delineated the extent of soil contamination.

1.2.1 Site Description and History

The primary mission of NAVSTA Roosevelt Roads is to provide full support for Atlantic Fleet weapons training and development activities. According to the IAS (Greenleaf/Telesca, 1984), Site 16 was under the jurisdiction of the Power Distribution Shop. The Power Distribution Shop maintained and repaired the electrical distribution system for NAVSTA Roosevelt Roads. This department was responsible for maintenance and servicing of electrical transformers of over 600 volt rating and maintains 13 main transformers in eight substations located at the airfield, industrial areas, Bundy area, and the Capehart Housing area.

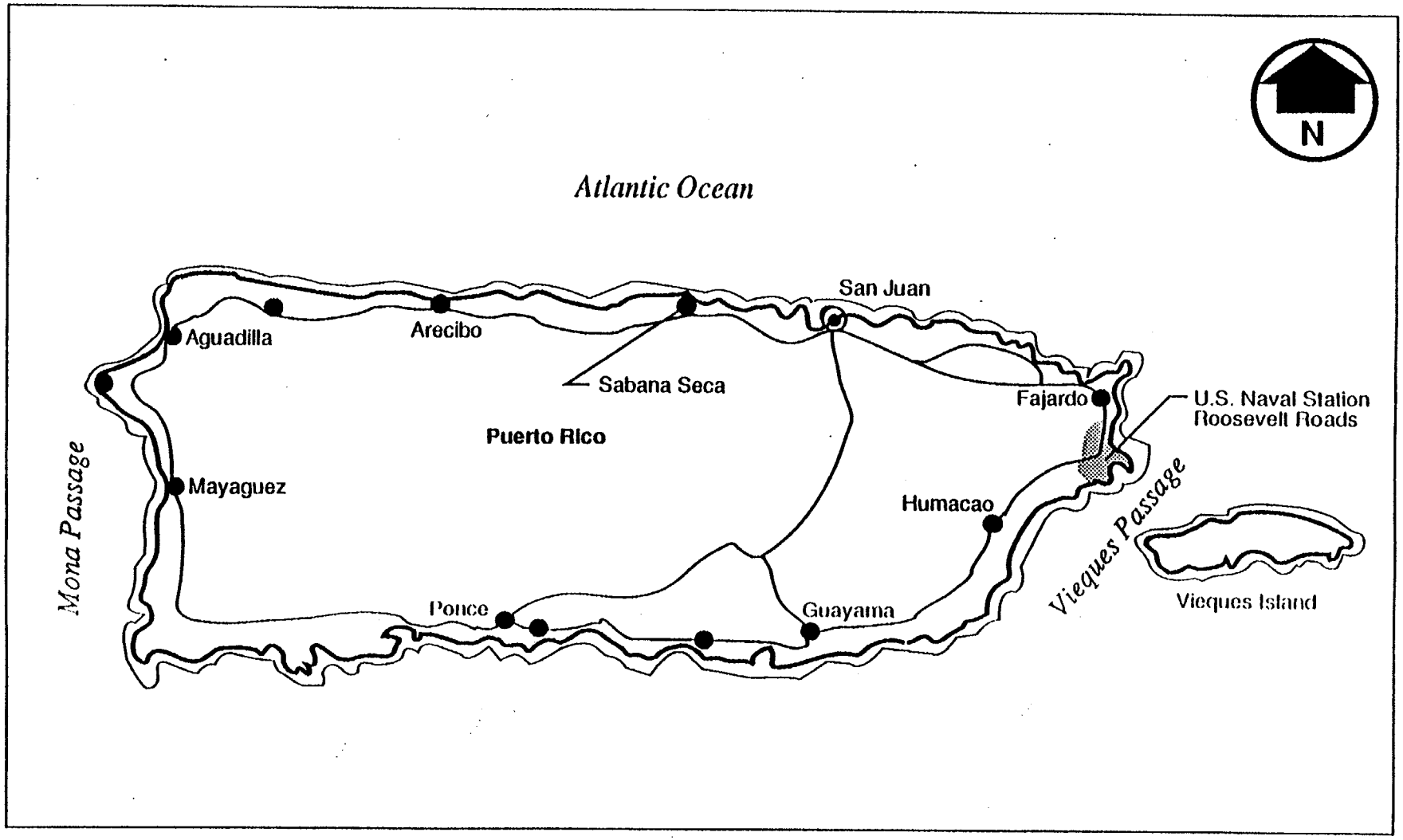

FIGURE 1
LOCATION OF NAVSTA ROOSEVELT ROADS, PUERTO RICO

Elevations on the base range from sea level to 1,050 feet above sea level, with the tallest peak located within 2 kilometers of the station's boundary. The station is located over an area with hills and valleys of the coastal plain extending from the Sierra de Luquillo range. In the low-lying shore area, seawater flooding results from storms, wind, and abnormally high tides. The region has a humid, tropical climate, moderate temperatures, dense vegetation, and high rainfall.

The Old Power Plant, Building 38, at the Naval Station (NAVSTA) Roosevelt Roads (Figures 2 an 3), was a 60-megawatt steam turbine facility that generated power from the early 1940s through 1949. The plant used Bunker "C" fuel, which was stored in two 50,000-gallon reinforced concrete tanks located directly northeast of the building. During heavy rainfalls in the 1970s, C fuel was observed in manholes near the building and discharged to an adjacent beach (i.e., Enlisted Beach) via the old cooling water outlet for the Power Plant. A cleanup contractor was hired twice to drain the underground fuel tanks and cleanup the spill. This area, where the USTs located, is now paved over with concrete.

From 1956 to 1964, transformer maintenance was performed at Building 38 by the Public Works Power Distribution Shop. The majority of transformer repair work was conducted just outside of the building at its northeast corner. As part of the maintenance of the transformers, the transformer oil was drained to facilitate repair of the inner cores and coils. Interviewees reported draining the transformers to the soil in the immediate vicinity of the building. The only exception to this practice was with Askarel (a type of PCB) transformers. Power Distribution Shop employees drained transformers containing Askarel directly to 55-gallon drums for disposal at the station landfill. The exact quantity of Askarel disposed of in this manner is unknown. The Power Distribution Shop ordered 200 gallons of replacement transformer fluid per year according to the IAS (Greenleaf/Telesca, 1984). Assuming the total 200 gallons were used each year, it is possible that over the 8 years during which Building 38 was used, approximately 1,600 gallons of transformer oil were drained to the soil in the vicinity of the building, with some portion going to the landfill. The transformer oil commonly used in this time frame was either "pure" PCBs or oil containing PCBs at a 300-ppm concentration (ESE 1988).

Contaminant migration from Site 16 could potentially occur by surface runoff and soil erosion through a concrete-lined drainage ditch that leads to a storm drain (Figure 3). Additionally, there are manways to the USTs and cooling water tunnel that may have been used for disposing of PCB-contaminated fluids. Surface runoff would occur from the series of drainage ditches between the power plant and the hillside that empty into the mangroves that fringe Ensenada Honda and Puerca Bay (Figures 1, 2, 3). Most of what is known of the

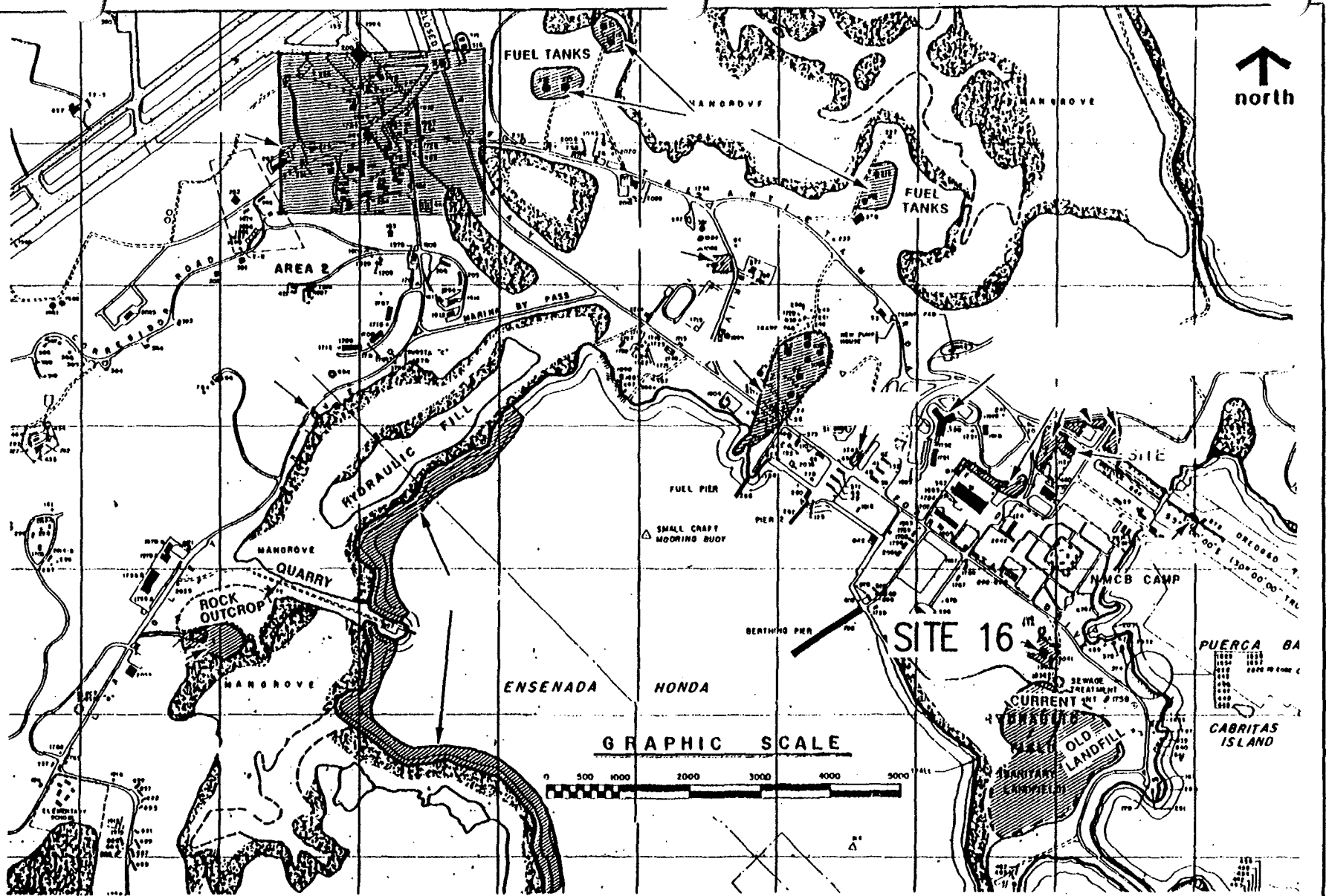

FIGURE 2
LOCATION OF SITE 16 NAVSTA ROOSEVELT ROADS

U.S. NAVAL COMPLEX
PUERTO RICO

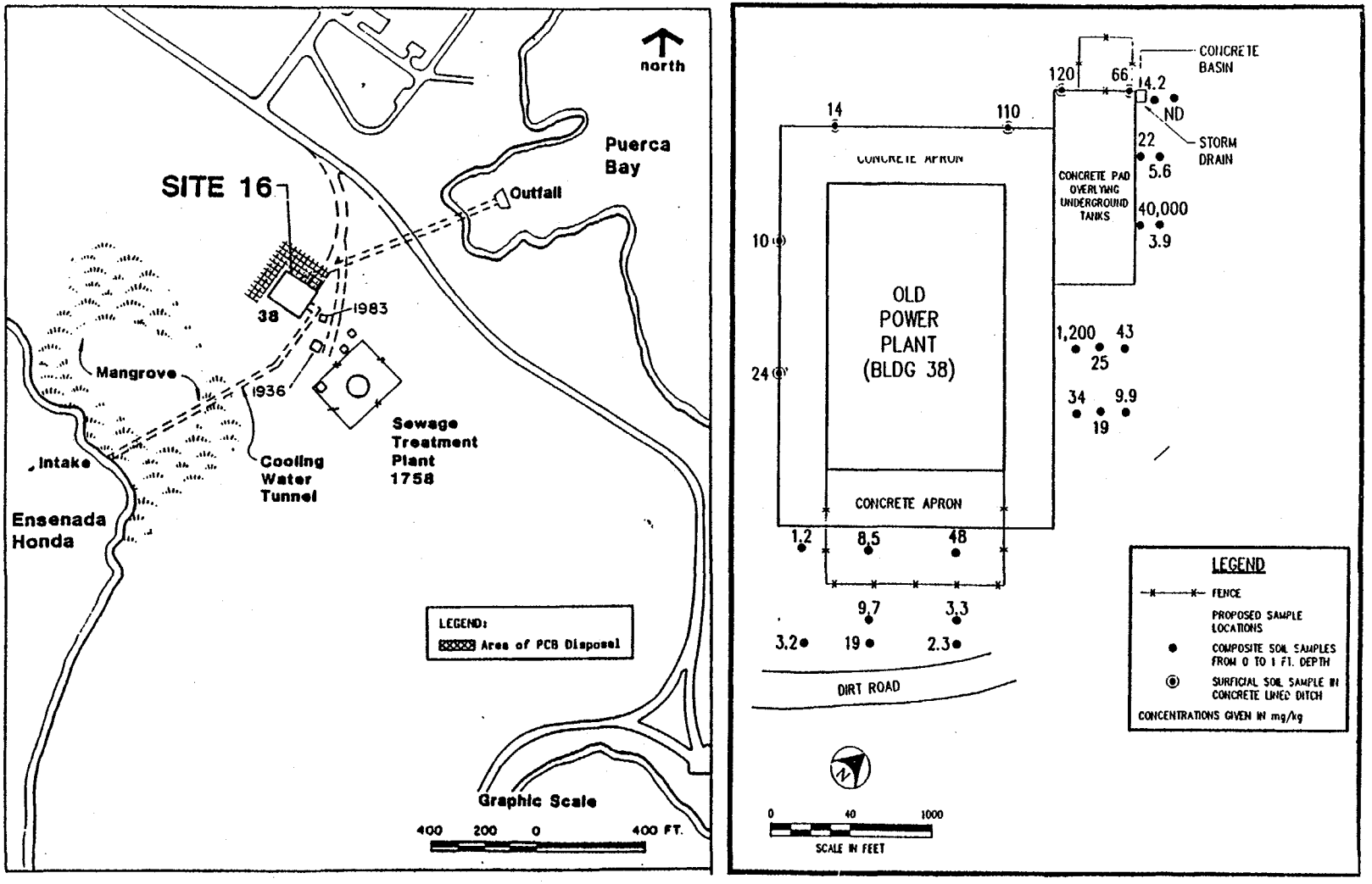

FIGURE 3

LOCATION AND CONFIRMATION STUDY SAMPLING LOCATIONS, SITE 16: OLD POWER PLANT, BUILDING 38 NAVSTA ROOSEVELT ROADS, PUERTO RICO

nature of contamination was gleaned through the PA/SI (IAS-Greenleaf/Telesca, 1984) conducted for the site.

1.2.2 Previous Investigations

The Old Power Plant (Site 16) was the subject of an initial assessment study (IAS) performed by Greenleaf/Telesca (1984). The IAS began with a records search at various government agencies, including the base and NAVFACENGCOM, national and regional archives and records centers, and U.S. Geological Survey offices. In this initial step, study team members reviewed records to assimilate information about the activity's mission, industrial processes, waste disposal records, and known environmental contamination. Typical examples of records include activity master plans and histories, environmental impact statements, historical records, and aerial photographs.

After the records search, the study team conducted an on-site survey to complete documentation of past operations and disposal practices and to identify potentially contaminated areas. With the assistance of an activity point of contact, the team inspected the activity during ground and aerial tours, and interviewed long-term employees and retirees.

The on-site survey for NAVSTA Roosevelt Roads was conducted from January 15 to February 10, 1984. Based on the information provided in the IAS Report, a Confirmation Study (SI, under CERCLA terminology) was performed for the Old Power Plant (Site 16). A Confirmation Study is typically divided into verification and characterization phases and is recommended only for sites at which (1) sufficient evidence exists to indicate the presence of contamination, and (2) the contamination poses a potential threat to human health or to the environment.

Thirty-eight soil samples were collected 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, and 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. Maximum levels for the constituents of concerns detected in the soil samples in Rounds 1 and 2 versus comparative values are presented below:

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Parameter	Round 1 Concentration	Round 2 Concentration	Comparative Value	
Lead (EP Tox) (µg/L)	-	45.9	5,000	40 CFR 264.94
Lead (mg/kg)	15,700	1,070	<10-700 range	Common in soils
PCB 1016 (mg/kg)	4.78	-	50	TSCA
PCB 1260 (mg/kg)	404	40,000	50	TSCA
Oil & Grease (mg/kg)	6350	(not sampled)	-	-
Methyl Ethyl Ketone (µg/kg)	1	(not sampled)	-	-

The sample results and locations were presented in a report entitled Remedial Action Alternatives Analysis for the Old Power Plant, Building 38, USNAVSTA Roosevelt Roads, Environmental Science and Engineering, Inc., February 1988. The full text of the ESE (1988) report is contained in Appendix B. No remedial actions have been performed at Site 16 to date.

From the preliminary risk assessment, the worst case scenario involved dermal adsorption, incidental ingestion, and inhalation of dust. The calculated Pathway Preliminary Pollutant Limit Value (PPLV) for PCBs is 16 mg/kg. Therefore, based on the ESE (1988) site-specific risk assessment, the calculated PCB clean-up level is 16 mg/kg or ppm. However, the more conservative TSCA clean-up standard or 10 ppm was used by ESE in the development of the site preliminary remedial alternatives to provide an added degree of protection of human health.

To determine if the PCB target level results in an acceptable risk level relative to the lead concentrations detected in the soil at Site 16, a chronic hazard risk index (HI) of 2.4×10^{-4} was calculated for lead to determine the associated health risk. This HI indicates a very low degree of risk posed by the observed concentrations of lead in the soil. Therefore, samples were not analyzed for lead during the Versar May 1991 sampling activity.

ESE (1988) proposed four preliminary remedial alternatives for Site 16. The four alternatives vary in degree of addressing the PCB contamination at the site. The remedial action alternatives for each site will be discussed in this section. The sampling proposed in the current RI/FS was designed to supplement the ESE data base, and aid in determining volume requirements to meet the objectives of Alternative 4 (excavation and disposal).

Remedial Action Alternatives for Site 16 identified by ESE (1988) are as follows:

Alternative 1: The "no action alternative". A 6-foot high galvanized chain link fence would be installed surrounding all areas of the site confirmed to have PCB concentrations above 10 ppm.

Alternative 2: A single-layered asphalt cap would be installed over the site. The cap would consist of 4 inches of base material and 1 inch of bituminous paving. The cap would cover those areas of the site confirmed to have PCB concentrations of 10 ppm or more.

Alternative 3: Both partial capping and excavation would occur. All areas of the site confirmed to have PCB concentrations above 25 ppm would be excavated. This would be removed to a depth of 1 foot. The excavated areas would then be backfilled with clean soil. Clean soil is defined by EPA as containing less than 1 ppm PCBs. Site areas confirmed to have PCB concentrations of 10 to 25 ppm would be capped with a single-layer asphalt cap. The cap would meet the same specifications as in Alternative 2. Excavated material would be disposed of by incineration in an incinerator permitted for PCB incineration.

Alternative 4: The most stringent of the four in meeting PCB cleanup criteria. All site areas confirmed to have PCB concentrations exceeding 10 ppm would be excavated. The excavated area would then be backfilled with clean soil. Excavated material would be disposed of by incineration.

Each media specific alternative proposed by ESE (1988) is included in the current RI/FS report as a process option. However, the FS section of this RI/FS report follows the FS screening process prescribed in the EPA (1988a) RI/FS guidance and results in slightly differed assembled remedial alternatives.

1.3 Report Organization

This RI/FS report contains a site characterization of the soil, sediment and exterior surfaces of Site 16. Qualitative/semiquantitative wipe and surface water samples were collected to determine the potential contamination of the USTs or cooling water tunnel with PCB oil. Soil and sediment can be considered a single operable unit at this site. The drainage ditches in which the sediments are found are normally not filled with water.

Sediments in concrete-line ditch are differentiated from soil in the discussion due to the potential for contaminated particulates to be transported by water through the bases storm sewer system. By examining the data in this summer, sediment ARARs can be used to assess whether further investigation of the storm system is warranted.

The building exterior operable unit was investigated using worst-case sampling locations to determine whole building decontamination requirements. Because the building and concrete surfaces are, in many places, covered with paint and show large stained areas, and given the long history of site use, unacceptable levels of contaminants would trigger a full decontamination of the entire exterior surface.

The building interiors, ground water, and surface water operable units were specifically not addressed by this RI/FS. Because the power plant is still used to stored hazardous materials, the building interiors are an occupational exposure (if contaminants are present) and the building is secure from the general public at all times. Therefore, investigation of the interior surfaces may be conducted at another time without affecting the selection of remedy for soil/sediment, or exterior surfaces.

Extensive surface water and ground-water investigations and investigations of sediment contamination at the mouth of the cooling water tunnel have been deferred from extensive discussion in this RI/FS report at the present time. The potential for contamination of either of these media can be more reliably assessed following scraping of the site and initial soil removal actions required by TSCA. Soil removal activities will expose the white coral located immediately below the thin soils, making the areas where contaminants could percolate to the water table more apparent. The IAS (Greenleaf/Telesca, 1984) indicates that the ground water at NAVSTA Roosevelt Roads is saline. Therefore, the ground water at the site would be classified as a Class III aquifer under EPA's (1986) ground-water classification guidance. Surface water is not normally present on site except for brief periods immediately after heavy rains. Neither the ground water or surface water operable units are a direct source of human exposure. While a potential for contamination of the cooling water tunnel and USTs has been realized from samples collected during Versar's May 1991 sampling activities, further investigations of this area are required to fully characterize the threat to Ensenada Honda and Puerca Bay. Selection of remedy for the soil/sediment operable unit at the site does not interfere with any future remedial actions for the ground water/surface water operable unit, and will facilitate the continued assessment nature and extent of contamination of the aqueous media.

Data from the site characterization and evaluation of potential exposure pathways are used to evaluate site risks for current and potential future exposure scenarios. This report

also contains a FS that screens potentially applicable remedial process options to arrive at assembled remedial alternatives to eliminate site risks. The scope of the selection of remedy for the FS is limited to the soil/sediment and building exterior operable unit only. The remedial alternatives are intended to define the first phase of remediation and to select the most cost-effective remedy to best protect human health and the environment. Confirmatory sampling, and additional characterization requirements/removal are acknowledged as an integral part of the site remedy and are to be included in the Remedial Action Plan (RAP) to be prepared for this site at a later date.

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2.0 STUDY AREA INVESTIGATION

Site 16 was identified as an area of concern regarding PCB contamination in the IAS. The RI/FS included field activities to assess the extent of this contamination. These activities included confirmatory sampling and sampling from areas not previously evaluated, and was conducted in order to provide thorough and representative analytical results. These analytical results are used to perform a risk assessment, and to delineate the extent of contamination for future remedial activities.

The sampling rationale for the RI/FS at Site 16 was to utilize the ESE data (ESE 1988) to the greatest degree possible in project scoping and remedial design, while supplementing this information with fully validated data that can be used for tasks that require the highest level of data quality, specifically, the risk assessment. As an unvalidated data, the highest level of use for the ESE (1988) data is screening and engineering purposes.

A major thrust of the soil sampling program had been to attempt to identify deeper areas where PCB-bearing fluids may have percolated to coral. However, the soil at Site 16 is a mixture of white and dark sands which is difficult to visually assess. Also, coral was encountered at depths of less than a foot; all but eliminating the possibility of horizontally stratified sampling. It will be necessary to scrape all of the soil from the site before the degree of coral contamination can be reliably assessed. The soil sampling program recognized the potential for contaminated soil to be transported by wind or water short distances from the actual spill area. Also, additional exposure pathways, such as the cooling water tunnels were further evaluated. Concrete bulk and wipe samples were intended to identify decontamination needs for concrete surface areas.

2.1 Surface Features

As part of the RI field activities, the important surficial features of Site 16 were mapped by Versar. These features include all concrete areas, fenced areas, cooling tunnel and storage tank manways, and storm drains located on site. The dimensions of the site and pertinent structures were measured in the field and used to field check and update the ESE (1988) maps. Additionally, important physical characteristics of the site including the location of the hillside and roads bounding the site, locations of trees, the presence or absence of vegetation, nature of the substrate and flow directions of drainage ditches were also mapped (see Figure 4).

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2.2 Contamination Source Investigation

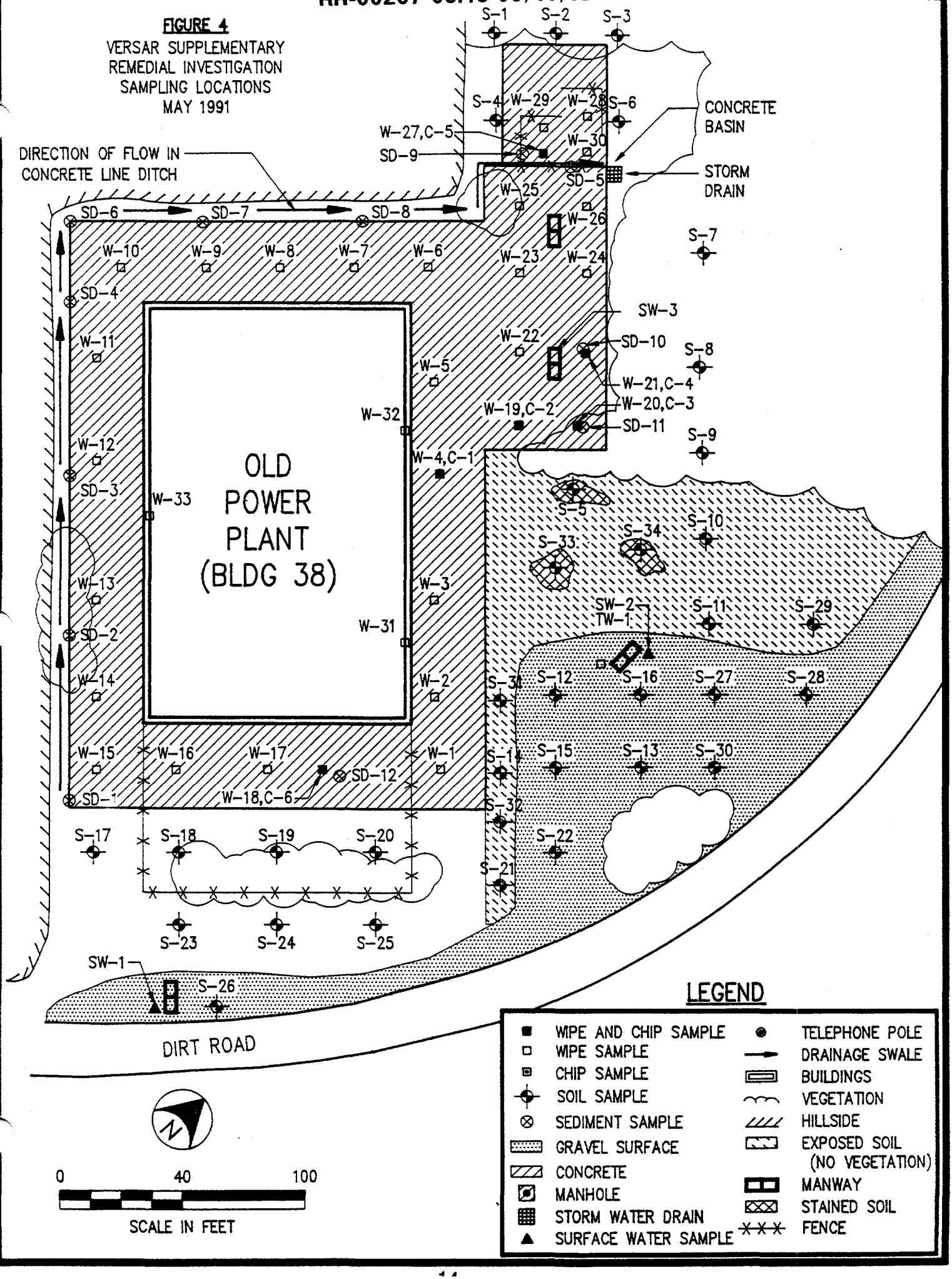
A total of 37 additional soil samples were collected from 34 locations to confirm previous analyses for PCB contamination and to further delineate the contaminated area. The sample locations are shown on Figure 4. These samples were collected from shallow (0 to 3 inches) soil. Deeper (8 to 12 inches) soil samples were planned, however, the soil was less than 6 inches thick at all sample locations. Coral is less than a foot thick throughout most of the site. The coral can be seen in the root structure of a large tree blown down by Hurricane Hugo. Twelve sediment samples were collected from locations in the ditch running along the margins of the Old Power Plant, between the building and the hillside and near the former transformer pad.

The six concrete chip samples and 33 wipe samples were collected from the concrete pads surrounding Building 38, at the former transformer pad and the concrete covering the area above the USTs to confirm suspected PCB contamination. Wipe and chip samples were used to characterize the unstained concrete surfaces to determine potential needs for remediation of these structures. A qualitative wipe sample was collected from a stained area above the water's surface in the cooling water tunnel to determine whether PCBs had ever been released to the tunnel. Additionally, two surface water samples were collected from the tunnel manways, and one surface water sample was collected from the day tank of the USTs to further determine whether these areas may have become contaminated.

Precleaned, dedicated stainless steel scoops were used to collect the soil and sediment samples. The soil or sediment was scooped from the earth and placed in aluminum pie pans for compositing. A clean pie pan was used and a fresh pair of PVC gloves was worn by the sampler for each sample. The sample was thoroughly homogenized using the stainless steel scoop, and the sample volume reduced to the appropriate aliquot using the cone and quarter technique. The sample was then placed in a precleaned I-Chem (or equivalent) 8-ounce glass sample container and held on ice under drain of custody. Equipment blanks and duplicate samples were collected to assess field quality assurance/quality control (QA/QC).

Concrete chips were collected using a bush hammer and chisel to pulverize the concrete surface to a depth of 1/4 to 1/2 inches deep. The hammer and chisel were decontaminated using a methanol, hexane, and distilled water rinse between each sampling location. Nitrile gloves and a stainless steel spatula were used to place the sample into precleaned sample jars. Wipe samples were collected by first using a 0.25m^2-template to delineate the sample area. A fresh pair of polyvinyl chloride (PVC) gloves were worn at each sampling location. A sterile gauze pad was then wetted with 8 ml of hexane. Due to the high

FIGURE 4
VERSAR SUPPLEMENTARY
REMEDIAL INVESTIGATION
SAMPLING LOCATIONS
MAY 1991



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D:\5295\004\FIG24A

daily temperatures, it was sometimes necessary to rewet the pad with hexane. Even and steady pressure to the pad was applied while drawing it in straight strokes from the left to the right in slightly overlapping, adjacent strokes. Following completion of the left to right wiping, the procedure was repeated from bottom to top of the wipe area. The gauze pad was then folded back onto itself twice and placed into a precleaned 8-ounce glass sampling container. Glove blanks were collected to assess field QA/QC; duplicate wipe samples are prevented by the sampling methodology.

While on site, oily stains were noted in the manways to the cooling water tunnels. A field decision was made to collect screening samples from these manways to determine whether PCBs had been introduced to the tunnels. Surface water samples were collected by immersing precleaned 1 liter I-Chem sampling containers affixed to a long pole used to lower the bottle to the water surface. The bottles were lowered into the water slowly so that water was preferentially drawn from the oily film noted on the water's surface. A duplicate sample was collected, however, because the sample was collected directly into the container, no equipment blank was necessary. To collect a sample of the oily residue on the sides of the manways, a sampling glove was used to cover the end of the pole used for surface water sampling. A clean gauze pad was affixed to the glove using duct tape. The wipe sample, TW-01, was not collected using a template to control the surface area wiped. Therefore, results from TW-01 are qualitative.

All samples collected at Site 16 were held in a cooler with ice under strict chain of custody procedures. Samples were shipped via overnight air express to Versar's laboratory in Springfield, Virginia, for analysis. All samples were analyzed according to current Contract Laboratory Program (CLP) protocols.

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3.0 PHYSICAL CHARACTERISTIC OF THE STUDY AREA

Site 16 is located off a paved side road to Forrestal Drive, that also leads to the activity's sewage treatment plant and the sanitary landfill (Figure 2 and 3). Beyond the landfill to the west, is a large mangrove swamp (Figure 2 and 3). The site is generally flat and located at 10 to 15 feet above mean sea level (msl). Puerca Bay is located approximately 500 feet northeast of the site and Ensenada Honda is located approximately 1,000 feet southwest of the site.

Site 16 consists of Building no. 38, the Old Power Plant and the surrounding area, which includes a former transformer pad (substation), and two 50,000-gallon USTs covered by a large concrete cover (Figure 4). A broad concrete apron surrounds the Old Power Plant. Building 38 is a massive two-story structure nestled tightly against a niche carved into the hillside. The structure appears to have been built to withstand bombardment, and the cliff face's angularity in the western corner of the site suggests that the face was wholly or partially reworked. In any case, the hillside is a sufficient natural boundary to define the western extent of contamination.

At the base of the hillside is a concrete-lined drainage ditch, constructed to collect drainage from the surrounding concrete apron. The direction of flow is from the southeast to northwest to the corner near sediment sample no. SD-6 (Figure 4). At that location, the ditch turns to flow southwest to northeast. The ditch borders the edge of the concrete apron surrounding Building 38 and pad covering the USTs and flows into a storm drain located in the northern part of the site (Figure 4). The ditch flows between the pad covering the USTs and the former substation area. Large amounts of sediments, debris, and plant matter clog the channels of the ditch, thereby limiting flow. Vines have largely over taken the channel and the concrete apron between the hillside and Building 38. There is a small fence in the area at the southeast end of Building 38 and remnants of a chain-link fence surrounding some parts of the former substation area in the northern part of the site (Figure 4). Other than those two areas, the site is not fenced.

The southern and eastern parts of the site are largely open areas. The south and east sides of the sites are bounded by a paved road. Gravel has been spread along the shoulder of the road, and in the open area in front of Building 38 (to create a turnout/parking area). In the southern part of the site, the gravel generally gives way to grass. There is a large area of bare soil (sparsely vegetated) between the gravel turnout and a stand of small trees and shrubs in the northeast corner of the site. Several large oil stains were noted in this area and soil sample nos. S-5, S-33, and S-34 were collected to characterize these stains (Figure 4). Two large trees once stood at the northeast edge of the concrete pad covering the USTs and

the site. One of the trees had been toppled by Hurricane Hugo. The tree's root system was very shallow, owing to the presence of coral located approximately 1 foot before the surface. The shallow coral was evident in the trees root structure.

There are two manways located on the pad covering the USTs. These manways open to what appears to be day tanks for the USTs. The two 50,000-gallon USTs held Bunker C oil to provide power to the Old Power Plant. There was water in the bottom of the day tanks and the bottoms felt as though filled with sludge when probed with a long pole. Two manways are also located on site for access to the cooling-water tunnels located beneath the site (Figure 3 and 4). The manway used to access the tunnel intake is located near the road, southeast of Building 38. The tunnel leads from the mid-point of the southeast wall of Building 38, parallels the road between the site and the sewage treatment plant and extends southwestward to Ensenada Honda (Figure 3). The manway shown on Figure 4 was the only access to the tunnel intake that could be located during the RI field investigation. The IAS (Greenleaf/Telesca, 1984), indicates that other manways to the tunnel intake may be buried below the station's sanitary landfill (Figure 2).

The manway located on the northeast side of Building 38 leads to the outfall tunnel. Numerous other access way are located across the road from the site approximately every to 50 to 100 feet. A long line of such access ways forms a small pier on Puerca Bay. Fishermen have been observed fishing from the end of this pier. The two manways to the cooling water tunnels on site were covered with large 4 x 4-foot wooden covers constructed of railroad ties. The covers broke up when removed and were replaced with steel covers. Near the pier, the access ways are not covered. From the end of the pier, the tunnel appears to be very large on the order of 10 x 10 feet across. An oil film and sheens were readily evident on the water's surface in the manways located on site. A 1-foot wide oil stain was visible on the walls of the tunnel at the water line, clearly indicating a substantial volume of oil had once been present in the tunnel. A similar oil stain was present in all of the access ways. Oil sheens on the water's surface were not prominent near the mouth of the tunnel at Puerca Bay. In the outfall tunnel manway located on site, long oil stains were noted on the walls of the shaft to the tunnel above the high water mark, suggesting that oils were poured from the surface in the past. Qualitative wipe sample TW-01 was collected to characterize this stain.

Information concerning the site's geology and soils, biology, meteorology, and other environmental setting information are contained in the following subsections.

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3.1 Geology and Soils

Within the area comprising NAVSTA Roosevelt Roads, there are major variations in the topographic features. The regional area of the Naval Station consists of an interrupted narrow coastal plain with small valleys extending from the Sierra de Luquillo range, which has been deeply eroded by streams into valleys several hundreds of feet deep. Slopes of 30 to 45 degrees are common.

In the immediate area of the station, elevations range from sea level to approximately 295 feet. Immediately to the north of the station boundary, the hills rise abruptly to heights of 800 to 1,050 feet above sea level. There are 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 called the Bundy area. Along the shoreline, lagoons and swamps are common.

The underlying geology of the station area is predominantly volcanic rock composed of lava and tuff, as well as sedimentary rocks derived from discontinuous beds of limestone. These rocks range in age from early Cretaceous to middle Eocene. The volcanic rocks and interbedded limestones have been complexly faulted, folded, metamorphosed, and intruded by dioritic rocks. This complex geological restructuring occurred sometime after the deposition of the limestone during the middle Tertiary age.

In addition to the predominate volcanic and sedimentary rock, the northwestern and western sectors of the base are covered by unconsolidated alluvial deposits deposited during the Quaternary period (Figure 5).

The primary geologic formations on and near NAVSTA Roosevelt Roads are various beach deposits, alluvium, quartz diorite and granodiorite, quartz kerotophyre, the Daguao Formation, and Figuera lava (see Appendix C).

There are six soil associations found on NAVSTA Roosevelt Roads, four of which are found primarily on the station, while the other two are limited to the western boundary of the station in the vicinity of the airfield. Two of the soil associations cover more than one-half of the station's surface area and are equally distributed. They are the Swamps-Marshes and Mak-Rio-Arriba-Cayagua Associations. The Swamps-Marshes Association is deep, poorly drained sandy or clayey, contains organic material from decaying mangrove trees, and is found slightly above sea level, on level or slightly level areas, and during high tide is covered or affected by salt or brackish water. Below the soil, there are deposits of coral, shells, and

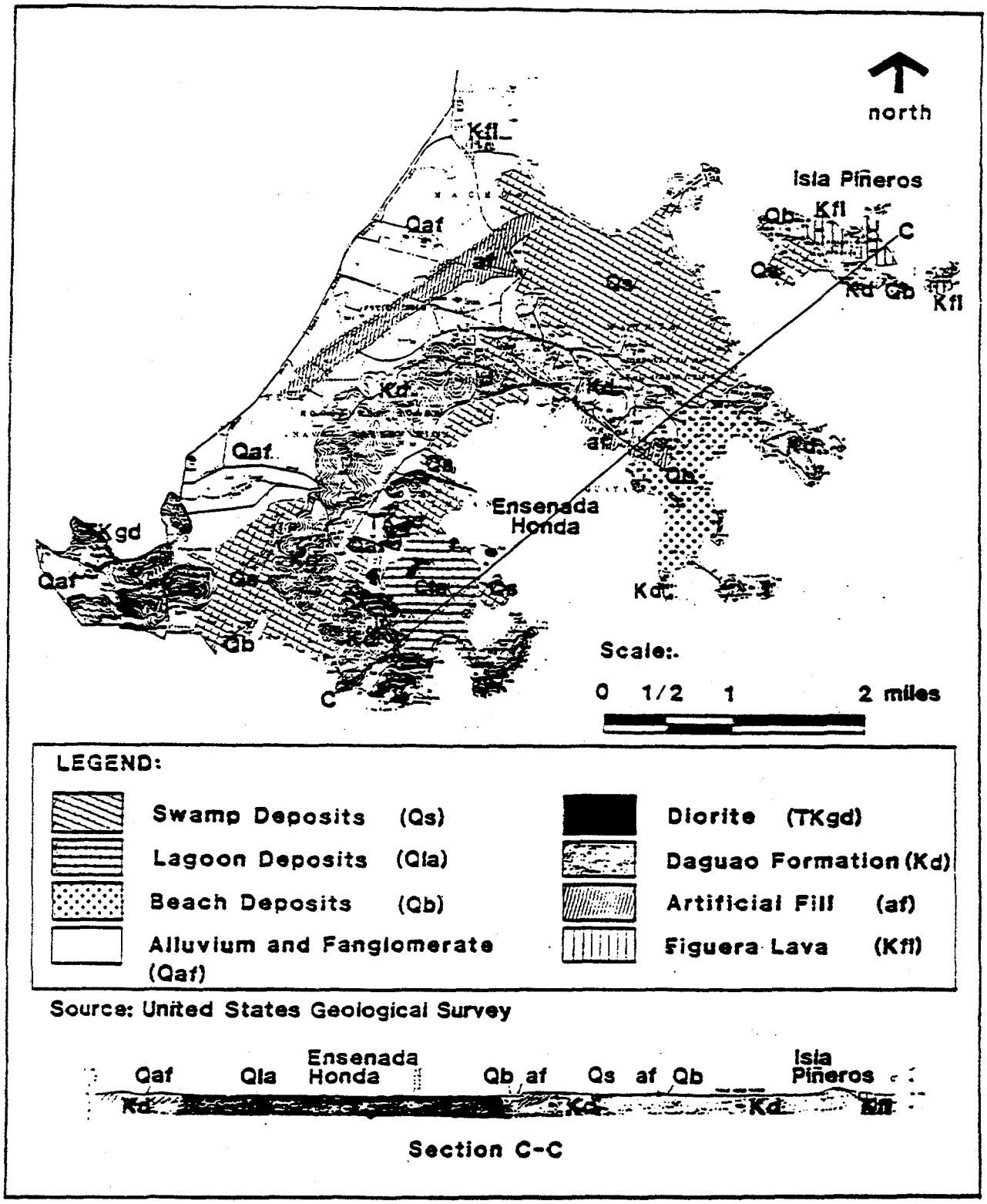

FIGURE 5
GEOLOGIC MAP OF NAVAL STATION
ROOSEVELT ROADS, PUERTO RICO

marl at varying depths. The Maki-Rio-Arriba-Cayagua Association is generally deep, poorly to moderately well-drained, clayey, or nearly level to moderately steep soils found on foot and side slopes, terraces, and alluvial fans.

The Descalabrada-Guayama and Caguabo-Mucara-Naranjito Associations cover most of the remaining surface area of the station. They are shallow to moderately deep, well drained, and are strongly sloping to steep soils on volcanic uplands. The Descalabrado-Guayama Association soils are found primarily in the hilly areas directly inland and adjacent to the Swamp-Marshes Association.

The remaining two soil associations are the Coloso-Toa-Bajura and Jacan-Amelia Fraternidad Associations. The Coloso-Toa-Bajura Association consists of deep, moderately well-drained to poorly drained, nearly level soils found in flood plains. While the Jacena-Amelia Fraternidad Association consists of moderately well-drained, nearly level to strong sloping soils on foot slopes, terraces and alluvial fans.

The Old Power Plant, Building 38 (Site 16) is located on a low-lying peninsula in the southeast part of the Naval Station. Puerca Bay is located 500 feet northeast of the site to the southeast. The site has a shallow, sandy, well drained soil underlaid by coral. The bedrock in this area is the Daguao Formation. This volcanic rock makes up the hillside on the southwest and northeast sides of Building 38. The Daguao Formation consists of interbedded breccia, lava, and occasional sandstone derived from the volcanics. Between the volcanic bedrock and the thin soil layer (<1 foot) are coral deposits of recent age. The thickness of the coral is not known. This coral is exposed in the root system of a large tree that was blown down during Hurricane Hugo. Because two 50-000 gallon USTs are located on site, and considering the impracticality of installing the tanks and cooling water tunnels into volcanic bedrock, the coral may be quite thick (greater than 20 feet).

3.2 Ground Water

Water from alluvial aquifers along the coast of the Naval 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. Based on their proximity to the sea, ground water at Site 16 is probable saline. NAVSTA Roosevelt roads has no ground-water wells used for drinking water supplies.

Little information exists concerning the geohydrology of NAVSTA Roosevelt Roads in the immediate vicinity of Site 16. The only known possible sources of ground water are lenticular beds of clay, sand gravel, and rock fragments which occur at a depth of less than 30 meters. Monitoring wells have been installed at other IAS sites at NAVSTA Roosevelt Roads; however, none are properly located to provide information concerning Site 16. Some wells were developed further inland, upgradient of the station, in the nearby town of Ceiba, some 3 kilometers from base headquarters. However, they were abandoned due to high levels of salinity (Greenleaf/Telesca, 1984).

3.3 Surface and Subsurface Water

The surface waters that flow across the northeastern plain of Puerto Rico, where the Naval Station is located, originate on the eastern slopes of the Sierra de Luquillo mountains. Surface runoff is channeled into various rivers and streams that eventually flow into the Caribbean Sea. 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 3 feet.

Surface water drainage from Site 16 generally flows through the storm water sewers to the north or northwest into the mangrove swamps and Puerca Bay or to the northeast and southwest into Ensenada Honda (Figures 2, 3, and 4). Subsurface water is also present in the cooling water tunnel located below Site 16. The intake and outfall to the tunnel are shown on Figure 3. Flow in this tunnel is tidally effected. Therefore, contamination from Site 16 could potentially move toward both Ensenada and Puerca Bay (Figure 3). The intake tunnel leading to Ensenada Honda may have been disrupted by landfilling activities southwest of Building 38 (Figure 2).

3.4 Biology

The NAVSTA Roosevelt Roads has four distinct ecosystems. They are: the upland forest, mangrove, marine, and freshwater ecosystems. The upland forest area includes trees with compound or simple leaves that are succulent or leathery with broad expansive crowns. The trees rarely get higher than 45 feet, and function as an erosion inhibitor, are the habitat used primarily by avian species.

There are three recognized mangrove associations at Roosevelt Roads: the riverine, fringe and basin. The mangrove ecosystems are perhaps the most important habitat type encompassed by the station. They provide cover, food, and nursery areas for the varied marine sport and commercial fish species, and marine organisms. They also provide nesting

and roosting areas for a variety of birds. The marine ecosystems can be generally characterized as coral reef and seagrass associations. The coral reefs are made up of stony and soft coral. Many of the coral reefs are pristine in more remote areas of NAVSTA Roosevelt Roads. The seagrass beds consist of turtlegrass and manatee grass are common in the clean, shallow embayments of the station. Their extent in Ensenada Honda alone is approximately 600 acres. The vegetation allows sediments to settle out of the water, and serves as food and cover for the myriads of marine vertebrates and invertebrates.

The fresh water ecosystem at Roosevelt Roads consists of two small ponds near the airport and Officers' Club. The ponds tend to dry seasonally, due to lack of rain.

3.5 Climate

The climate is classified as tropical-maritime, with uniform temperatures ranging from 64°F to 88.2°F. The coolest months are January and February, with average temperature of 82.0°F. The warmest months are August and September with an average temperature of 88.2°F. The average annual precipitation at NAVSTA Roosevelt Roads is 60 inches and the rainy season extends from May through October.

The prevailing wind direction reflects the easterly trade winds. However, 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.

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

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4.0 NATURE AND EXTENT OF CONTAMINATION

Soil, sediment, wipe, chip samples have been collected in accordance with the procedures outlined in the work plans prepared for this site. Three surface water samples were also collected as part of the RI field investigation.

The remedial investigation at Site 16 emphasized the compilation and evaluation of existing data; collection of additional information to fill any gaps in the ESE (1988) data needed to characterize contamination on and off site; and the determination of the extent of contamination, migration pathways, and the potential receptors.

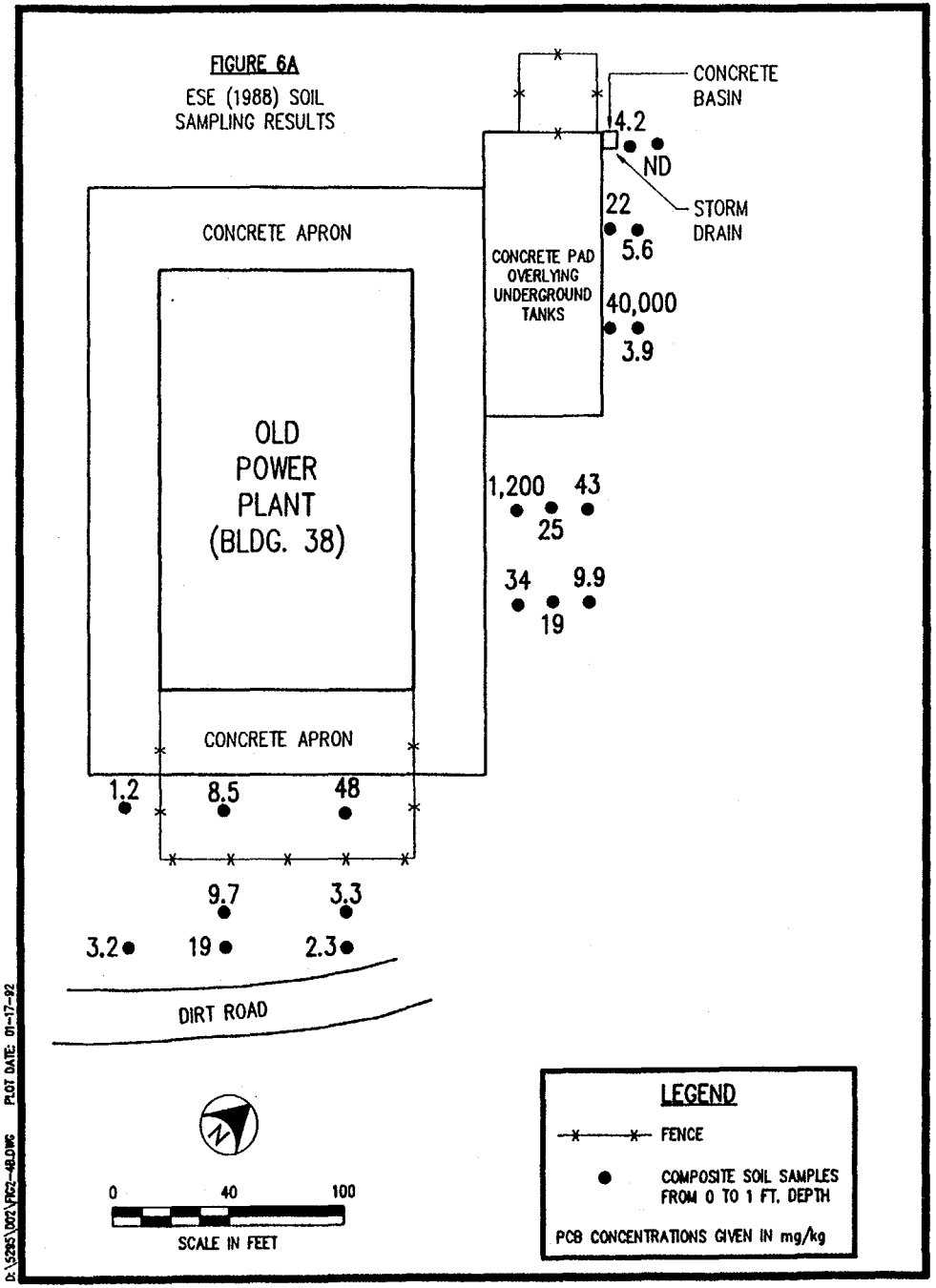
The primary goals of the RI are as follows:

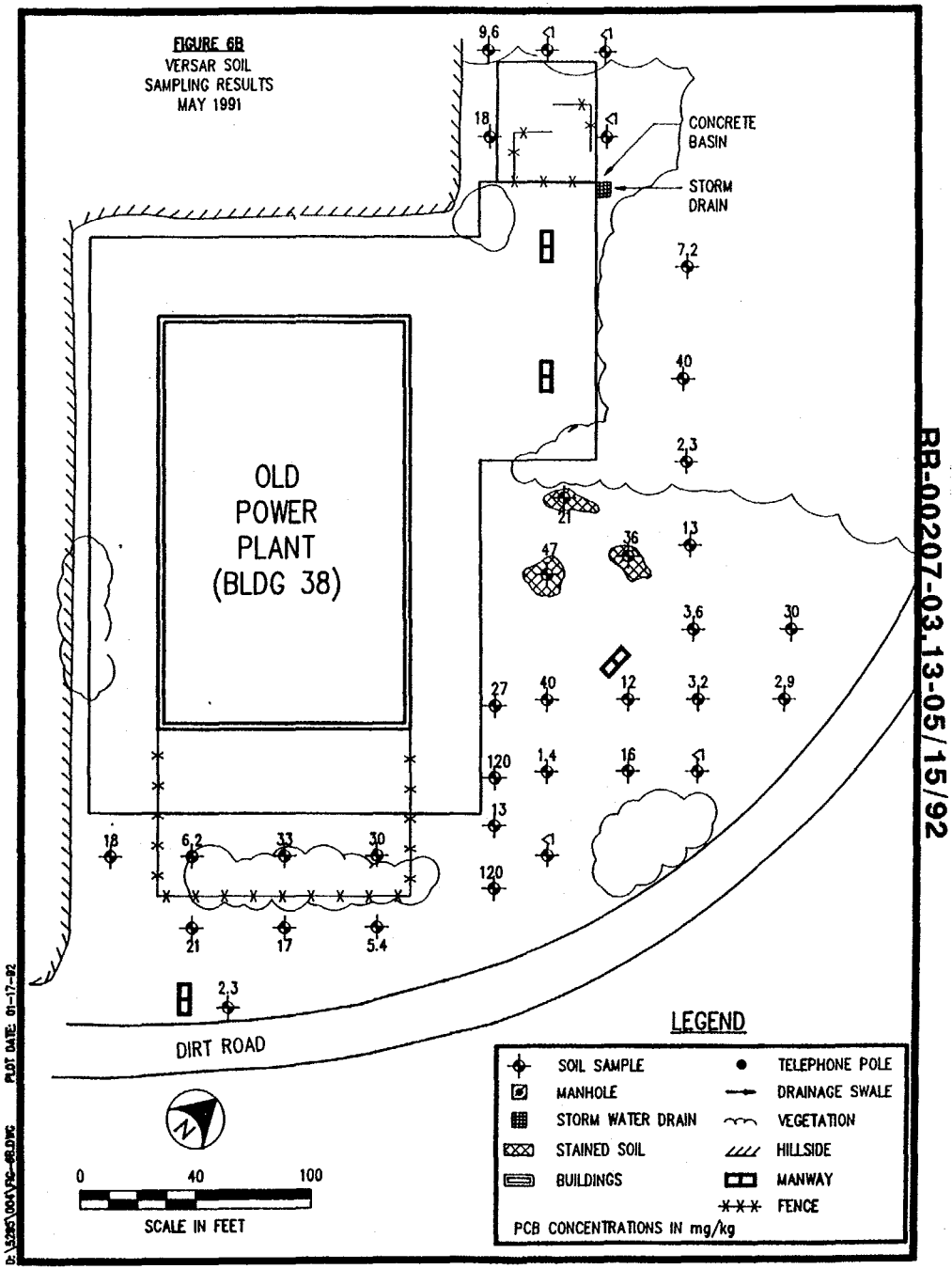
- To define the nature and extent of PCB contamination in surficial soil/sediment and building/concrete exterior surfaces using previous (ESE, 1988) and newly collected data.
- To identify and evaluate contamination migration pathways and potential routes of exposure.
- To evaluate risks to potential receptors.
- To identify and define parameters affecting the feasibility of potential remedial alternatives.

Analytical results for each media (soil, sediment, concrete, and surficial wipes will be discussed separately. Contaminant concentration data from the samples collected during the May 1991 RI field activities are included in this section and compared with available ARARs wherever possible.

4.1 Soil Analytical Results

During the May 1991 RI field activities, 37 soil samples were collected from 34 locations. These locations were based on a uniform grid at 30-foot centers (Figures 4 and 6). The areas covered by the grid were intended to supplement the existing data from the ESE (1988) investigation (Figures 3 and 6). ESE (1988) PCB data ranged from not detected to 40,000 mg/kg. Versar data ranged from less than 1 mg/kg to 120 mg/kg. It was not possible to collect soil samples from depths greater than 6 inches due to the presence of coral deposits





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at shallow depths across the site. In Table 4-1, shallow soil samples (0-6") are designated with the letter, "A", as in S-1A; the designation, "D", following the sample location number indicates a duplicate.

Data from duplicate soil samples indicates good agreement in concentration values for duplicates collected at S-05A (21 mg/kg and 43 mg/kg), at S-33A (47 mg/kg and 44 mg/kg), and at S-34A (36 mg/kg and 33 mg/kg). From an order of magnitude perspective, there is also good agreement between the Versar May 1991 data and the ESE (1988) data (Figure 6). Some of the ESE (1988) data are considerably higher than the Versar May 1991 data. This apparent difference results from the differing purposes of the two sampling investigations: the ESE (1988) data focused on hot spots, the Versar 1991 data was from locations specifically chosen to try to place a boundary on the extent of contamination (horizontally). As a result, the Versar 1991 sample locations were biased toward lower values. Versar soil sample data from areas chosen to coincide with ESE (1988) data at locations S-17, 18, 19, 20, 23, 24, and 25, indicate PCB contamination present at similar concentrations as the earlier investigation disclosed (Figures 4 and 6). This finding suggests a low degree of uncertainty in the data base due to sampling error.

Data from both sets are somewhat variable from one location to the next. Because the source of the PCB contamination results from slops and spills during the change-out of transformer fluids, such variability over short distances is to be expected. Areas where the transformers may have been emptied have higher concentrations, but other areas would also have sporadic detections resulting from drips and spills occurring as the transformers were moved from place to place, was tracked by workers, or distributed by the wheels of vehicles moving on the site. It is note worthy that the two highest PCB concentrations were obtained from samples collected in the immediate vicinity of two large trees that provide the only shade in the area in the front of the Old Power Plant. It is likely that the shaded areas were preferred by the workers during the transformer fluid maintenance.

As an industrial area with unrestricted access, the applicable ARAR is the 10 mg/kg TSCA standard. The 10 mg/kg standard was exceeded in 18 of the 34 sample locations in the Versar data and in 12 of the 20 sample locations in the ESE (1988) data (Figure 6). The Versar data confirm the variability and the relative concentrations of the PCB data (ESE, 1988) from areas near the Old Power Plant where confirmatory samples were collected near the southeast and northeast sides of Building 38 (Figure 4 and 6).

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TABLE 4-1

Versar May 1991 Soil Sampling Results
Arochlor, PCB Concentration (mg/kg)

Sample No.	1016Q	1221Q	1232Q	1242Q	1248Q	1254Q	1260Q
RR16S01A	0.27 U	0.27 U	0.27 U	0.27 U	4.8	0.55 U	9.6
RR16S02A	0.0265 U	0.0265 U	0.0265 U	0.0265 U	0.0265 U	0.055	0.91
RR16S03A	0.026 U	0.026 U	0.026 U	0.026 U	0.026 U	0.05 U	0.44
RR16S04A	0.255 U	0.255 U	0.255 U	0.255 U	0.255 U	14 X	18 X
RR16S05A	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	21
RR16S05AD	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.55 U	43
RR16S06A	0.026 U	0.026 U	0.026 U	0.026 U	0.026 U	0.1 U	0.66
RR16S07A	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.55 U	7.2
RR16S08A	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.55 U	40
RR16S09A	0.0205 U	0.0205 U	0.0205 U	0.0205 U	0.0205 U	0.05 U	2.3
RR16S10A	0.255 U	0.255 U	0.255 U	0.255 U	0.255 U	0.5 U	13
RR16S11A	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.05 U	3.6
RR16S12A	0.265 U	0.265 U	0.265 U	0.265 U	0.265 U	0.55 U	40
RR16S13A	0.285 U	0.285 U	0.285 U	0.285 U	0.285 U	0.55 U	16
RR16S14A	0.29 U	0.29 U	0.29 U	0.29 U	0.29 U	0.6 U	13
RR16S15A	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.05 U	1.4
RR16S16A	0.265 U	0.265 U	0.265 U	0.265 U	0.265 U	0.55 U	12
RR16S17A	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	18
RR16S18A	0.029 U	0.029 U	0.029 U	0.029 U	0.029 U	0.06 U	6.2
RR16S19A	0.34 U	0.34 U	0.34 U	0.34 U	0.34 U	0.7 U	33
RR16S20A	0.295 U	0.295 U	0.295 U	0.295 U	0.295 U	0.6 U	30
RR16S21A	0.315 U	0.315 U	0.315 U	0.315 U	0.315 U	0.65 U	23
RR16S22A	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.05 U	0.71
RR15S23A	0.275 U	0.275 U	0.275 U	0.275 U	0.275 U	0.55 U	21
RR16S24A	0.265 U	0.265 U	0.265 U	0.265 U	0.265 U	0.55 U	17
RR16S25A	0.255 U	0.255 U	0.255 U	0.255 U	0.255 U	0.5 U	5.4
RR16S26A	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.05 U	2.3
RR16S27A	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.05 U	3.2
RR16S28A	0.026 U	0.026 U	0.026 U	0.026 U	0.026 U	0.05 U	2.9
RR16S29A	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.5 U	30

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TABLE 4-1

Versar May 1991 Soil Sampling Results
Arochlor, PCB Concentration (mg/kg)

Sample No.	1016Q	1221Q	1232Q	1242Q	1248Q	1254Q	1260Q
RR16S30A	0.026 U	0.026 U	0.026 U	0.026 U	0.026 U	0.05 U	0.43
RR16S31A	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.5 U	27
RR16S32A	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	5 U	120
RR16S33A	2.65 U	2.65 U	2.65 U	2.65 U	2.65 U	5.5 U	47
RR16S33AD	0.255 U	0.255 U	0.255 U	0.255 U	0.255 U	0.5 U	44
RR16S34A	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.5 U	36
RR16S34AD	0.255 U	0.255 U	0.255 U	0.255 U	0.255 U	0.5 U	33

Notes:

U = Undetected; numerical value is one half detection limit.
X = Inflated results due to cross contribution by PCBs in a mixture.
COMP = Composite.

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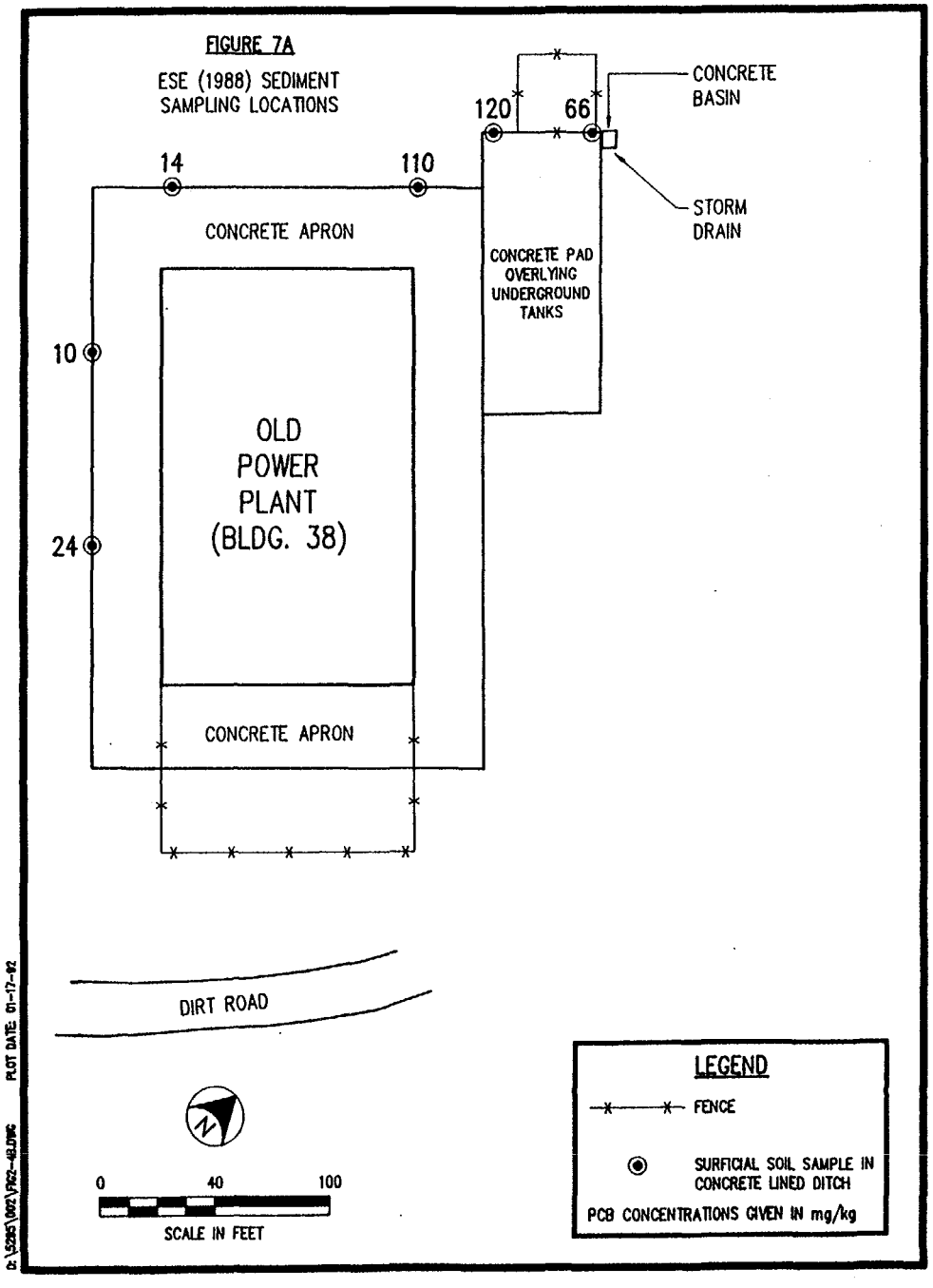
4.2 Sediment Sample Results

Sediment samples were collected from twelve locations during the May 1991 RI field activities to extend the data set, upgradient and downgradient of ESE's (1988) data base (Figure 7). Four sample locations, SD-2, 3, 5, and 8, were selected to coincide with the ESE (1988) data (Figure 3 and 7). ESE (1988) PCB concentrations detected in sediments ranged from not detected to 40,000 mg/kg. Versar (1991) data measured PCB concentrations between not detected at 2.1 mg/kg to 1,000 mg/kg (Table 4-2). Versar's data included both sediments from within the concrete-lined ditches and from soil and plant detritus that had accumulated on the concrete pad covering the USTs. Samples were collected from the concrete areas to determine the potential for wind and rain transport of sediment and soil during storms such as Hurricane Hugo. From the relatively high concentrations detected in sample nos. SD-10 (1,000 mg/kg) and SD-11 (40 mg/kg), it appears that all of the materials covering the pad should be considered to be contaminated, and that major Atlantic storms may have dispersed PCB bearing soils across the site.

Data from the duplicate sediment sample, SD-8 and SD-8D indicate very good agreement of 44 and 46 mg/kg, respectively. Comparison of the Versar 1991 sediment data and the ESE (1988) data indicate good agreement between the two rounds of data. Both data sets indicate the same order of magnitude in concentration values, and both data sets generally indicate higher values in the northern part of the drainage ditches near the former substation area.

ARARs for PCBs in sediment are the interim sediment quality criteria (EPA, 1990) of 19 mg/kg for fresh water and 33 mg/kg for salt water. Both the Versar May 1991 data and ESE (1988) sediment data greatly exceeds the ARAR.

The sediment quality criteria are generally normalized to the organic carbon content of the sediment. Because the sediments observed in the ditches and on the concrete pads appears to be largely plant detritus, the highest value for the ARAR was assumed because no total organic carbon data was collected. It is important to note that the sediment ARAR can be below the values of 19 to 33 mg/kg being used above. Under any circumstances, the values for sediments at Site 16 are clearly higher than the maximum concentration the ARAR allows. This finding suggests that further investigation of the storm sewer outlet is certainly warranted. At present, there is no information available on the outlet to the storm drain located on site. The drain may be connected to the cooling water tunnel, or may be part of a separate system.



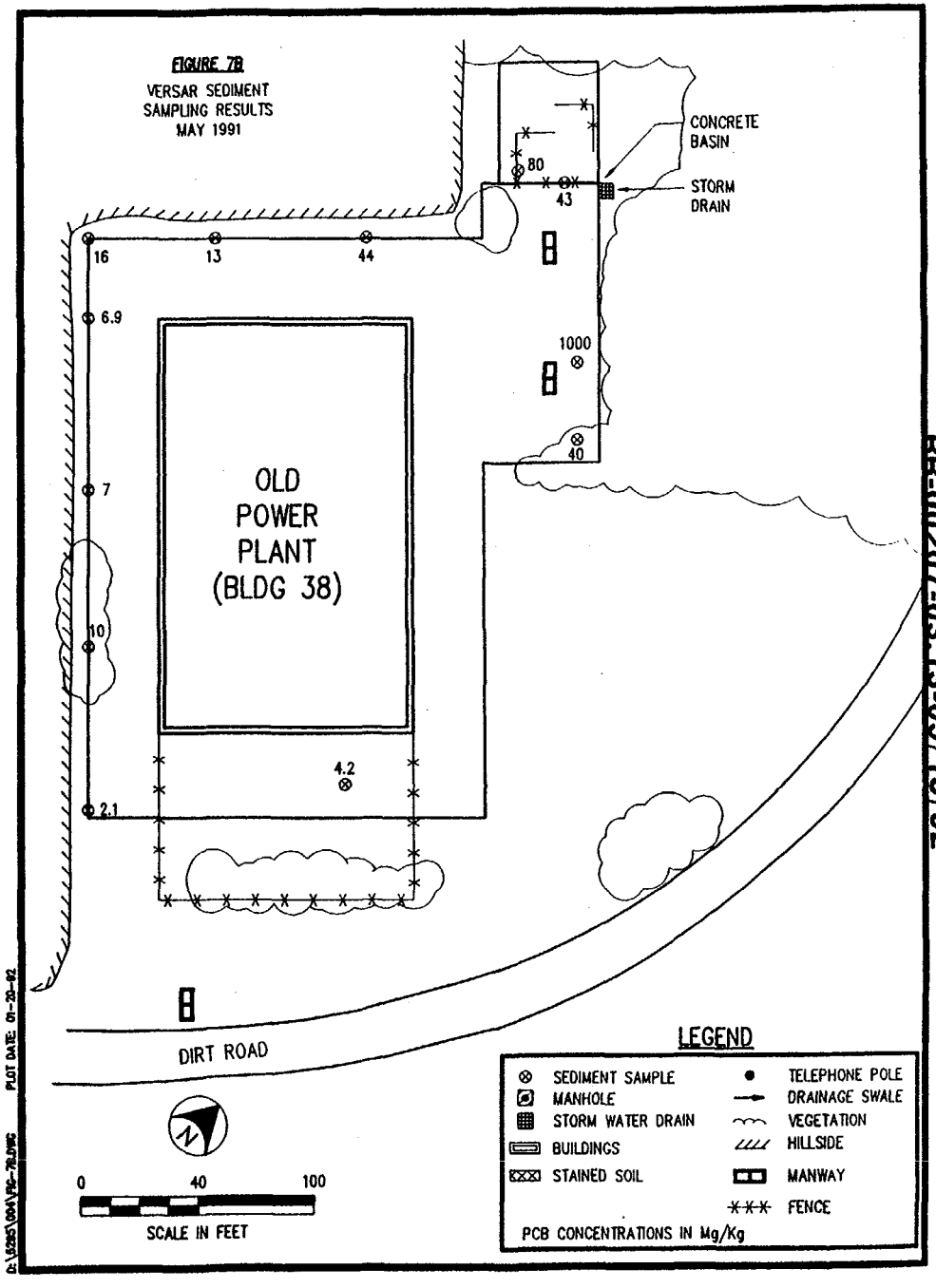


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TABLE 4-2

Versar May 1991 Sediment Sampling Results
Arochlor, PCB Concentration (mg/kg)

Sample No.	1016	1221	1232	1242	1248	1254	1260
RR16SD09	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	7 U	80
RR16SD10	6.5 U	6.5 U	6.5 U	6.5 U	6.5 U	13 U	1,000
RR16SD11	0.385 U	0.385 U	0.385 U	0.385 U	0.385 U	0.75 U	40
RR16SD12	0.0525 U	0.0525 U	0.0525 U	3.4 A	0.0525 U	0.1055 U	4.2
RR16SD01	0.0345 U	0.0345 U	0.0345 U	0.0345 U	0.0345 U	0.07 U	2.1
RR16SD02	0.065 U	0.065 U	0.065 U	0.065 U	0.065 U	0.125 U	10
RR16SD03	0.0465 U	0.0465 U	0.0465 U	0.0465 U	0.0465 U	0.095 U	7
RR16SD04	0.045 U	0.045 U	0.045 U	0.045 U	0.045 U	0.09 U	6.9
RR16SD05	0.45 U	0.45 U	0.45 U	0.45 U	0.45 U	0.9 U	43
RR16SD06	0.325 U	0.325 U	0.325 U	0.325 U	0.325 U	0.65 U	19
RR16SD07	0.047 U	0.047 U	0.047 U	0.047 U	0.047 U	0.095 U	13
RR16SD08A	0.36 U	0.36 U	0.36 U	0.36 U	0.36 U	0.7 U	44
RR16SD08D	0.295	0.295	0.295 U	0.295 U	0.295 U	0.7 U	46

Notes:

U = Undetected; numerical value is one-half the detection limit.
A = Suggests the presence of PCB in the quantitation analysis, however, the result did not confirm in the secondary analysis.
COMP = Composite.

Because the drainage ditches are often dry and the sediment is essentially identical to the surrounding soil, the TSCA 10 mg/kg soil ARAR is a relevant standard. A reasonable application of this standard would require the removal of all of the material between the hillside, and the substation and large transformer area.

4.3 Wipe and Chip Sample Results

Wipe samples were collected from 33 locations and concrete chip samples were collected from six locations at Site 16 (Figure 8). There are large areas of concrete surfaces at Site 16: the concrete apron surrounding Building 38, and the concrete pads in the former substation area, and covering the USTs. Most of the concrete surface is stained in one fashion or another. The area has clearly been used for painting in the past and it is difficult to determine whether stains resulted from transformer fluid maintenance or from other activities. ESE (1988) did not attempt to characterize these or other stained concrete surfaces.

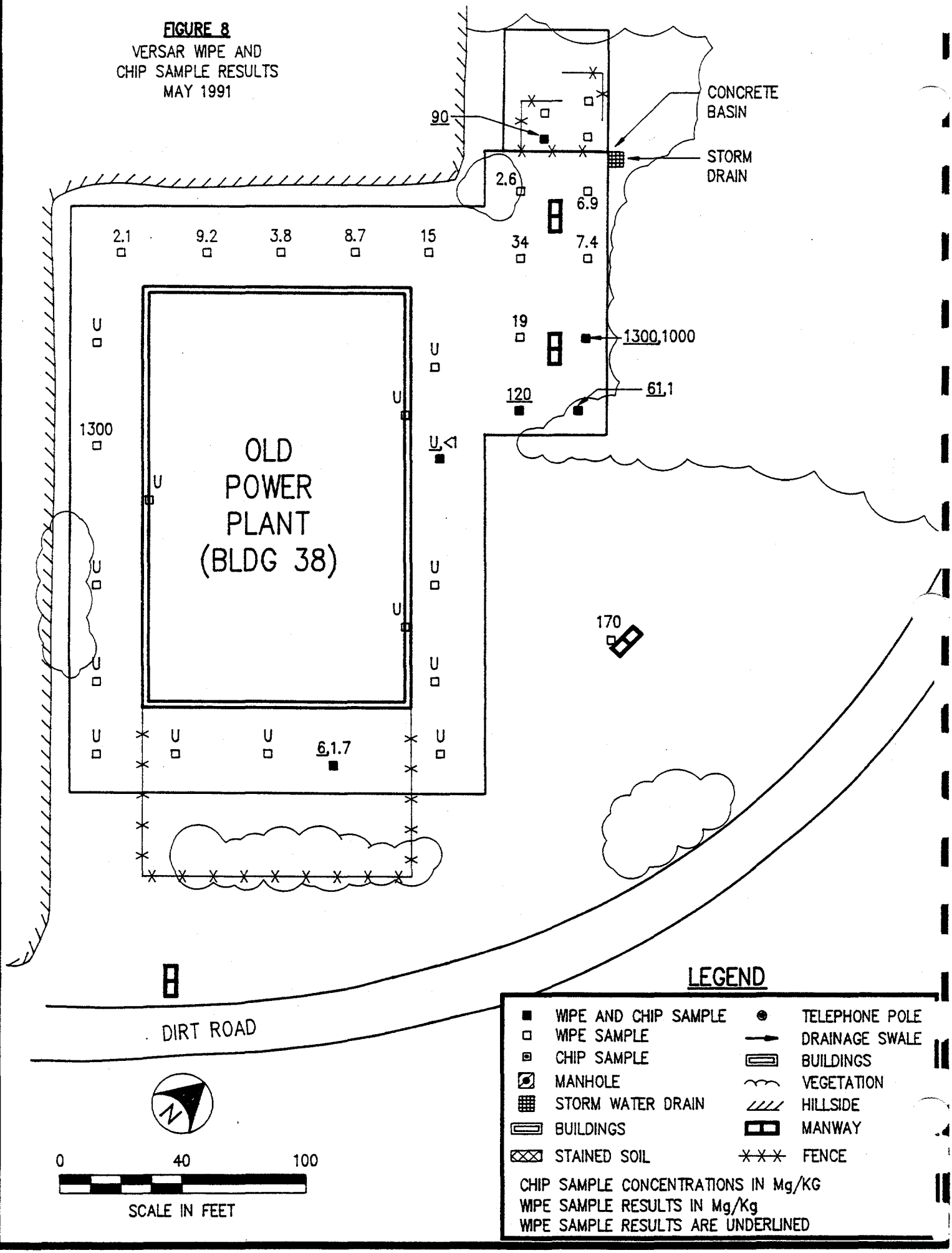
Roughly half of the wipe samples did not detect PCBs, and only two wipe samples exceeded the 1,000 $\mu g/m^2$ ($10\mu g/100\ cm^2$) ARAR set for out door high contact surfaces under TSCA for industrial areas and nonrestricted access areas. These two locations are W-12 (1,300 $\mu g/m^2$), and W-21 (1,300 $\mu g/m^2$).

There is fair agreement in the trends for PCB concentration between wipes and chips from the same locations. The highest concentration from a wipe sample corresponds with the highest concentration chip sample. Wipe samples were collected in all six concrete chip sample locations. No detects correlate at the W-4/C-1 location, high concentrations correlate at the W-21/C-4 location, and moderate concentrations coincide at the W-27/C-5 location (see Figures 4 and 8).

Although most of the wipe sample data suggest that extensive decontamination of exterior concrete surfaces is not required, Versar believes that the two detections of PCBs above ARARs provide ample data to warrant full decontamination of all exterior surfaces. This is due in part to limitations on sampling methodology and by prior site use.

Due to the tropical weather conditions that rapidly dried the gauze pad used for sampling and the very rough nature of the deeply weathered concrete surfaces, it is likely that the wipe sample data may under represent the concentration of PCBs contained in the stained

FIGURE 8
VERSAR WIPE AND
CHIP SAMPLE RESULTS
MAY 1991



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D:\5295\004\FIG-8.DWG

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TABLE 4-3

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

Versar INC.

TABLE 4-3

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.

concrete surfaces. Also, large areas of paint over sprayed on the northwest side of the building may have bound PCBs to the concrete. Furthermore, there are a great number of stains that could not be characterized individually, that conceivably could yield unacceptable values.

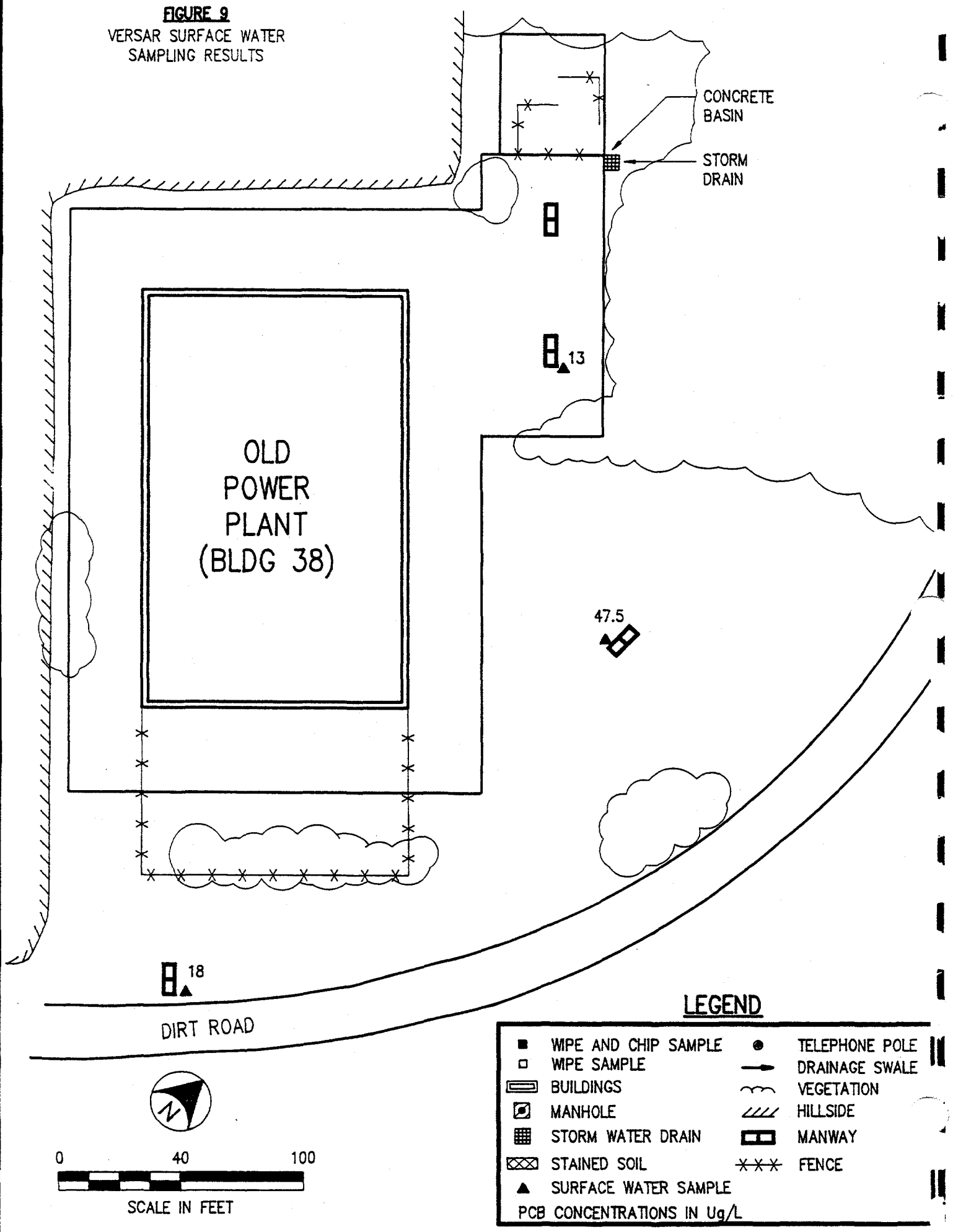
In addition to the quantitative wipe samples collected (W-1 to W-33), a qualitative/semiquantitative wipe sample (TW-01) was collected from oil stains observed on the wall of the shaft of the manway to the cooling water tunnel (Figures 4 and 8). The stain being sampled was a vertically elongate stain on the wall extending from the surface towards the water. From the appearance of the stain, it appeared to have resulted from oil being poured from the surface into the manway. The sample was not collected according to standard techniques (see Section 2.2); no attempt was made to wipe a specified surface area. Therefore, the results are qualitative, or at best, semiquantitative. TW-01 detected PCB's at a concentration of 170 $\mu g/m^2$. Although the numerical value is not quantitatively significant, it clearly indicates that PCB-bearing fluids were at times poured into the cooling water tunnel from above and indicates a more extensive investigation of the tunnel is warranted.

4.4 Surface Water Sample Results

During the May 1991 RI field investigation, three surface water screening samples were collected from the manways to the cooling water tunnel (SW-1 and SW-2) and from the day tank for the USTs (SW-3) (Figures 4 and 9). These samples, in conjunction with the qualitative wipe sample, TW-01, were intended to determine whether PCBs had been disposed of in these subsurface structures. These data, although from subsurface structures, are considered surface water samples because of the direct connection of the cooling water tunnel and the ocean (SW-1, SW-2), or because the water accumulated in the day tank appears to result from surficial runoff (SW-3). The Versar data ranges between 13 µg/L and 54 µg/L and clearly indicates that PCB-bearing fluids were disposed of in these structures (Table 4-4).

Originally, the Work Plan specified sediment samples were to be collected from the tunnels using an Eckman dredge. However, even after repeated attempts, no sediments could be retrieved from the manways (the sediment layer is thin to nonexistent below the site). Furthermore, a layer of oil floating on the surface of the water contaminated the dredge so extensively that field decontamination was not reliable. Therefore, surface water samples were collected instead. All of the samples greatly exceeded the Clean Water Act water quality criteria (0.014 µg/L freshwater, 0.03 µg/L saltwater) and MCL (0.5 µg/L). PCBs are very poorly soluble in water. The relatively high values detected in these samples indicate that it is unlikely that the water became contaminated from surficial runoff of contaminated soil above

FIGURE 9
VERSAR SURFACE WATER
SAMPLING RESULTS



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D:\5295\004\FIG-9.DWG

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TABLE 4-4

Versar May 1991 Surface Water Sample Results
Arochlor, PCB Concentration (µg/L)

Water Sample No.	1016Q	1221Q	1232Q	1242Q	1248Q	1254Q	1260Q
RR16SW01	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	18
RR16SW02	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	54
RR16SW02D	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	41
RR17SW03	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	13

Notes:

U = Undetected.

but rather, implies that PCB-bearing fluids were dumped into these structures. Data from duplicates SW-2 and SW-2D shows good agreement (54 µg/L and 41 µg/L, respectively).

4.5 Site Characterization Summary

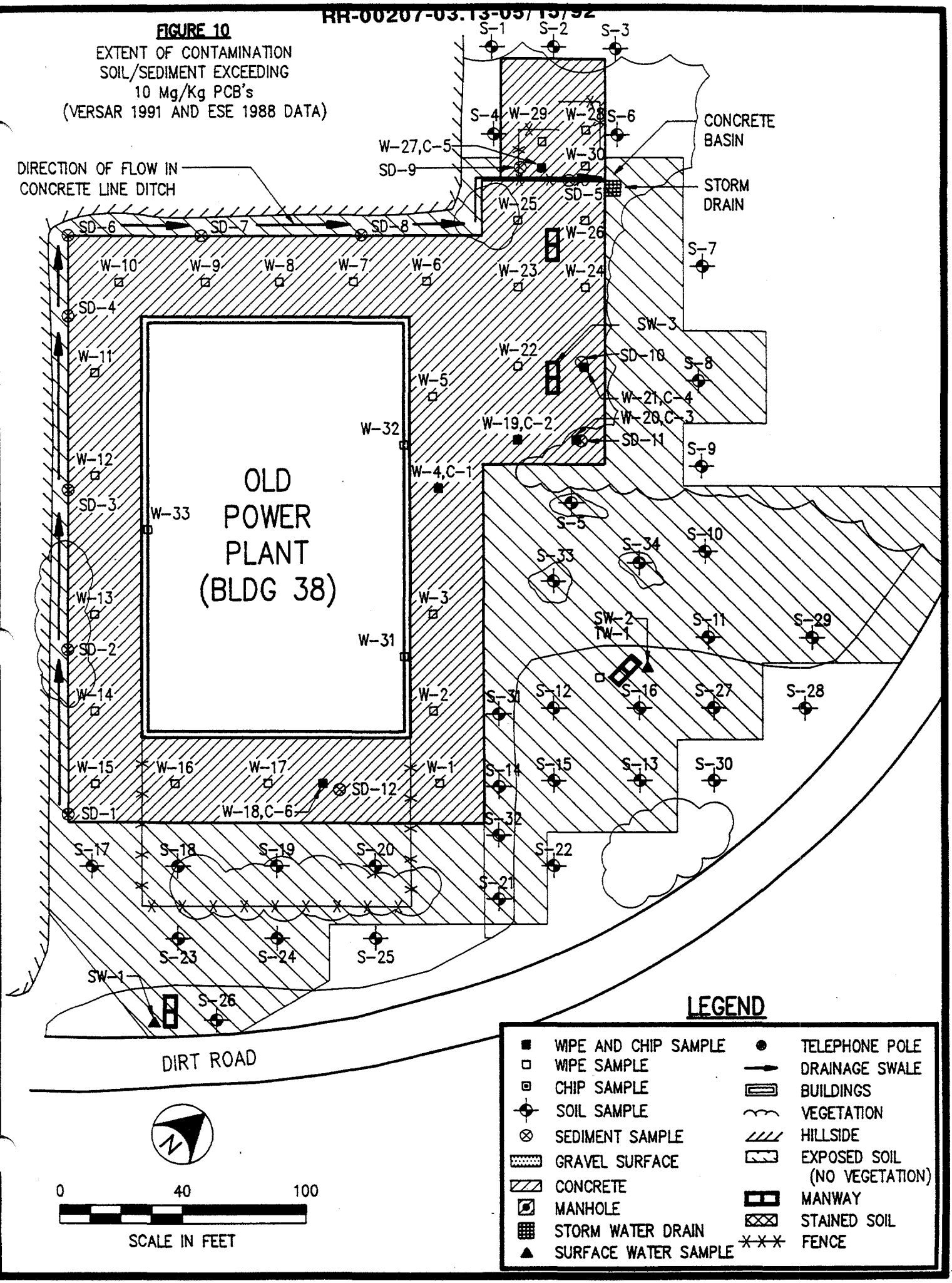
Using the Versar May 1991 data and the data from ESE (1988), areas requiring remediation under the 10 mg/kg TSCA ARAR can be delineated (Figure 10). The outlines of this region is bounded by physical barriers (such as the hillside or roadways) or by sample data showing concentrations of PCBs less than 10 mg/kg at all locations, except RR16S08 and RR16S29 where 40 mg/kg and 30 mg/kg, respectively, were detected.

Confirmatory samples will be required during remedial action to determine whether the coral below the site is extensively contaminated (after the overlying soil has been stripped off). At this time, additional shallow soil samples northeast of RR16S08 and RR16S29 will be required to confirm that all soil exceeding the ARAR has been removed.

Soil and sediment PCB contamination from Site 16 have been adequately defined for remediation of the surficial operable unit to proceed. However, screening sample data collected from the cooling tunnels indicate further investigation of at least three more operable units will be required; these include (1) the tunnel itself, (2) the seawater and sediment at the month of the tunnel intake and outfall, and (3) the USTs located at Site 16. Supplemental RI/FS activities are required to characterize known and potential releases via these subsurface structures. Additionally, the discharge to the storm drain located on site should be determined and sampled. It is likely, given the site's somewhat remote location on base, that the storm drain is connected to the cooling water tunnel, but this cannot be confirmed at this time. Nevertheless, RI activities for the subsurface operable units will not interfere with remediation of contaminated surficial soil and sediments present at Site 16.

Although data from RR16S08 and RR16S29 indicate that some additional soil may need to be removed in the northernmost part of the site, it is unlikely that the amount of additional remediation will require large volumes of soil to be removed, based on the available data on the amount of contaminants spilled, and soil and sediment data from this investigation. Additional remediation requirements are believed to be defined in sufficient detail to be within the +50 to -30 percent accuracy range for the cost estimates within the FS for the soil operable unit.

FIGURE 10
EXTENT OF CONTAMINATION
SOIL/SEDIMENT EXCEEDING
10 Mg/Kg PCB's
(VERSAR 1991 AND ESE 1988 DATA)



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D:\5295\004\FIG-10

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5.0 BASELINE RISK ASSESSMENT

The risk assessment for Site 16 focuses on known site contaminants identified through the field activities conducted as part of the RI and previous investigations (ESE, 1988). The principal contaminants of concern identified during these investigations were PCBs. Aroclor 1260 was found in all samples where PCBs were detected; Aroclor 1254 was found in only one soil sample. Aroclor 1248 was also found in only one soil sample; and Aroclor 1242 was found in only one sediment sample. The Aroclor 1254 sample result was flagged to indicate that the result may be inflated due to analytical interference resulting from a PCB mixture. The Aroclor 1242 sample result was flagged to indicate that the sample suggests the presence of PCB in the quantitation analysis but was not confirmed in the secondary analysis.

Analytical data collected by Versar are presented in Tables 4-1, 4-2, 4-3 and 4-4. The data validation reports are contained in Appendix A. Validated data were used to calculate a mean concentration and a 95-percent upper confidence limit (UCL) around the mean. The 95% UCL concentration indicates that 95 percent of the PCB concentrations at Site 16 will be below this value. This value is used to yield a conservative estimate of risk. It was assumed that PCBs, if not detected in a sample, were present in a sample at one-half the detection limit. This prevents biasing the mean either high or low. Table 5-1 presents the 95 percent UCL concentrations for each media at Site 16.

5.1 Fate and Transport

PCBs are a family of compounds that vary widely in physical, chemical and biological properties. For compounds with fewer than five chlorine atoms per molecule, biodegradation by soil microorganisms appears to be the dominant fate process, resulting in significant destruction and transformation. PCBs with five or more chlorine atom per molecule can be photolyzed with ultraviolet light. This process can be extremely slow; however, it may the most important degradation process for PCBs.

Nondestructive processes that affect the distribution and transport of PCBs are absorption, volatilization and bioaccumulation. In natural water systems, PCBs may be sorbed to the suspended and bed sediments due to their very low solubility in water. PCBs' tendency for absorption increases with the degree of chlorination and organic content of the sorbent. Once bound, the PCBs may persist for years with slow desorption providing continuous, low-level exposure to the surrounding locality. PCB-compounds may also be strongly partitioned and accumulated into biota. When bioaccumulation does occur, most of the absorbed PCBs are stored in the adipose (i.e., fatty) tissue.

TABLE 5-1
STATISTICAL DATA FOR PCBs AT SITE 16
Naval Station Roosevelt Roads

COMPOUND	SOIL 95% UCL (mg/Kg)	SEDIMENT 95% UCL (mg/Kg)	SURFACEWATER 95% UCL (mg/L)
Arachlor 1242	NA	4.24E+00	NA
Arachlor 1248	1.67E+00	NA	NA
Arachlor 1254	2.19E+00	NA	NA
Arachlor 1260	2.50E+01	2.31E+02	5.41E-02

PCBs are relatively inert and, therefore, persistent in the environment. PCBs have low vapor pressures and high log octonol/water partition coefficients. Despite their low vapor pressures, PCBs have a high water activity coefficient and a higher rate of volatilization than might be expected. Volatilization and transport as an aerosol followed by fallout of dust or precipitation is the probable cause of the ubiquitous distribution of PCBs in the environment. At Site 16, PCBs in the soil are localized in the area near building 38 and concrete pads reflecting the nature of site use (i.e., draining and maintenance of transformers). It is very likely that PCB oils leaked onto the ground in the areas where the transformer fluids were changed, and from drips and spills as the transformers were moved from one location to another. The more highly chlorinated species are less volatile than the lighter species. The presence of suspended solids tends to reduce volatilization because the solids absorb PCBs and reduce PCB concentration in solution.

Individual PCBs vary widely in their physical properties according to the degree and position of chlorination. Because PCBs have very low solubilities in water, and a high dielectric constant, they were used widely in industrial processes. Additionally, PCBs have excellent thermal stability and are strongly resistant to oxidation and hydrolysis.

5.2 Exposure Assessment

The objective of this exposure assessment is to estimate the type and magnitude of exposures to the contaminants of concerns on or migrating from the site. This section evaluates exposures for their possibility and plausibility, and quantitatively estimates exposures. For the purposes of this risk assessment, any potential exposures from contaminants inside site buildings will not be included in this risk assessment; the interiors of the buildings are being considered separately, as another operable unit.

An exposure is considered to be complete if all four of the following elements are intact:

(1) a contaminant source and release mechanism
(2) a contaminant migration pathway
(3) an exposure point and mechanism for uptake
(4) a receptor

This section will address these elements with respect to Site 16. The results of this exposure assessment were combined with toxicity information to characterize potential risks.

5.2.1 Identification of Potential Exposure Pathways

This section develops the potential exposure pathways associated with the site. Migration pathways will be identified and evaluated. Exposure point concentrations, chemical intakes and resulting risks can then be estimated.

Several migration pathways are possible for contaminant releases at Site 16. These include air, soil, sediment, and surface water.

5.2.1.1 Air Pathways

There are two pathways for contaminant releases into the air: volatilization and fugitive dust emissions. The sampling locations were screened using a photoionization detector (PID) but no elevated readings were noted. Analyses for volatile compounds were not conducted, and air samples were not collected. Additionally, the site's proximity to the ocean provides for relatively continuously breezy conditions, greatly minimizing the potential for hazardous atmospheres given the soil concentrations observed on site. Therefore, this pathway will not be evaluated.

The second air pathway, the release of fugitive dust particles may be of concern at the site. The soils at the site are characterized as coarse to medium sand. Additionally, the area between the road and Building 38 is unvegetated (Figure 4). The remainder of the site is covered with grasses or other vegetation. The bare portion of the site is potentially amenable to high wind erosion potential; however, as of the writing of this manual, there are no toxicity constants accepted by EPA for the inhalation of PCBs. Therefore, this pathway can not be evaluated at this time.

5.2.1.2 Soil Pathways

Contaminants present in soil may contribute to air contamination via fugitive dust emissions, ground water via infiltration, and surface water via soil erosion and runoff. However, these contributions will probably be insignificant compared to the risks from direct contact with soils through inadvertent ingestion and dermal absorption.

Inadvertent soil ingestion is usually evaluated in the context of children between one and 6 years of age. However, soil ingestion is typically possible for site workers (adult), trespassers (child and adult), and future residents (adult and child) on the site. Although the site is currently part of a naval station, EPA guidance requires that the site be evaluated for risks from residential use either by the Navy, or by a future landowner. Additionally, although

portions of the site are fenced and access is limited to workers at the naval station, the site, for the most part, is not fenced off. Residents and children residing at the naval station could potentially gain access to the site. Exposures would occur by sitting or standing in the sand. These activities will be evaluated for risk to children because they represent the more sensitive population. These scenarios are limited to exposures to surface soils.

Exposures to subsurface soils would be plausible for excavation workers at the site; however, excavation work at the site is expected to be of short duration (i.e., two weeks). Exposures of less than 3 months are difficult to assess. Additionally, subsurface soils are not present at most sampling locations providing a limited database of samples for statistical evaluation. Coral occurs at a depth of approximately one foot over most of the site.

5.2.1.3 Sediment Pathways

There are soil residues and sediments present in the drainage ditches at Site 16. These ditches are open and readily accessible to trespassing children from the naval station. Exposure to contaminants in the sediments could occur via incidental ingestion and dermal absorption. These pathways will be evaluated in the risk assessment. Workers on the site are not expected to have prolonged unprotected contact with the sediments. Also, it can be assumed that the ditches will be filled and replaced with subsurface drains if residences are constructed in the future.

5.2.1.4 Surface Water Pathways

Surface water bodies are not present on the site. There are concrete-lined drainage ditches that periodically collect stormwater; however, these drain quickly and it is unlikely that children would wade there during rainstorms. Also, there are concrete tunnels on Site 16 that drain into Puerca Bay and Ensenada Honda. Fishing has been observed from a Pier in the bay built using the tunnel as support for the pier. Swimming or wading in the bay had not been observed at the time of the field activities. Fish ingestion will be evaluated for both adults and children for Site 16.

5.2.1.5 Ground-water Pathways

As discussed in previous sections of this report, any ground-water contamination will be considered as a separate operable unit, and not evaluated as part of this risk assessment. Although PCBs in soil may migrate slowly into the ground water, site ground water is reportedly saline, and therefore nonpotable (Greenleaf/Telesca, 1984). Therefore, no exposure would take place under current or future scenarios.

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5.2.2 Potentially Significant Exposure Pathways

Based on the discussion above, the following exposure pathways are considered potentially significant and will be evaluated:

1. Direct ingestion of surface soils by trespassing and future on-site residential children

2. Dermal absorption of surface soils by trespassing and future on-site residential children

3. Direct ingestion of surface soils by workers at Site 16

4. Dermal absorption of surface soils by workers on Site 16

5. Direct ingestion of soil/sediments in drainage ditches by trespassing children on Site 16

6. Dermal absorption of soil/sediments in drainage ditches by trespassing children on Site 16

7. Ingestion of fish by residential adults

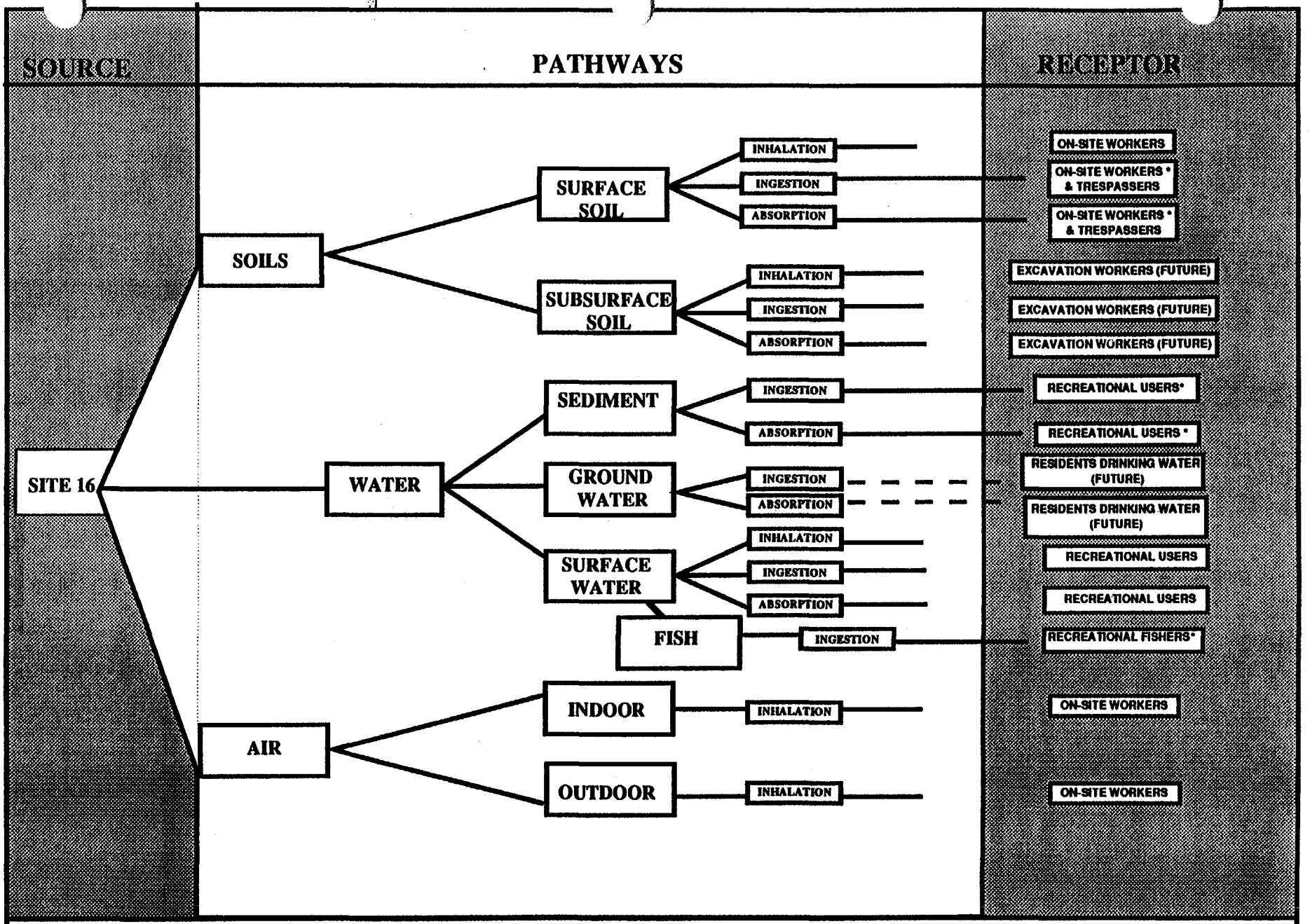
8. Ingestion of fish by residential children

The selection of these exposure pathways is presented in Figure 11

5.2.3 Evaluation of Exposure and Chemical Intakes

This chapter includes detailed descriptions and related calculations that estimate exposure point concentrations for each identified exposure pathway.

The chemical intakes for potential receptors were estimated using the formulas recommended in EPA's Risk Assessment Guidance for Superfund (U.S.EPA, 1989). For each exposure route, intakes were calculated in units of milligrams of chemical per kilogram of body weight on a daily basis. The general equation for this calculation is



NOTES: INCOMPLETE EXPOSURE ROUTES ARE SHOWN BY DASHED LINES FOR INCOMPLETE PATHWAY.
INCOMPLETE LINES DENOTE UNASSESSABLE EXPOSURE ROUTES SINCE INSUFFIECIENT DATA IS AVAILABLE.
ASTERISK (*) DENOTES EXPOSURE ROUTES THAT WERE EVALUATED FOR RISK.

FIGURE 11 EXPOSURE ROUTES AT ROOSEVELT ROADS - SITE 16

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$$I = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

where:

I	=	intake (mg/kg-day),
C	=	chemical contraction at exposure point (mg/kg),
CR	=	contact rate (g/event),
EF	=	exposure frequency (events/year),
ED	=	exposure duration (hours),
BW	=	body weight of exposed individual (kg), and
AT	=	period of time over which exposure is averaged (days).

Additional route-specific terms may be introduced into the equation to account for other important factors such as rates of absorption, percent of chemical absorbed in the body and site soil characteristics.

The values for some of the variables in the intake equations must be assumed. Most of these assumptions are standardized and recommended values are published by EPA in various guidance documents. Other variables are site-related and situation-specific, and must be estimated using best professional judgment. In all cases, conservative values were used to provide an over-estimation of risk, thus, ensuring protection of public health.

5.2.3.1 Surface Soil Ingestion Exposure

The surface soil ingestion scenario was evaluated to consider possible inadvertent ingestion of contaminants in the surface soil by trespassing or future residential children, and by site workers.

Children

Because of the temperate climate for the region, it is feasible that children will be playing on the site year-round either as on-site trespassers from the Naval Station or as future residents.

The equation for estimating intakes via inadvertent soil ingestion is:

$$\text{Intake} = \frac{C_s \times IR \times CF \times EF \times ED}{BW \times AT}$$

where:

C_s = contaminant concentration in soil (mg/kg),
IR = ingestion rate (mg soil/day),
CF = conversion factor (kg soil/mg soil),
EF = exposure frequency (days/year),
ED = exposure duration (years),
BW = body weight (kg), and
AT = averaging time (days).

Values assigned to these variables for children are:

C_s = 95% UCL from Table 5-1
IR = 200 (U.S.EPA, 1991a)
CF = 10^{-6}
EF = 350 (U.S.EPA, 1991a)
ED = 6 (U.S.EPA, 1991a)
BW = 15 (U.S.EPA, 1991a)
AT = 2,190 (U.S. EPA, 1991a)

Table 5-2 shows the input variables and calculations of intakes for trespassing children and children of future on-site residents.

Adult Workers

The soil ingestion equation used for adults would be identical to that used for workers; however, the values assigned to the variables would differ. The values used for the adult worker soil ingestion scenario are as follows:

C_s = 95% UCL from Table 5-1
IR = 100 (U.S.EPA, 1991a)
CF = 10^{-6}
EF = 250 (U.S.EPA, 1991a)
ED = 25 (U.S.EPA, 1991a)
BW = 70 (U.S.EPA, 1991a)
AT = 25,690 (U.S. EPA, 1991a)

Table 5-2 presents dose calculations for adult workers inadvertently ingesting soil.

TABLE 5-2

INCIDENTAL INGESTION OF SOIL (SITE WORKERS)

COMPOUND	Soil Concentration (mg/kg)	Ingestion Rate (mg/day)	Conversion Factor (kg/mg)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Non-Carc Averaging Time (days)	Carcinogenic Averaging Time (days)	Non-Carc CDI (mg/kg-day)	Carcinogenic CDI (mg/kg-day)
Arachlor 1242	NA	100	1E-06	250	25	70	9125	25550	NA	NA
Arachlor 1248	1.67E+00	100	1E-06	250	25	70	9125	25550	1.63E-06	5.84E-07
Arachlor 1254	2.19E+00	100	1E-06	250	25	70	9125	25550	2.14E-06	7.65E-07
Arachlor 1260	2.50E+01	100	1E-06	250	25	70	9125	25550	2.45E-05	8.75E-06

INCIDENTAL INGESTION OF SOIL (CHILDREN)

COMPOUND	Sediment Concentration (mg/kg)	Ingestion Rate (mg/day)	Conversion Factor (kg/mg)	Exposure Frequency (events/year	Exposure Duration (years)	Body Weight (kg)	Non-Carc Averaging Time (days)	Carcinogenic Averaging Time (days)	Non-Carc CDI (mg/kg/day)	Carcinogenic CDI (mg/kg/day)
Arachlor 1242	NA	200	1E-06	350	6	15	2190	25550	NA	NA
Arachlor 1248	1.67E+00	200	1E-06	350	6	15	2190	25550	2.14E-05	1.83E-06
Arachlor 1254	2.19E+00	200	1E-06	350	6	15	2190	25550	2.80E-05	2.40E-06
Arachlor 1260	2.50E+01	200	1E-06	350	6	15	2190	25550	3.20E-04	2.74E-05

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5.2.3.2 Surface Soil Dermal Absorption

Children

Dermal exposure to children would expect to take place at the same frequency as incidental ingestion; therefore all the variables corresponding to exposure duration and frequency are identical. There are a few route-specific variables used in the equation. Skin surface area available for exposure would be hands, arms, and legs. This would total 0.391 m^2, or 3,910 cm^2.

Exposure will also be affected by the soil-to-skin adherence, which is dependent on the amount of clay in the soil. Site soils contain little clay and are made up almost exclusively of sand. Typical adherence factors used are 1.45 mg/cm^2 for commercial potting soil and 2.77 mg/cm^2 for pure kaolin clay. For the purposes of this risk assessment, the soil-to skin adherence value for commercial potting soil (1.45 mg/cm^2) was used as a conservative estimate of soil adherence.

Once soil particles have adhered to the skin, it is unlikely that all of the contaminants will be sorbed from the soil through the skin-cell membranes into the bloodstream. Information on soil absorption through the skin is limited and the intake calculated would be an absorbed dose, not an ingested dose. However, cancer slope factors available in the literature are usually based on ingestion of contaminants, which do not account for absorption through the skin. Therefore, 100 percent absorption from the soil through the skin will be assumed. This also ensures that a conservative estimate of risk will be calculated. The equation for estimating dose via soil absorption is:

$$\text{Intake} = \frac{C_s \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

C_s = contaminant concentration in soil (mg/kg)
CF = conversion factor (kg soil/mg soil)
SA = skin surface area available for contact (cm^2/event)
AF = soil to skin adherence factor (mg soil/cm^2)
ABS = absorption factor (unitless)
EF = exposure frequency (events/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

Values assigned to these variables for children are:

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C_s = 95 percent UCL from Table 5-1
CF = 10^{-6}
SA = 3,910 (U.S. EPA, 1989)
AF = 1.45 (U.S. EPA, 1989)
ABS = 100
EF = 350 (U.S.EPA, 1991a)
ED = 6 (U.S.EPA, 1991a)
BW = 15 (U.S.EPA, 1991a)
AT = 2,190 (U.S. EPA, 1991a)

Table 5-3 shows the input variables and calculations of intakes for trespassing children and children of future on-site residents.

Adult Workers

The same equation is used for children and adults to calculate exposures to soils via dermal absorption; however, assumptions for body weight and exposure times must be adjusted. It can be assumed that site workers will be wearing long pants, eliminating the leg surface area from exposure. The total surface area available for exposure would be from the hands and arms, a total of 0.312 m^2, or 3,120 cm^2. The values assigned to the equation variables for an adult worker are:

C_s = 95% UCL from Table 5-1
CF = 10^{-6}
SA = 3,120 (U.S. EPA, 1989)
AF = 1.45 (U.S. EPA, 1989)
ABS = 100%
EF = 250 (U.S.EPA, 1991a)
ED = 25 (U.S.EPA, 1991a)
BW = 70 (U.S.EPA, 1991a), and
AT = 25,690 (U.S. EPA, 1991a).

Table 5-3 shows the input variables and calculations of intakes for trespassing children and children of future on-site residents.

5.2.3.3 Sediment Ingestion

The sediment ingestion scenario was evaluated to consider possible inadvertent ingestion of contaminants in the sediments by trespassing children.

Because of the temperate climate for the region, it is feasible that children from the Naval Station could play on the site year-round.

TABLE 5-3

DERMAL CONTACT WITH SOIL (SITE WORKERS)

COMPOUND	Soil Concentration (mg/kg)	Conversion Factor (kg/mg)	Skin Surface Area (cm2/event)	Adherance Factor (mg/cm2)	Exposure Frequency (events/year)	Exposure Duration (years)	Absorption Factor (unitless)	Body Weight (kg)	Non-Carc Averaging Time (days)	Carcinogenic Averaging Time (days)	Non-Carc CDI (mg/kg-day)	Carcinogenic CDI (mg/kg-day)
Arachlor 1242	NA	1E-06	3120	1.45	250	25	1	70	9125	25550	NA	NA
Arachlor 1248	1.67E+00	1E-06	3120	1.45	250	25	1	70	9125	25550	7.39E-05	2.64E-05
Arachlor 1254	2.19E+00	1E-06	3120	1.45	250	25	1	70	9125	25550	9.69E-05	3.46E-05
Arachlor 1260	2.50E+01	1E-06	3120	1.45	250	25	1	70	9125	25550	1.11E-03	3.96E-04

DERMAL CONTACT WITH SOIL WHILE TRESPASSING (CHILDREN)

COMPOUND	Soil Concentration (mg/kg)	Conversion Factor (kg/mg)	Skin Surface Area (cm2/event)	Adherance Factor (mg/cm2)	Exposure Frequency (events/year)	Exposure Duration (years)	Absorption Factor (unitless)	Body Weight (kg)	Non-Carc Averaging Time (days)	Carcinogenic Averaging Time (days)	Non-Carc CDI (mg/kg/day)	Carcinogenic CDI (mg/kg/day)
Arachlor 1242	NA	1E-06	3910	1.45	350	6	1	15	2190	25550	NA	NA
Arachlor 1248	1.67E+00	1E-06	3910	1.45	350	6	1	15	2190	25550	6.05E-04	5.19E-05
Arachlor 1254	2.19E+00	1E-06	3910	1.45	350	6	1	15	2190	25550	7.94E-04	6.80E-05
Arachlor 1260	2.50E+01	1E-06	3910	1.45	350	6	1	15	2190	25550	9.08E-03	7.78E-04

The equation for estimating intakes via inadvertent sediment ingestion is:

$$\text{Intake} = \frac{C_s \times IR \times CF \times EF \times ED}{BW \times AT}$$

where:

C_s = contaminant concentration in sediment (mg/kg)
IR = ingestion rate (mg soil/day)
CF = conversion factor (kg sediment/mg sediment)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

Values assigned to these variables for children are:

C_s = 95% UCL from Table 5-1
IR = 200 (U.S.EPA, 1991a)
CF = 10-6
EF = 350 (U.S.EPA, 1991a)
ED = 6 (U.S.EPA, 1991a)
BW = 15 (U.S.EPA, 1991a)
AT = 2,190 (U.S. EPA, 1991a)

Table 5-4 shows the input variables and calculations of intakes for trespassing children via the sediment ingestion scenario.

5.2.3.4 Sediment Dermal Absorption

The same assumptions used for the dermal absorption of soils can be used for the sediments. Sediments from Site 16 are derived from the site soils.

Values assigned to the dermal absorption equation variables for children are:

C_s = 95% UCL from Table 5-1
CF = 10^{-6}
SA = 3,910 (U.S. EPA, 1989)
AF = 1.45 (U.S. EPA, 1989)
ABS = 100%
EF = 350 (U.S.EPA, 1991a)
ED = 6 (U.S.EPA, 1991a)
BW = 15 (U.S.EPA, 1991a)
AT = 2,190 (U.S. EPA, 1991a)

TABLE 5-4

INCIDENTAL INGESTION OF STREAM SEDIMENTS (CHILDREN)

COMPOUND	Sediment Concentration (mg/kg)	Ingestion Rate (mg/day)	Conversion Factor (kg/mg)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Non-Carc Averaging Time (days)	Carcinogenic Averaging Time (days)	Non-Carc CDI (mg/kg/day)	Carcinogenic CDI (mg/kg/day)
Arachlor 1242	4.24E+00	200	1E-06	350	6	15	2190	25550	5.42E-05	4.65E-06
Arachlor 1248	NA	200	1E-06	350	6	15	2190	25550	NA	NA
Arachlor 1254	NA	200	1E-06	350	6	15	2190	25550	NA	NA
Arachlor 1260	2.31E+02	200	1E-06	350	6	15	2190	25550	2.95E-03	2.53E-04

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Table 5-5 shows the input variables and calculations of intakes for trespassing children from dermal absorption of sediments.

5.2.3.5 Fish Ingestion

The fish ingestion scenario is evaluated to consider possible ingestion of fish of adults and children that reside near Site 16.

Children

The equation for estimating intakes via fish ingestion is:

$$\text{Intake} = \frac{C_\tau \times IR \times CG \times EF \times ED}{BW \times AT}$$

where:

C^τ	=	contaminant concentration is surface water (mg/kg)
IR	=	ingestion rate (mg fish/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

Values assigned to these variable for children are:

C_τ	=	95% UCL form Table 5-1
IR	=	0.0125 (***)
EF	=	350 (U.S. EPA, 1991a)
ED	=	6 (U.S. EPA, 1991a)
BW	=	15 (U.S. EPA, 1991a)
AT	=	2,190 (U.S. EPA, 1991a)

Table 5-6 shows the input variables and calculations of intakes for children.

Adults

The fish ingestion for adults would be identical to that used for children; however, the values assigned to the variables would differ. The values used for the adults fish ingestion scenario are as follows:

TABLE 5-5

DERMAL CONTACT WITH STREAM SEDIMENT WHILE RECREATING (CHILDREN)

COMPOUND	Sediment Concentration (mg/kg)	Conversion Factor (kg/mg)	Skin Surface Area (cm2/event)	Adherance Factor (mg/cm2)	Exposure Frequency (events/year)	Exposure Duration (years)	Absorption Factor (unitless)	Body Weight (kg)	Non-Carc Averaging Time (days)	Carcinogenic Averaging Time (days)	Non-Carc CDI (mg/kg-day)	Carcinogenic CDI (mg/kg-day)
Arachlor 1242	4.24E+00	1.00E-06	3910	1.45	350	6	1	15	2190	25550	1.54E-03	1.32E-04
Arachlor 1248	NA	1.00E-06	3910	1.45	350	6	1	15	2190	25550	NA	NA
Arachlor 1254	NA	1.00E-06	3910	1.45	350	6	1	15	2190	25550	NA	NA
Arachlor 1260	2.31E+02	1.00E-06	3910	1.45	350	6	1	15	2190	25550	8.36E-02	7.17E-03

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C^{τ} = 95% UCL from Table 5-1
IR = 0.0125 (***)
EF = 350 (U.S. EPA, 1991a)
ED = 30 (U.S. EPA 1991a)
BW = 15 (U.S. EPA, 1991a)
AT = 10950 (***)

Table 5-6 show dose calculations for adults ingesting fish.

5.3 Toxicity Assessment

The objective of this toxicity assessment is to provide a summary of the potential health and environmental hazards that may be associated with PCBs at Site 16 at Roosevelt Roads Naval Station through the exposure routes identified in the previous section of this report. Available information concerning human health effects and environmental toxicity were included for PCBs. Aroclor-specific information was also included where applicable.

It is not the intent of this section to provide a comprehensive summary of all toxicological information; rather, it provides a summary of available information at the time as it relates to the exposure scenarios evaluated in this report. The complete IRIS listing for PCBs is given in Appendix D.

5.3.1 Chemical Characteristics

Polychlorinated biphenyls (PCBs) constitute a large class of compounds produced by the partial (or complete) chlorination of the biphenyl molecule (U.S. EPA, 1976). Commercial PCBs are mixtures of isomers of chlorinated biphenyls exhibiting varying degrees of chlorination.

5.3.2 Noncancer Toxicity

PCBs have a low acute toxicity, but because of their high absorption rate, high lipid solubility, low water solubility, and relative chemical inertness, PCBs tend to concentrate in the food chain, accumulate in body fat, persist in biological tissue, and show persistent toxicity (U.S. EPA, 1976).

The major routes of entry of PCBs into the human body are inhalation, ingestion, and absorption. Studies have shown that all routes have approximately the same affects on the body. The majority of these studies have been on animals, predominantly mice and rats, as well as guinea pigs and monkeys. The classical pathological changes in the liver of animals

TABLE 5-6

FISH INGESTION (ADULT)

COMPOUND	95% UCL Surface Water Concentration (mg/L)	BCF (L/kG)	Amount Ingested (Kg/Day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Carcinogenic Averaging Time (days)	Non-Carcinogenic Averaging Time (days)	Carcinogenic Adult CDI (mg/kg-day)	Non-Carcinogenic Adult CDI (mg/kg-day)
Arachlor 1242	NA	1.00E+05	0.0125	350	30	70	25550	10950	NA	NA
Arachlor 1248	NA	1.00E+05	0.0125	350	30	70	25550	10950	NA	NA
Arachlor 1254	NA	1.00E+05	0.0125	350	30	70	25550	10950	NA	NA
Arachlor 1260	0.05413	1.00E+05	0.0125	350	30	70	25550	10950	3.97E-01	9.27E-01

FISH INGESTION (CHILDREN)

COMPOUND	95% UCL Surface Water Concentration (mg/L)	BCF (L/kG)	Amount Ingested (Kg/Day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Carcinogenic Averaging Time (days)	Non-Carcinogenic Averaging Time (days)	Carcinogenic Children CDI (mg/kg-day)	Non-Carcinogenic Children CDI (mg/kg-day)
Arachlor 1242	NA	1.00E+05	0.0125	350	6	15	25550	2190	NA	NA
Arachlor 1248	NA	1.00E+05	0.0125	350	6	15	25550	2190	NA	NA
Arachlor 1254	NA	1.00E+05	0.0125	350	6	15	25550	2190	NA	NA
Arachlor 1260	5.41E-02	1.00E+05	0.0125	350	6	15	25550	2190	3.71E-01	4.33E+00

exposed to PCBs include infiltration of fat, increased cell and liver size, degeneration of cellular contents, and ultimately cell death. The latent nature of these effects is demonstrated by the fact that most severe histopathology known occurred 5 to 13 weeks after PCB ingestion has ceased. PCBs have also been shown to enhance the effects of other carcinogens in mice and rats.

In humans exposed to PCBs in the work place or through accidental contamination of food, reported adverse effects include chloracne (a long-lasting disfiguring skin disease), impairment of liver function, a variety of neurobehavioral and affective symptoms, menstrual disorders, and minor birth abnormalities. There is inadequate, yet suggestive, evidence of excess liver cancer in humans by ingestion, inhalation, or dermal contact.

5.3.2.1 Animal Studies

Animal studies have demonstrated that the potencies of the individual compounds vary according to the degree and position of chlorination. A study of rhesus monkeys was performed in 1974 and included the feeding of 25 ppm of Aroclor 1248 for two months. The average total intake of PCBs was approximately 250 mg. The effects on all the monkeys included facial swelling, liver necrosis and reproductive inability. Additionally, reproductive and neurobiological effects were reported at the lowest dose level tested, 11 µg/kg body weight/day over a period of several months. The surviving monkeys continued to have high adipose tissue levels, acne, tissue swelling and hair loss two years after this short term, low level exposure (U.S. EPA, 1972).

Dermal toxicity studies have been performed on rabbits using technical PCB samples which contained an average of 60 percent chlorine. Studies have shown lesions of the skin, liver, and kidneys in the rabbits. Studies have also shown possible immunosuppressive effects in rabbits (U.S. EPA, 1972).

PCBs have been shown to affect reproduction in several different species. Egg production, egg hatchability, and shell thickness were decreased by feeding low levels of various PCB mixtures to chickens (U.S. EPA, 1972). Female rats fed 20 ppm of Aroclor 1254 had a decrease in the number of litters and litter size. In a two-generation study, 5 ppm was the no effect level for rat reproduction. Higher dietary levels caused decreased rat offspring survival and decreased mating performance. Even at 1 ppm, male rats were born with enlarged livers. In another study, levels as low as 2.5 ppm resulted in a marked decrease in the ability of monkeys to conceive.

A more recent study of occurred in 1981 at the State Office Building in Binghamton, New York. Electrical arcing and explosions caused the leakage of PCBs from an electrical transformer. Between 180 and 200 gallons of fluid containing Aroclor 1254 leaked from the transformer and was burned in the resulting fire. Toxicological studies using the soot from the Binghamton State Office Building showed that chick embryo teratogenicity and fetal lethality tests were positive. Liver ultrastructural changes were seen at all dose levels in one oral dose study in guinea pigs. These studies of the soot produced a LD50 value of 410 mg/kg. Dermal applications of the saline-moistened soot were administered to rabbits. Dermal inflammatory reactions were noted. The dermal minimum lethal dose in rabbits is from 1.26 to 2.00 g/kg (NIOSH, 1986).

PCBs are bioaccumulated and can be biomagnified; therefore, their toxicity increases with the length of exposure and place of the exposed species in the food chain. The toxicity of the various PCB mixtures is also dependent on their composition. There is some evidence that mixtures containing more highly chlorinated biphenyls are more potent inducers of hepatocellular carcinoma in rats than mixtures containing less chlorine by weight (IRIS, 1991b).

Three primary ways that PCBs can affect terrestrial wildlife are by inducing outright mortality, adversely affecting reproduction, and by changing behavior. PCBs generally can cause mortality in all species depending on the length and level of exposure. Some mammalian species are especially sensitive to PCBs. PCBs have caused lower egg production, eggshell thinning, increased deformities, decreased hatchability, decreased growth and an increase in mortality in birds (Clement, 1985).

5.3.2.2 Human Episodes

A few cases of human exposure to PCBs have been noted. In 1968 in Yusho, Japan, a PCB containing 48 percent chlorine, had leaked into rice oil and was subsequently consumed by approximately 1,000 persons. The exposure levels calculated were approximately 15,000 mg/day. The average total dose causing an effect in these victims were reported at 2000 mg. The lowest level that produced human effect was reported at 500 mg (U.S. EPA, 1976).

The affects of the exposure included chloracne, pigmentation of skin and nails, weight loss, and fetal toxicity. Symptoms such as transient visual disturbance, feeling of weakness, numbness of limbs, and headache, are signs of damage to the nervous system.

In 1969 and 1970, 159 patients were examined. It was found that 50 percent still showed no clinical improvement. This shows an indication of persistence of PCBs in the human body (U.S. EPA, 1976).

Initial findings for the Binghamton State Office Building PCB fire recorded PCB air levels 80 µg/m3, in soot found in stairwells of 10 percent by weight, in soot found on the floor of 2,000 to 4,700 µg/m3. A voluntary medical surveillance of 50 of the 500 people believed to be exposed, showed chloracne, transient skin rashes, skin cancers, liver pathology, nervousness, irritability, difficulty sleeping, and fatigue (Schecter and Tiernan, 1985).

PCBs have been shown in studies to affect the human body by impairment of liver function, a variety of neurobehavioral symptoms, and affective symptoms. PCBs are bioaccumulated and can be biomagnified. Therefore, their toxicity increases with length of exposure. Toxicity of the PCBs mixtures also depends on their composition. There is some evidence that the mixtures containing more highly chlorinated biphenyls are more potent inducers of hepatocellular carcinoma in rats than mixtures containing less chlorine by weight.

5.3.3 Carcinogenicity

Evidence suggests that polychlorinated biphenyl mixtures containing more highly chlorinated biphenyls are more potent inducers of hepatocellular carcinoma in rats than mixtures containing less chlorine by weight. This may prove that the toxicity of PCB mixtures may be dependant on their composition.

Adenofibrosis has been reported in some studies. Abnormal growth and development of the gastric mucosa has also been reported, further evidence of the carcinogenic potential of PCBs.

The Health Effects Assessments Summary (HEAS) list PCBs in the carcinogenicity Table (EPA, 1990). Table B of HEAS states that PCBs are a potential carcinogen by means of inhalation and oral exposures. Oral exposure has shown that rats being fed a diet of Aroclor 1254 for 6 and 11 months have demonstrated adenofibrosis. In a second study, female Sherman Strain rats were fed 100 ppm of Aroclor 1260 for approximately 21 months. This study concluded that Aroclor 1260 had a hepatocarcinogenic effect in these rats (U.S. EPA, 1976).

The EPA has assigned a drinking water unit risk value for PCBs of 2.2E-4 µg/l and a value for human exposure of 4.3396 $(mg/kg\text{-}day)^{-1}$. The slope factor for PCBs is 7.7 $(mg/kg\text{-}day)^{-1}$ (IRIS, 1990). The case for the carcinogenic association of PCB exposure with human

inhalation still needs conclusive evidence. The EPA classifies PCBs in Group B2, a probable human carcinogen. This classification indicates there is sufficient evidence of carcinogenicity in animals, but inadequate evidence of carcinogenicity in humans.

5.4 Risk Characterization

The objective of this risk assessment is to combine information on exposures and toxicity to evaluate potential human health risks associated with NAVSTA Roosevelt Roads Site 16. This section begins with a discussion and presentation of risk calculations for noncarcinogenic and carcinogenic effects of PCBs. These risks will be summed for each receptor group. The two receptor groups identified in this risk assessment are trespassing children and site workers. The site risks associated with each receptor population will be discussed in the following section.

5.4.1 Noncarcinogenic Contaminants

Noncarcinogenic impacts of chemicals on human health are evaluated by comparing projected or estimated intakes to reference levels for chemicals of concern. A reference level represents an exposure level at which there should be no observable adverse affects associated with a chemical. Reference doses (RfD) are the currently accepted human reference levels for noncarcinogenic effects. RfDs can be obtained from many sources. An RfD for PCBs was not available through IRIS or the HEAS Tables (EPA, 1990). Because PCBs have been identified as the principal contaminant of concern at Site 16, it is important that both carcinogenic and noncarcinogenic effects are assessed. The RfD value used in this risk assessment was obtained from a study of adverse affects of PCB-contaminated fish, and is currently under consideration by EPA for inclusion in the IRIS data base.

As of this writing, there is no RfD developed for inhalation exposures. Exposures via ingestion and absorption were considered to be chronic (i.e., small doses over a long time period) rather than subchronic (i.e., large doses over a short period of time).

Emphasis on subchronic risks has waned since U.S. EPA first introduced guidance for quantifying subchronic risks in 1986. Consequently, many subchronic RfDs have been repealed, and valid subchronic RfDs are only available for a few chemicals. Furthermore, the nature of the site and the work done make it more likely for chronic exposures to occur. Therefore, risks for subchronic exposures were not evaluated. Table 5-7 summarizes the toxicity values used in this risk assessment.

TABLE 5-7

TOXICITY VALUES FOR PCB ARACHLOR MIXTURES

COMPOUND	INHALATION RfC	INHALATION SF	ORAL RfD	ORAL SF
Arachlor 1242	NA	NA	1.00E-04 *	7.70E+00
Arachlor 1248	NA	NA	1.00E-04 *	7.70E+00
Arachlor 1254	NA	NA	1.00E-04 *	7.70E+00
Arachlor 1260	NA	NA	1.00E-04 *	7.70E+00

* Value obtained from Dourson and Clark, 1990.

To determine if there is an unacceptable noncarcinogenic risk posed by Site 16, the calculated chronic daily doses (CDI) were compared to the RfD in the following manner:

$$\text{Hazard Index} = \frac{CDI_{PCB}}{RfD_{PCB}}$$

If the quotient exceeds one, there is unacceptable noncarcinogenic risk posed by Site 16 and there is a potential for adverse health effects on human health.

Tables 5-8, 5-9, and 5-10 present the noncarcinogenic risk calculations for each of the receptor groups evaluated in each media.

5.4.1.1 Children

The stream sediment hazard index and the soil hazard index for both incidental ingestion and dermal contact exceeded the threshold value of 1. Consequently, adverse effects may be experienced as a result of soil or stream sediment dermal absorption or incidental ingestion. This is a conservative estimate of noncarcinogenic risk and actual risk amy be several orders of magnitude lower.

5.4.1.2 Site Workers

The soil hazard index from the dermal absorption pathway was slightly above the threshold value of 1. Consequently, adverse health effects may be experienced as a result of dermal absorption from soil. This is a conservative estimate of noncarcinogenic risk and actual risk may be several orders of magnitude lower.

5.4.2 Carcinogenic Risk

Carcinogenic risk values are generally expressed in scientific notation. An individual lifetime risk of 1 in 10,000 is represented as 1.0E-04. Lifetime daily doses (LADEs) are multiplied by the carcinogenic potency factor (CPF for that chemical. Carcinogenic risk is determined by the following equation:

$$\text{Risk} = LADE_{PCB} \times CPF_{PCB}$$

The impact of carcinogenic contaminants is assessed by comparing calculated risk to the acceptable range. The acceptable range of risks is 1.0E-04 to 1.0E-06.

TABLE 5-8

STREAM SEDIMENT HAZARD INDICES (CHILDREN)

COMPOUND	Sediment Incidental Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	Sediment Dermal Contact CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Arachlor 1242	5.42E-05	1.00E-04	5.42E-01	1.54E-03	1.00E-04	1.54E+01
Arachlor 1248	NA	1.00E-04	NA	NA	1.00E-04	NA
Arachlor 1254	NA	1.00E-04	NA	NA	1.00E-04	NA
Arachlor 1260	2.95E-03	1.00E-04	2.95E+01	8.36E-02	1.00E-04	8.66E+02

TABLE 5-9

SOIL HAZARD INDICES (ADULTS)

COMPOUND	Dermal Contact CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	Soil Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Arachlor 1242	NA	1.00E-04	NA	NA	1.00E-04	NA
Arachlor 1248	7.39E-05	1.00E-04	7.39E-01	1.63E-06	1.00E-04	1.63E-02
Arachlor 1254	9.69E-05	1.00E-04	9.69E-01	2.14E-06	1.00E-04	2.14E-02
Arachlor 1260	1.11E-03	1.00E-04	1.11E+01	2.45E-05	1.00E-04	2.45E-01
	Absorption Hazard Index =		1.11E+01	Ingestion Hazard Index =		2.45E-01

SOIL HAZARD INDICES (CHILDREN)

COMPOUND	Dermal Contact CDI (mg/kg/day)	Oral RfD (mg/kg/day)	Hazard Index (Intake/RfD)	Soil Inhalation CDI (mg/kg/day)	Oral RfD (mg/kg/day)	Hazard Index (Intake/RfD)
Arachlor 1242	NA	1.00E-04	NA	NA	1.00E-04	NA
Arachlor 1248	6.05E-04	1.00E-04	6.05E+00	2.14E-05	1.00E-04	2.14E-01
Arachlor 1254	7.94E-04	1.00E-04	7.94E+00	2.80E-05	1.00E-04	2.80E-01
Arachlor 1260	9.08E-03	1.00E-04	9.08E+01	3.20E-04	1.00E-04	3.20E+00
	Absorption Hazard Index =		9.08E+01	Ingestion Hazard Index =		3.20E+00

TABLE 5-10

SURFACE WATER HAZARD INDICES (ADULTS)

COMPOUND	Surface Water Fish Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Arachlor 1242	NA	1.00E-04	NA
Arachlor 1248	NA	1.00E-04	NA
Arachlor 1254	NA	1.00E-04	NA
Arachlor 1260	9.27E-01	1.00E-04	9.27E-05
	Ingestion Hazard Index =		9.27E-05

SURFACE WATER HAZARD INDICES (CHILDREN)

COMPOUND	Surface Water Fish Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Arachlor 1242	NA	1.00E-04	NA
Arachlor 1248	NA	1.00E-04	NA
Arachlor 1254	NA	1.00E-04	NA
Arachlor 1260	4.33E+00	1.00E-04	4.33E-04
	Ingestion Hazard Index =		4.33E-04

Tables 5-11, 5-12, and 5-13 present the carcinogenic risk calculations for each receptor group in each media.

5.4.2.1 Children

The carcinogenic risks for all scenarios were above IE-04. Carcinogenic risks ranged from 2.11E-04 (soil ingestion) to 2.85E00 (fish ingestion). The highest risk was for orders of magnitude above the acceptable level.

5.4.2.2 Site Workers

Carcinogenic risks were above the acceptable level of IE-04 for the dermal contact and fish ingestion scenarios. Carcinogenic risks ranged from 6.74E-05 (soil ingestion) to 3.06E00 (fish ingestion).

5.4.3 Uncertainties

There are a number of uncertainties associated with risk estimates. These uncertainties are introduced because of (1) the need to extrapolate below the dose range of experimental tests using animals, (2) the variability of the receptor population, (3) assumed equivalency of dose-response relationships between animals and humans, (4) differences in experimental exposure routes (i.e., gavage) versus exposure routes expected on site and (5) sampling error in the environmental sampling data used to make the calculations. In addition to chemical concentration, route and duration of exposure, there are many other factors which may influence the likelihood of developing adverse health effects. These include differences between individual nutritional health and status, age, sex, inherited characteristics, and recreational habits (e.g., smoking vs. non-smoking) that may affect susceptibility.

5.5 Environmental Assessment

NAVSTA Roosevelt Road is located on the east coast of Puerto Rico, bounded by private and public lands, the Caribbean Sea and offshore islands and keys. The total area of the station is 8055.5 acres, approximately 70 percent available for fish and wildlife management. Station acreage is defined as follows:

> 30% improved: includes areas actively utilized for housing, administration, air operations, surface operations and other ancillary facilities;

TABLE 5-11

CARCINOGENIC RISK ESTIMATES FROM STREAM SEDIMENTS (CHILDREN)

COMPOUND	Sediment Incidental Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	Sediment Dermal Contact CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)
Arachlor 1242	5.42E-05	7.70E+00	4.17E-04	1.32E-04	7.70E+00	1.01E-03
Arachlor 1248	NA	7.70E+00	NA	NA	7.70E+00	NA
Arachlor 1254	NA	7.70E+00	NA	NA	7.70E+00	NA
Arachlor 1260	2.95E-03	7.70E+00	2.27E-02	7.17E-03	7.70E+00	5.52E-02
	Incidental Ingestion Carc. Risk =		2.27E-02	Absorption Carc. Risk =		5.52E-02

TABLE 5-12

CARCINOGENIC RISK ESTIMATES FOR SOIL (ADULTS)

COMPOUND	Dermal Contact CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	Soil Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)
Arachlor 1242	NA	7.70E+00	NA	NA	7.70E+00	NA
Arachlor 1248	2.64E-05	7.70E+00	2.03E-04	5.84E-07	7.70E+00	4.49E-06
Arachlor 1254	3.46E-05	7.70E+00	2.67E-04	7.65E-07	7.70E+00	5.89E-06
Arachlor 1260	3.96E-04	7.70E+00	3.05E-03	8.75E-06	7.70E+00	6.74E-05
	Absorption Carcinogenic Risk =		3.05E-03	Ingestion Carcinogenic Risk =		6.74E-05

CARCINOGENIC RISK ESTIMATES FOR SOIL (CHILDREN)

COMPOUND	Dermal Contact CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	Soil Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)
Arachlor 1242	NA	7.70E+00	NA	NA	7.70E+00	NA
Arachlor 1248	6.05E-04	7.70E+00	4.66E-03	1.83E-06	7.70E+00	1.41E-05
Arachlor 1254	7.94E-04	7.70E+00	6.11E-03	2.40E-06	7.70E+00	1.85E-05
Arachlor 1260	9.08E-03	7.70E+00	6.99E-02	2.74E-05	7.70E+00	2.11E-04
	Absorption Carcinogenic Risk =		6.99E-02	Ingestion Carcinogenic Risk =		2.11E-04

TABLE 5-13

CARCINOGENIC RISK ESTIMATES
FROM SURFACE WATER (ADULTS)

COMPOUND	Surface Water Fish Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)
Arachlor 1242	NA	7.70E+00	NA
Arachlor 1248	NA	7.70E+00	NA
Arachlor 1254	NA	7.70E+00	NA
Arachlor 1260	3.97E-01	7.70E+00	3.06E+00
	Ingestion Carcinogenic Risk		3.06E+00

CARCINOGENIC RISK ESTIMATES
FROM SURFACE WATER (CHILDREN)

COMPOUND	Surface Water Fish Ingestion CDI (mg/kg-day)	CPF 1/(mg/kg-day)	Chemical-specific Risk (Intake*CPF)
Arachlor 1242	NA	7.70E+00	NA
Arachlor 1248	NA	7.70E+00	NA
Arachlor 1254	NA	7.70E+00	NA
Arachlor 1260	3.71E-01	7.70E+00	2.85E+00
	Ingestion Carcinogenic Risk		2.85E+00

12% semi-improved: includes small arms ranges, unpaved access roads, and improved areas that have been abandoned;

58% unimproved.

There are four ecosystems present on the base: tidal forests predominated by mangroves, coral reef associations, drywood coastal forests found in high relief areas in semi-improved or unimproved associations, and grassbeds present on improved and maintained semi-improved areas. Over 10 percent of Puerto Rico's mangrove forests are found on NSRR.

The station also contains various marine ecosystems, generally characterized as coral reef associations and seagrass associations. The coral reefs at NSRR are made of both stony and soft corals and utilized by a tremendous variety of marine fish.

Approximately 600 acres of seagrass beds, consisting of turtlegrass and manatee grass are common in the clear shallow embankments off NSRR. These plants serve as food and cover for marine vertebrates and invertebrates.

The wide variety of habitat and temperate climate support a large number of species. Table 5-14 lists the fish species found on NSRR. Table 5-15 presents a detailed species list of the avifauna found on NSRR as developed by the U.S. Fish and Wildlife Service (FWS 1978).

The station supports a variety of federally protected biota that have been listed pursuant to the Rare and Endangered Species Act of 1973. These species are presented in Table 5-16. The entire station has been designated as "critical habitat" for the Yellow-Shouldered Blackbird (Agelaius xanthomus). "Critical habitat" are areas considered vital to the continued existence and well-being of a given species. Yellow-shouldered blackbirds are endangered due to several factors, including contagious disease, lack of mangrove nesting areas free from rodent predation, and nest parasitization by other bird species (U.S. Fish and Wildlife, 1978).

Puerto Rico's major concentration of the West Indian manatees (Trichechus manatus manatus) is found within the station's waters.

Marine turtles have been sighted by coral reefs and grassbeds. All marine turtles, except the green sea turtle, have been listed as rare and endangered (U.S. Fish and Wildlife, 1978).

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TABLE 5-14 Fish in the Mangrove of Naval Station Roosevelt Roads	
Stingrays (Dasyatidae)	
Dasyatis americana	Southern Stingray
Aetobatis narinari	Spotted Eagle Bay
Tarpons (Elopidae)	
Megalops atlanticus	Tarpon
Herrings (Clupeidae)	
Opistahonema oglium	Thread Herring
Herengula humeralis	Red Ear Sardine
Lizardfishes (Synodontidae)	
Synodus interdedius	Sand Diver
Needlefishes (Belonidae)	
Stongylura timucu	Timucu
Mullets (mugilidae)	
Mugil curema	White Mullet
Great Barracuda (Sphyraenidae)	
Sphyraena barracuda	Great Barracuda
Threadfins (Polynemidae)	
Polydactilus virginicus	Barbu
Groupers (Surranidae)	
Epinephelus striatus	Nassau Grouper
Fairy Basslets (Grammidae)	
Fairy basslets	Gramma Loreto
Snook (Centropomidae)	
Centorpomus undecimalis	Snook
Halfbeaks (Hemiramphidae)	
Hemirampus balao	Balao
Jacks (Carangidae)	

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TABLE 5-14 Fish in the Mangrove of Naval Station Roosevelt Roads	
Caranx fusus	Blue Runner
Carans latus	Horse-eye Jack
Oligophlites saurus	Leather jacket
Snappers (Lutjanidae)	
Lutjamus apodus	Schoolmaster
Lutjamus jocu	Dog Snapper
Lutjamus mahogoni	Mahogany Snapper
Ocyurus chysurus	Yellowtail Snapper
Grunts (Pomadasydae)	
Haemulon sciurus	Bluestripped Grunt
Haemulon flavolineatun	French Grunt
Haemulon macrostomum	Spanish Grunt
Anisotremus virginicus	Porkfish
Porgies (Sparidae)	
Archosarqus rhomboidalis	Sea Bream
Mojarras (Gerreidae)	
Gerres cinereus	Yellowfin Mojarra
Eucinostomus lefroyi	Mottled Mojarre
Spadefish (Ephippidae)	
Chaetodlipterus faber	Spadefish
Scorpionfishes (Scorpaenidae)	
Scorpaena plumeri	Spotted Scorpionfish
Flying Gurnards (Dactylopteridae)	
Dactylopterus volitans	Flying Gunard
Butterflyfishes (Chaetodontidae)	
Chaetoclon capistratus	Foureye Butterflyfish
Damselfishes (Pomacentridae)	

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TABLE 5-14 Fish in the Mangrove of Naval Station Roosevelt Roads	
Eupomacentrus fuscus	Dusky Danselfish
Eupomacentrus leucostictus	Beau Gregory
Abuclefcluf saxatillis	Sergeant Major
Wrasses (Labridae)	
Lachnollaimus maximus	Hogfish
Halichoeres burittatus	Slippery Dick
Halichoeres poeyi	Black-ear Wrasse
Thallasoma bifasciatum	Bluehead
Parrotfishes (Scaridae)	
Sparisoma rubrippine	Yellowtail Parrotfish
Sparisoma aurofrenatum	Redband Parrotfish
Scarus guacamaia	Rainbow Parrotfish

Source: Puerto Rico Department of Natural Resources

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TABLE 5-15

Birds of Naval Station Roosevelt Roads

1. Pied-billed Grebe, Podilymbus podicaps
   Red-billed Tropicbird, Phaethon aethereus (2)
   Brown Pelican, Pelecanus occidentalis (4)
   Brown Booby, Sula leucogaster

2. Magnificent Frigatebird, Fregata magnificens
   Great Blue Heron, Ardea herodias (3)
   Louisiana Heron, Hydranassa tricolor B
   Snowy Egret, Egretta thula B (3)
   Great Egret, Egretta alba B(3)

3. Green Heron, Butorides virescens B
   Little Blue Heron, Florida caerulea B
   Cattle Egret, Bubulcus ibis
   Least Bittern, Ixobrychus exilis B
   Yellow-crowned Night Heron, Nyctanassa violacea B

4. Black-crowned Night Heron, Nycticorax (2)
   Bahama Pintail, Anas Bahamensis B (1)
   Blue-winged Teal, Anas discors
   American Widgeon, Anas americana
   Red-tailed Hawk, Buteo jamaicensis B

5. Osprey, Pandion haliaetus B (3)
   Merlin, Falco columbarious
   Clapper Rail, Rallus longirostris B
   American Coot, Fulica americana
   Caribbean Coot, Fulica caribaea B (3)

6. Common Gallinule, Gallinula chloropus B
   Piping Plover, Charadrius melodus
   Semipalmated Plover, Charadrius semipalmatus
   Black-bellied Ployer, Squatarola
   Wilson's Plover, Charadrius wilsonia B

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7. Killdeer, Charadrius vociferus B
   Ruddy Turnstone, Arenaria interpres
   Black-necked stilt, Himantopus B
   Whimbrel, Numenius phaeopus (2)
   Spotted Sandpiper, Actitis macularia

8. Semipalmated Sandpiper, Calidris pusilla
   Short-billed dowitcher, Limnodromus griseus (3)
   Greater Yellowlegs, Tringa melanoleuca
   Lesser Yellowlegs, Tringa flavipes
   Willet, Catoptrophorus semiplamatus (3)

9. Stilt Sandpiper, Micropalama himantopus
   Pectoral Sandpiper, Calidris melanotos
   Laughing Gull, Larus atricilla
   Royal Tern, Thalasseus maximus 92)
   Least Tern, Thalasseus maximus (2)

10. Sandwich Tern, Thalasseus sandvicensis (2)
    Bridled Tern, Sterna anaethetus
    Brown Noddy, Anous stolidus (5)
    White-winged Dove, Zenaida astatica B
    Zenaida Dove, Zenaida aurita B

11. White-crowned Pigeon, Columba leucocephala B (4)
    Mourning Dove, Zenaida macroura B
    Red-necked Pigeon, Columba squamosa
    Common Ground Dove, Columbina passerina B
    Bridled Quail Dove, Geotrygon mystacea

12. Ruddy quail Dove, Geotrygon montana
    Caribbean Parakeet, Aratinga pertinax
    Smooth-billed Ani, Crotophaga ani B
    Yellow-billed Cuckoo, Coccyzus americanus B
    Mangrove Cuckoo, Coccyzus minor B

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13. Short-eared Owl, Asio flammeus B (2)
    Chuck-will's Widow, Caprimulgus carolinensis
    Common Nighthawk, Chordeiles minor (5)
    Antillean Crested Hummingbird, Orthorhyncus cristatus B
    Green-throated Carib, Sericotes holosericeus B

14. Antillean Mango, Anthracothorax dominicus B
    Belted Kingfisher, Ceryle alcyon
    Gray Kingbird, Tyrannus dominicensis B
    Loggerhead Kingbird, Tyrannus caudifasciatus
    Stilid Flycatcher, Myriarchus stolidus

15. Caribbean Elaenia, Elaenia martinica
    Purple Martin, Progne subis
    Cave Swallow, petrochelidon fulva B
    Barn Swallow, Hirundo rustica
    Northern Mockingbird, Mimus polyglottos B

16. Pearly-eyed Thrasher, Margarops fuscatus B
    Red-legged Thrush, Mimocichla plumbea B
    Black-whishered Vireo, Vireo altiloquus B
    Prairie Warbler, Dendroica discolor
    American Redstart, Setophaga ruticilla

17. Yellow warbler, Dendroica petechia B
    Parula Warbler, Parula americana
    Magnolia Warbler, Dendroica magnolia
    Black and White Warbler, Mniotilta varia
    Cape May Warbler, Dendroica tigrina

18. Black-throated Blue Warbler, Dendroica caerulescens
    Adelaide's Warbler, Dendroica adelaidae
    Palm Warbler, Dendroica palmarum
    Ovenbird, Seiurus aurocapillus
    Northern Water Trush, Seirurus noveboracensis

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19. Bananaquit, Coereba flaveola B
    Stripe-headed Tanager, Spindalis zena B
    Shiny Cowbird, Molothrus bonariensis B (4)
    Black-cowled Oriole, Jeterus dominicensis B
    Greater Antillean Grackle, Quiscalus niger B

20. Yellow-shouldered Blackbird, Angelaius xanthomus B (4)
    Hooded Mannikin, Lonchura cucullata B
    Yellow-faced Grassquit, Tiaris bicolor
    Ruddy Duck, Oxyura jamaicensis (3)

21. Peregrine Falcon, Falcon peregrinus (2)
    Marbled Godwit, Limosa fedoa (2)
    Puerto Rican Lizard Cuckoo, Saurothera vieilloti
    Prothonotary Warbler, Protonotaria citrea (1)

Addendum:Green-winged Teal, anas carolinensis

Data compiled by James W. Wiley, USDA Forest Service, Institute of Tropical Forestry, Rio Piedras, Puerto Rico, 1976. Symbols after species names are as follows: B = breeding; (1) = very endangered, (2) endangered, (3) on the verge of being endangered, (4) status undetermined, and (5) peripheral, according to Rare and Endangered Animal Species of Puerto Rico.

Source: U.S. Department of Agriculture, National Forest Service, 1976.

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TABLE 5-16 Federally Listed Rare and Endangered Fauna	
Scientific Name	**Common Name**
Eretmochelys imbricata	Hawksbill turtle
Dermochelys coriacea	Leatherback turtle
Epicrates inornatus	Puerto Rican boa
Pelecanus occidentalis	Eastern brown pelican
Falco peregrinus anatum	American Peregrine Falcon
Columbia inornata wetmori	Puerto Rican plain pigeon
Agelaius xanthomus*	Yellow-shouldered blackbird
Trichechus manatus	West Indian manatee

*Entire Station has been designated "Critical Habitat" for the specie.

Source: U.S. Fish and Wildlife Service, DES, Mayaguez

The Puerto Rican boa (Epicrates inornatus) also takes refuge in the station's mangrove forests (U.S. Fish and Wildlife, 1978).

Hunting is not permitted on the station. Personnel are limited to shell collecting and fishing as consumptive uses of the station's natural resources. The station has also forbidden the harvesting of land crabs.

Plants, birds, insects, and fishes are all potential ecological receptors on the station; however, the pathways necessary to significantly impact the flora and fauna are not always complete, and exposure is not likely to occur. Although exposure is not likely to occur, remedial actions at the site will be directed towards minimizing adverse impacts to the flora and fauna encountered at the site. Site 16 makes up less than 1 percent of the total station area. Most vegetation was cleared from the site area when first constructed, and there has only been sparse revegetation by grasses, with some shrubs at the perimeter of the site. Most of the biota on the station would be found in the lusher areas of the station, especially in the mangrove forests, rather than on Site 16. There are no surfacewater bodies present on the site. The concrete-lined drainage ditches on Site 16 only contain water immediately after a rainstorm, and consequently, do not support multicellular aquatic life.

In order to characterize the potential impact on aquatic organisms, average and maximum surface water PCB concentrations from the cooling water tunnel and UST day tank at Site 16 were compared to Ambient Water Quality Criteria for Freshwater Aquatic Life (AWQC-FAL) of 0.014 µg/L. Because of the proximity of bay waters, these concentrations were also compared to the Ambient Water Quality Criteria for Marine Aquatic Life (AWQC-MAL) of 0.03 µg/L. These criteria for the protection of aquatic life specify pollutant concentration, which should protect most, but not necessarily all, aquatic life and its uses, if not exceeded (Federal Register, Vol. 45, No. 231, Nov 28, 1990). Surface water levels at collected from the cooling water tunnel at Site 16 are approximately four orders of magnitude above the AWQL's set for freshwater and marine aquatic life.

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6.0 FEASIBILITY STUDY

The purpose of this Feasibility Study is to systematically screen technology alternatives to determine the overall best possible process to apply to polychlorinated biphenyl-contaminated (PCB-contaminated) soil and concrete located at Site 16 on the Roosevelt Roads Naval facility in Puerto Rico.

This Feasibility Study (FS) is divided into four parts:

Section 1: Introduction and Background;
Section 2: Screening and Analysis of Alternatives;
Section 3: Discussion and Conclusions; and
Section 4: Appendix.

Sections 6.1 and 6.2 gives background information and introduces several important assumptions upon which the report is based. Section 6.3 discusses the available remedial technologies, screening criteria used to select appropriate technologies, and a description of the technologies remaining after the screening. Section 6.4 uses the information developed in Section 6.3 to draw conclusions and make recommendations about the site. Appendix E contains cost breakdown sheets, vendor file memos, and other background information.

The scope of the Feasibility Study was established using several key factors. These factors include the National Contingency Plan (NCP), OSWER Directive 9355.3-01, which specifies the process to be followed in conducting RI/FS work; and Section 121 of the Superfund Amendments and Reauthorization Act of 1986 (SARA).

6.1 Applicable or Relevant and Appropriate Requirements (ARARs)

Applicable or relevant and appropriate requirements are used to determine the extent of site cleanup, to scope and formulated remedial action alternatives, and to govern the implementation and operation of the selected action or actions. The NCP requires that remedial actions taken under the federal Comprehensive Environmental Response , Compensation, and Liability Act of 1980 (CERCLA) comply with all federal regulations that are applicable or relevant and appropriate to the remedial activities performed at the site unless specific waivers are granted by the EPA.

The remedial action selected under CERCLA Section 121(d) for NAVSTA Roosevelt Roads, Site 16 must comply with federal and territorial environmental laws that are either applicable or relevant and appropriate (ARAR). Applicable requirements are those

standards,criteria, or limitations dictated under federal or state law that specifically address a hazardous substance, waste constituent, remedial action, location, or other circumstance at a CERCLA site. "Relevant and appropriate" requirements are those that are not "applicable", but still address problems or situations similar enough to those encountered at the site so that their use is well suited to that site.

Chemical-specific ARARs are health- or risk-based numeric values applied to site-specific conditions. These values establish a cut-off level for determining how much of a medium must be treated or removed. The ARAR assessment for this FS follows the protocols outlined in the August 8, 1988 interim final version of the US EPA guidance, CERCLA Compliance With Other Laws Manual.

The Toxic Substances Control Act (TSCA) established cleanup levels for areas contaminated with PCBs. Policy promulgated after inception of TSCA requires clean-up of PCB-contaminated soil to different levels, depending upon the spill location, potential for exposure to residual PCBs remaining after clean-up, the concentration of the PCBs initially spilled, and the nature and size of the population potentially at risk of exposure. The potential ARAR for PCB in soil is 25 parts per million (ppm) where access control will be maintained. The 25 milligram per kilogram (mg/kg) limit is potentially relevant and appropriate for all sites. For PCB spill areas where there is a greater potential for human exposure to the contamination, the policy requires more stringent clean-up standards. The TSCA PCB regulations are presented below by spill location description:

Spill Location Description	PCB Criterion
Spills at outdoor electrical substations with restricted access	25-50 ppm
Spills at restricted access locations other than electrical substations	25 ppm
Spills at unrestricted access industrial areas	10 ppm

The soil contamination at Site 16 exists in an open area with unrestricted access to lawn maintenance and other station personnel; therefore, the 10 ppm clean-up standard is an ARAR for the site.

According to SARA, requirements may be waived by EPA under five specific conditions, provided that protection of human health and the environment is still ensured. The conditions under which waivers are permitted under SARA include the following:

- The selected remedial action is an interim remedy or portion of a total remedy which will attain the standard when complete;
- Compliance with such requirements will result in greater risk to human health and the environment than alternative options;
- Compliance with such requirements is technically impractical from an engineering perspective;
- The selected remedial action will provide an equivalent standard of performance using another approach; and
- The requirement is a state requirement that has been inconsistently applied.

6.2 Bases and Assumptions

In order to be able to develop and screen alternatives and receive information from vendors, several important assumptions or generalizations were made. It is important to note that the screening and cost quotes are based on these assumptions.

All of the alternative technologies considered in this report are cost-sensitive to the volume of contamination and are based on the assumption that the contamination is under this area and has not migrated to other areas. If it is later determined that the contamination has migrated, additional treatment of possibly large amounts of soil will be needed at additional expense.

The extent of contamination at Site 16 measures approximately 2,959 square yards (yd^2); the volume of contamination is estimated to be 986 cubic yards (yd^3) (Figure 9) and is estimated to be approximately 1,480 tons. This figure includes debris from cleaning of approximately 20,000 square feet of concrete surfaces at the site.

The depth to ground water at Site 16 is estimated to be uniform at nine feet. It is further assumed that the ground water has not become contaminated by the PCBs. Again, if further investigation reveals leaching of PCBs into the ground water, additional expense may be necessary to remediate the ground water.

Where possible, vendor quotes were used for developing the costs for the various remedial alternatives. The vendor costs were developed based on previously noted assumptions used to characterize the contaminated site. If it later becomes apparent that these assumptions require revision, the costs associated with the various remedial alternatives will be similarly affected.

6.3 Screening and Analysis of Alternatives

Versar combined general response actions and the process options chosen to represent the various technology types for the contaminated soil and concrete to form viable, potentially effective site-wide remedial plans. Alternatives are developed and assembled to be consistent with remedial action objectives at the site. These remedial action objectives are based on the 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.

These evaluation criteria serve as the basis for performing the detailed analyses during the FS and for subsequently selecting an appropriate remedial action. A brief synopsis of each are presented below:

- Overall protection of human health and the environment. This provides a final check to assess whether each alternative adequately protects human health and the environment.

- Compliance with ARARs. This discusses whether alternatives will meet all Federal and State ARARs previously identified for the site. When an alternative does meet ARARs, then this criteria describes how it does. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA is discussed.

- Long-term effectiveness and permanence. This addresses the results of a remedial action in terms of the risk remaining at the site after remedial objectives are met. Any controls required to manage the risk posed by treatment residuals or untreated wastes are described.

- Reduction of toxicity, mobility, or volume through treatment. This criterion addresses the statutory preference for selecting remedial actions employing

treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances.

- Short-term effectiveness. This criterion addresses the effects of the alternatives during the construction and implementation phase until remedial objectives are met. Alternatives are evaluated with respect to their effects on human health and the environment, if applicable, during implementation of the remedial action.

- Implementability. The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. Technical feasibility addresses construction and operational concerns and the reliability of technologies used. Administrative feasibility addresses activities needed to coordinate with Agencies (e.g., obtaining permits).

- Cost. This criterion addresses how total alternative costs, including capital and operation and maintenance (0&M) expenses, compare to one another.

- Local government acceptance. This criterion evaluates the technical and administrative issues and concerns that the State Agency may have regarding each of the remedial alternatives.

- Community acceptance. This assessment evaluates the issues and concerns that the public may have regarding each of the alternatives.

The universe of remedial technologies includes those that have been widely applied as standard construction techniques, as well as those that have been recently developed for specific remedial situations. In cases where a technology is commonly well understood (such as containment and removal response actions), extensive discussion is unnecessary. Where a technology is innovative or used in an "alternative" application (e.g., for waste treatment and disposal) more discussion is provided.

US EPA guidance suggests that a single option can be selected for subsequent development and evaluation of alternatives where more than one process option exists for a technology (US EPA, 1987a). In some cases, this is a useful and valid approach (e.g., for the variety of common cover options). In other cases where a technology is more innovative, there may be only one available option or vendor. This is particularly true of treatment technologies specific to a particular waste constituent. In these situations, the option is more

fully reviewed prior to screening. Table 6-1 summarizes remedial technologies and process options identified for potential application at Site 16.

US EPA guidance specifies that screening be performed on the basis of "effectiveness" and "implementability" (US EPA 1987a). Consistent with this guidance, the screening process for this feasibility study considers the following requisite conditions:

- This technology must be demonstrated at, or approaching, full scale on actual waste materials for the constituent of concern (PCBs), and

- The technology must be commercially available at the time of FS preparation, i.e., at least one vendor must be prepared to enter into a contract for providing the necessary equipment and processing.

Technologies that did not meet both of these conditions were screened from further consideration.

Some of the technologies that pass the screening could require treatability studies to determine important treatment parameters. While a specific technology may appear reasonable based on past experience, its use may require verification because of site-specific or other conditions.

Treatability testing satisfies a number of purposes. The most important is to ensure that the technology is appropriate for the site and constituent or constituents of concern; in this case, PCBs. Another purpose for testing is the development of the necessary design parameters. During the remedial design phase, a site-specific design is developed at the bench, pilot, or field scale. These parameters facilitate proper sizing of units and generate measures of effectiveness to ensure that the design is efficient and cost effective.

The retention of any particular technology does not necessarily mean that it will be applicable to the site. The screening process eliminates technologies that have a low probability of being successfully applied at the site to meet the site requirements.

The screening and evaluation of process options is performed in two phases. The first phase consists of identifying potentially applicable process options and technology types, and evaluating these options with respect to technological implementability. During this phase, options were screened based on site characteristics, contaminant types and concentrations, and technology constraints. Those options that could not be effectively implemented were screened out from further evaluation.

TABLE 6-1: IDENTIFICATION AND PHASE ONE SCREENING OF REMEDIATION ALTERNATIVES FOR SITE 16.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
NO ACTION	NONE	NOT APPLICABLE	REQUIRED FOR CONSIDERATION BY NCP	NOT FEASIBLE. DOES NOT REDUCE MOBILITY, TOXICITY, OR VOLUME OF CONTAMINANT.
INSTITUTIONAL ACTIONS	ACCESS RESTRICTIONS	DEED RESTRICTIONS	DEEDS FOR SITE PROPERTY WOULD RESTRICT POSSIBLE SITE USES AND DEVELOPMENT.	POTENTIALLY FEASIBLE.
		FENCE SITE	INSTALL SECURITY FENCING AROUND THE SITE.	POTENTIALLY FEASIBLE.
CONTAINMENT	CAPPING	ASPHALT	LAYER OF ASPHALT IS SPRAYED OVER THE SITE.	NOT FEASIBLE. GROUNDWATER COULD STILL LEACH CONTAMINANTS FROM SOIL. DOES NOT REDUCE MOBILITY, TOXICITY, OR VOLUME OF CONTAMINANT.
		CONCRETE	CONCRETE SLAB IS INSTALLED OVER THE SITE.	
		CLAY/SOIL	COMPACTED CLAY AND VEGETATIVE COVER OVER THE SITE.	
REMOVAL, TRANSPORTATION, AND OFF-SITE TREATMENT OR DISPOSAL	TREATMENT OR DISPOSAL OF EXCAVATED AND TRANSPORTED WASTE	PERMITTED LANDFILL	TRANSPORT UNTREATED SOILS TO A PERMITTED LANDFILL.	POTENTIALLY FEASIBLE. MAY REQUIRE PRETREATMENT OF SOILS.
		THERMAL TREATMENT FACILITY	TRANSPORT UNTREATED SOILS TO AN INCINERATION FACILITY FOR PROCESSING.	POTENTIALLY FEASIBLE.

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TABLE 6-1: IDENTIFICATION AND PHASE ONE SCREENING OF REMEDIATION ALTERNATIVES FOR SITE 16. CONTINUED

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
ON-SITE SOIL TREATMENT	BIODEGRADATION	COMPOSTING	CONTAMINATED SOILS ARE PLACED IN A CONTROLLED ENVIRONMENT WITH ADDITION OF HEAT AND AIR TO AID MICROBIAL DEGRADATION OF ORGANICS.	NOT FEASIBLE FOR PCB CONTAMINATION AT SITE 15
		SOLID PHASE TREATMENT	CONTAMINATED SOILS ARE TREATED IN AN ABOVE-GRADE SYSTEM USING CONVENTIONAL SOIL MANAGEMENT PRACTICES TO ENHANCE MICROBIAL DEGRADATION OF ORGANICS.	
		SLURRY PHASE TREATMENT	CONTAMINATED SOILS PLACED IN A MOBILE BIOREATOR IN A SLURRY FORM. SLURRY IS MECHANICALLY AGITATED IN THE REACTOR TO MAINTATHE APPROPRIATE ENVIRONMENTAL CONDITIONS FOR MICROBIAL DEGRADATION OF ORGANICS.	
		IN SITU BIODEGRADATION	INDIGENOUS OR INTRODUCED AEROBIC OR ANAEROBIC BACTERIA ARE INTRODUCED TO CONTAMINATED SOILS TO BIODEGRADE ORGANIC COMPOUNDS. NATURAL BIODEGRADATION PROCESS IS ENHANCED BY INJECTING NUTRIENTS.	
	PHYSICAL/CHEMICAL TREATMENT	SOIL WASHING	USE OF WATER, STEAM, OR SOLVENT-BASED SOLUTION TO WASH OR VOLATILIZE AND FLUSH CONTAMINANTS FROM SOIL. OPERATION PERFORMED IN A CONTACTOR.	NOT FEASIBLE FOR PCB CONTAMINATION
		IN-SITU VAPOR EXTRACTION	REMOVAL OF VOLATILE ORGANIC COMPOUNDS BY APPLICATION OF VACUUM ON SYSTEM THROUGH A SYSTEM OF WELLS.	NOT FEASIBLE FOR PCB CONTAMINATION
		EMERGING TECHNOLOGIES DECHLORINATION (e.g., KPEG, LARC PROCESSES) SOLVENT EXTRACTION (e.g., ACUREX) BIOREMEDIATION (e.g., BIO CLEAN) PYROLYSIS (e.g., ADVANCED ELECTRIC REACTOR) VITRIFICATION (e.g., BATELLE PACIFIC PROCESS	VARIOUS NOVEL TREATMENT PROCESSES	PROCESSES FOR PCB SOILS HAVE NOT BEEN COMMERCIALLY DEVELOPED. THE KPEG PROCESS, BASED ON A NUCLEOPHILC SUBSTITUTION FOR CHLORINE ATOMS, HAS BEEN SUCCESSFULLY PILOT-TESTED, BUT HAS NOT BEEN SCALED UP. THE LARC PROCESS, WHICH USES RADIANT ENERGY TO DECHLORINATE THE BIPHENYL COMPOUND, HAS ONLY BEEN SUCCESSFULLY DEMONSTRATED IN THE LABORATORY. EXCEPT FOR THE ADVANCED ELECTRIC REACTOR (AER) PYROLYSIS PROCESS, THE EMERGING TECHNOLIGIES FOR PCB WASTES HAVE NOT BEEN DEMONSTRATED, AND ARE IN VARIOUS STAGES OF DEVELOPMENT FROM LABORATORY-SCALE THROUGH FIELD TESTS. ALTHOUGH THE AER PROCESS IS PERMITTED UNDER TSCA BY EPA REGION VI, THE FINAL SYSTEM DESIGN STILL MUST BE DETERMINED FROM ADDITIONAL DATA, AND THERE IS NO AVAILABLE COMMERCIAL CAPACITY FOR TREATMENT USING THIS PROCESS.
	THERMAL TREATMENT	ON-SITE ROTARY KILN INCINERATION	COMBUSTION OF SOLIDS IN A MOBILE HORIZONTALLY ROTATING CYLINDER DESIGNED FOR UNIFORM HEAT TRANSFER.	POTENTIALLY FEASIBLE, HOWEVER, VENDORS WERE EXTREMELY RELUCTANT TO REMIDIATE LESS THAN 5000 CUBIC YARDS. COST IS VERY HIGH FOR SMALL QUANTITIES.
		LOW TEMPERATURE THERMAL TREATMENT	SOIL IS FED INTO HEATED SCREW AUGER. CONTAMINANTS ARE GENERALLY VAPORIZED AND RECOVERED	NOT FEASIBLE FOR PCB CONTAMINATION. PCB'S ARE NOT VOLATILE ENOUGH.

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The second phase consists of further evaluation of the alternatives that were considered to be implementable based on the first evaluation and screening phase. Within technology type the effectiveness, implementability, and cost are further evaluated and compared to one another. Emphasis is placed on the effectiveness of the options. Where possible, one representative option is selected for further evaluation from each technology type. The following sections present the screening an evaluation of process options for the Roosevelt Roads Naval facility. Detailed descriptions are presented in the Phase II discussion.

Alternatives were eliminated from consideration during Phase I and Phase II screening 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 extensive site characterization and successful laboratory or pilot field tests to demonstrate viability. Care was taken to ensure that the surviving technologies did not require restrictions on future land use, and did not require a continuing operations and maintenance (O&M) program.

It is noted here that although the screening of technologies was is limited to remediation of PCB-contaminated soil. There are approximately 20,000 ft^2 of PCB-contaminated concrete surfaces in and around Building 38 to be remediated. Technologies associated with the remediation of the concrete were not explicitly subject to a feasibility study because the residue can effectively be considered to require the same treatment/disposal considerations as soil. Remediation of the concrete will be effected via gritblasting, scarification/chipping, and powerwashing of the contaminated surfaces of the building.

Gritblasting involves the spray application of an abrasive material to concrete surfaces to effectively erode the contaminated material. This technique is most effective when contamination has penetrated less than 2 inches into the concrete.

Scarification/chipping would be necessary if PCBs have penetrated deeper than 2 inches into the concrete. Scarification employs pneumatically-operated piston heads to remove up to 3 inches of the surface of contaminated brick or concrete. This technique is particularly effective when the contamination has penetrated more than 1 inch into the surface of the material, as it probably has done due to long-term contact with the floor. Upon completion of the scarification/chipping and gritblasting, the residual dust and contamination-laden debris is vacuumed from the surfaces, packed in appropriate containers for disposal, and is treated in the same manner as the contaminated soil. After the scarification/chipping process, the remediated part of the floor will require rebuilding and refinishing.

Powerwashing is accomplished with high-pressure water equipment. A surface acting agent, called a surfactant is applied to the concrete. The role of the surfactant is to suspend the PCB-containing particles and prevent them from being driven deeper into the concrete. A high pressure jet of water is directed at the concrete to blast the PCB-contaminated dirt particles from the surface. This technique is effective for walls and surfaces where the depth of PCB penetration is less than one inch. The contaminated effluent from the powerwashing operation is collected and run through granular activated carbon canisters which adsorb the PCB-contaminated particles. The canisters are disposed as PCB-contaminated waste in a similar manner as contaminated soil from the site.

6.3.1 Phase I Screening of Potential Alternatives

Table 6-1 presents the results of the Phase I screening of available process options for the PCB contamination at Site 16. Included in the table are general response actions, associated remedial technologies and process options, descriptions of the options, and the associated screening comments. Most technologies are potentially applicable to the PCB contamination at the site; however, determining whether these technologies are definitely applicable or not applicable would in some cases require extensive hydrogeologic characterization, or pilot studies, or both. Performing these characterizations or pilot tests may not prove justifiable in light of the added costs associated with these processes, with no additional effectiveness compared to other technologies.

6.3.2 Phase II Screening of Process Options

Table 6-2 presents the results of the Phase II screening of available process options for the PCB contamination at Site 16. Included in the table are general response actions, remedial technology, process options, and the evaluation of the process options concerning effectiveness, implementability, and relative cost.

Three process alternatives survived Phase II screening: Alternative A represents transportation to an approved incineration facility for thermal destruction of PCB-contaminated soil; Alternative B represents transportation to an approved landfill facility for land disposal; and Alternative C represents soil excavation, followed by on-site incineration of PCB-contaminated soil.

6.3.3 Detailed Analysis of Alternatives

After the phase-one and phase-two screening evaluations were performed on the universe of potentially applicable remedial technologies, three process options carried forward

TABLE 6-2: PHASE TWO SCREENING OF REMEDIATION ALTERNATIVES FOR SITE 16.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	SCREENING CRITERIA: EFFECTIVENESS	SCREENING CRITERIA: IMPLEMENTABILITY	SCREENING CRITERIA: COST	
INSTITUTIONAL ACTIONS	ACCESS RESTRICTIONS	DEED RESTRICTIONS	NOT EFFECTIVE. REQUIRES RESTRICTIONS ON FUTURE SITE USE. DOES NOT REDUCE MOBILITY, TOXICITY, OR VOLUME OF CONTAMINANT.	EASILY IMPLEMENTABLE.	NONE.	
REMOVAL, TRANSPORTATION, AND OFF-SITE TREATMENT OR DISPOSAL	TREATMENT OR DISPOSAL OF EXCAVATED AND TRANSPORTED WASTE	PERMITTED LANDFILL	VERY EFFECTIVE. LEAVES RESIDUAL LIABILITY IF LANDFILL CLOSES.	MODERATELY EASILY IMPLEMENTED. REQUIRES TRANSPORTATION OF 1600 TONS OF SOIL BY BARGE.	EXCAVATION TRANSPORTATION DISPOSAL BACKFILL TOTAL:	3/TON 400/TON 296/TON 10/TON 709/TON
		INCINERATION FACILITY	VERY EFFECTIVE.	MODERATELY EASILY IMPLEMENTED. REQUIRES TRANSPORTATION OF 1600 TONS OF SOIL BY BARGE.	EXCAVATION TRANSPORTATION DISPOSAL BACKFILL TOTAL:	3/TON 400/TON 2000/TON 10/TON 2413/TON

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into detailed analysis: Alternative A - excavation and transportation to an approved incineration facility for PCB-contaminated soil and incineration; Alternative B - excavation and transportation to an approved Landfill facility; and Alternative C - soil excavation, followed by on-site incineration of PCB-contaminated soil.

The detailed analysis of alternatives consists of the evaluation and presentation of the relevant information needed to select a site remedy. In the detailed analysis, each alternative is assessed against the nine CERCLA evaluation criteria described previously. The results of this assessment are arrayed to compare the alternatives and identify the key tradeoffs among them. This approach to analyzing alternatives provides sufficient information to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the CERCLA remedy selection requirements.

The specific statutory requirements for remedial actions which must be supported by this report for Site 16 are listed below. The alternative must:

- Be protective of human health and the environment
- Attain ARARs (or provide grounds for invoking a waiver)
- Be cost-effective
- Utilize permanent solutions and alternative treatment technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces the toxicity, mobility, or volume, or provide an explanation as to why it does not.

In addition, Section 121(b)(1)(A) of CERCLA emphasizes evaluation of long-term effectiveness and related considerations for each of the remedial alternatives.
Below are the detailed descriptions of the three remaining alternatives. Although institutional controls are screened out as a stand alone remediation, such controls will be necessary with the remaining remedies to ensure that the site will remain an industrial area. A 10-ppm ARAR has been applied based on the site's continued use for industrial purposes. Residential use would require a cleanup to 1 ppm (EPA, 1990b).

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6.3.3.1 Alternative A - Excavation, Transportation, and Incineration

This remedial alternative is applicable to PCB-contaminated soil at Site 16 which has total PCB concentrations greater than 10 ppm. An estimated total of 986 cubic yards of PCB-contaminated soil at the site require remediation. The excavation and transportation to incineration facility remedial alternative involves the removal of the contaminated soil using conventional construction techniques (e.g., backhoe or track-mounted excavator). All soil measuring above 10 ppm PCBs is excavated and replaced with clean backfill. After the contaminated soil is excavated, the material is loaded into internodal containers and placed on barges for transportation to Corpus Christi, Texas. There, the manifested wastes are then transported via rail to Las Vegas, Nevada, and transferred to trucks for transportation to the incineration facility. The properly licensed facility is U.S. Ecology in Beaty, Nevada. There are no incineration facilities in Puerto Rico that are properly licensed to receive PCB-bearing wastes. U.S. Ecology is the nearest facility. Off-site incineration in accordance with 40 CFR 761 as it pertains to incineration of PCB solids is effected by subjecting the wastes to very high temperatures at which the contaminants are oxidized to carbon dioxide, water, and chlorine gas, which is recovered. Any noncombustibles in the contaminated soil will appear as ash residue in the incineration process, and will require disposal by landfilling.

Assessment of Alternative A

This remedial alternative will adequately protect human health and the environment from PCBs associated with contaminated soil. Soils and underlying coral contaminated above 10 ppm, the established clean-up standard for soil at the site, will be excavated, thereby removing the contaminant source.

Compliance with ARARs will be attained because (1) all materials contaminated with PCBs at concentrations above 10 ppm will be removed from the site for incineration, and (2) the removed soils will be incinerated according to requirements of the facility's TSCA permit for PCB destruction.

Excavating PCB-contaminated soils is an appropriate way to eliminate the major source of continued PCB migration from a soil to the subsurface environment. PCBs will drain from a soil saturated with PCB under the force of gravity until residual saturation is reached. At residual saturation, no additional fluid migration will occur unless precipitation washes PCB from the soil profile. It is the characteristics of the soil that determine its capacity to retain PCB in liquid and gaseous phases under saturated and unsaturated conditions. Excavation of soils at residual saturation can effectively remove product from the environment, if the soil is

of a type that can retain large amounts of product. It is the finer-textured sands like the soil at Site 16 that are most effectively excavated, because these soils retain the most PCBs.

After the removal of PCB-contaminated soil, no residual contamination levels above 10 ppm will be present in the remaining soil. Consequently, no future remedial controls will be required to monitor and maintain the long term effectiveness of this remedial alternative for all known contamination at the property.

This alternative will significantly reduce the toxicity and volume of the contaminated media. Theoretically, all PCBs will undergo complete combustion to yield carbon dioxide and water. Any products of incomplete combustion will be captured and removed from the stack gas by an air pollution control system. Any wastewater streams containing by-products of the incineration process also will be treated prior to discharge. Noncombustibles will carry through the process and exit as solid waste ash, which could then be disposed in a landfill.

Provided that workers performing soil excavation at the property are properly equipped with personal protective equipment and are fully certified for hazardous waste work (according to OSHA regulations in 40 CFR 1910), implementation of this alternative should not pose a risk to human health or the environment. As a precautionary measure, the soils could be kept saturated at all times during excavation work, thereby minimizing release of possibly-contaminated dust particles.

This remedial alternative is moderately easy to implement. Equipment and labor required for the excavation work are available in Puerto Rico or are easily transported to the site. OSHA-certified workers are required for the work, but they are also available in Puerto Rico or the United States. Clean backfill is available on the island of Puerto Rico and is relatively inexpensive.

This alternative should be acceptable to the local regulatory agencies and the local community. The contaminated soil will be permanently removed from the property, thereby eliminating any significant risk to human health and the environment associated with exposure to PCB contaminated soil. The material will be properly managed and ultimately destroyed according to applicable regulations. Also, the remedial action could be implemented within a relatively short time period, thereby not restricting future development or use of the site.

Factors found to affect costs of excavation/removal, transportation, and disposal are:

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A. Excavation or on-site transfer:
   1. Excavation depth
   2. Site surface characteristics
   3. Health and safety requirements
   4. Material
   5. Waste quantity

B. Transportation
   1. Distance to disposal facility
   2. Accessibility to road
   3. Material type and quantity

C. Disposal
   1. Material type and quantity

The excavation depth for the soil on this site is only 1 to 2 feet, which makes it very easy to reach all of the contaminated soil without necessitating large, expensive earth-working equipment. The site is a flat, wide open area with few obstructions. These factors work in favor of reducing the cost for excavation. Working against low cost is the Level C personal protective equipment (PPE) needed by the ground crew during removal activities due to the elevated levels of PCBs in the soil, which reduces efficiency by about 50 percent. Also adding greatly to the cost is the large expense of incineration. Affecting transportation costs, the material is to be transported to Nevada and requires travel by barge, rail, and trucks. Working in favor of lower costs, the material is easy to handle, and site is easily accessible.

Remedial cost estimates and vendor information are contained in Appendix E. Costs for Alternative A are as follows: excavation of the soil via backhoe is priced on a per day basis at about $1,000 per day. Approximately 300 tons can be loaded in a day, putting the per-ton price at about $3 per ton. Transportation to the licensed incineration facility in Beaty, Nevada was quoted by vendors at $500 per ton. Incineration at the facility is expected to cost about $1 per pound, or $2,960,000 for 1,480 tons. Replacing backfill in the hole will cost $10 per ton. Cost for gritblasting and powerwashing of the concrete walls and floors is estimated to be $10,000. The capital cost including QA/QC for Alternative A is $3,915,702. Adding costs for engineering design (15%). Construction management (15%), startup (10%), bonds and permits (2.5%), legal fees (3%), and unforeseen contingencies (20%) brings the total capital cost for this alternative to $6,284,702. It is noted here that the cost is based on remediation of Sites 15 and 16 at NAVSTA Roosevelt Roads concurrently. If only one site were to be remediated at one time, the per-ton cost would be expected to be higher. However, the cost variance would not be expected to affect the selection of remedy.

Because all contaminated soil will be removed, no future operation and maintenance costs will be incurred as a result of this remedial alternative.

6.3.3.2 Alternative B - Excavation, Shipment, and Landfill Disposal

This remedial alternative is applicable to PCB-contaminated soil and underlying coral at Site 16 which has total PCB concentrations greater than 10 ppm. An estimated total of 986 cubic yards of PCB-contaminated soil at the site require remediation.

The excavation and transportation to landfill facility remedial alternative involves the removal of the contaminated soil using conventional construction techniques (e.g., backhoe or track-mounted excavator). All soil or coral measuring above 10 ppm PCBs is excavated and replaced with clean backfill. After the contaminated soil is excavated, the material is loaded into internodal containers and placed on barges for transportation to Corpus Christi, Texas. There, the manifested wastes are then transported via rail to Las Vegas, Nevada, and transferred to trucks for transportation to the landfill facility. The properly licensed facility is U.S. Ecology in Beaty, Nevada. There are no landfills in Puerto Rico that are licensed to receive PCB-bearing wastes. U.S. Ecology is the nearest properly licensed facility. The contaminated wastes are to be properly landfilled at the facility.

Assessment

This remedial alternative will adequately protect human health and the environment from PCBs associated with contaminated soil. Soils or coral contaminated above 10 ppm, the established clean-up standard for soil at the site, will be excavated, thereby removing the contaminant source.

Compliance with ARARs will be attained because (1) all materials contaminated with PCBs at concentrations above 10 ppm will be removed from the site for pretreatment and landfilling, and (2) the removed soils will be pretreated and landfilled according to requirements of the facility's TSCA or RCRA permit for PCB treatment and disposal.

After the removal of PCB-contaminated soil, no residual contamination levels above 10 ppm will be present at the site. Consequently, no future remedial controls will be required to monitor and maintain the long term effectiveness of this remedial alternative for all known contamination at the site.

This alternative will significantly reduce the remaining contaminant volume by removing all soil contaminated above 10 ppm total PCBs concentration. However, regardless of the

pretreatment method employed, the waste toxicity may or may not be reduced prior to landfilling. Therefore, potential future liabilities associated with the disposal of the pretreatment waste material in a landfill may exist.

Provided that workers performing soil excavation at the property are properly equipped with personal protective equipment and are fully certified for hazardous waste work (according to OSHA regulations in 40 CFR 1910), implementation of this alternative should not pose a risk to human health or the environment. As a precautionary measure, the soils should be kept saturated at all times during excavation work, thereby minimizing release of potentially-contaminated dust particles.

This remedial alternative is moderately easy to implement. Equipment and labor required for the excavation work are available in Puerto Rico or are easily transported to the site. OSHA-certified workers are required for the work, but they are also available in Puerto Rico or the United States. Clean backfill is available on the island of Puerto Rico and is relatively inexpensive.

This alternative should be acceptable to the local regulatory agencies and the local community. The contaminated soil will be permanently removed from the site, thereby eliminating any significant risk to human health and the environment associated with exposure to PCB-contaminated soil. The material will be properly managed and ultimately disposed according to applicable regulations. Also, the remedial action could be implemented within a relatively short time period, thereby not restricting future development and use of the site.

It is conservatively assumed that all PCB soil removed from Site 16 will require some type of pretreatment prior to acceptance for landfilling at the licensed facility. Measured levels of PCBs (as Aroclor 1260) in soil samples from the property were generally below 500 ppm. However, "hot spots" in the soil are possible, and any batch shipment of excavated soils from the site may be subject to Federal restrictions on landfilling.

Factors found to affect costs of excavation/removal, transportation, and disposal are:

A. Excavation or on-site transfer:
   1. Excavation depth
   2. Site surface characteristics
   3. Health and safety requirements
   4. Material
   5. Waste quantity

B. Transportation
   1. Distance to disposal facility
   2. Accessibility to road
   3. Material type and quantity
C. Disposal
   1. Material type and quantity

The excavation depth for the soil on this site is only 1 to 2 feet, which makes it very easy to reach all of the contaminated soil without necessitating large, expensive earth-working equipment. The site is generally a flat, wide open area with few obstructions. These factors work in favor of reducing the cost for excavation. Working against low cost is the Level C PPE needed by the ground crew during removal activities due to the elevated levels of PCBs in the soil, which reduces efficiency by about 50 percent. Affecting transportation costs, the material is to be transported to Nevada and requires travel by barge, rail, and trucks. Working in favor of lower costs, the material is easy to handle, and site is easily accessible.

Remedial cost estimates and other vendor information are contained in Appendix E. Costs for Alternative B are as follows: excavation of the soil via backhoe is priced on a per day basis at about $1,000 per day. Approximately 300 tons can be loaded in a day, putting the per-ton price at about $3 per ton. Transportation to and disposal at the licensed landfill facility in Beaty, Nevada was quoted by vendors at $696 per ton. Backfill for the hole costs $10 per ton. Cost for powerwashing and gritblasting of the concrete walls and floors is estimated to be $10,000. The capital cost for Alternative B, including QA/QC, is $1,059,320. Adding costs for engineering design (15%), construction management (15%), startup (10%), bonds and permits (2.5%), legal fees (3%), and unforeseen contingencies (20%) brings the total capital cost for this alternative to $1,785,219. It is noted here that the cost is based on remediation of Sites 15 and 16 concurrently. If only one site were to be remediated at one time, the per-ton cost is expected to be higher. However, the cost variance would not be expected to affect the selection of remedy.

Because all contaminated soil will be removed, no future operation and maintenance costs will be incurred as a result of this remedial alternative.

6.3.3.3 Alternative C - Soil Excavation and On-site Incineration

This remedial alternative is applicable to PCB-contaminated soil or the underlying coral at Site 16 which has total PCB concentrations greater than 10 ppm. An estimated total of 986 cubic yards of PCB-contaminated soil at the site require remediation.

The excavation and on-site incineration remedial alternative involves the excavation of the contaminated soil using conventional construction techniques (e.g., backhoe or track-mounted excavator). All materials measuring above 10 ppm PCBs is excavated and replaced with clean backfill. After the contaminated soil is excavated, the material is loaded into a mobile incineration trailer for thermal destruction. The contaminated soil is subjected to high temperatures where it breaks down into carbon dioxide, water, and chlorine gas, which is collected from the exhaust before it can enter the atmosphere. Any noncombustible materials in the contaminated soil will appear as ash residue in the incineration process, and will require disposal by landfilling.

Assessment

This remedial alternative will adequately protect human health and the environment from PCBs associated with contaminated soil or the underlying coral. Soils or coral contaminated above 10 ppm, the established clean-up standard for soil at the site, will be excavated, thereby removing the contaminant source.

Compliance with ARARs will be attained because all materials contaminated with PCBs at concentrations above 10 ppm will be excavated, incinerated, and returned to the ground as clean fill. Cleanup efficiencies for on-site incineration is equivalent to that of off-site incinerators.

After the incineration and replacement of the soil, no residual contamination levels above 10 ppm will be present at the site. Consequently, no future remedial controls will be required to monitor and maintain the long-term effectiveness of this remedial alternative for all known contamination at the site. This alternative will significantly reduce the remaining contaminant volume by removing all soil contaminated above 10 ppm total PCBs concentration.

Provided that workers performing soil excavation at the property are properly equipped with personal protective equipment and are fully certified for hazardous waste work (according to OSHA regulations in 40 CFR 1910), implementation of this alternative should not pose a risk to human health or the environment. As a precautionary measure, the soils should be kept saturated at all times during excavation work, thereby minimizing release of potentially-contaminated dust particles.

This remedial alternative is extremely difficult to implement. At the time of this writing, no vendor was willing to quote a price on the relatively small amount of soil at the site.

OSHA-certified workers are required for the work, and they are available in Puerto Rico or the United States.

This alternative should be acceptable to the local regulatory agencies and the local community. However, local citizens are often greatly concerned by on-site incineration programs. The contaminated soil will be permanently reduced in toxicity, thereby eliminating any significant risk to human health and the environment associated with exposure to PCB-contaminated soil. The material will be properly managed and ultimately disposed according to applicable regulations. Also, the remedial action could be implemented within a relatively short time period, thereby not restricting future development and use of the site.

The excavation depth for the soil on this site is only 1 to 2 feet, which makes it very easy to reach all of the contaminated soil or coral without necessitating large, expensive earth-working equipment. The site is a flat, wide open area with few obstructions. These factors work in favor of reducing the cost for excavation. Working against low cost is the Level C personal protective equipment needed by the ground crew during removal activities due to the elevated levels of PCBs in the soil, which reduces efficiency by about 50 percent. Additionally, the cost of on-site incineration is extremely expensive due to the limited number of companies willing to do the incineration. Working in favor of lower costs, the material is easy to handle, and site is easily accessible.

Remedial cost estimates and vendor information are contained in Appendix E. Costs for Alternative C would be as follows: excavation of the soil via backhoe is priced on a per day basis at about $1,000 per day. Approximately 300 tons can be loaded in a day, putting the per-ton price at about $3 per ton. Incineration is expected to cost approximately $2,000 per ton, or $2,960,000. Cost for spalling and gritblasting of the concrete walls and floors is estimated to be $10,000. The capital cost including QA/QC for Alternative C is $3,123,162. Adding costs for engineering design (15%), construction management (15%), startup (10%), bonds and permits (2.5%), legal fees (3%), and unforeseen contingencies (20%) brings the total capital cost for this Alternative C to $5,012,675. It is noted here that the cost is based on remediation of Sites 15 and 16 concurrently at NAVSTA Roosevelt Roads. If only one site were to be remediated at one time, the per-ton cost would be expected to be higher. However, the cost variance is not large enough to affect the selection of remedy.

Because all contaminated soil will be treated and replaced when clean, no future operation and maintenance costs will be incurred as a result of this remedial alternative.

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6.4 Discussion and Conclusions

Potential remedial technologies have been described and screened. The following is an analysis of the findings presented in the preceding sections and recommendations based on the analysis.

Three remedial alternatives remain after the screening:

- Alternative A - Soil Excavation, Transportation, and Off-Site Incineration,
- Alternative B - Soil Excavation, Transportation, and Off-Site Land Disposal, and
- Alternative C - Soil Excavation and On-Site Incineration.

The alternatives were screened according to effectiveness, implementability, and other pertinent criteria designed to determine suitability of each alternative to the remediation goal. Cost was used as the final determinant, but only if all other criteria were equal between multiple alternatives.

Based on this feasibility study, Alternative B - Excavation, Shipment, and Landfill Disposal is the remedial technology recommended for Site 16. This process option was selected based on probable achievement of the nine CERCLA criteria for 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. The total cost for this alternative is estimated to be $1,785,219.

Alternative A met the criteria for alternatives and promised to be equally effective for remediation of the site. Alternative A has a decreased liability in the long run, due to the elimination of contaminated soil, rather than the landfilling of it. The cost for Alternative A is prohibitively expensive compared to Alternative B, $6,284,702 compared to $1,785,219. The reduced cost for Alternative B is more than compensatory for the increased potential liability.

Alternative C is equally effective as Alternative B. It has the added advantages of decreased potential liability and elimination of the need for backfill at the site, since the incinerated soil is replaced in the ground. The cost for on-site incineration was quoted between $600 to $2,000 per ton. If a contract could be secured at the lower figure, on-site incineration would be almost the same cost as Alternative B, but would be more desirable sue to its previously noted inherent advantages. Unfortunately, no vendor was willing to quote at this time on jobs of less than 5,000 tons. This option should be reviewed at the time of

remediation, since the field of remediation is growing at a rapid pace and a contractor may be found who is willing to undertake remediation of the site in the future.

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APPENDIX A

Chain of Custody Records
and Data Validation Reports
for May 1991 Samples

Versar INC.

CHAIN OF CUSTODY RECORD

1 of 1

PROJECT NO.	PROJECT NAME	PARAMETERS	INDUSTRIAL HYGIENE SAMPLE Y/N
5295.3	NAVSTA Roosevelt Roads		

SAMPLERS: (Signature) [signature] (Printed) Julie de la Fuente

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	PCB								REMARKS
RR16SD01	5/10	13:59	✓		NGS Site 16-Sed-1	1	1								75673
RR16SD02	5/10	13:51	✓		" " -2	1	1								75674
RR16SD03	5/10	13:43	✓		" - " - 3	1	1								75675
RR16SD04	5/10	13:37	✓		" - " - 4	1	1								75676
RR16SD05	5/10	13:21	✓		" - " - 5	1	1								75677
RR16SD06	5/10	13:12	✓		" - " - 6	1	1								75678
RR16SD07	5/10	13:15	✓		" - " - 7	1	1								75679
RR16SD08	5/10	13:09	✓		" - " - 8	1	1								75680
RR16SD08D	5/10	13:10	✓		" - " - 8D	1	1								75681
~~RR16SD13~~	~~5/10~~		✓		~~" - " - 13~~	~~1~~	~~1~~								~~75682~~
~~RR16SD14~~	~~5/10~~		✓		~~" - " - 14~~	~~1~~	~~1~~								~~75683~~
~~RR16SD15~~	~~5/10~~		✓		~~" - " - 15~~	~~1~~	~~1~~								~~75684~~

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[signature]	5/10/92				
(Printed) Julie de la Fuente		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
(Printed)		(Printed)		Use field sample nos. on Analytical Reports; three-part label nos. are for cross-reference and verification only.

Distribution: Original Plus One Accompanies Shipment (white and yellow); Copy to Coordinator Field Files (pink).

RR-00207-03.13-05/15/92

Versar INC.

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME
5295.3	NAVSTA Roosevelt Roads

SAMPLERS: (Signature) [signature] (Printed) Julie De La Fuente

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS		PARAMETERS: PCB								REMARKS
RR16W01	5/9	9:10		✓	Site 16 - Wipe - 1	1	1									75604
RR16W02	5/9	9:15		✓	Site 16 - Wipe - 2	1	1									75605
RR16W03	5/9	9:20		✓	" - " - 3	1	1									75606
RR16W04	5/9	9:25		✓	" - " - 4	1	1									75607
RR16W05	5/9	9:30		✓	" - " - 5	1	1									75608
RR16W06	5/9	9:35		✓	" - " - 6	1	1									75609
RR16W07	5/9	14:25		✓	" - " - 7	1	1									75610
RR16W08	5/9	14:32		✓	" - " - 8	1	1									75611
RR16W09	5/9	14:35		✓	" - " - 9	1	1									75612
RR16W10	5/9	14:45		✓	" - " - 10	1	1									75613
RR16W11	5/9	14:48		✓	" - " - 11	1	1									75614
RR16W12	5/9	14:53		✓	" - " - 12	1	1									75615

INDUSTRIAL HYGIENE SAMPLE: Y / N

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[signature]	[illegible]				
(Printed) [illegible]		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
(Printed)		(Printed)		Use Field Sample nos. on Analytical Reports; Three-part label nos. are for cross-reference and verification only.

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RR-00207-03.13-05/15/92

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Versar INC.

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME	PARAMETERS	INDUSTRIAL HYGIENE SAMPLE
3295.3	NAVSTA Roosevelt Roads		Y / N

SAMPLERS: (Signature) Julie de la Fuente (Printed) [illegible]

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	PCB								REMARKS
RR16W13	5/9	15:00		✓	Site16 - Wipe - 13	1	1								75616
RR16W14	5/9	15:04		✓	" - " - 14	1	1								75617
RR16W15	5/9	15:05		✓	" - " - 15	1	1								75618
RR16W16	5/9	14:11		✓	" - " - 16	1	1								75619
RR16W17	5/9	14:08		✓	" - " - 17	1	1								75620
RR16W18	5/9	14:02		✓	" - " - 18	1	1								75621
RR16W19	5/9	9:53		✓	" - " - 19	1	1								75622
RR16W20	5/9	11:55		✓	" - " - 20	1	1								75623
RR16W21	5/9	13:45		✓	" - " - 21	1	1								75624
RR16W22	5/9	9:50		✓	" - " - 22	1	1								75625
RR16W23	5/9	9:45		✓	" - " - 23	1	1								75631
RR16W24	5/9	9:47		✓	" - " - 24	1	1								75627

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[illegible]	5/10/92 [illegible]				
(Printed) Julie de la Fuente		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
				Use Field Sample nos. on Analytical Reports; Three-part label nos. are for cross-reference and verification only.
(Printed)		(Printed)		

Distribution: Original Plus One Accompanies Shipment (white and yellow); Copy to Coordinator Field Files (pink).

RR-00207-03.13-05/15/92

Versar INC.

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME	PARAMETERS	INDUSTRIAL HYGIENE SAMPLE Y / N
5295.3	NAVSTA Roosevelt Roads		

SAMPLERS: (Signature) [illegible] (Printed) [illegible]

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	PCB								REMARKS
RR16W25	5/9	9:40		V	Site 16 - Wipe - 25	1	1								75628
RR16W26	5/9	10:10		V	" - " - 26	1	1								75629
RR16W27	5/9	13:55		V	" - " - 27	1	1								75630
RR16W28	5/9	10:20		V	" - " - 28	1	1								756[redacted]26
RR16W29	5/9	10:25		V	" - " - 29	1	1								756[redacted]32
RR16W30	5/9	10:45		V	" - " - 30	1	1								75633
RR16W31	5/9	10:55		V	" - " - 31	1	1								75634
RR16W32	5/9	11:02		V	" - " - 32	1	1								75635
RR16W33	5/9	14:50		V	" - " - 33	1	1								75636
RR16GB01	5/9	10:00		V	Site 16 - GB	1	1								75660
RR16GB02	5/9	11:02		V	Site 16 - GB	1	1								75661
RR16SD09	5/9	12:05		V	Site 16 - Sediment - 9	2	2								75662

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
(Printed) [illegible]		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
(Printed)		(Printed)		Use Field Sample nos. on Analytical Report. Three-part label nos. are for cross-reference and verification only.

Distribution: [illegible]al Plus One Accompanies Shipment (white and yellow); Copy to Coordinator Fiel[illegible] (pink).

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CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME	INDUSTRIAL HYGIENE SAMPLE
5295.3	NAVSTA Roosevelt Roads	Y / N

SAMPLERS: (Signature) (Printed) Julie de la Fuente

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	PCB							REMARKS
RR16SD10	5/9	11:45		✓	Site 16-Sediment-10	2	2							75663
RR16SD11	5/9	11:55		✓	Site 16- " -11	2	2							75664
RR16SD12	5/9	11:40		✓	" - " -12	2	2							75665
RR16GB03	5/9	15:10		✓	Site 16 GB 3	1	1							75672
RR16C01	5/9	15:34		✓	Site 16-Chip-3	1	1							75666
RR16C02	5/9	1535		✓	Site 16-Chip-2	1	1							75667
RR16C03	5/9	1541		✓	" - " - 3	1	1							75668
RR16C04	5/9	15:44		✓	" - " - 4	1	1							75669
RR16C05	5/9	15:37		✓	" - " - 5	1	1							75670
RR16C06	5/9	15:30		✓	" - " - 6	1	1							75671
None to follow for Site 16														

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
(Printed)		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
(Printed)		(Printed)		Use Field Sample nos. on Analytical Report; Three-part label nos. are for cross-reference and verification only

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CHAIN OF CUSTODY RECORD

1 of 7

PROJECT NO.	PROJECT NAME	PARAMETERS	INDUSTRIAL HYGIENE SAMPLE
5295.3	NAVSTA Roosevelt Roads		Y / N

SAMPLERS: (Signature) [signature] (Printed) Juliana de la Fuente

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	PCBs								REMARKS
RR16S01A	5/15/91	13:30	✓		Site 16-Soil-1	1	1								75765
RR16S02A		13:35	✓		" - " - 2	1	1								75766
RR16S03A		13:40	✓		" - " - 3	1	1								75767
RR16S04A		13:25	✓		" - " - 4	1	1								75768
RR16S05A		15:55	✓		" - " - 5	1	1								75769
RR16S05AD		15:55	✓		" - " - 5	1	1								75753
RR16S06A		13:45	✓		" - " - 6	1	1								75770
RR16S07A		12:50	✓		" - " - 7	1	1								75771
RR16S08A		13:55	✓		" - " - 8	1	1								75772
RR16S09A		14:00	✓		" - " - 9	1	1								75773
RR16S10A		14:05	✓		" - " - 10	1	1								75774
RR16S11A	↓	14:10	✓		" - " - 11	1	1								75775

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[signature]	5/16/91				
(Printed) Juliana de la Fuente		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
				Use field sample no.s on analytical reports; time-part lab ID #s are for cross-reference and verification only
(Printed)		(Printed)		

Distribution: Original Plus One Accompanies Shipment (white and yellow); Copy to Coordinator Field Files (pink).

RR-00207-03.13-05/15/92

Versar INC.

CHAIN OF CUSTODY RECORD

29-1

PROJECT NO.	PROJECT NAME	PARAMETERS	INDUSTRIAL HYGIENE SAMPLE
5295.3	NAVSTA Roosevelt Roads		Y / N

SAMPLERS: (Signature) [signature] (Printed) Juliana de la Tuente

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	PCBs								REMARKS
RR16S12A	5/15/92	14:45	✓		site 16 - Soil - 12	1	1								75776
RR16S13A		14:51	✓		" - " - 13	1	1								75777
RR16S14A		15:05	✓		" - " - 14	1	1								75778
RR16S15A		14:55	✓		" - " - 15	1	1								75779
RR16S16A		14:45	✓		" - " - 16	1	1								75780
RR16S17A		16:20	✓		" - " - 17	1	1								75781
RR16S18A		15:25	✓		" - " - 18	1	1								75782
RR16S19A		15:30	✓		" - " - 19	1	1								75783
RR16S20A		15:15	✓		" - " - 20	1	1								75784
RR16S21A		16:00	✓		" - " - 21	1	1								75785
RR16S22A		16:30	✓		" - " - 22	1	1								75786
RR16S23A	↓	16:15	✓		" - " - 23	1	1								75787

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[signature]	5/15/92				
(Printed) Juliana de la Tuente		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
				Use field sample #'s on analytical reports; three-part label #'s are for cross-reference and verification only
(Printed)		(Printed)		

Distribution: Original Plus One Accompanies Shipment (white and yellow); Copy to Coordinator Field Files (pink).

RR-00207-03.13-05/15/92

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CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME	INDUSTRIAL HYGIENE SAMPLE
5295.3	NAVSTA Roosevelt Roads	Y / N

SAMPLERS: (Signature) Juliana de la Fuente (Printed) Juliana de la Fuente

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	PCBs								REMARKS
RR165 24A	5/15/91	16:00	✓		Site 16 - Soil - 24	1	1								75789
RR165 25A		16:05	✓		" - " - 25	1	1								75790
RR165 26A		16:25	✓		" - " - 26	1	1								75788
RR165 27A		14:25	✓		" - " - 27	1	1								75752
RR165 28A		14:20	✓		" - " - 28	1	1								75791
RR165 29A		14:15	✓		" - " - 29	1	1								75792
RR165 30A		14:30	✓		" - " - 30	1	1								75793
RR165 31A		15:10	✓		" - " - 31	1	1								75794
RR165 32A		15:00	✓		" - " - 32	1	1								75795
RR165 33A		15:30	✓		" - " - 33	1	1								75796
RR165 33AD		15:50	✓		" - " - 33	1	1								75797
RR165 34A		15:45	✓		" - " - 34	1	1								75798

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Juliana de la Fuente	5/16/91				
(Printed) Juliana de la Fuente		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
				use field sample #'s on analytical reports. Three-part label #'s are FOR cross-reference and verification only.
(Printed)		(Printed)		

Distribution: Original Plus One Accompanies Shipment (white and yellow); Copy to Coordinator Field Files (pink).

RR-00207-03.13-05/15/92

Vers Inc.

CHAIN OF CUSTODY RECORD

4 of 4

PROJECT NO.	PROJECT NAME	INDUSTRIAL HYGIENE SAMPLE (Y / N)
5295.3	NAVSTA Roosevelt Roads	

SAMPLERS: (Signature) Juliana de la Fuente (Printed) Juliana de la Fuente

FIELD SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS		PARAMETERS	REMARKS
RR16S34AD	5/15/91	15:45	✓		Site 16 - Soil - 34	1	1		75799
RR16SW01		12:55	✓		" - Water - 1	1	1		note: ran out
RR16SW02		12:30	✓		" - 2	1	1		of three part
RR16SW02D		12:35	✓		" - 2	1	1		labels
RR16W03		16:40	✓		" - 3	1	1		
RR16FB		16:45	✓		" - 34	1	1		
RR16TW01		12:45	✓		" - Wipe 2	1	1		
~~[illegible]~~			✓		"				
~~[illegible]~~			✓		"				
~~[illegible]~~			✓		"				
~~[illegible]~~			✓		"				
~~[illegible]~~			✓		"				

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Juliana de la Fuente	5/16/91				
(Printed) Juliana de la Fuente		(Printed)	(Printed)		(Printed)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
(Printed)		(Printed)		Use field sample no: 01 [illegible] re-prints; [illegible] Label #5 only for cross-reference and verification only.

Distribution: Original Plus One Accompanies Shipment (white and yellow); Copy to Coordinator Field Files (pink).

RR-00207-03.13-05/15/92

Versar INC.

MEMORANDUM

TO: Noel Simmons

FROM: Justine Alchowiak

DATE: September 6, 1991

SUBJECT: Data Validation for Roosevelt Road

Attached are the results of the data validation completed for Roosevelt Road. A summary of the data validation was completed for each batch of analytical data. The data were reviewed for the following items:

- Holding time
- Calibration
- Blanks
- Surrogate recoveries
- Matrix spike/matrix spike duplicate recovery
- Field duplicates
- Compound identification and quantification

An assessment of the data usability was also completed.

Data Validation
Versar Control No. 4774, B #1
Sediments

The following field numbers are included in B #1:

Field Number	Surrogate Recovery Outside Range (60-140%)
Laboratory Batch 1	
RR16SD09DL2 (1/100)	X
RR16SD09MS	X
RR16SD09MSD	X
RR16SD10DL2 (1/100)	X
RR16SD11DL (1/10)	X
RR16SD12	X
RR16SD01	X
RR16SD02	X
RR16SD03	X
RR16SD04	X
RR16SD05DL (1/10)	X
RR16SD06DL (1/10)	X
RR16SD07	X
RR16SD08DL (1/10)	X
RR16SD08DDL (1/10)	X
RB0385 (Reagent Blank)	
MSTD50052 (Method Standard)	X
Laboratory Group 2	
RR15CO2DL (1/10)	X
RR15CO1	X
RR16CO2	X
RR16CO3	X
RR16CO4DL3 (1/1000)	X
RR16CO5DL2 (1/100)	X
RR16CO6	X
RB0383	
MSTD50014	X
RR15CO2MS	X
RR15CO2MSD	X
Laboratory Group 3	
RR16CO1	X
RB0419	
MSTD50057	X

Holding Time	All samples were extracted and analyzed within the holding specified in the April 9, 1991, QAPjP. The holding time specified is 10-day extraction and 40 days to analysis.
Calibration	All appropriate calibration criteria were met.
Blanks	No Aroclors were detected in the blanks.
Surrogates	HBB was used as the surrogate; however, this surrogate elutes in the PCB chromatographic pattern. Due to the presence of Aroclor 1260 in the samples, the results for the surrogates for most samples were either inflated due to the Aroclor concentrations or were diluted out in samples requiring 1/10, 1/100, or 1/1000 dilutions to quantify the Aroclor levels. The poor surrogate recovery should be noted with a qualifier stating they were either inflated due to Aroclor presence or were diluted out, but the surrogate recovery results should not impact the usability of the sample data.
Matrix Spikes/ Matrix Spike Duplicate Recoveries	Matrix spike and matrix spike duplicates were completed for samples RR15CO2. The results were outside the required precision and accuracy limits; however, the samples were not spiked with a sufficient level of Aroclor 1260 over the native level of the sample. In the case of sample RR16SD09, the native level is 206,226 ug/kg and the sample was only spiked with 142.857 and 143.430 ug/kg for MS and MSD, respectively. In the case of sample RR15CO2, the native level is 6538.84 ug/kg and the sample was only spiked with 98.8142 and 98.5221 ug/kg, respectively. The poor matrix spike recoveries should be noted in the final report, with a qualifier stating that the poor recovery levels resulted from adding an insufficient spike amount when compared to the native level in the sample. These poor recoveries should not impact the quality of the results for the non-spiked samples. The method standards (MSTD50052, MSTD50057, and MSTD50014) had recoveries of 102, 136, and 118 percent, respectively. This indicates that the laboratory adequately followed the method.
Field Duplicates	The results of the field duplicates RR15SD08DL and RR16SD08DDL are 44,000 and 46,000 ug/kg, respectively for Aroclor 1260. This is an RPD of 4.4 percent. There were no QC criteria specified for field duplicates.

Compound Identification and Quantification	Presence of the Aroclors were confirmed with a secondary column as specified in the analytical procedure. Data not confirmed with the secondary column were flagged with an "A" to indicate the potential presence of the Aroclor, but that its presence was not confirmed. Note that sample RR16SD12 is flagged with an "A" for Aroclor 1242. Therefore, the sample should be used with caution and should be flagged as "present but not confirmed with secondary column." However, the data value should represent a worst case.
Usability	All sample results for this batch are usable, however, data should be flagged as noted above.

Data Validation - Roosevelt Road
Control #4795
VLI No. 420.1, B #2, Set A

The following field numbers were included:

Field Number	Surrogate Recovery Outside Range (60-140%)
RR15SD01A	
RR15SD01B	
RR15SD02A	X
RR15SD02AMS	X
RR15SD02AMSD	X
RR15SD03A	X
RR15SD03B	
RR15SD04A	
RR15SD04B	
RR15SD05A	X
RR15SD06A	
RR15SD06DA	
RR15SD07A	X
RR15SD07B	X
RR15S01A	X
RR15S01B	X
RR15S02A	
RR15S03A	
RR15S04A	X
RR15S05A	X
RR15S05DA	X
RR15S06A	X
MSTD50270	X
PBLK03 (No data)	
PBLK04	

Holding Time — All samples were extracted and analyzed within the holding time specified in the April 9, 1991, QAPjP. Holding time is 10 days to extraction and 40 days to analysis.

Calibration — All appropriate calibration criteria were met.

Blanks — PBLK04 contained an estimated 69 ug/kg (J) of Aroclor 1260, however, this is below the detection limit of 100 ug/kg. Since value was below the detection limit, no corrective action was required to be taken. Data do not need to be adjusted or flagged; blank value on data report is reported as < 100 ug/kg.

Surrogates	HBB was used as the surrogate, however, this surrogate elutes in the PCB chromatographic pattern. Surrogate recoveries were within the ±40 percent accuracy range for 14 of 25 samples. For the remaining samples, the surrogate recoveries were inflated due to presence of one of the Aroclors. The poor surrogate recoveries in this case should be flagged with a data qualifier stating the results were inflated due to the presence of the Aroclors in the samples, but the surrogate recovery results should not impact the usability of the sample data.
Matrix Spike/ Matrix Spike Duplicate Recoveries	Matrix spike and matrix spike duplicate recoveries were 85 and 173 percent, respectively. Therefore, one value met the QC objectives of ±40 percent and one did not. The difference in the two values is probably due to the nonhomogenity of the sample matrix. The qualification of the data should be limited to the MS/MSD. The method standard had a recovery of 105 percent which indicates that the laboratory was able to adequately follow the method.
Field Duplicates	The results of the field duplicate, RR15SD06A and RR15SD06DA, were 1000 and 970 ug/kg for Aroclor 1260. These samples have an RPD of 3.0 percent. The results of the field duplicate, RR15SD05A and RR15SD05DA, were 2,500 and 1,700 ug/kg for Aroclor 1260. These samples have an RPD of 38.1 percent. No precision requirements were specified for field duplicates.
Compound Identification and Quantification	All samples were identified and quantified as specified in the method. All Aroclor results identified using the primary column were confirmed using the secondary column.
Usability	All sample results for this batch are usable, however, data should be flagged as note above.

Data Validation - Roosevelt Road
Control #4795
VLI No. 420.1, B #2, Set C

The following samples were included in B #2, Set C:

Field Number	Surrogate Outside Control Limit
RR15S24A	
RR15S24AMS	
RR15S24AMSD	X
RR15S24B	
RR15S25A	
RR15S25AD	
RR15S26A	
RR15S26AD	X
RR15S27A	
RR15S28A	
RR15S24AMSTD	
PBLK07	
PBLK08	

Holding Times — All samples were extracted and analyzed within the holding time specified in the April 9, 1991, QAPjP. Holding time specified is 10 days to extraction and 40 days to analysis.

Calibration — All appropriate calibration criteria were met.

Blanks — No Aroclors were detected in the blanks.

Surrogates — HBB was used as the surrogate, however, this surrogate elutes in the PCB chromatographic pattern. Due to the high concentration of Aroclor 1260 in sample RR15S26AD the surrogate recovery level was elevated and outside the QC objective limits of 60 to 140 percent. Sample RR15S24AMSD also had a surrogate recovery (145 percent) outside the QC range due to the presence of Aroclor 1260, however, this sample is a matrix spike duplicate and the recoveries of the sample and matrix spike of 138 and 140 percent, which are within the QC criteria. Therefore, the surrogate recoveries outside the QC range should be flagged for the specific sample with a qualifier stating the results were inflated due to the presence of Aroclors in the samples, but the surrogate recovery results should not impact the usability of the sample data.

Matrix Spike/ Matrix Spike Duplicate Recoveries	The MS/MSD recoveries for RR15S24AMS and RR15S24AMSD were 96 and 90 percent and the RPD was 6 percent. Therefore, the results are in the specified QC limits of 60 to 140 percent for accuracy as measured by the recovery and 40 percent for precision as measured by the RPD. In addition, the method standard had a recovery of 96 percent, therefore, indicating that the laboratory adequately followed the method.
Compound Identification/ Quantification	All sample results from primary column analysis indicating the presence of Aroclors was confirmed with the secondary column.
Usability	All sample results for this batch are usable, however, data should be flagged as noted above.
Field Duplicates	There are no QC criteria established to evaluate the field duplicates. The field duplicates RR15S25A and RR15S25AD had results for Aroclor 1260 of 290 and 200 ug/kg, respectively. The RPD for the sample was 36.7 percent. The field duplicate results for RR15S26A and RR15S26AD for Aroclor 1260 were 1,500 and 59,000 ug/kg, respectively. The RPD for the sample was 190.1 percent.

Data Validation - Roosevelt Road
Control #4803
VLI No. 420.1, B #3, Set A

The following samples were included in B #3, Set A:

Field Number	Surrogate Outside Control Limit
Water	
PBLK43	
PBLK44	
RR16SW01	X
RR16SW02	X
RR16SW02MS	X
RR16SW02D	X
RR16SW02MSD	X
RR16SW03	
RR16EB	
50475MSTD	X
Soil	
PBLK41	
PBLK42	
RR16S01A	
RR16S02A	
RR16S03A	
RR16S04A	
RR16S05A	
RR16S05AD	
RR16S06A	
RR16S07A	
RR16S08A	X
RR16S09A	X
RR16S10A	X
RR16S11A	X
RR16S12A	X
RR16S13A	X
RR16S14A	X
RR16S15A	X
RR16S16A	X

Field Number	Surrogate Outside Control Limit
Soil (continued)	
RR16S17A	X
RR16S18AMS	X
RR16S18AMSD	X
RR16S19A	X
50437MSTD	
Wipes	
PBLK39	
PBLK40	
RR16TW01	
50474MSTD	

Holding Times	All samples were extracted and analyzed within the holding time specified in the April 9, 1991, QAPjP. Holding time specified is 10 days to extraction and 40 days to analysis.
Calibration	All appropriate calibration criteria were met.
Blanks	No Aroclors were detected in the blanks.
Surrogates	HBB was used as the surrogate, however, this surrogate elutes in the PCB chromatographic pattern. Due to the presence of Aroclors in the samples, the results for the surrogate for the majority of the water and soil samples were outside of the QC objective of 60 to 140 percent. The poor surrogate recoveries should be noted for the specific samples with a data qualifier stating the results were inflated due to the presence of the Aroclors in the samples, but the surrogate recovery results should not impact the usability of the sample data.
Matrix Spike/ Matrix Spike Duplicate Recoveries	For water, the MS/MSD recoveries were 0 and 77 percent, respectively. The MS/MSD were prepared from different samples. The results of the sample RR16SW02M5 with 0 percent recovery should be flagged with a qualifier explaining poor recovery was obtained, sufficient sample was not available to repeat analysis; however, it may be possible that no spike was added to the sample. The method standard had a recovery of 106 percent and the MSD had a recovery within the limit indicating that the method was followed by the laboratory. For soils, the MS/MSD had recoveries of 45 percent and 279 percent, respectively. These data indicate that there may be a

problem with sample nonhomogenity. The data for the MS/MSD should be flagged as being outside the QC limit and may be from matrix interferences or from sample nonhomogenity. The data for the method standard for soils indicates that a 70 percent recovery was obtained. These data indicate that the method was adequately followed by the laboratory. For the wipes, a MS/MSD was not completed. The method standard had a recovery of 99 percent indicating that the method was adequately followed by the laboratory.

Field Duplicates

There are no QC criteria established to evaluate the field duplicates. For water matrix, the results of the field duplicates RR16SW02 and RR16SW02D for Aroclor 1260 were 54 and 41, respectively. The RPD for the field duplicate was 27.4 percent. For the soil matrix, the results of the field duplicate RR15S05A and RR16S05AD for Aroclor 1260 were 21,000 and 43,000, respectively. The RPD for the field duplicate was 68.75 percent. There was no field duplicate for the wipe samples.

Compound Identification/ Quantification

All sample results from primary column analysis indicating presence of Aroclors were confirmed with the secondary column. Sample RR16S01A contained Aroclors 1248 and 1260. Sample RR16S04A contained Aroclors 1254 and 1260; the data for this sample was flagged with an "X" indicating inflated results due to cross contribution by PCBs in a mixture.

Usability

All sample results for this batch are usable, however, data should be flagged as noted above.

RR-00207-03.13-05/15/92

REMEDIAL ACTION
ALTERNATIVES ANALYSIS
FOR THE OLD POWER PLANT, BUILDING 38,
SITE 16
U.S. NAVAL STATION ROOSEVELT ROADS

CONFIRMATION STUDY TO DETERMINE
POSSIBLE DISPERSION AND MIGRATION
OF SPECIFIC CHEMICALS
U.S. NAVAL STATION ROOSEVELT ROADS

Contract No. N62470-85-B-7972

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
Sacramento, California

May 1988

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1.0 BACKGROUND

This report presents the remedial action alternatives analysis for the contaminated soil at the Old Power Plant, Site 16, Naval Station (NAVSTA) Roosevelt Roads, Puerto Rico. The potential contaminants at Site 16 include polychlorinated biphenyls (PCBs) and lead. The alternatives analysis presented herein includes an evaluation of four remedial action alternatives with different clean-up requirements for the soil at Site 16. The clean-up criteria used are based on a risk assessment and, for PCBs, the levels established by the Environmental Protection Agency (EPA) in the Toxic Substance Control Act (TSCA) policy for more recent spills (occurring after May 4, 1987).

The characterization of Site 16 was performed as part of the Confirmation Study of NAVSTA Roosevelt Roads. The objective of the study is to determine if specific toxic or hazardous materials have contaminated the environment at the Navy Activities and may include consideration of various remedial alternatives. The study is part of the Navy Assessment and Control of Installation Pollutants (NACIP) program designed to identify contamination of Navy lands resulting from past operations and to institute corrective measures, as needed.

The NACIP program consists of three distinct phases:

- Initial Assessment Study (IAS)--record searches and personnel interviews to collect and evaluate all evidence supporting the existence of a contamination problem at an installation.

- o Confirmation Study--on-site investigations including physical and analytical monitoring to confirm or refute the existence of contamination, and, if necessary, recommending both interim and long-term corrective measures.
- o Corrective Measures--institution of needed interim and/or long-term remedial measures to control and mitigate contamination.

The IAS phase of the NACIP for NAVSTA Roosevelt Road was conducted in 1984. IAS results for the Old Power Plant (Building 38), Site 16, indicated the potential presence of PCBs and fuel-related contamination in the soil which can pose a health or environmental threat on or off the Naval facility. Consequently, Site 16 was recommended for further investigation in the second phase of the NACIP program, the Confirmation Study.

Building 38 was a 60-megawatt steam turbine facility that generated power from the early 1940's through 1949. The plant used Bunker "C" fuel, which was stored in the two 50,000-gallon underground reinforced concrete tanks located along the northeast side of the building. This area where the underground tanks are located is paved over with concrete. According to the IAS, Bunker "C" fuel was reported to have been found in manholes near Building 38 in the 1970's and was reportedly discharged to the Enlisted Beach via the cooling water outlet for the power plant. During the period of 1956 to 1964, Site 16 was used by the Public Works Department-Power Distribution Shop for the repair and storage of electrical transformers. The majority of the repair was conducted outside of Building 38, along its northeast side. IAS interviewees reported the draining of PCB-containing

transformer oil onto the soil in order to repair the inner cores and coils. The only known exception to this practice was with transformers containing Askarel (a type of PCB). Reportedly, the Askarel fluid was drained into 55-gallon drums for disposal at the Station Landfill.

The Confirmation Study phase of the NACIP program is being performed in sequential efforts, termed Steps, which are defined below.

Step	Description
IA	Verification of existence of contamination.
IB	Characterization of extent and rate of migration of contaminants, geohydrological, geophysical, and other factors.
II	Evaluation of alternatives to achieve compliance, preparation of cost estimates, and project effectiveness of alternatives.
III	Preparation of site operation and draft Government project documentation with cost estimate(s) satisfactory for project funding requests.

Verification Step sampling and analysis for Site 16 was completed in May 1986. This sampling program consisted of the collection of soil samples for analysis of PCBs and fuel-related components, including lead. Because PCBs and lead contamination were detected, the study proceeded onto Step IB of the Confirmation Study phase of the NACIP, the Characterization Step, which was completed in January 1988. Results from the Characterization Study were then used to complete a remedial action alternatives analysis for Site 16.

Section 2.0 of this report presents the results of the Verification sampling which led to the Characterization Study of Site 16. The chemical data collected during the Characterization Step are presented in Section 3.0, and the risk assessment for the contaminants of concern is discussed in Section 4.0. Finally, in Section 5.0, the remedial action alternatives for Site 16 are described and illustrated, and a cost analysis for each proposed action is also included in Section 5.0.

2.0 VERIFICATION STEP RESULTS

During the Round 1 Verification Step (Step IA) of the NAVSTA Roosevelt Roads Confirmation Study, nine soil samples were collected at Site 16. As shown in Figure 2-1, six samples were collected along the northeast and southeast sides of Building 38, and three samples were collected north of the building around the fenced transformer station. Seven of the nine samples collected were composites of the soil in the 0- to 1-foot (ft) depth interval. The remaining two (16S7A and 16S9A) were surficial soil grab samples collected from the concrete-lined drainage ditch along the southeast side of the fenced transformer area.

The soil samples collected during the Round 1 Verification Step were analyzed for PCBs and fuel-related components, specifically oil and grease, volatile organic compounds, lead, ethylene dibromide (EDB), xylenes, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK). Table 2-1 presents the analytical results for the soil samples. Data is presented only for those constituents that were detected, and the complete database for the Verification sampling is contained in Appendix A. The analytical results indicate that PCB contamination exists adjacent to Building 38 as well as adjacent to the fenced area north of the building. In addition, elevated lead levels were detected along the north and northeast side of Building 38 (16S1A, 16S3A, and 16S4A). Figures 2-2 and 2-3 depict the PCB and lead concentration data, respectively. Other constituents detected, but not at levels of concern, were MEK and oil and grease.

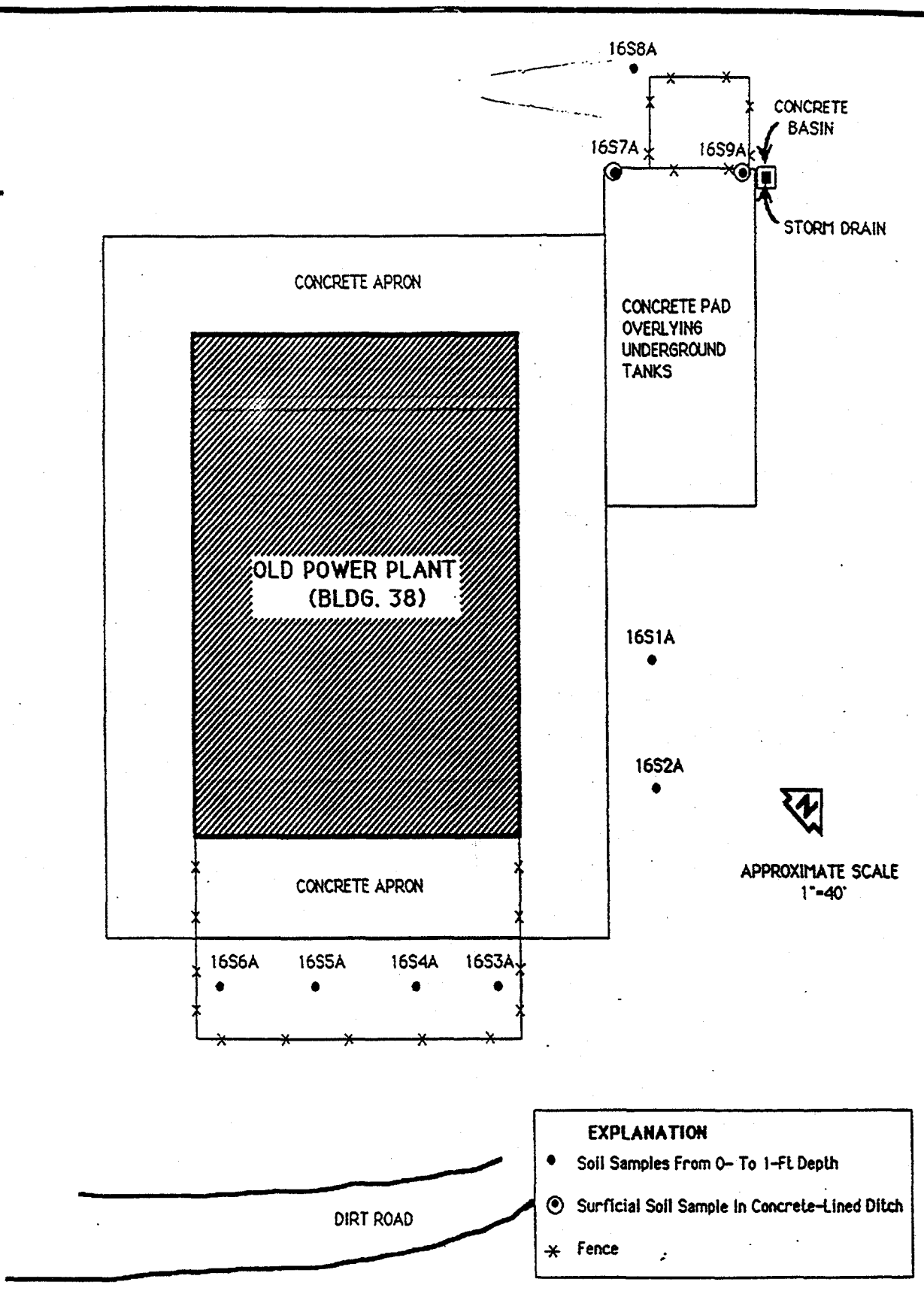

FIGURE 2-1
VERIFICATION STEP SAMPLING LOCATIONS AT SITE 16, THE OLD POWER PLANT, BUILDING 38

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Table 2-1. Verification Step Soil Sampling Results for the Old Power Plant, Building 38, Site 16

Constituent	Concentrations (ug/g, dry)								
	16S1A	16S2A	16S3A	16S4A	16S5A	16S6A	16S7A	16S8A	16S9A
Lead	3,910	420	15,700	834	151	12.7	69.8	215	---
Oil & Grease	109	---	6,350	5,720	919	574	1,310	840	22
Methyl Ethyl Ketone	---	---	---	1	---	---	---	---	1
PCB 1016	---	---	---	---	---	---	---	---	4.78
PCB 1260	---	404	92.9	55.9	3.39	8.85	22.8	---	2.73

Note: --- = Not detected.

Source: ESE, 1986.

RR-00207-03.13-05/15/92

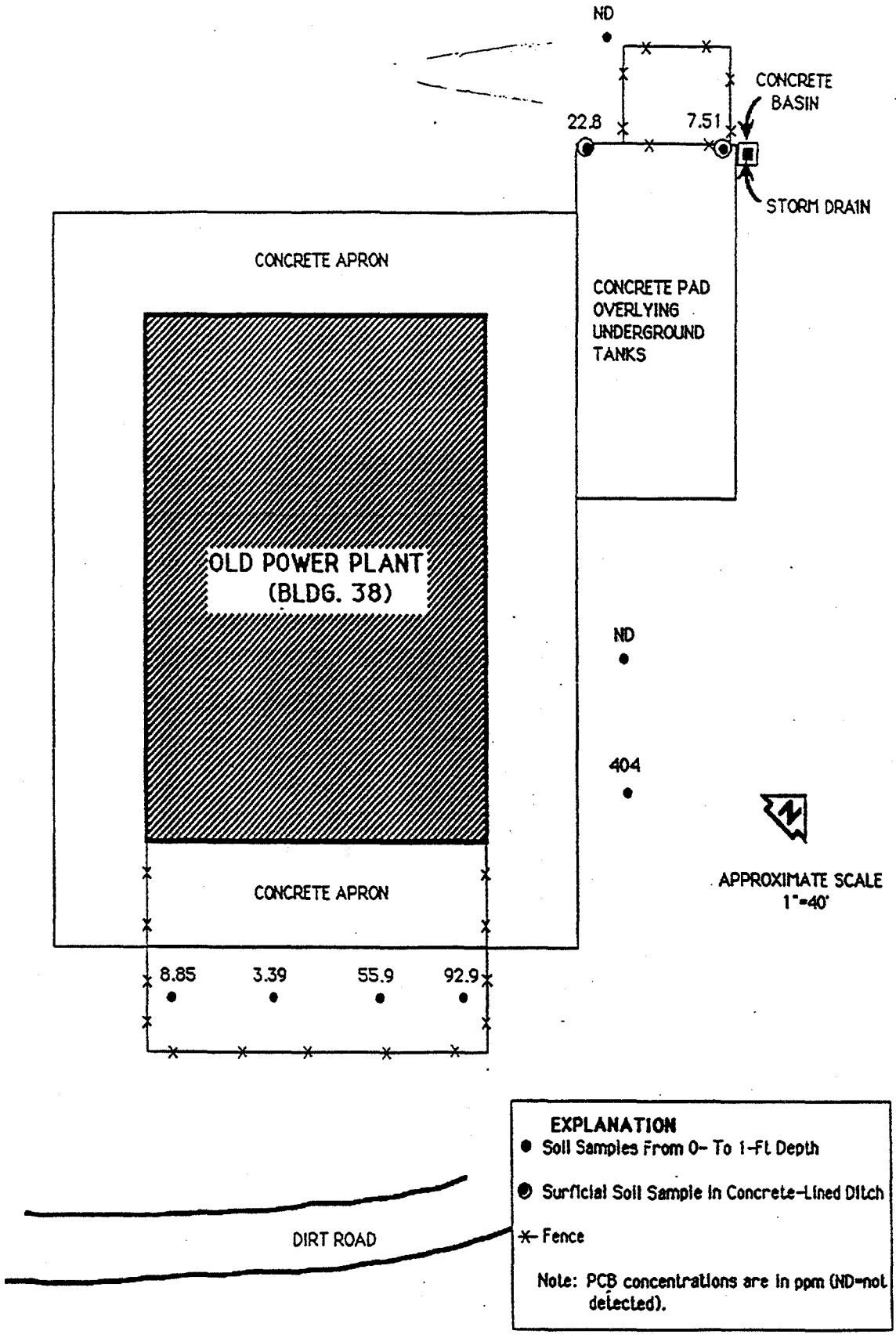

FIGURE 2-2
VERIFICATION STEP PCB RESULTS
AT SITE 16, THE OLD POWER PLANT,
BUILDING 38

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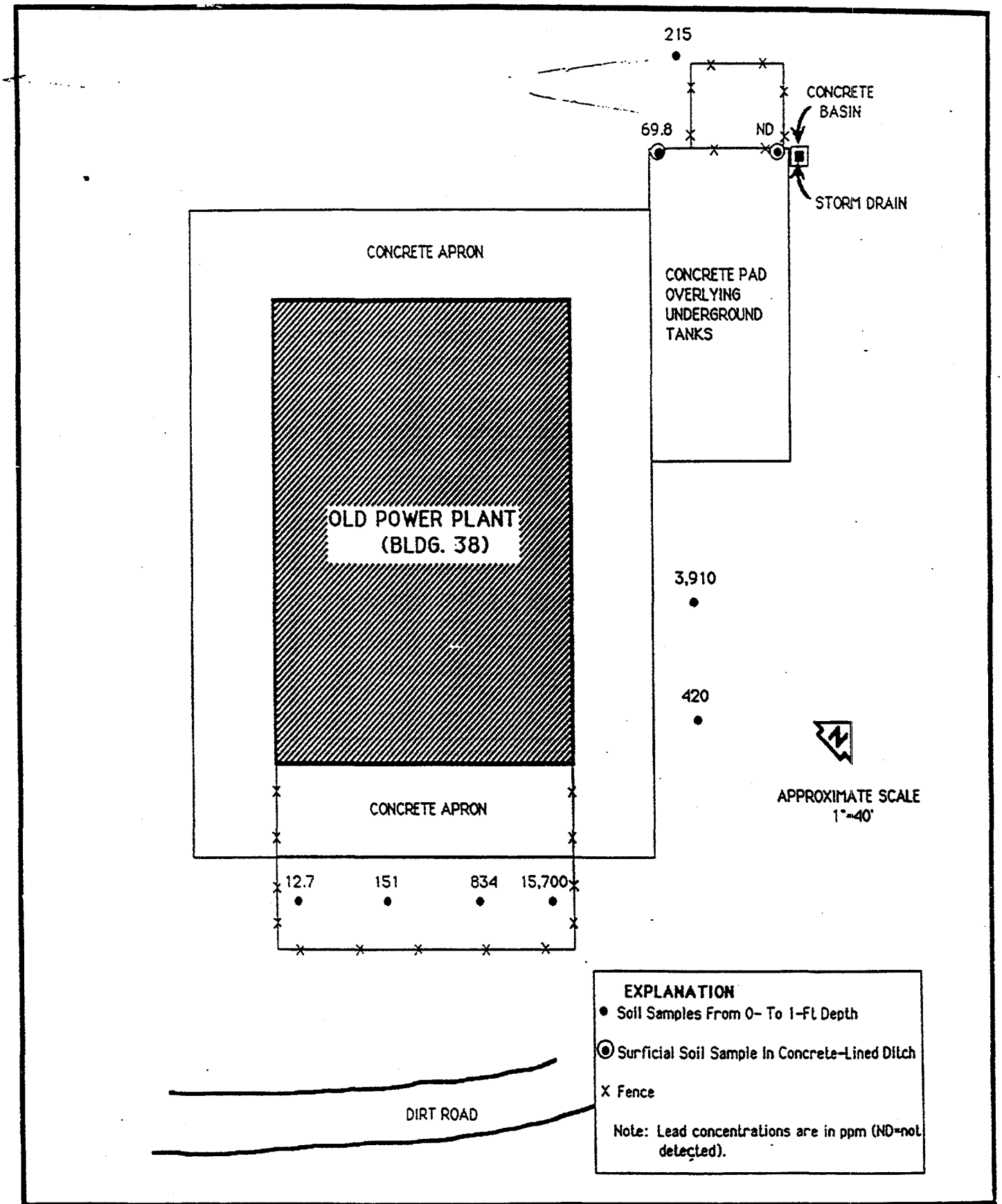

FIGURE 2-3
VERIFICATION STEP LEAD RESULTS AT SITE 16, THE OLD POWER PLANT, BUILDING 38

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Based on results from the Round 1 Verification Step sampling, Site 16 was recommended for additional soil sampling and analysis to delineate the extent of PCB and lead contamination. EPA Extraction Procedure (EP) toxicity testing for lead was also recommended.

3.0 CHARACTERIZATION STEP RESULTS

The work plan for the characterization of Site 16 specified the hand-augering of 20 soil borings with the collection of three soil samples per boring, and the collection of six surficial soil samples (one per sampling location) from along the concrete-lined drainage ditch. The sampling locations are shown in Figure 3-1. The borings were to be drilled to a depth of 3 ft, and composite soil samples were to be collected from the 0- to 1-ft, 1- to 2-ft, and 2- to 3-ft depth intervals. Thus, a total of 66 samples were to be collected; 60 composite samples from the 20 soil borings and 6 surficial grab samples from the concrete-lined drainage ditch. However, because coral was encountered at a depth ranging from 9 to 12 inches over most of the site, only 23 samples were collected from the twenty soil boring locations. Composite samples from the 0- to 1-ft depth interval were collected from each of the twenty soil boring locations, but composite samples from the 1- to 2-ft depth interval were collected from only three of the twenty boring locations (Boring locations 16S26, 16S27, and 16S32). None of the composite samples could be collected from the 2- to 3-ft depth interval as planned because of coral. Therefore, a total of 29 soil samples were collected as follows:

No. of Samples	Description
20	Composite from 0- to 1-ft depth interval from twenty boring locations

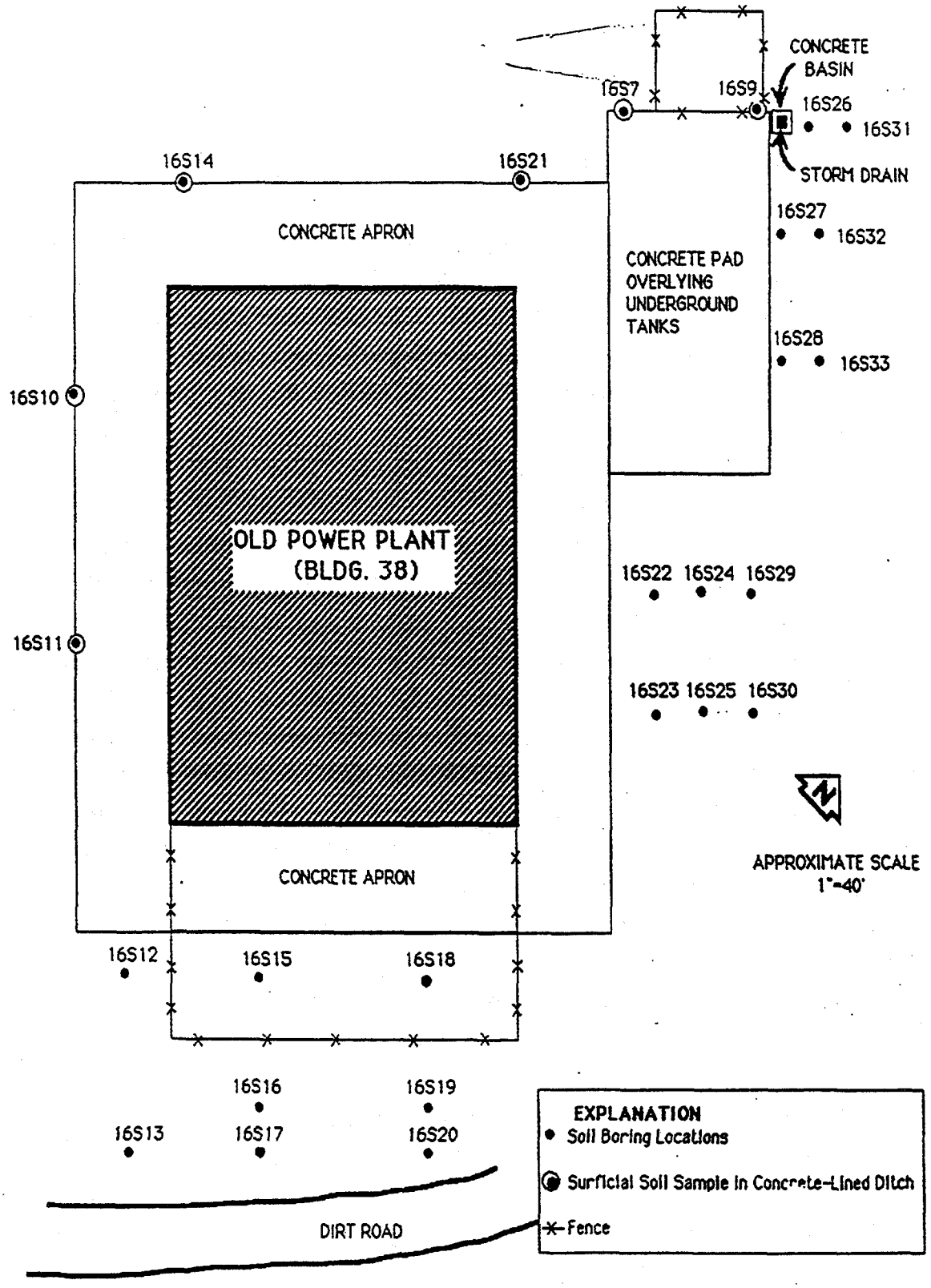

FIGURE 3-1
CHARACTERIZATION STEP SAMPLING LOCATIONS AT SITE 16, THE OLD POWER PLANT, BUILDING 38

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No. of Samples	Description
3	Composite from 1- to 2-ft depth interval from three of the twenty boring locations
6	Surficial grab samples from concrete-lined drainage ditch

The planned analytical program for the Site 16 soil samples included PCB and lead analyses, as well as EP toxicity testing for lead. A phased approach was used in the analyses for PCBs and lead to minimize the analytical costs. This approach involved analyzing one batch of samples selected on the basis of proximity to the source areas (as indicated by the Verification sampling results). Based on the analytical results for the first batch of samples, a second batch was selected for analysis to more fully delineate the extent of contamination. The maximum number of planned PCB analyses coincided with the total planned number of soil samples (66). However, with the reduced number of actual soil samples collected and the phased analytical approach, a total of 27 samples were analyzed for PCBs. Figures 3-2 and 3-3 show the PCB concentration data for the 0- to 1-ft and 1- to 2-ft depth intervals, respectively. The complete characterization sampling database is contained in Appendix B.

A maximum of 33 lead analyses was included in the planned analytical program. This maximum was derived assuming the analysis of all composite soil samples collected from the 0- to 1-ft depth interval from all twenty soil boring locations, and all six surficial grab samples from the concrete-lined drainage ditch. The remaining seven samples of the maximum of 33 were to be selected from those composite samples collected

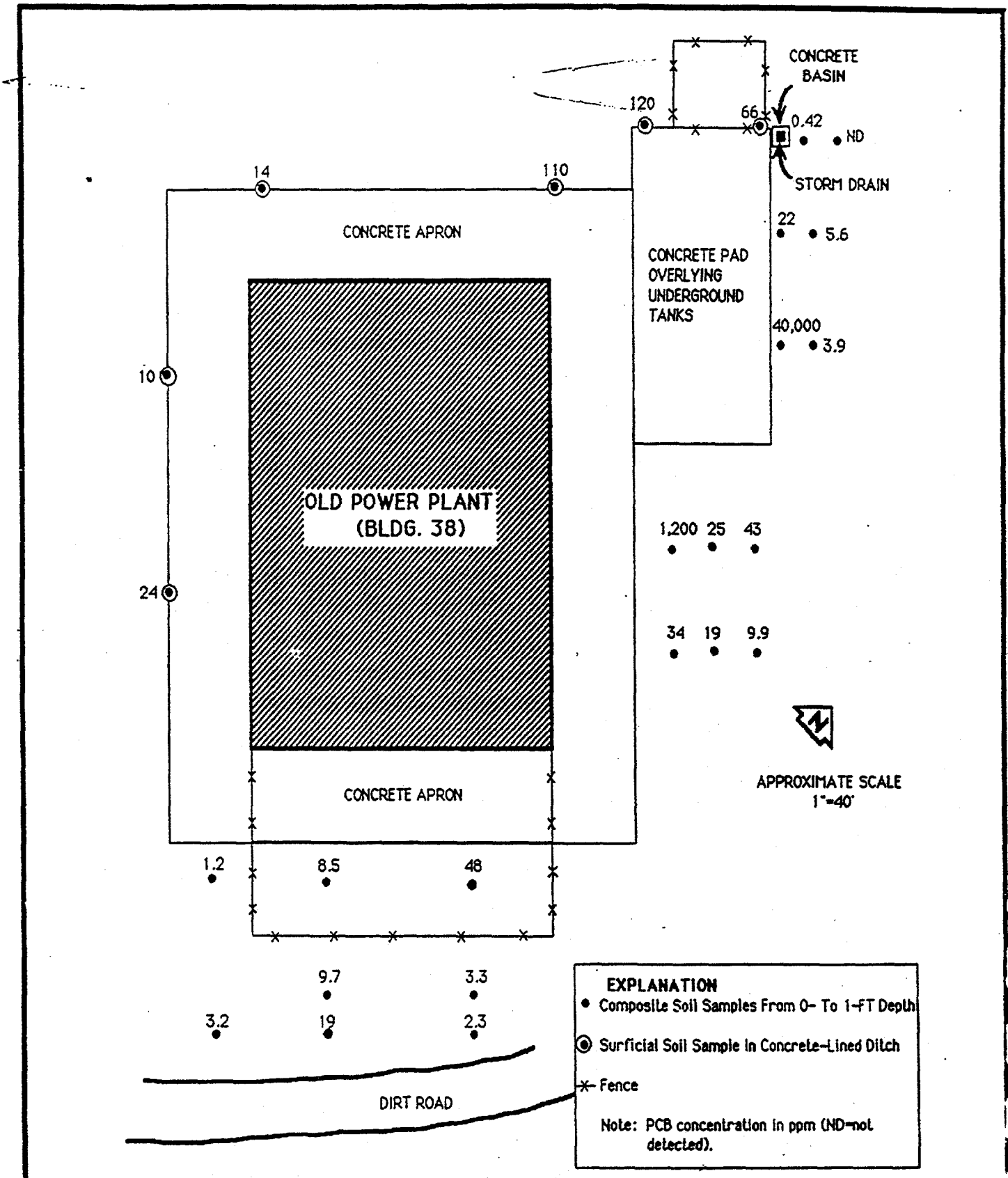

FIGURE 3-2
CHARACTERIZATION STEP PCB RESULTS FOR THE 0- TO 1-FOOT DEPTH INTERVAL AT SITE 16, THE OLD POWER PLANT, BUILDING 38

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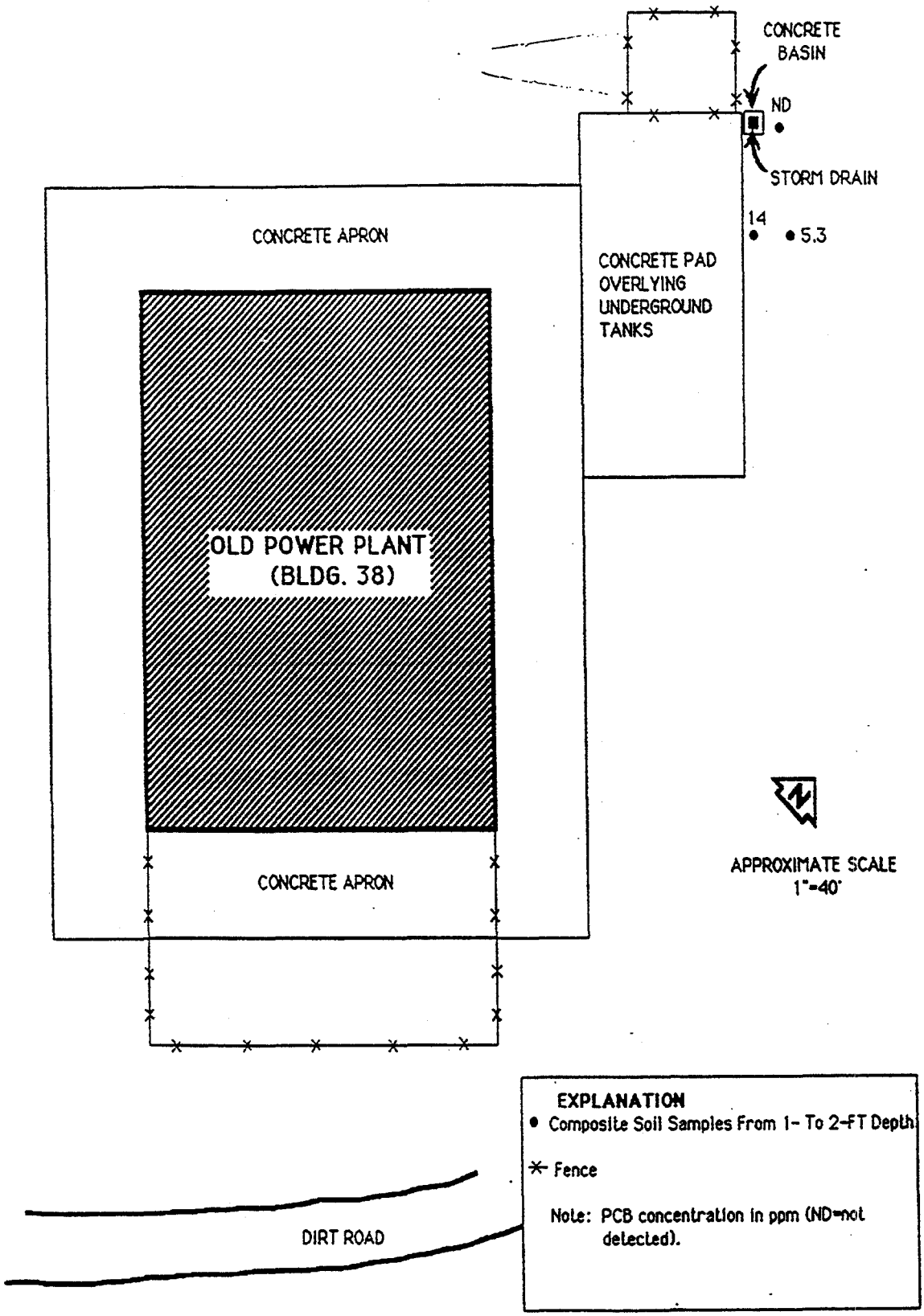

FIGURE 3-3
CHARACTERIZATION STEP PCB RESULTS FOR THE 1- TO 2-FOOT DEPTH INTERVAL AT SITE 16, THE OLD POWER PLANT, BUILDING 38

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from the 1- to 2-ft depth interval of those boring locations showing the highest lead levels in the 0- to 1-ft depth interval. However, with the reduced number of actual soil samples collected and the phased analytical approach, a total of 28 samples were analyzed for lead. Figures 3-4 and 3-5 show the lead concentration data for the 0- to 1-ft and 1- to 2-ft depth intervals, respectively.

A maximum of 14 EP toxicity tests for lead was included in the planned analytical program. This program involved the selection of those samples with the highest total lead concentration for EP toxicity testing. However, because of the generally low levels of lead detected in the soil samples, only seven samples were subjected to the EP toxicity test for lead. The EP toxicity test results are depicted in Figure 3-6. As shown in Figure 3-6, none of the EP toxicity test lead concentrations exceeded the maximum contaminant lead of 5 milligrams per liter (mg/L), or 5,000 micrograms per liter (ug/L), which would classify the soil sample as a hazardous waste.

As previously mentioned the complete analytical database for the Characterization Step is contained in Appendix B. In this database, the first two characters in all of the sample identification numbers are "16" which stands for Site 16. Following the site number, the letter "S" indicates the sample consists of soil. Next every sample location within the site is assigned a number. Finally, the letter following the sample location number indicates the depth interval from which the sample was collected, as follows:

A = 0- to 1-ft depth interval

B = 1- to 2-ft depth interval
C = 2- to 3-ft depth interval

For example, sample "16S23B" provides the following identification:

16	-	Site 16
S	-	Soil
23	-	Sample location number 23
B	-	Sample interval from 1- to 2-ft below the ground surface

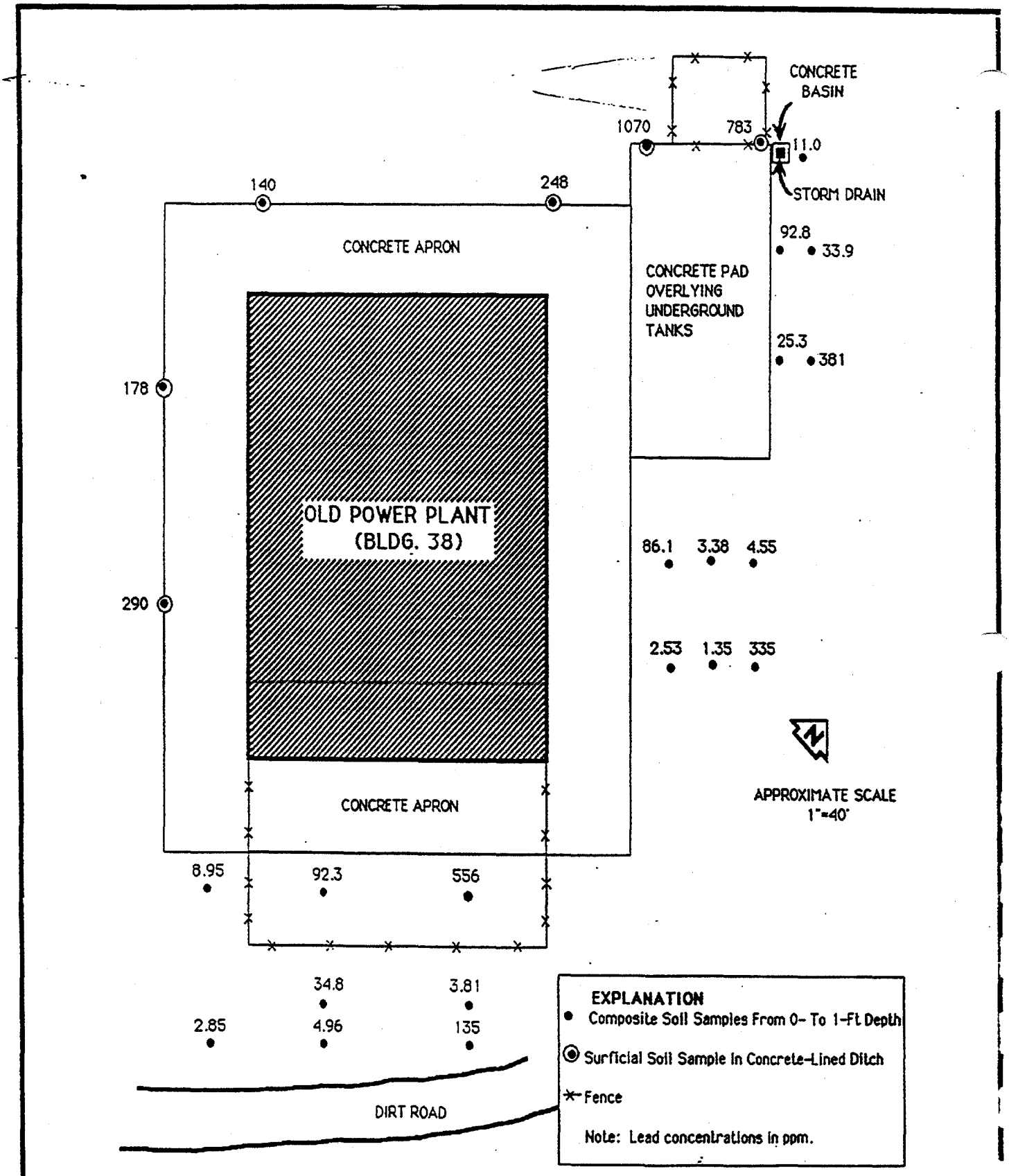

FIGURE 3-4
CHARACTERIZATION STEP LEAD RESULTS FOR THE 0- TO 1-FOOT DEPTH INTERVAL AT SITE 16, THE OLD POWER PLANT, BUILDING 38

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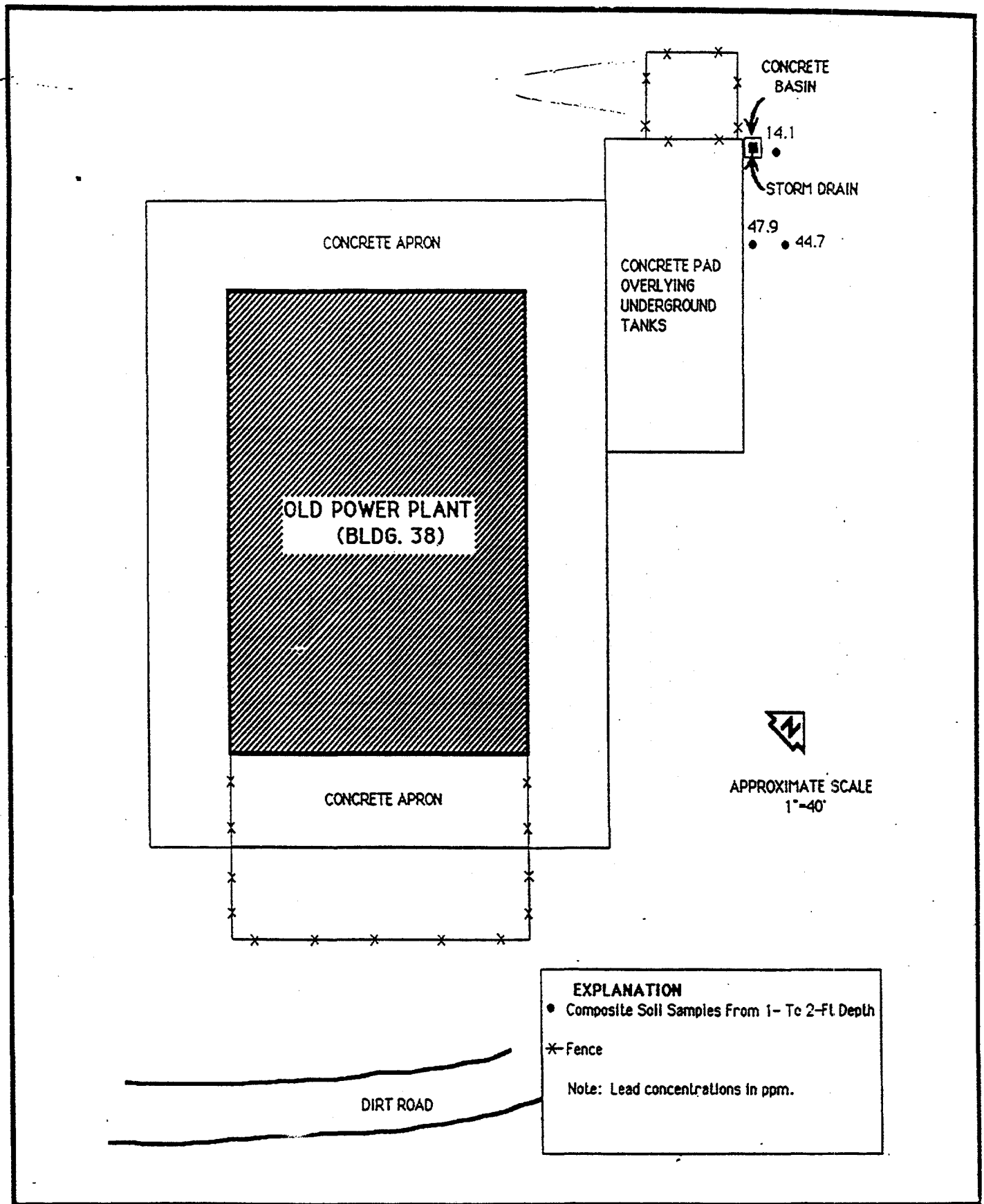

FIGURE 3-5
CHARACTERIZATION STEP LEAD RESULTS FOR THE 1- TO 2-FOOT DEPTH INTERVAL AT SITE 16, THE OLD POWER PLANT, BUILDING 38

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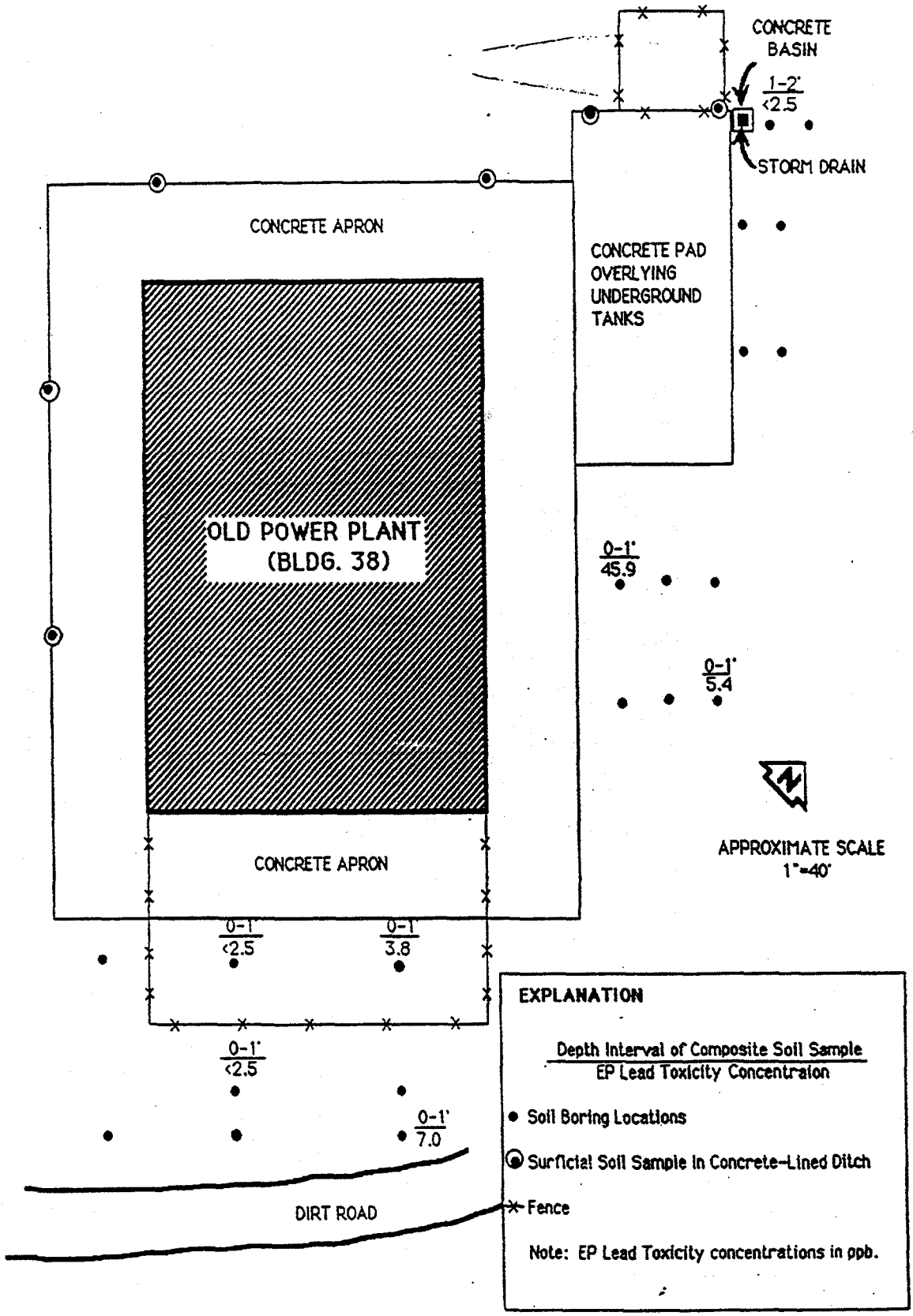

FIGURE 3-6
CHARACTERIZATION STEP EP TOXICITY TEST LEAD RESULTS AT SITE 16, THE OLD POWER PLANT, BUILDING 38

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4.0 RISK ASSESSMENT

The objective of this risk assessment is to determine if the levels of PCBs and lead in the soil at Site 16 pose a threat to human health and/or the environment, and, if so, soil criteria for PCBs and lead that represent safe levels of residual soil contamination.

The development of a PCB soil criterion involved the evaluation of the PCB clean-up requirements set forth by EPA in the TSCA policy to determine their applicability to Site 16, and the performance of a site specific risk assessment. In the TSCA policy, EPA has established criteria to be used in determining the adequacy of the clean-up of spills resulting from the release of materials containing PCBs at concentrations of 50 parts per million (ppm) or greater occurring after May 4, 1987. This policy requires clean-up of PCB-contaminated soil to different levels depending upon the spill location, potential for exposure to residual PCBs remaining after clean-up, the concentration of the PCBs initially spilled, and the nature and size of the population potentially at risk of exposure. For PCB spill areas where there is a greater potential for human exposure to the PCB contamination, the policy requires more stringent clean-up standards. The TSCA PCB regulations are presented below by spill location description.

Spill Location Description	PCB Criterion
(1) Spills at outdoor electrical substations with restricted access	25-50 ppm

Spill Location Description	PCB Criterion
(2) Spills at other restricted access locations other than electrical substations	25 ppm
(3) Spills at nonrestricted access areas	10 ppm

Because the soil contamination at Site 16 exists in an open area with nonrestricted access to lawn maintenance and other station personnel, the 10 ppm clean-up standard would be applicable to the site.

To further evaluate the appropriateness of the 10 ppm clean-up standard for Site 16, a site specific risk assessment was performed. The objective of the risk assessment was the development of a safe level of residual PCB contamination (termed target concentration) based on site specific conditions.

The first step in determining target concentrations is the identification of actual and potential exposure pathways. Only complete exposure pathways are considered for the purpose of developing target concentrations. If any of these components are not present, then the exposure pathway is incomplete and would not be expected to contribute to the total exposure from the site.

A complete exposure pathway has four components:

1. A source of chemical release,

2. An environmental transport medium,
3. A point where human or environmental receptors could be exposed, and
4. A likely exposure route.

A screening of current and potential exposure pathways was conducted to determine which pathways are most significant for the site in terms of human exposure to contaminants. This screening step serves to eliminate from consideration those exposure scenarios in which contaminants may be released from the site but for which there is little or no potential for human contact. This screening also identifies those exposure pathways that are complete and will require detailed quantitative analysis to estimate the extent of human exposure. Environmental receptors were eliminated from further consideration because the contaminated area is too small to support significant populations.

The following routes of exposure have been identified for Site 16 based on the pathway screening analysis:

1. Exposure of workers or the public through dermal absorption of contaminated surface soil,

2. Exposure of workers or the public through incidental ingestion of contaminated surface soil,

3. Exposure of workers or the public through ingestion of contaminated drinking water, and

4. Exposure of workers or the public through inhalation of contaminated dusts and/or vapors.

The following paragraphs describe the rationale for selection or exclusion of the various exposure pathways for developing a target PCB concentration for Site 16.

Exposure Of Workers Or The Public Through Dermal Absorption Of Contaminated Surface Soil--The access to Site 16 by lawn maintenance crews and other station personnel could result in direct contact with soil on exposed skin surfaces and subsequent percutaneous absorption of contaminants. This exposure to soil through dermal absorption represents a complete pathway and, therefore, was included in subsequent analysis of a target PCB concentration.

Exposure Of Workers Or The Public Through Incidental Ingestion Of Contaminated Surface Soil--As a result of persons coming into direct contact with soil contaminants at Site 16, contaminated soil may be accidentally ingested. Persons who have been exposed to soil contaminants through direct contact may consume food items with soiled hands or otherwise ingest soil as a result of unintentional hand-to-mouth contact. Through these mechanisms, persons may actually ingest small quantities of contaminated soil from the site. Because this pathway is considered to be complete, it was included in the development of a target PCB concentration for the site.

Exposure Of Workers Or The Public Through Ingestion Of Contaminated Drinking Water--There are no drinking water wells on or near the site, and it is unlikely that significant leaching and migration of PCB to the ground water, by infiltrating rainwater, is occurring because of the low solubility of PCB in water. Because no exposure point has

been identified and environmental transport is unlikely, this pathway is classified as incomplete and is eliminated from further consideration.

Exposure Of Workers Or The Public Through Inhalation Of Contaminated Dusts Or Vapors--Field investigations of Site 16 have indicated that some of the area is thinly vegetated. Consequently, dispersion of airborne PCB-contaminated dust during lawn mowing is a likely transport mechanism. However, migration via volatilization is an unlikely transport mechanism because PCBs are not very volatile and are not expected to volatilize from the soil. Therefore, dust inhalation, but not vapor inhalation, is considered a complete pathway and was included in development of a target PCB concentration for Site 16.

Based on this exposure pathways analysis, it appears likely that the worst case scenario involves dermal absorption, incidental ingestion, and dust inhalation of residual soil contaminants. Maximum conditions of exposure correspond to a worker performing ground maintenance 2 hours per day for 26 days out of the year. These assumptions were used to modify the dermal absorption factor of 38 milligrams per day (mg/day) developed by Hawley (1985) to yield an annualized average dermal human intake factor of 0.226 milligrams (mg) of soil per day using the following equation:

$$38 \text{ mg/day} \times \frac{26 \text{ workdays/year}}{365 \text{ days/year}} \times \frac{2 \text{ hours/workday}}{24 \text{ hours/day}} = 0.226 \text{ mg/day}$$

The same level of activity was used to modify the lifetime average soil ingestion rate of 100 mg/day suggested by EPA

(1986a) to yield an annualized average incidental soil ingestion human intake factor of 0.594 mg/day.

The inhalation rate for an adult male engaged in moderate activity is 2.8 cubic meters (m^3) per hour (EPA, 1986). In addition, Hawley (1985) has suggested a 75 percent retention of inhaled particles. Assuming that the concentration of suspended particulates at the site will not exceed 10 milligrams per cubic meter (mg/m^3) [threshold limit value for nuisance particles; American Conference of Governmental Industrial Hygienists (ACGIH, 1986)] of which 100 percent can be attributed to site contamination and that weather conditions favorable to airborne dust occur 70 percent of the year, based on an average of 255 dry days per year (EPA, 1986c), an average daily exposure inhalation factor of 0.209 m^3/day can be calculated in a fashion similar to the other exposure factors as follows:

$$2.8\ m^3/\text{hour} \times 24\ \text{hours/day} \times \frac{26\ \text{workdays/year}}{365\ \text{days/year}} \times$$

$$\frac{2\ \text{hours/workday}}{24\ \text{hours/day}} \times 0.75 \times 0.7 = 0.209\ m^3/\text{day}$$

According to EPA policy, a total carcinogenic risk level of 10^{-6} is an acceptable risk for exposure of an individual to a hazardous waste site. The EPA approach (1986a) is to apportion an equal level of risk to each potential carcinogen at the site. But, because PCBs is the only observed carcinogen at the site, the PCB target risk level is the same as the total carcinogen risk level.

The target PCB oral chronic daily intake (CDI) at the site was then determined by dividing the target risk level of 10^{-6} by

the oral route cancer potency factor of 4.34 $(mg/kg/day)^{-1}$ yielding a value of 2.30×10^{-7} mg/kg/day [kg = kilogram].

The target PCB inhalation CDI was calculated in a similar manner. However, because an inhalation route cancer potency factor for PCB was not available in the technical literature, an assumed inhalation factor was used. In general, the inhalation factor is about an order of magnitude less than the oral route cancer potency factor, which is 4.34 $(mg/kg/day)^{-1}$ for PCB. Therefore, an inhalation factor of 0.4 $(mg/kg/day)^{-1}$ was used to yield a target PCB inhalation CDI of 0.25×10^{-5} mg/kg/day.

Using Pathway Preliminary Pollutant Limit Values (PPLV) methodology, significant source-to-receptor pathway is quantified and the effects combined to ensure that an exposed individual will not receive an unacceptably large dose. Intermediate results of the method are referred to as single-pathway preliminary pollutant limit values (SPPPLVs) and represent residual levels of contamination that would be safe if only that single pathway were operating. Several pathways are combined by the following equation:

$$PPLV = \frac{1}{\frac{1}{SPPPLV,1} + \frac{1}{SPPPLV,2} + \ldots}$$

The dermal absorption exposure pathway is defined as:

$$SPPPLV_{(D)} = B_W/W_S \times CDI$$

where: B_W = body weight of an adult (70 kg)

W_s = annualized average dermal human intake factor (0.226 mg/day or 2.26×10^{-7} kg/day)

CDI = 2.30×10^{-7} mg/kg/day

$$SPPPLV_{(D)} = \frac{70 \text{ kg}}{2.26 \times 10^{-7} \text{ kg/day}} \times 2.30 \times 10\text{-}7 \text{ mg/kg/day}$$

$$= 71.2 \text{ mg/kg}$$

The incidental soil ingestion exposure pathway is defined as:

$$SPPPLV_{(I)} = B_w/W_{si} \times CDI$$

where: B_w = body weight of an adult (70 kg)

W_{si} = annualized average incidental soil ingestion human intake factor (0.594 mg/day or 5.94×10^{-7} kg/day)

CDI = 2.30×10^{-7} mg/kg/day

$$SPPPLV_{(I)} = \frac{70 \text{ kg}}{5.94 \times 10^{-7} \text{ kg/day}} \times 2.30 \times 10\text{-}7 \text{ mg/kg/day}$$

$$= 27.1 \text{ mg/kg}$$

The dust inhalation exposure pathway is defined as:

$$SPPPLV_{(R)} = \frac{B_w \times CDI}{RB \times C_{ss}}$$

where: B_w = body weight of an adult (70 kg)

RB = annualized average inhalation exposure factor (0.209 m^3/day)

C_{ss} = concentration of suspended particles in the air (10 mg/m^3)

CDI = 0.25×10^{-5} mg/kg/day

$$SPPPLV_{(R)} = \frac{70 \text{ kg} \times 0.25 \times 10\text{-}5 \text{ mg/kg/day}}{0.209 \text{ m}^3 \times 10 \text{ mg/m}^3}$$

$$= 8.37 \times 10^{-5} \text{ kg/kg or } 83.7 \text{ mg/kg}$$

The soil PCB PPLV criterion, i.e., the target residual PCB soil concentration, was developed assuming an average, representative scenario, where the same worker is exposed to contaminated soils through each of the 3 exposure routes. This PPLV is defined as follows:

$$PPLV = \frac{1}{\frac{1}{SPPPLV_{(D)}} + \frac{1}{SPPPLV_{(I)}} + \frac{1}{SPPPLV_{(R)}}}$$

The calculated PPLV for PCB is 16 mg/kg. Therefore, based on the site specific risk assessment, the calculated PCB clean-up level is 16 mg/kg or ppm. However, the more conservative TSCA clean-up standard of 10 ppm will be used to provide an added degree of protection to human health in the remediation of Site 16.

To determine if the PCB target level results in acceptable risk level relative to the lead concentrations detected in soil at Site 16, a chronic hazard risk index (HI) was calculated for lead to determine the associated health risk. The HI is defined as the ratio of the actual dermal exposure to the acceptable exposure. The actual exposure (3.39 x 10-7

mg/kg/day) is calculated by multiplying the average concentration at the site (105 mg/kg) by the human dermal intake factor (0.226×10^{-6} kg/day) and dividing by the average adult body weight of 70 kg. The acceptable dermal exposure for lead given by EPA is 1.40×10^{-3}. When the HI exceeds unity, a certain degree of health risk is indicated. The HI for lead was calculated as follows:

$$HI = \frac{3.39 \times 10^{-7} \text{ mg/kg/day}}{1.4 \times 10^{-3} \text{ mg/kg/day}} = 2.4 \times 10^{-4} < 1$$

This HI indicates a very low degree of risk posed by the observed concentrations of lead in the soil. Therefore, the proposed action for excavation ensures an acceptable risk level for lead at its current levels in the soil.

5.0 ALTERNATIVES ANALYSIS

The four remedial alternatives developed for Site 16 are described below, and illustrated in Figures 5-1 through 5-4 at the end of this section. These alternatives were developed based on the contaminant routes of exposure and clean-up level identified in the previous section. The four alternatives vary in the degree to which they address the PCB contamination at the site. For example, Alternative 1 applies the least stringent requirements for clean-up while Alternative 4 applies the most stringent. None of the alternatives include any action relative to the PCB contamination within the already fenced areas. The reason being, the fence restricts the public's access into these areas.

Alternative 1 is the "no action" alternative. In this alternative a 6-foot (ft) high, galvanized chain link fence is to be installed around the site to restrict public access. The fence is to encompass all areas of the site confirmed to have PCB concentrations above 10 ppm, approximately 2,246 square yards (S.Y.). Figure 5-1 shows the configuration of the proposal fenced area, and the total length of fence required is 652 linear feet (L.F.).

In Alternative 2, the concrete-lined ditch which runs along the southwest and northwest sides of Building 38 and along the southeast side of the fenced transformer station is to be scraped to remove the soil in the ditch (see Figure 5-2). The ditch is approximately 1.5 ft wide and contains about 1 inch of soil along the bottom of the ditch. This action will result in the removal of approximately 2 cubic yards (C.Y.) of soil, which will be spread out over the areas to be capped.

Then, a single-layered asphalt cap is to be installed over areas of the site confirmed to have PCB concentrations above 10 ppm. The cap is to consist of 4 inches of base material and 1 inch of bituminous paving. The areas to be capped as shown in Figure 5-2 total 1,780 S.Y. The capped areas do not include the area between Building 38 and the rock outcropping shown in Figure 5-2 because this area mainly consists of rock and weathered rock with little soil.

Alternative 3 specifies both partial excavation and capping. In this alternative, the concrete-lined ditch is to be scraped to remove the soil in the ditch (approximately 2 C.Y.), and the area having PCB concentrations above 25 ppm is to be excavated to a depth of 1 ft (see Figure 5-3). A total of 469 C.Y. of PCB-contaminated soil is to be removed from the ditch and excavated areas. The area that is excavated is to be backfilled with clean soil, which is defined by EPA as containing less than 1 ppm PCB. Furthermore, the site area having PCB concentrations between 10 and 25 ppm is to be capped with a single-layered asphalt cap as shown in Figure 5-3. The cap is to cover an area totaling 379 S.Y., and is to meet the same specifications as those specified in Alternative 2. Removed material is to be disposed of by incineration in an incinerator permitted for PCB incineration.

Alternative 4 is the most stringent in meeting PCB clean-up criteria. In this alternative site areas having PCB concentrations exceeding 10 ppm are to be removed by scraping or excavating. These areas include the soil in the concrete-lined ditch and the area shown in Figure 5-4, which will be excavated down to 1 ft. A total of 595 C.Y. of PCB-contaminated soil is to be removed. Areas that are excavated

are to be backfilled with clean soil. Removed material is to be disposed of by incineration.

Table 5-1 presents the estimated costs to implement each of the four remedial action alternatives, and Appendix C contains the detailed cost estimates for each alternative. Most of the cost estimates for these alternatives were performed using the Means Site Work Cost Data 1987. The exceptions are the hauling and disposal costs for the PCB-contaminated soil. These figures were obtained from ENSCO, the firm that operates the PCB-permitted incinerator nearest to Site 16, which is located in El Dorado, Arkansas. Hauling costs include freight charges from Site 16 to this location in Arkansas.

As shown in Table 5-1, the two alternatives with the lowest costs are Alternative 1, which involves the construction of a fence around the area with a PCB concentration exceeding 10 ppm, and Alternative 2, capping. The costs for Alternatives 3 and 4 are significantly higher than those for Alternatives 1 and 2 because of the high costs associated with hauling and incineration of the contaminated soil.

The disadvantage of Alternatives 1 and 2 is that although the fencing/capping eliminates the human exposure pathways, these alternatives do not accomplish any reduction in toxicity or volume of the contamination. Likewise, Alternative 3, which provides treatment and destruction of a portion of the contaminated soil, only provides partial reduction of waste volume. The highest cost alternative, Alternative 4, provides treatment and destruction of all of the contaminated soil with PCB concentrations exceeding 10 ppm.

Table 5-1. Summary of Cost Estimates for Remedial Action Alternatives for Site 16, the Old Power Plant, Building 38

Alternative	Capital Cost ($)	Annual O&M Cost ($/YR)	Total Cost ($)*
1	$9,670	$50	$10,070
2	$7,758	$50	$8,158
3	$1,177,219	$50	$1,117,619
4	$1,491,415	0	$1,491,415

* Total Cost = Sum of capital cost and present worth of annual O&M cost assuming a period of 20 years at 10 percent interest rate.

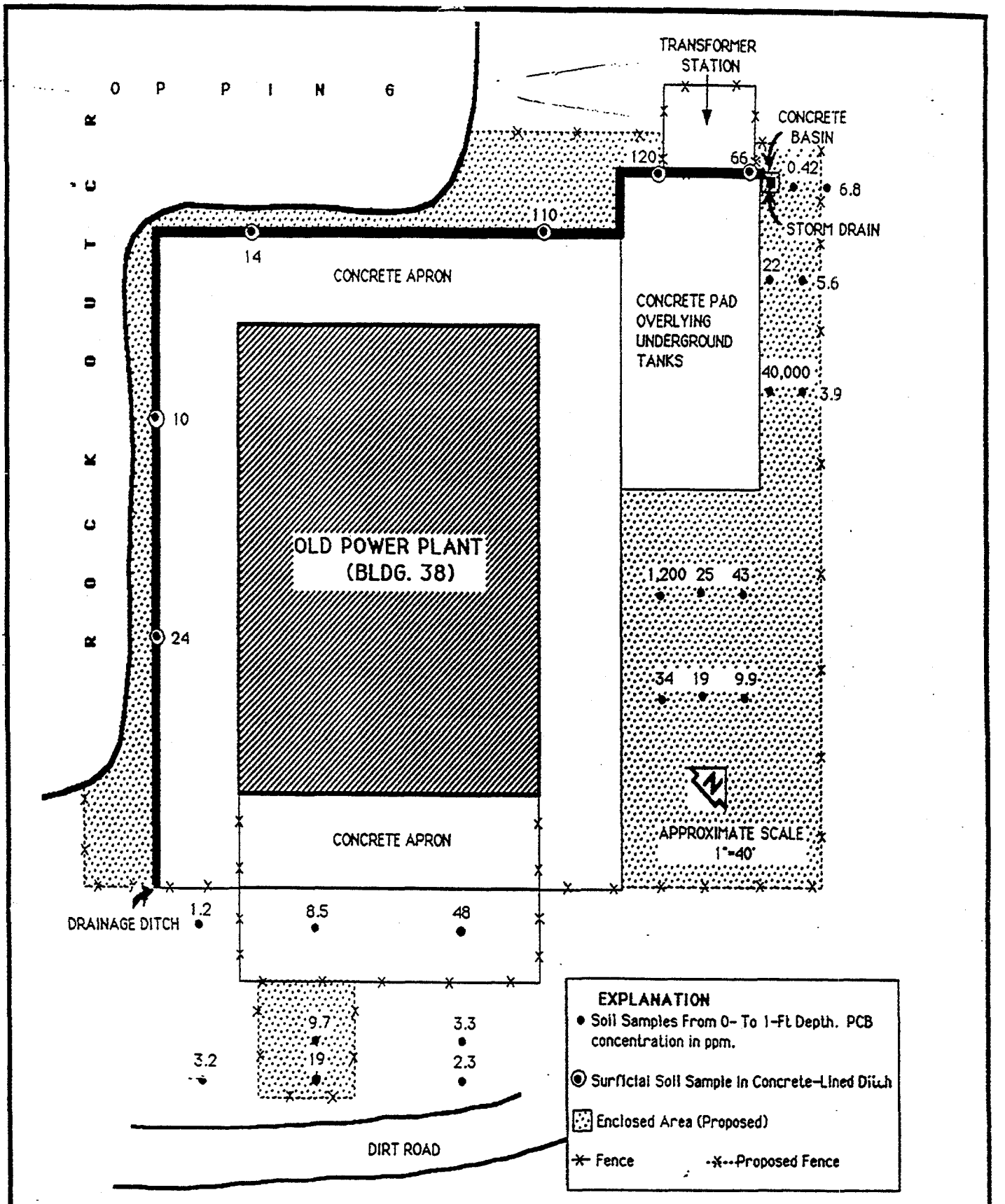

FIGURE 5-1
ALTERNATIVE 1, NO ACTION,
SITE 16, THE OLD POWER PLANT,
BUILDING 38

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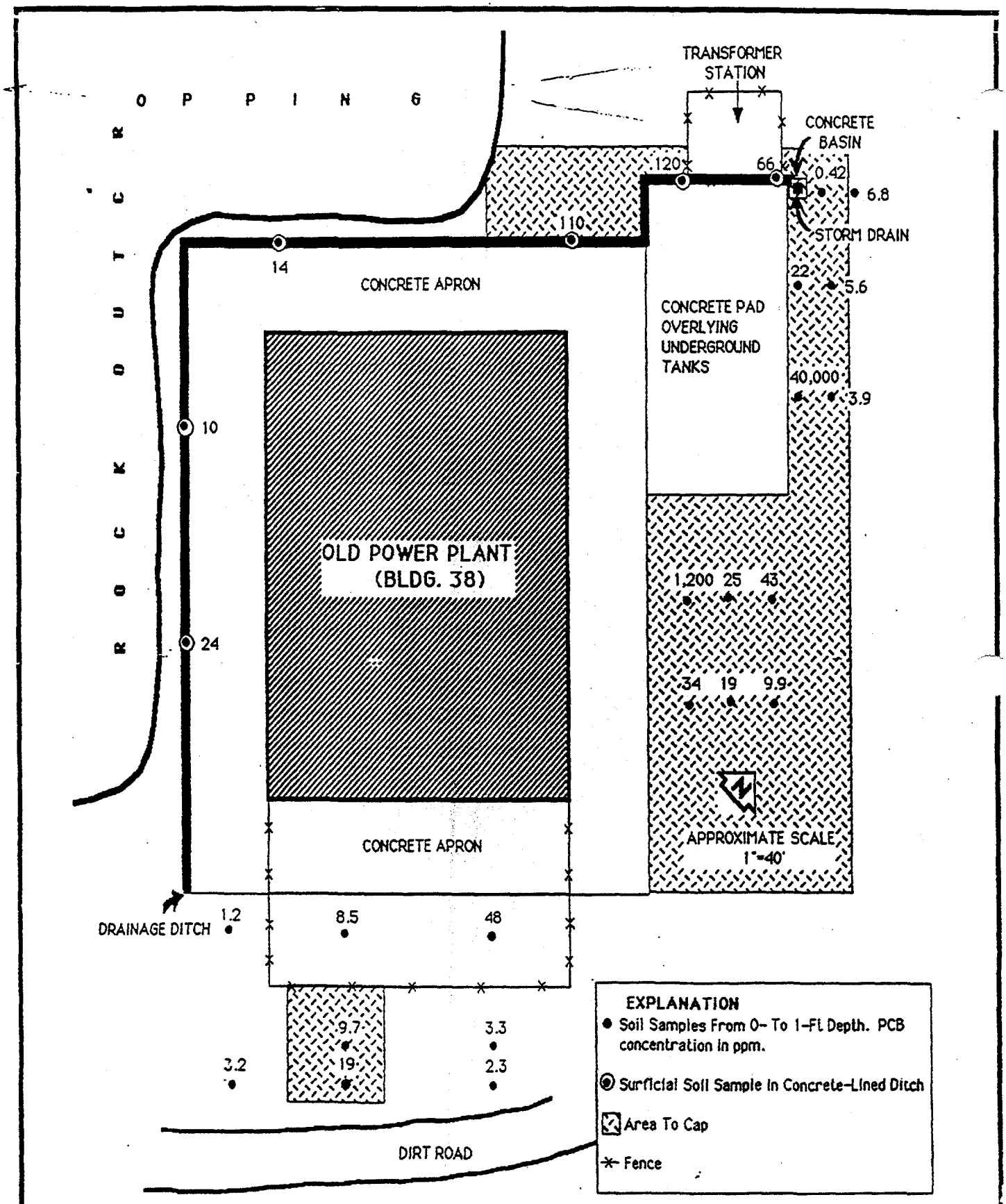

FIGURE 5-2
ALTERNATIVE 2, CAPPING,
SITE 16, THE OLD POWER PLANT,
BUILDING 38

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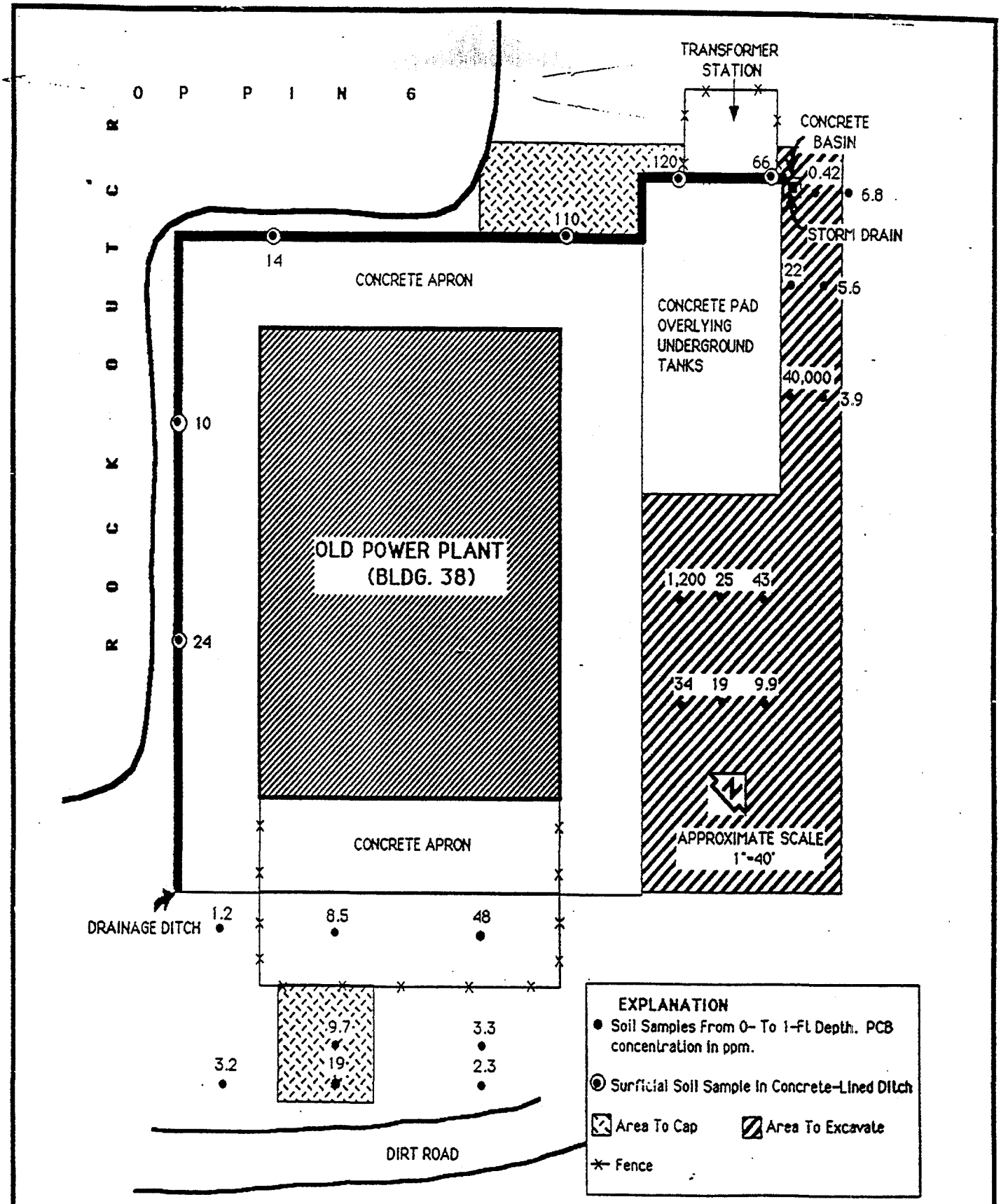

FIGURE 5-3
ALTERNATIVE 3, PARTIAL EXCAVATION AND CAPPING, SITE 16, THE OLD POWER PLANT, BUILDING 38

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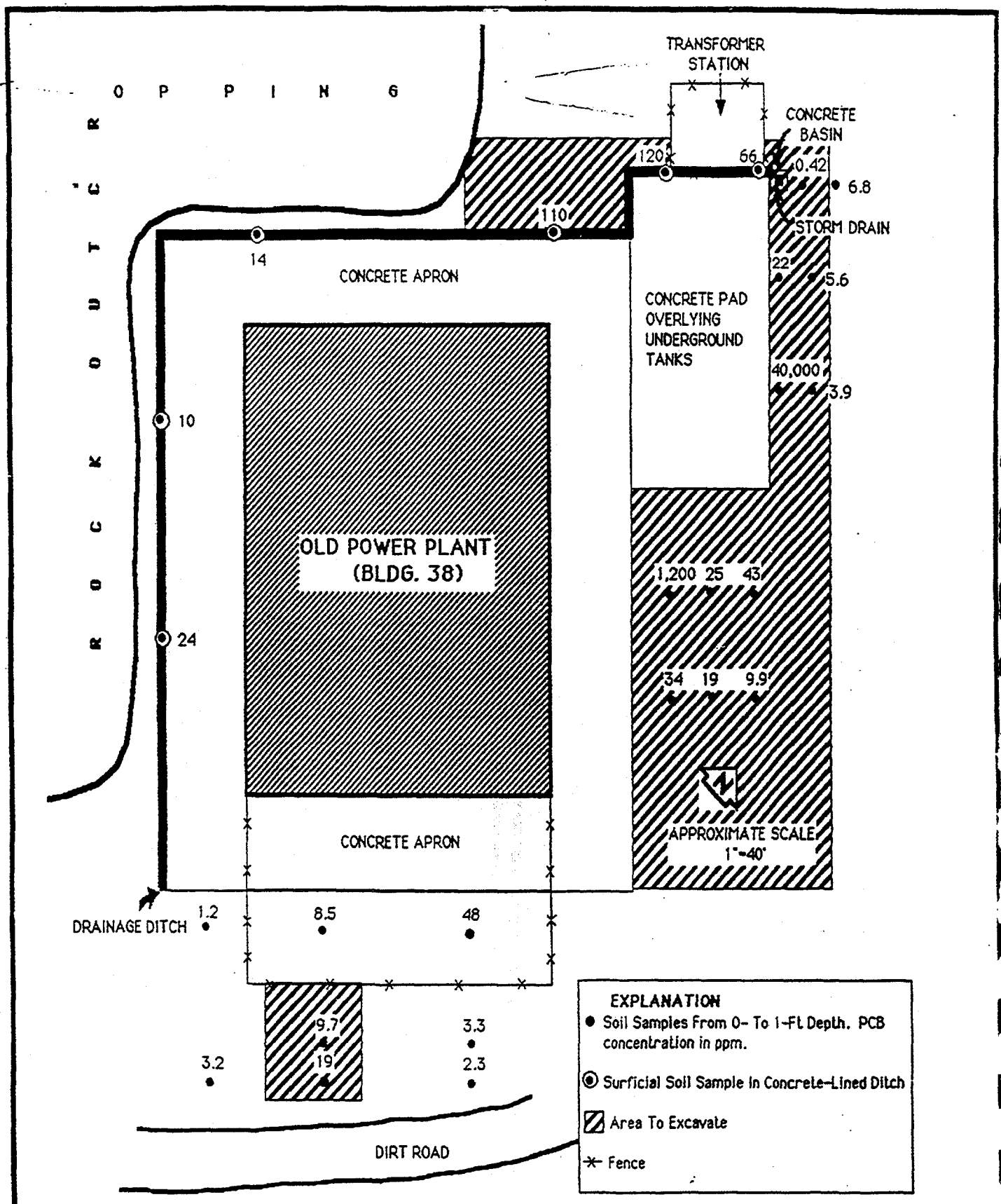

FIGURE 5-4
ALTERNATIVE 4, EXCAVATION,
SITE 16, THE OLD POWER PLANT,
BUILDING 38

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6.0 REFERENCES

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APPENDIX A
SITE 16 VERIFICATION STEP DATABASE

Data Validation - Roosevelt Road
Control #4803
VLI No. 420.1, B #3, Set B

The following samples were included in B #3, Set B:

Field Number	Surrogate Outside Control Limit
RR16S20A	X
RR16S21A	
RR16S22A	
RR16S23A	X
RR16S24A	X
RR16S25A	X
RR16S26A	X
RR16S27A	X
RR16S28A	X
RR16S29A	X
RR16S30A	
RR16S31A	X
RR16S32A	X
RR16S33A	X
RR16S33AMS	X
RR16S33AMSD	X
RR16S33AD	X
RR16S34A	X
RR16S34AD	X
PBLK45	X
50457MSTD	
PBLK23	

Holding Time — All samples were extracted and analyzed within the holding time specified in the April 9, 1991, QAPjP. Holding time specified is 10 days to extraction and 40 days to analysis.

Calibration — All appropriate calibration criteria were met.

Blanks — No Aroclors were detected in the blanks.

Surrogates — HBB was used as the surrogate, however, this surrogate elutes in the PCB chromatographic pattern. Due to the presence of Aroclors in the samples, the results of the surrogates were outside the QC limit of 60 to 140 percent for most of the samples. The poor surrogate recoveries should be noted for the specific samples with a data qualifier stating the results were inflated due to the presence of the Aroclors in the samples. The surrogate recovery for one of the blanks was only 40 percent,

however, the other blank had a recovery of 90 percent. However, the poor surrogate recoveries of the samples and the one blank should not impact the usability of the sample data.

Matrix Spike/ Matrix Spike Duplicate Recoveries	The MS/MSD recovery for the RR16S33AMS and RR16S33AMSD was zero percent. The poor recovery was due to the addition of an insufficient spike quantity in comparison to the native concentration level. The poor spike recovery should be noted in the report with a data qualifier stating the reason for the poor recovery. The method standard (50457MSTD) had a recovery of 102 percent. This indicates that the laboratory adequately followed the method.
Field Duplicates	The results of the field duplicates (RR16S33A and RR16S33AD) for Aroclor 1260 were 47,000 and 44,000 ug/kg, respectively. This is an RPD of 6.6 percent. There were no QC criteria established for field duplicates.
Compound Identification/ Quantification	Presence of the Aroclors were confirmed with a secondary column as specified in the analytical procedure.
Usability	All sample results for this batch are usable, however, data should be flagged as noted above.

Data Validation - Roosevelt Road
Control #4795
VLI No. 420.1, B #2, Set B

The following samples were included in B #2, Set B:

Field Number	Surrogate Outside Control Limit
PBLK05	* (low)
RR15S06DA	
RR15S06DAMS	* (low)
RR15S06DAMSD	* (low)
RR15S07A	
RR15S08ADL	* (low)
RR15S09A	* (low)
RR15S010A	* (low)
RR15S011ADL	* (low)
RR15S012A	* (low)
RR15S013A	* (low)
RR15S013B	
RR15S014ADL	* (low)
RR15S015A	
RR15S016A	
RR15S017A	
RR15S018A	
RR15S019A	
RR15S019B	
RR15S020ADL	* (low)
RR15S021ADL	* (low)
RR15S022ADL	
RR15S023A	
MSTD50290	* (low)

Holding Time	All samples were extracted and analyzed within the holding time specified in the April 9, 1991, QAPjP. Holding time is 10 days to extraction and 40 days to analysis.
Calibration	All appropriate calibration criteria were met.
Blanks	No Aroclors were detected in the blank.

Surrogates	HBB was used as the surrogate; this surrogate elutes in the PCB chromatographic pattern. The presence of Aroclors in the sample had a matrix interference on the HBB peak and quantification of the surrogate was difficult. Therefore, the surrogate results outside the specified QC range of 60 to 140 percent should be flagged. However, although there are interferences present that make quantification of the surrogate difficult, there should be no impact on the usability of the data.
Matrix Spike/ Matrix Spike Duplicate Recoveries	The MS/MSD recovery for RR15S06A was zero percent. The poor recovery was due to the addition of an insufficient quantity of the spike in comparison with the native concentration level (less than 50 percent of native level). Nonhomogenity of the sample may also contribute to the poor recovery. The poor spike recovery should be noted in the report with a data qualifier stating the reason for the poor recovery is due to an insufficient spike amount added to the sample and may also be a result of nonhomogenity of the native level. The method standard (MSTD50890) had a recovery of 66 percent, which is at the low end of specified QC recovery range of 60 to 140 percent. However, since it is in the acceptable range, it does appear that the laboratory was able to adequately complete the analytical procedures.
Compound Identification/ Qualification	Presence of the Aroclors were confirmed with a secondary column as specified in the analytical procedure. The Aroclor 1260 result for sample RR15S21A is flagged with an "X" indicating that the sample result was outside the standard calibration range. A review of the calibration data and the sample data indicate that the sample results may be low, therefore, it represents a conservative estimate of the Aroclor 1260 present in the sample. The data should be flagged qualifying the data.
Usability	All sample results for this batch are usable, however, the data should be flagged as noted above. The Aroclor 1260 result for Sample RR15S21A should be used as a conservative estimate of Aroclor 1260.

Data Validation - Roosevelt Road
Control #4774
VLI No. 420.1, B #1, Set B

The following samples were included in B #1, Set B:

Field Number	Surrogate Outside Control Limit
RR16W17	
RR16W18	X
RR16W19	X (reported as ND)
RR16W20	X (reported as ND)
RR16W21DL	X (reported as ND)
RR16W22	X
RR16W23	X
RR16W24	
RR16W25	
RR16W26	X
RR16W27	X (reported as ND)
RR16W28	
RR16W29	
RR16W30	
RR16W31	
RR16W32	
RR16W33	
RR16GB01	
RR16GB02	
RR16GB03	
RB0381	
MSTD50033	X

Holding Time	All samples were extracted and analyzed within the holding time specified in the April 9, 1991, QAPjP. Holding time is 10 days to extraction and 40 days to analysis.
Calibration	All appropriate calibration criteria were met.
Blanks	No Aroclors were detected in the blank.

Surrogates	HBB was used as the surrogate; this surrogate elutes in the PCB chromatographic pattern. The presence of Aroclors in the sample had a matrix interference effect on the HBB peak and quantification of the surrogate could not be made; therefore, the results are reported as ND. (The samples affected are RR16W19, RR16W20, RR16W21DL, and RR16W27.) For five samples, the reported surrogate results were inflated due to the Aroclors present in the sample. The poor surrogate recoveries should be noted for the specific samples with a data qualifier stating the results were inflated due to the presence of the Aroclors in the sample, but the surrogate recovery results should not impact the usability of the sample data.
Matrix Spike/ Matrix Spike Duplicate Recoveries	A matrix spike and matrix spike duplicate were completed for the wipe samples due to the matrix of the samples. The method standard (spiked reagent water) had a recovery of 128 percent. This indicates that the laboratory adequately completed the analytical procedure.
Field Duplicates	There were no field duplicates.
Compound Identification/ Quantification	All sample results from the primary column were confirmed with the secondary column with the following exceptions. The results from Samples RR16W18 and RR16W22 are flagged with an "A" indicating that there was evidence to suggest the presence of PCB in the quantitation analysis, however, the results did not confirm in the secondary analysis. The results of these two samples should be flagged; the results can be used to indicate a worst case scenario. The results for Aroclor 1260 for Sample RR16W26 is flagged with a "Y" indicating that the results were reported from the confirmation analysis because the quantification results were inflated due to matrix interferences. The results should be flagged; however, the data are usable.
Usability	All sample results for this batch are usable, however, data should be flagged as noted above.

Data Validation - Roosevelt Road
Control #4774
VLI No. 420.1, B #1, Set A

The following samples were included in B #1, Set A:

Field Number	Surrogate Outside Control Limit
RR15W01	
RR15W02	X (ND)
RR15W03	X (ND)
RR15GB01	
RR16W01	
RR16W02	
RR16W03	
RR16W04	
RR16W05	
RR16W06	X
RR16W07	X
RR16W08	
RR16W09	
RR16W10	
RR16W11	
RR16W12	
RR16W13	
RR16W14	
RR16W15	
RR16W16	
RB0379	
MSTD50011	X

Holding Time — All samples were extracted and analyzed within the holding time specified in the April 9, 1991, QAPjP. Holding time is 10 days to extraction and 40 days to analysis.

Calibration — All appropriate calibration criteria were met prior to analysis of sample extracts. Sample analysis continued after outlying results for Aroclors 1242 and 1254 were obtained since these Aroclors were not tentatively identified in any of the samples analyzed after the calibration was determined to be out of specification. If either of these Aroclors had been detected, the samples would have been reanalyzed. Aroclor 1254 was detected in one sample; however, that sample was analyzed shortly after the initial calibration for the batch was completed and was not affected by the standard that did not meet the calibration criteria.

Blanks	No Aroclors were detected in the blanks.
Surrogate	HBB was used as a surrogate; this surrogate elutes in the PCB chromatographic pattern. The presence of Aroclors in the sample had a matrix interference effect on the HBB peak and quantification of the surrogate was either inflated or could not be made in which case it was reported as ND. The poor surrogate recoveries should be noted for the specific samples with a data qualifier indicating that recoveries outside the QC limit were obtained, however, these poor recoveries should not impact the usability of the sample data.
Matrix Spike/ Matrix Spike Duplicate Recoveries	Matrix spike and matrix spike duplicates were not completed due to the matrix (wipes) of the samples. The recovery for the method standard was 136 percent which indicated that the laboratory adequately performed the method.
Field Duplicates	No field duplicates were completed.
Compound Identification/ Quantification	Presence of the Aroclors were confirmed with secondary column as specified in the analytical procedure. The Aroclor data for Sample RR15W03 is flagged with an "X" indicating that Aroclor 1254 and 1260 were detected and the results may be inflated due to the contribution of PCBs in the mixture. The data should be qualified and probably represents a worst case scenario. The results for Aroclor 1260 for Sample RR16W03 is flagged with a "Y." This indicates that the results were reported from the confirmation analysis rather than the quantitation analysis, since there were method intererences for the quantitation result. For Sample RR16W10, the Aroclor 1260 result is flagged with an "A" which indicates that there was evidence to suggest the presence of the Aroclor in the quantitation analysis, however, the result was not confirmed in the secondary analysis. The data should be flagged and can be used to represent a worst case scenario. For Sample RR16W12, the Aroclor 1260 result is flagged with a "Z," which indicates that the result is an estimate reported below the detection limit. The results is 1.9 ug/m^2 and the detection limit is 2.0 ug/m^2. The data should be flagged indicating this.
Usability	All sample results for this batch are usable, however, data should be flagged as noted above.

Versar INC

APPENDIX B

Remedial Action Alternatives
Analyses for Old Power Plant, Building 38,
Site 16, U.S. Naval Station
Roosevelt Roads (ESE, 1988)

ENVIRONMENTAL SCIENCE & ENGINEERING 05/12/86 STATUS: FINAL PAGE# 1

PROJECT NUMBER 85275 3000 PROJECT NAME PUERTO RICO CONFIRMATION STUDY
FIELD GROUP PRS01 PROJECT MANAGER R. BOWEN
NAVYPS LAB COORDINATOR LISA BARE

SAMPLE ID/#

PARAMETERS	STORET #	16S1A	16S2A	16S3A	16S4A	16S5A	16S6A	16S7A	16S8A	16S8A	16S9A
		PRS01	PRS01	PRS01	PRS01	PRS01	PRS01	PRS01	PRS01	PRS01	PRS01
UNITS	METHOD	49	50	51	52	53	54	55	56	109	57
DATE		11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	12/03/85	11/30/85
TIME		07:10	07:23	07:40	07:45	08:00	08:10	08:20	08:30	08:09	08:40
MOISTURE	70320	11.8	11.5	11.1	13.1	11.6	9.6	11.5	14.4	13.7	12.1
%WET WT	0										
OIL&GR,IR,SED	561	3910	420	6350	5720	919	574	1310	840	NRQ	221
UG/G- DRY	0										
PCB 1016,SED	98140	<1.13	<1.13	<1.12	<1.15	<1.13	<1.11	<1.13	<1.17	NRQ	4.78
UG/G-DRY	0										
PCB-1221,SOIL	98351	<1.13	<1.13	<1.12	<1.15	<1.13	<1.11	<1.13	<1.17	NRQ	<1.14
UG/G-DRY	0										
PCB-1232,SOIL	98352	<1.13	<1.13	<1.12	<1.15	<1.13	<1.11	<1.13	<1.17	NRQ	<1.14
UG/G- DRY	0										
PCB-1242,SOIL	98353	<1.13	<1.13	<1.12	<1.15	<1.13	<1.11	<1.13	<1.17	NRQ	<1.14
UG/G-DRY	0										
PCB1254-SOIL	98354	<1.13	<1.13	<1.12	<1.15	<1.13	<1.11	<1.13	<1.17	NRQ	<1.14
UG/G- DRY	0										
PCB-1248 SOIL	98802	<1	<1	<1	<1	<1	<1	<1	<1	NRQ	<1
UG/G-DRY	0										
PCB 1260,SED	98139	<1.13	404	92.9	55.9	3.39	8.85	22.8	<1.17	NRQ	2.73
UG/G-DRY	0										
BENZENE	98699	<0.06	<0.09	<0.04	<0.10	<0.10	<0.10	<0.10	NA	<0.07	<0.10
UG/G-DRY	10										
BROMODICHLOROMETHANE	98783	<0.08	<0.10	<0.08	<0.12	<0.13	<0.13	<0.12	NA	<0.13	<0.12
UG/G-DRY	10										
BROMOFORM	98784	<0.18	<0.25	<0.19	<0.27	<0.46	<0.47	<0.26	NA	<0.26	<0.27
UG/G-DRY	10										
BROMOMETHANE	98785	<0.22	<0.22	<0.18	<0.25	<0.21	<0.21	<0.24	NA	<0.26	<0.25
UG/G-DRY	10										
CARBON TETRACHLORIDE	98680	<0.07	<0.09	<0.16	<0.09	<0.11	<2.2	<0.09	NA	<0.23	<0.09
UG/G-DRY	10										
CHLOROBENZENE	98681	<0.06	<0.08	<0.06	<0.08	<0.08	<0.09	<0.08	NA	<0.09	<0.09
UG/G-DRY	10										
CHLOROETHANE	98786	<0.43	<0.46	<0.26	<0.55	<0.63	<0.64	<0.54	NA	<0.36	<0.56
UG/G-DRY	10										
2-CHLOROETHYLVINYLET	98796	<0.81	<0.49	<0.17	<0.53	<0.89	<0.91	<0.52	NA	<0.27	<0.54
HER UG/G-DRY	10										
CHLOROFORM	98682	<0.068	<0.090	<0.072	<0.102	<0.101	<4.43	<0.100	NA	<0.111	<0.104
UG/G-DRY	10										
CHLOROMETHANE	98787	<0.21	<0.22	<0.21	<0.39	<0.35	<0.36	<0.39	NA	<0.34	<0.40
UG/G-DRY	10										
DIBROMOCHLOROMETHANE	98788	<0.12	<0.17	<0.14	<0.17	<0.23	<0.23	<0.17	NA	<0.20	<0.18
UG/G-DRY	10										

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PROJECT NUMBER 85275 3000 PROJECT NAME PUERTO RICO CONFIRMATION STUDY
FIELD GROUP PRSOI PROJECT MANAGER R. BOWEN
NAVYPS LAB COORDINATOR LISA BARE

PARAMETERS	STORET #	16S1A	16S2A	16S3A	16S4A	16S5A	16S6A	16S7A	16S8A	16S8A	16S9A
		SAMPLE ID/#									
		PRSOI	PRSOI	PRSOI	PRSOI	PRSOI	PRSOI	PRSOI	PRSOI	PRSOI	PRSOI
UNITS	METHOD	49	50	51	52	53	54	55	56	109	57
DATE		11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	12/03/85	11/30/85
TIME		07:10	07:23	07:40	07:45	08:00	08:10	08:20	08:30	08:09	08:40
1,1-DICHLOROETHANE	98683	<0.11	<0.14	<0.07	<0.18	<0.16	<0.16	<0.18	NA	<0.10	<0.18
UG/G-DRY	10										
1,2-DICHLOROETHANE	98684	<0.09	<0.12	<0.13	<0.14	<0.13	<1.7	<0.14	NA	<0.21	<0.15
UG/G-DRY	10										
1,1-DICHLOROETHENE	98789	<0.20	<0.24	<0.15	<0.30	<0.30	<0.31	<0.30	NA	<0.21	<0.31
UG/G-DRY	10										
TRANS-1,2-DICHLOROET	98687	<0.20	<0.23	<0.14	<0.30	<0.31	<0.32	<0.29	NA	<0.21	<0.30
ENE UG/G-DRY	10										
1,2-DICHLOROPROPANE	98790	<0.19	<0.30	<0.08	<0.33	<0.27	<0.28	<0.33	NA	<0.14	<0.34
UG/G-DRY	10										
CIS-1,3-DICHLOROPROP	98791	<0.08	<0.11	<0.06	<0.12	<0.14	<0.14	<0.12	NA	<0.10	<0.12
ENE UG/G-DRY	10										
TRANS-1,3-DICHLOROPR	98792	<0.08	<0.11	<0.16	<0.12	<0.36	<0.37	<0.12	NA	<0.28	<0.12
OPENE UG/G-DRY	10										
ETHYLBENZENE	98688	<0.13	<0.17	<0.13	<0.19	<0.18	<0.19	<0.19	NA	<0.22	<0.19
UG/G-DRY	10										
METHYLENE CHLORIDE	98689	<0.16	<1.5	<0.13	<0.26	<6.1	<35	<0.26	NA	<0.20	<0.27
UG/G-DRY	10										
1,1,2,2-TETRACHLOROE	98793	<0.24	<0.33	<0.09	<0.40	<0.29	<0.29	<0.39	NA	<0.12	<0.40
THANE UG/G-DRY	10										
TETRACHLOROETHENE	98690	<0.12	<0.16	<0.21	<0.17	<0.18	<1.2	<0.17	NA	<0.29	<0.17
UG/G-DRY	10										
TOLUENE	98691	<0.09	<0.12	<0.07	<0.13	<0.13	<0.13	<0.13	NA	<0.11	<0.13
UG/G-DRY	10										
1,1,1-TRICHLOROETHAN	98692	<0.08	<0.10	<0.14	<0.11	<0.12	<0.71	<0.11	NA	<0.23	<0.11
E UG/G-DRY	10										
1,1,2-TRICHLOROETHAN	98693	<0.18	<0.25	<0.14	<0.25	<0.27	<0.28	<0.25	NA	<0.20	<0.26
E UG/G-DRY	10										
TRICHLOROETHENE	98694	<0.11	<0.16	<0.14	<0.19	<0.18	<0.18	<0.19	NA	<0.21	<0.20
UG/G-DRY	10										
TRICHLOROFLUOROMETHA	98794	<0.30	<0.34	<0.11	<0.36	<0.34	<0.35	<0.35	NA	<0.20	<0.37
NE UG/G-DRY	10										
VINYL CHLORIDE	98795	<0.19	<0.19	<0.17	<0.28	<0.35	<0.36	<0.28	NA	<0.23	<0.29
UG/G-DRY	10										
DICHLOROBENZENE,TOTA	98803	<0.07	<0.08	<0.08	<0.07	<0.09	<0.09	<0.07	NA	<0.13	<0.07
L UG/G-DRY	10										
LEAD,SED	1052	109	<3.25	15700	834	151	12.7	69.8	215	NRQ	<2.81
UG/G-DRY	0										
1,2-DIBROMOETHANE (E	98798	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NRQ	<0.002
DB) MG/KG-DRY	0										

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PROJECT NUMBER 85275 3000 PROJECT NAME PUERTO RICO CONFIRMATION STUDY
FIELD GROUP PRSOI PROJECT MANAGER R. BOWEN
NAVYPS LAB COORDINATOR LISA BARE

PARAMETERS	STORET #	16S1A PRSOI 49	16S2A PRSOI 50	16S3A PRSOI 51	16S4A PRSOI 52	16S5A PRSOI 53	16S6A PRSOI 54	16S7A PRSOI 55	16S8A PRSOI 56	16S8A PRSOI 109	16S9A PRSOI 57
		SAMPLE ID/#									
UNITS	METHOD										
DATE		11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	11/30/85	12/03/85	11/30/85
TIME		07:10	07:23	07:40	07:45	08:00	08:10	08:20	08:30	08:09	08:40
M-XYLENE	98799	<0.05	<0.05	<0.04	<0.05	<0.05	<0.05	<0.05	NA	<0.19	<0.05
MG/KG-DRY	10										
O,P-XYLENE	98800	<0.04	<0.05	<0.02	<0.05	<0.19	<0.43	<0.05	NA	<0.08	<0.05
MG/KG-DRY	10										
METHYL ETHYL KETONE	98801	<0.58	<2.4	<0.17	1.0	<11	<7.6	<0.98	NA	<1.5	1.0
UG/G-DRY	10										
MIBK	98696	<0.45	<0.62	<0.14	<0.68	<0.30	<0.31	<0.67	NA	<0.19	<0.69
UG/G-DRY	10										

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APPENDIX B
SITE 16 CHARACTERIZATION STEP DATABASE

ENVIRONMENTAL SCIENCE & ENGINEERING 07 88 STATUS: FINAL PAGE# 1

PROJECT NUMBER 07488 0000 PROJECT NAME PUERTO RICO - NAVSTA
FIELD GROUP RPR16S PROJECT MANAGER RUSS BOWEN
ROOSEVELT ROADS SITE 16 SOILS LAB COORDINATOR LISA BARE

SAMPLE ID/#

PARAMETERS	UNITS	STORET # METHOD	16S07A RPR16S 1	16SP9A RPR16S 2	16S010A RPR16S 3	16S011A RPR16S 4	16S012A RPR16S 5	16S013A RPR16S 8	16S014A RPR16S 11	16S015A RPR16S 12	16S016A RPR16S 15	16S017A RPR16S 18	16S018A RPR16S 21	16S019A RPR16S 24	16S020A RPR16S 27	16S021A RPR16S 30	16S022A RPR16S 31
DATE			11/10/87	11/10/87	11/10/87	11/10/87	11/11/87	11/11/87	11/10/87	11/11/87	11/11/87	11/11/87	11/11/87	11/11/87	11/11/87	11/10/87	11/10/87
TIME			14:13	14:10	14:28	14:38	08:20	08:13	14:23	08:38	08:46	08:00	08:28	07:55	07:45	14:18	11:51
MOISTURE		70320	32.2	28.7	40.2	30.4	7.5	13.0	10.6	12.7	10.7	14.6	13.6	5.2	4.9	46.3	11.9
	%WET WT	1															
PCB 1016		39514	<37900	<36000	<4270	<3680	<220	<2370	<2300	<2930	<2850	<2410	<29400	<2680	<2160	<47800	<117000
	UG/KG-DRY	EC															
PCB-1221		39491	<38000	<36000	<4300	<3700	<220	<2400	<2300	<2900	<2800	<2400	<29000	<2700	<2200	<48000	<120000
	UG/KG-DRY	EC															
PCB-1232		39495	<38000	<36000	<4300	<3700	<220	<2400	<2300	<2900	<2800	<2400	<29000	<2700	<2200	<48000	<120000
	UG/KG-DRY	EC															
PCB-1242		39499	<38000	<36000	<4300	<3700	<220	<2400	<2300	<2900	<2800	<2400	<29000	<2700	<2200	<48000	<120000
	UG/KG-DRY	EC															
PCB-1248		39503	<38000	<36000	<4300	<3700	<220	<2400	<2300	<2900	<2800	<2400	<29000	<2700	<2200	<48000	<120000
	UG/KG-DRY	EC															
PCB-1254		39507	<38000	<36000	<4300	<3700	<220	<2400	<2300	<2900	<2800	<2400	<29000	<2700	<2200	<48000	<120000
	UG/KG-DRY	EC															
PCB-1260		39511	120000	66000	10000	24000	1200	3200	14000	8500	9700	19000	48000	3300	2300	110000	1200000
	UG/KG-DRY	EC															
LEAD,SED		1052	1070	783	178	290	0.95	2.85	140	92.3	34.0	4.96	556	3.81	135	248	86.1
	UG/G-DRY	GFAA															
LEAD,DISS		1049	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	<2.5	<2.5	NRQ	3.0	NRQ	7.0	NRQ	45.9
	UG/L	GFAA															
EP-TOX,DATE OF EXTRACTION		97078 M	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	3-3-88	3-3-88	NRQ	3-3-88	NRQ	3-3-88	NRQ	3-3-88

RR-00207-03.13-05/15/92

PROJECT NUMBER 87488 0000 PROJECT NAME PUERTO RICO - NAVSTA
FIELD GROUP RPR16S PROJECT MANAGER RUSS BOWEN
ROOSEVELT ROADS SITE 16 SOILS LAB COORDINATOR LISA BARE

PARAMETERS	UNITS	STORET # METHOD	SAMPLE ID/# 16S023A RPR16S 34	16S024A RPR16S 37	16S025A RPR16S 40	16S026A RPR16S 43	16S026B RPR16S 44	16S027A RPR16S 46	16S027B RPR16S 47	16S028A RPR16S 49	16S029A RPR16S 52	16S030A RPR16S 55	16S031A RPR16S 58	16S032A RPR16S 61	16S032B RPR16S 62	16S033A RPR16S 64
DATE			11/10/87	11/10/87	11/10/87	11/10/87	11/19/87	11/10/87	11/19/87	11/10/87	11/10/87	11/10/87	11/10/87	11/10/87	11/19/87	11/10/87
TIME			12:40	12:15	12:50	13:50	09:05	13:30	09:30	13:15	12:30	13:00	14:00	13:40	09:45	13:25
MOISTURE		70320	6.7	6.0	7.2	7.2	10.8	14.0	21.4	15.9	7.4	5.1	NA	10.2	15.7	11.5
	%WET WT	1														
PCB 1016		39514	<27600	<2690	<2770	<222	NA	<2990	<2600	<3790000	<21900	<2160	NA	<2290	<2430	<23300
	UG/KG-DRY	EC														
PCB-1221		39491	<28000	<2700	<2800	<220	NA	<3000	<2600	<3800000	<22000	<2200	NA	<2300	<2400	<23000
	UG/KG-DRY	EC														
PCB-1232		39495	<28000	<2700	<2800	<220	NA	<3000	<2600	<3800000	<22000	<2200	NA	<2300	<2400	<23000
	UG/KG-DRY	EC														
PCB-1242		39499	<28000	<2700	<2800	<220	NA	<3000	<2600	<3800000	<22000	<2200	NA	<2300	<2400	<23000
	UG/KG-DRY	EC														
PCB-1248		39503	<28000	<2700	<2800	<220	NA	<3000	<2600	<3800000	<22000	<2200	NA	<2300	<2400	<23000
	UG/KG-DRY	EC														
PCB-1254		39507	<28000	<2700	<2800	<220	NA	<3000	<2600	<3800000	<22000	<2200	NA	<2300	<2400	<23000
	UG/KG-DRY	EC														
PCB-1260		39511	34000	25000	19000	420	NA	22000	14000	40000000	43000	9900	NA	5600	5300	39000
	UG/KG-DRY	EC														
LEAD,SED		1052	2.53	3.38	1.35	11.0	14.1	92.8	47.9	25.3	4.55	335	NRQ	33.9	44.7	381
	UG/G-DRY	GFAA														
LEAD,DISS		1049	NRQ	NRQ	NRQ	NRQ	<2.5	NRQ	NRQ	NRQ	NRQ	5.4	NRQ	NRQ	NRQ	NRQ
	UG/L	GFAA														
EP-TOX,DATE OF EXTRACTION		97078 M	NRQ	NRQ	NRQ	NRQ	3-3-88	NRQ	NRQ	NRQ	NRQ	3-3-88	NRQ	NRQ	NRQ	NRQ

RR-00207-03.13-05/15/92

APPENDIX C
COST ESTIMATES FOR REMEDIAL ACTION ALTERNATIVES

ALTERNATIVE 1 NO ACTION

CAPITAL COST

FENCE, CHAIN LINK INDUSTRIAL 6' HIGH PLUS 3 STRANDS BARBED WIRE, 2" LINE POST @ 10' O.C. 1 - 5/8" TOP RAIL

6 GA WIRE, GALV. STEEL

652 L.F. X $11.90/L.F.	=	$7,759

CORNER POSTS, 3" DIA GALV. STEEL

5 POSTS X $66 EA	=	$330

BRACES, GALV. STEEL

10 BRACES X $23 EA	=	$230

GATE FOR 6' HIGH FENCE, 1-5/8" FRAME 3' WIDE, GALV. STEEL

1 X $90	=	$90
SUBTOTAL		$8,409
CONTINGENCY (15%)		$1,261
TOTAL CAPITAL COST		$9,670

ANNUAL O&M COST

ASSUME $50/YR

ALTERNATIVE 2 CAPPING

CAPITAL COST

SCRAPING (2 CY)	8 HRS X $15/HR	=	$120
BITUMINOUS CAP, 1" THICK PAVING, 4" GRAVEL BASE			
BORROW	198 CY X $7.30/CY	=	$1,445
COMPACTION	198 CY X $3.24/CY	=	$642
BITUMINOUS CAP	1,780 SY X $2.55/SY	=	$4,539
SUBTOTAL			$6,746
CONTINGENCY (15%)			$1,012
TOTAL CAPITAL COST			$7,758

ANNUAL O&M COST

ASSUME $50/YR

ALTERNATIVE 3 PARTIAL EXCAVATION & CAPPING

CAPITAL COST

EXCAVATION & BACKFILL

EXCAVATING	467 CY X $2.83/CY	=	$1,322
SCRAPING (2 CY)	8 HRS X $15/HR	=	$120
BORROW	467 TONS X $1.98/TON	=	$925
HAUL BACKFILL	467 CY X $6.95/TON	=	$3,246
BACKFILL & COMPACTION	467 CY X $2.82/CY	=	$1,317
REVEGETATION	1,400 SY X $3.24/SY	=	$4,536

HAULING & INCINERATION

CONTAINERIZATION	469 CY X $251.46/CY	=	$117,935
FREIGHT SOIL	469 CY X $237.50/CY	=	$111,388
INCINERATION SOIL	469 CY X $1666.25/CY	=	$781,471

CAP

BORROW	42 CY X $7.30/CY	=	$307
COMPACTION	42 CY X $3.24/CY	=	$136
CAP	379 SY X $2.55/SY	=	$966

SUBTOTAL	$1,023,669
CONTINGENCY (15%)	$153,550
TOTAL CAPITAL COST	$1,177,219

ANNUAL O&M COST

ASSUME $50/YR

ALTERNATIVE 4 EXCAVATION

CAPITAL COST

EXCAVATION & BACKFILL

EXCAVATING	593 CY X $2.83/CY	=	$1,678
SCRAPING (2 CY)	8 HRS X $15/HR	=	$120
BORROW	593 TONS X $1.98/TON	=	$1,174
HAUL BACKFILL	593 CY X $6.95/TON	=	$4,121
BACKFILL & COMPACTION	593 CY X $2.82/CY	=	$1,672
REVEGETATION	1,780 SY X $3.24/SY	=	$5,767

HAULING & INCINERATION

CONTAINERIZATION	595 CY X $251.46/CY	=	$149,619
FREIGHT	595 CY X $237.50/CY	=	$141,313
INCINERATION	595 CY X $1666.25/CY	=	$991,419
SUBTOTAL			$1,296,883
CONTINGENCY (15%)			$194,532
TOTAL CAPITAL COST			$1,491,415

ANNUAL O&M COST

ASSUME $0/YR

Versar INC.

APPENDIX C

NAVSTA Roosevelt Roads
Stratigraphy

Versar INC.

GEOLOGIC FORMATIONS AT NAVAL STATION ROOSEVELT ROADS

BEACH DEPOSITS OF PEBBLES AND COBBLES (HOLOCENE)

- Moderately sorted, generally well-rounded local pebble and cobble deposits. Composed mainly of volcanic rock fragments from lavas and dikes, coral fragments, and calcareous sand. Gradational into sandy beach deposits. Thickness ranges from two to four meters or more.

LAGOON DEPOSITS (HOLOCENE)

- Mud and calcareous sand deposits periodically inundated by very shallow marine waters. Gradational into swamp deposits. Found on western side of Ensenada Honda. Thickness uncertain.

SWAMP DEPOSITS (HOLOCENE)

- Black to dark brown organic-rich soil and muck in poorly drained part of alluvial plains. In large part covered with mangroves. Thickness probably as much as five meters locally.

BEACH DEPOSITS (HOLOCENE AND PLEISTOCENE)

- Unconsolidated fine-to coarse-grained sand and pebble deposits. South of Ensenada Honda these desposits are composed of quartz and feldspar grains and plutonic and volcanic rock fragments, with considerable amounts of shell, algal, and coral fragments locally. From Ensenada Honda northward, quartz grains are rare and plutonic rock fragments uncommon; deposits are principally of calcium carbonate grains with local admixtures of volcanic rock fragments and pebble clasts. Gradational into, and partly overlain by, alluvial and swamp deposits. Thickness is probably more than 20 meters locally.

ALLUVIUM AND FANGLOMERATE (HOLOCENE AND PLEISTOCENE)

- Unconsolidated to poorly consolidated, poorly to well-sorted, clay to boulder-sized material in fans and in stratified alluvial valley fill deposits. Locally terraced; includes slope wash, small landslides, and channel fill deposits. Gradational into units mapped as predominantly alluvium, alluvial plain, and terraced deposits. Thickness locally more than 25 meters.

QUARTZ DIORITE AND GRAND DIORITE (TERTIARY AND UPPER CRETACEOUS)

- Light gray to light olive gray stocks of medium- to fine-grained unfoliated rock with hypodiomorphic-granular texture. Composition ranges from quartz diorite

to grandodiorite. Hornblende is the predominant mafic mineral; only minor amounts of biotite are present. Rounded metavolcanic xenoliths are locally present. A sample from the stock at the head of the Rio Daguao exhibits a peculiar fine-grained allotrimorphic-granular quarts and feldspar groundmass for the otherwise normally developed medium-grained minerals in the quartz diorite.

QUARTZ KEROTOPHYRE (TERTIARY AND UPPER CRETACEOUS)

- Stocks of medium-dark-gray to medium-bluish-gray porphyritic rock with an aphanitic matrix in north-central part of mapped area. Contains oliogoclasse and bipyramidal quartz phenocrysts. Weathers to grayish yellow, dusky yellow, and light brown. The quartz phenocrysts and the light colors are distinctive, interior parts of the intrusive are massive in aspect, although the rock is commonly much jointed and locally shattered. Borders of the intrusive are often irregular, with numerous apophyses and dikes extending into the county rock. Groundmass is an intricate intergrowth of quartz albite and oligoclase. X-ray diffraction indicates that somewhat more than 10% of the rock is potassium feldspar, but this could not be confirmed optically. Phenocrysts of plagioiclase are albite and aligoclase in crystals about one to four millimeters in length. The three-millimeter-long quartz phenocrysts appear to be resorbed and rounded, although a bipyramidal shape is plainly evident in many of them. Epidote is common as patches and stringers throughout the rock.

FIGUERA LAVA (LOWER CRETACEOUS)

- Andesitic lava sequence with intercalations of volcaniclastic breccia and tuft. Exposures generally confined to artificial cuts; most slopes show only float of lava fragments in soil. Medium-dark-gray to dark-gray, reddish-brown weathering lavas are generally fine-grained, medium-bedded to massive, and locally autobrecciated. The lava contains small, scattered andesine phenocrysts and sparese pyroxene pheoncrysts. Quart is fairly common in inlets, stringers, and blebs ranging from three to nine centimeters in length. The original composition of the groundmass appears to have been largely andesine and clinopyroxene with minor magnetite, but in most places the groundmass is altered to epidote, chlorite, tremolite-actinolite, quartz, and clay. Local amygdaloidal lavas have quartz, epidote, and calcite as vesice fillings. Some lenticular zones of pillow lava are scattered through the section; the pillows range from one to two meters in diameter, and generally a light-colored, aphanitic, silicified material occupies the interstices between the pillows. One thin, light gray tuft bed crossed by Highway 975 along the ridge crest west of Ceiba appears in thin section to contain devitrified pumice fragments and glass shards in a brown cryptocrystalline groundmass containing scattered broken plagioclase and pyroxene crystals. A planar texture is readily discernible in the rock, and it is interpreted as a nonwelded andesitic ash flow tuft, relatively rich in crystal fragments. Volcaniclastic rocks occur in units a few meters thick as interbeds within the main lava sequence. These rocks include some graded tufts

in layers two to eight centimeters thick, but are mainly medium- to thick-bedded coarse tuft to lapilli tuft and tuft breccia. Clasts include some cherty-looking material that may be a silicified tuft as well as minor pumaceous fragments, but are generally fine-grained lava and amygdaloidal lava, like that of the main part of the figuera. An especially thick massive breccia underlying pillow lavas can be found along route 972 on the ridge in the northwest part of the Naquabo quadrangle. The breccia is made up of angular to rounded pebble-sized clasts of pumice, amygdaloidal fine-grained lavas, and locally, silicified tuft in calcareous clinopyroxene-bearing tuft matrix. As much as 2,000 meters of Figuera Lava may be exposed in the area.

MIXED ZONE (LOWER CRETACEOUS)

- Interstratified Figuera Lava and Daguao Formation.

DAQUAO FORMATION (LOWER CRETACEOUS)

- Interbedded volcanic breccia, lava, and subordinate volcanic sandstone and crystal tuft. The volcanic breccia is medium gray, massive, and is composed of clasts of dark-gray irregularly shaped subangular to subrounded granule-to cobble-size porphyritic andesite lava in a medium gray coarse-grained plagioclase and clinopyroxene crystal tuft matrix. The breccia units are commonly cut by fine-grained and prophyritic lava dikes. Breccia beds are generally exposed only in artificial excavations, and float on natural slopes consists largely of lava clasts. Lavas are principally medium-dark gray andesites with a pilo-taxitic texture and andesine and clinopyroxene phenocrysts; they are locally amygdaloidal. Some of these lavas are flow breccias, with porphyritic andesite clasts commonly more than five centimeters in diameter, either welded together or in a matrix of speared andesite. Some dark-greenish-gray, very fine-grained flows are also autobrecciated. Typical massive tuft breccia can be seen in housing excavations just northwest of Daquao; good breccia and lava exposures can be found along the coast southeast of Hucares. Coarse autoclastic lavas may be found throughout the section in the ridge directly west of Ensenada Honda and Langley Drive, on the Roosevelt Roads Naval Reservation. Dark- to medium-gray volcanic sandstones and tufts are usually laminated to thin-bedded and graded, and are locally crossbedded. A few crystals tufts are hornblende-rich; most sand stones and tufts are composed of plagioclase and clinopyroxene grains like the matrix of the massive volcanic breccias, and calcareous are fairly common. The sandstones and tufts generally form units only a few meters thick in the western part of the mapped area. Notably thicker sequences in the east are shown by diagonal lines. Thick sequences of thin-bedded to laminated tuft are well exposed along the coast from Punta Algodones to Punta Cascajo, on the roosevelt roads Naval Reservation. Rocks of the Daguao Formation are commonly epidotized and chloritized in varying degrees. Volcaniclastic hornfels occurs in a few places near the diorite and granodiorite stocks, and small exposures of phyllitic to schistone rocks (s) occur in one area

north of Daquao, south of the keratophyre stocks. The formation interfingers with the overlying Figuera Lava in a few places; its base is not exposed. The thickness of the Daguao is estimated to be on the order of 1,000 to 1,500 meters.

DAGUAO INTRUSIVE BRECCIA (LOWER CRETACEOUS)

- Hypabyssal intrusive rock medium-dark-gray brecciated andesite. Contains subangular clasts of dark-gray andesite with large plagioclase and clinopyroxene phenocrysts in a brecciated matrix of the same composition. The clasts seem to be lithologically identical to andesite clasts in the tuft breccias and autoclastic lavas of the Daguao Formation. The clasts of the two intrusive bodies in the Naguabo quadrangle east of Daguao range from three to 15 centimeters in length; on Isla Pineros in the Punta Puerca quadrange blocks as large as 90 centimeters in length are found in an intrusive body making up a small hill on the northwest corner of the island. The intrusive rocks are locally much epidotized and silicified; the epidote and quartz occur in veins and in irregular patches. In a quarry in the intrusive body that is south of the Roosevelt Roads airfield some podshaped zones several meters long have been largely replaced by epidote and quartz, yet the original texture of the porphyritic andesite breccia is discernible. An exposure of massive andesite lava about 100 meters wide and 200 meters long on the crest of the ridge to the northwest of Naquabo may also be an intrusive body. The lave is lithogically similar to the other intrusive breccias; although it is only partly brecciated, it does show some near vertical banding (flow lines).

Versar INC.

APPENDIX D

IRIS Listing (U.S. EPA, 1991)

1 - HSDB
NAME - POLYCHLORINATED BIPHENYLS
RN - 1336-36-3
RELT - 6352 [AROCLOR 1016]
RELT - 6353 [AROCLOR 1221]
RELT - 6354 [AROCLOR 1232]
RELT - 6355 [AROCLOR 1242]
RELT - 6356 [AROCLOR 1248]
RELT - 6357 [AROCLOR 1254]
RELT - 1822 [AROCLOR 1260]
RELT - 3946 [2,4,5,2',4',5'-HEXACHLOROBIPHENYL]
RELT - 3947 [2,4,5,3',4',5'-HEXACHLOROBIPHENYL]
RELT - 3948 [3,4,5,3',4',5'-HEXACHLOROBIPHENYL]
RELT - 3949 [3,4,3',4'-TETRACHLOROBIPHENYL]
SY - Chlorinated diphenyl **PEER REVIEWED**
SY - PCB **PEER REVIEWED**
SY - 1,1'-Biphenyl, chloro derivs **PEER REVIEWED**
SY - Caswell no 672A **PEER REVIEWED**
SY - EPA pesticide chemical code 017801 **PEER REVIEWED**
SY - Clophen **PEER REVIEWED**
SY - Kanechlor **PEER REVIEWED**
SY - Aroclor **PEER REVIEWED**
SY - Fenclor **PEER REVIEWED**
SY - Chlorextol **PEER REVIEWED**
SY - Inerteen **PEER REVIEWED**
SY - Monter **PEER REVIEWED**
SY - Phenoclor **PEER REVIEWED**
SY - Pyralene **PEER REVIEWED**
SY - Pyranol **PEER REVIEWED**
SY - Santotherm **PEER REVIEWED**
SY - Sovol **PEER REVIEWED**
SY - Therminol **PEER REVIEWED**
SY - Noflamol **PEER REVIEWED**
SY - Biphenyl, polychloro- **PEER REVIEWED**
SY - Chlorinated biphenyl **PEER REVIEWED**
SY - Chlorinated diphenylene **PEER REVIEWED**
SY - Chloro 1,1-biphenyl- **PEER REVIEWED**
SY - Dykanol **PEER REVIEWED**
SY - Montar **PEER REVIEWED**
SY - Santotherm fr **PEER REVIEWED**
SY - Therminol fr-1 **PEER REVIEWED**
SY - Chloro biphenyl **PEER REVIEWED**
SY - Polychlorobiphenyl **PEER REVIEWED**
MF - ND
ASCH - Aroclor;12767-79-2
MMFG - ... FROM DIPHENYL & NAPHTHALENE WHICH MAY BE REACTED TO VARYING DEGREES WITH CHLORINE TO PRODUCE A NUMBER OF CMPD DESIGNATED BY VARIOUS TRADE NAMES SUCH AS AROCLOR. ... [HAMILTON. INDUS TOX 3RD ED 1974 , p. 289] **PEER REVIEWED**
MMFG - Chlorinated anilines are coupled with chlorinated benzenes by using an excess of the latter reactant which also serves as the solvent medium. The coupling reaction proceeds smoothly after the addition of isoamyl

nitrate, and the PCB product is readily isolated after a series of chromatographic procedures. [Mullin MD et al; Environ Sci Technol 18 (6): 468-76 (1984)] **PEER REVIEWED**

MMFG - PCBS ARE PREPD INDUSTRIALLY BY THE CHLORINATION OF BIPHENYL WITH ANHYDROUS CHLORINE IN THE PRESENCE OF A CATALYST SUCH AS IRON FILINGS OR FERRIC CHLORIDE. THE PRODUCTS ARE COMPLEX MIXT OF CHLOROBIPHENYLS, WHOSE DEGREE OF CHLORINATION DEPENDS PRINCIPALLY ON THE TIME OF CONTACT (12-36 HR) OF THE BIPHENYL WITH ANHYDROUS CHLORINE. [IARC MONOGRAPHS. 1972-PRESENT V18 54 (1978)] **PEER REVIEWED**

FORM - Aroclor mixtures which General Electric used in transformers have contained anywhere from 13% to 60% trichlorobenzene, with the remainder being pentachlorobiphenyl or hexachlorobiphenyl or mixtures of either tri-, penta-, or hexachlorobiphenyl and tetrachlorobenzene. [USEPA; PCDDs and PCDFs From PCBs Transformer and Capacitor Fires p.23 (1984) USEPA 600/2-85/036] **PEER REVIEWED**

FORM - In the USA, Aroclor is the most familiar requested trademark, but PCBs have also been marketed as Chloretol, Dyknol, Inerteem, Noflamol, and Pyranol. In other countries, PCB formulations have been sold as Pyralene (France), Phenoclor (France), Kanechlor (Japan), Santotherm (Japan), Fenclor (Italy), Apirolio (Italy), Soval (USSR), Delor (Czechoslovakia) and Clophen (West Germany). [US Dept of Interior/Fish & Wildlife Service Contaminant Reviews; Polychlorinated Biphenyls Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review Biol Rept No (85) 1.7 p.5 (1986)] **PEER REVIEWED**

FORM - There are 209 isomers/congeners of which 5 to 10 generally contribute more than 10% to the polychlorinated biphenyl content of Aroclor, Clophen, Phenochlor, and Kanechlor. [USEPA; Drinking Water Quality Criteria Doc: Polychlorinated Biphenyls (PCBs) ECAO-CIN-414 p.II-1-7 (1987)] **PEER REVIEWED**

MFS - Monsanto, the sole domestic manufacturer of PCB's /manufactured/ this chemical in its Sauget, IL plant. [Durfee RL; p.103-107 in Conference Proceedings: National Conference on Polychlorinated Biphenyls (1976) USEPA 560/2-75/004] **PEER REVIEWED**

OMIN - Commercial production /of PCB's/ was initiated in the United States in 1929 in response to the electrical industry's need for an improved dielectric insulating fluid (nonconductor of direct current) for use in transformers and capacitors which would also provide increased fire resistant benefits. [KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT V5 844] **PEER REVIEWED**

OMIN - Domestic /USA/ production of polychlorinated biphenyls was stopped in October 1977. [KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT V5 844] **PEER REVIEWED**

OMIN - All Aroclor products are characterized by a four digit number. The first two digits represent the type of molecule; 12= chlorinated biphenyl, 54= chlorinated terphenyl. Aroclor 25-- and 44-- are blends of PCB and chlorinated terphenyls (75% and 60% PCB, respectively). The last two digits give the weight percent of chlorine, Aroclor 1016 contains 41% chlorine per weight but the penta-, hexa-, heptachlorobiphenyl content is significantly reduced. [Hutzinger O et al; The Chemistry of PCBs p.7 (1974)] **PEER REVIEWED**

USE - EPA AUTHORIZED THE USE OF POLYCHLORINATED BIPHENYLS IN A NON-TOTALLY ENCLOSED MANNER IN HYDRAULIC SYSTEMS, HEAT TRANSFER SYSTEMS, IN

MICROSCOPY AS MOUNTING MEDIUM, & IN SMALL QUANTITIES FOR RESEARCH & DEVELOPMENT UNTIL JULY 1, 1984 (EPA IS PROPOSING TO AMEND THE RULE GOVERNING USE OF PCBS AS MOUNTING MEDIUM & IN RESEARCH & DEVELOPMENT). [48 FR 52402 (1983)] **PEER REVIEWED**

USE - /Used/ in electrical capacitors, electrical transformers, vacuum pumps, & gas-transmission turbines. [MERCK INDEX. 10TH ED 1983 , p. 1091] **PEER REVIEWED**

USE - PCBS /SRP: AS AROCLORS/ ARE WIDELY USED AS ENZYME INDUCERS IN RESEARCH LABORATORIES THROUGHOUT THE WORLD. THERE ARE INDICATIONS THAT CHLORINE CONTENT OF PCB MIXTURES IS RELATED TO LEVEL OF INCR ENZYMATIC ACTIVITY: MIXTURES CONTAINING LOWER PERCENTAGE OF CHLORINES WERE LESS ACTIVE THAN THOSE CONTAINING A HIGHER PERCENTAGE. [IARC MONOGRAPHS. 1972-PRESENT V18 74 (1978)] **PEER REVIEWED**

USE - The fire-resistant nature of the polychlorinated biphenyls ... combined with outstanding thermal stability made them excellent choices as hydraulic and heat transfer fluids alone or in formulations. They were also used to improve the waterproofing characteristics of surface coatings and have been used in the manufacture of carbonless copy paper, printing inks, plasticizers, special adhesives, lubricating additives, and vacuum pump fluids. [KIRK-OTHMER ENCYC CHEM TECH 3RD ED 1978-PRESENT V5 p.844] **PEER REVIEWED**

USE - Former uses of PCB's /as of 1974/ hydraulic fluids, plasticizer in synthetic resins, adhesives, plasticizer in rubbers, heat transfer systems, wax extenders, dedusting agents, pesticide extenders, inks, lubicants, cutting oils, carbonless reproducing paper. [Hutzinger O et al; The Chemistry of PCB's p.8 (1974)] **PEER REVIEWED**

CPAT - Capacitors, 70%; Transformers, 30% (1975) /Aroclors/ [Durfee RL et al; p.103-107 in Conference Proceedings: National Conference on Polychlorinated Biphenyls (1976) USEPA 560/2-75/004] **PEER REVIEWED**

PROD - ND

IMPT - Imports /of PCB's/ were terminated in 1980 in response to compliance with the Toxic Substances Control Act (TSCA) [Holton GA et al; Haz Waste & Haz Materials 2 (4): 453 (1985)] **PEER REVIEWED**

EXPT - (1986) ND [CITATION] **PEER REVIEWED**

COFO - Lower chlorinated Aroclors (1221, 1232, 1016, 1242, and 1248) are colorless mobile oils. Increasing chlorine content results in mixtures taking on the consistency of viscous liquids (Aroclor 1254) or sticky resins (Aroclors 1260 and 1262). Arclors 1268 and 1270 are white powders. [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p. A-3 (1980) EPA 440/5-80-068] **PEER REVIEWED**

BP - ND

SOL - ND

VAP - ND

EVAP - ND

OCPP - Solubility in water is extrememly low; soluble in oils and organic solvents. [IARC MONOGRAPHS. 1972-PRESENT V18 49 (1978)] **PEER REVIEWED**

OCPP - With the exception of Aroclors 1221 and 1268, Aroclors do not crystallize upon heating or cooling, but at a specific temperature, defined as a "pour point", change into a resinous state. [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p.A-3 (1980) EPA 440/5-80-068] **PEER REVIEWED**

TOXS - ND

TXHR - Classification of carcinogenicity: 1) evidence in humans: limited; 2) evidence in animals: sufficient. Overall summary evaluation of carcinogenic risk to humans is Group 2A; the agent is probably carcinogenic to humans. /From table/ [IARC MONOGRAPHS. 1972-PRESENT S7 70 (1987)] **PEER REVIEWED**

HTOX - IN SURVEY OF 3 GROUPS OF WORKERS EXPOSED TO POLYCHLORINATED BIPHENYLS (PCBS) SERUM PCB CONCN WERE QUANTITATED AS LOWER PCB & HIGHER PCB. SERUM LOWER PCB & HIGHER PCB CONCN WERE MANY TIMES GREATER AMONG WORKERS EMPLOYED IN POWER CAPACITOR MANUFACTURING THAN AMONG GENERAL POPULATION. POSITIVE CORRELATIONS OF SYMPTOMS SUGGESTIVE OF MUCOUS MEMBRANE & SKIN IRRITATION, MALAISE & ALTERED SENSATION WERE NOTED WITH INCR CONCN OF SERUM PCB. NO CLINICAL ABNORMALITIES ATTRIBUTABLE TO EXPOSURE TO PCB WERE OBSERVED. SERUM CONCN WERE POSITIVELY CORRELATED WITH INCR OF GLUTAMIC-OXALACETIC TRANSAMINASE, SERUM GAMMA-GLUTAMYL TRANSPEPTIDASE & PLASMA TRIGLYCERIDE, & INVERSELY CORRELATED WITH PLASMA HIGH DENSITY LIPOPROTEIN-CHOLESTEROL. [SMITH AB ET AL; BR J IND MED 39 (4): 361-9 (1982)] **PEER REVIEWED**

HTOX - Deaths that occurred up to 5 1/2 yr after first exposure to PCB's ... were reported. Nine (41%) of 22 deaths were due to malignant neoplasms. Three of the tumors occurred in the stomach, one in the liver, two in the lung and one in the breast, and two were malignant lymphomas. (Kuratsune, 1976; Omae, 1975) [IARC MONOGRAPHS. 1972-PRESENT V18 82 (1978)] **PEER REVIEWED**

HTOX - A significant correlation was found between plasma levels of polychlorinated biphenyls(PCBs) in mothers occupationally exposed to these cmpd and the PCB milk levels. It has been observed that if these mothers nursed their babies for more than three months, the PCB levels in the infants exceeded that of their mothers. These cmpd were subsequently retained in the children for many years. ... [ENCYC OCCUPAT HEALTH & SAFETY 1983 , p. 1755] **PEER REVIEWED**

HTOX - /RESPONSES TO PCBS/: ACNE; HYPERPIGMENTATION OF SKIN; HYPERACTIVE MEIBOMIAN GLANDS; CONJUNCTIVITIS; EDEMA OF EYELIDS; SUBCUTANEOUS EDEMA; KERATIN CYSTS IN HAIR FOLLICLES; HYPERPLASIA OF HAIR FOLLICLE EPITHELIUM; HEPATIC HYPERTROPHY; DECR NUMBER OF RED BLOOD CELLS; DECR HEMOGLOBIN; SERUM HYPERLIPIDEMIA; LEUCOCYTOSIS. [IARC MONOGRAPHS. 1972-PRESENT V18 70 (1978)] **PEER REVIEWED**

HTOX - A leaking heat exchanger in a chemical plant discharged polychlorinated biphenyl (PCB) vapors. No employees worked routinely at the point of leakage, but breathing zone levels in work areas were found to be 0.1 mg/cu m. The period of exposure was 19 months. Seven of 14 exposed workers developed mild to moderate chloracne after exposure durations of 5-14 months. Liver function tests showed normal serum bilirubin, 24 and 48 hr cephalin flocculations, thymol turbidities, and serum alkaline phosphatase activities in six of the seven workers, but borderline increases in cephalin flocculation and thymol turbidity in the seventh. After 13 months, the thymol turbidity but not the cephalin flocculation had improved. [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p.C-56 (1980) EPA 440/5-80-068] **PEER REVIEWED**

HTOX - An analysis of the health effects of polychlorinated biphenyls (PCB) on eight laboratory workers involved in testing dielectric fluids was

made. ... The workers, all males 25 to 49 yr of age, had been employed 2.5 to 18 yrs. Breathing zone, point source, and general work area samples were collected on three separate occasions. The ranges were: breathing zone, 0.014 to 0.073 mg/cu m; point source (near an oven), 0.042 to 0.264 mg/cu m; and room area, 0.013 to 0.15 mg/cu m. Blood concns were 36 to 286 ppb which is substantially above the range in several studies of general populations. Workers complained of dry, sore throat (6/8), skin rash (3/8), gastrointestinal disturbances (3/8), and eye irritation and headache (2/8). Examination disclosed one patient with skin rash, two with nasal irritation, one showing rales, and four with high blood pressure, but no abnormalities in liver function. [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p.C-55 (1980) EPA 440/5-80-068] **PEER REVIEWED**

HTOX - Irregular menstrual cycles, early abortions and the birth of small, hyperpigmented and hyperkeratotic infants have been observed. [IARC MONOGRAPHS. 1972-PRESENT V18 37 (1978)] **PEER REVIEWED**

HTOX - Spirometric findings in a retrospective cohort of 136 capacitor workers with occupational exposure to polychlorinated biphenyls (PCBs) during active use (1976) and after the PCB ban (1979 and 1983) are reported. Quantitative exposure levels are not known. Subjects were categorized as having high, medium, or low exposure depending primarily on the extent of dermal contact. Mean 1979 serum PCB levels were elevated 35 to 40 times the normal level. Duration of employment ranged from 1-35 yr. Obstructive impairment was consistently found in 15% of the workers in 1976 and 1979. A history of respiratory illness and reduced FEV 1/FVC was correlated in a dose-response fashion with PCB exposure category and serum PCB levels in females in 1976 but the association disappeared in 1979. It is not clear whether the association held when controled for smoking. There was no association between PCB exposure and abnormal pulmonary function tests in males. [Lawton R et al; J Occup Med 28 (6): 453-6 (1986)] **PEER REVIEWED**

HTOX - PCBS ARE LIVER TOXINS & CAUSE CHLORACNE & POSSIBLY PERIPHERAL NEUROPATHY IN MAN. [NRC. DRINKING WATER & HEALTH 1977 , p. 757] **PEER REVIEWED**

HTOX - The first documentation of human effects as a result of ingestion of PCBs was derived from the Japanese poisoning incident that occurred in 1968. The victims suffered an acute toxicosis from consuming rice oil contaminated with an industrial oil, Kanechlor-400, consisting of a mixture of polychlorinated biphenyls (PCB), polychlorinated dibenzofurans (PCDF), and polychlorinated quinones (PCQ). The average total amount of PCBs consumed was estimated to be approximately 2 g, with approximately 0.5 g being the least total amount consumed by an affected group of some 325 people at the time. ... The most notable symptoms of Yusho among 189 patients included dark brown pigmentation of nails and skin, follicular accentuation, acneform eruptions, increased eye discharge, increased sweating at the palms and feeling of weakness. ... [Kuratsune M et al; Environ Health Perspect 1: 119-28 (1972) as cited in USEPA; Drinking Water Qual Crit Doc: Polychlorinated Biphenyls (PCBs) ECAO-CIN-414 p.VI-15 (1987)] **PEER REVIEWED**

HTOX - A mass outbreak of a peculiar skin disease /including pigmentation and acne from eruptions/ was recorded in Taichung and Changwa in Central Taiwan. The cause of the disease was later identified to be the

ingestion of rice bran oil contaminated with polychlorinated biphenyls (PCBs), and there were > 1900 victims. Blood PCB levels of 66 affected persons ranged from 11-720 ppb (mean 49 ppb) at approx 9-12 months after consumption of the PCB-contaminated oil. [Chen PH et al; Bull Environ Contam Toxicol 25: 325-9 (1980) as cited in USEPA; Drinking Water Qual Crit Doc: Polychlorinated Biphenyls (PCBs) ECAO-CIN-414 p. VI-14 (1987)] **PEER REVIEWED**

HTOX - Polychlorinated biphenyl blood residues were measured in 29 infertile males and in 14 matched control subjects at a hospital in Jerusalem, Israel. The patients' ages ranged from 25 to 45 years. The patients exhibited one or more impaired semen characteristics such as decreased spermatozoa count, lower sperm motility, or a greater proportion of morphologically abnormal spermatozoa. The control group, matched by age and smoking habits, consisted of randomly selected patients with minor illnesses. Each of them had at least one child not older than two years of age. None of the subjects had a history of occupational exposure to organochlorine compounds. The polychlorinated biphenyl levels were measured by GC-ECD. The mean concentration of total polychlorinated biphenyls in the infertile patients was 11.21 +/- 13.48 ng/g blood serum (range 0 to 64.2 ng/g). The control subjects had a mean concentration of 7.94 +/- 14.69 ng/g (range 0 to 47.3 ng/g). [Pines A et al; Arch Environ Contam Toxicol 16: 587-597 (1987)] **QC REVIEWED**

HTOX - A retrospective cohort mortality study of workers exposed to polychlorinated biphenyl (PCBs) in two plants manufacturing electrical capacitors was reported in 1981. The study was conducted primarily to examine the risk of cancer mortality associated with exposure to PCBs: due to the availability of animal data, liver cancer was the disease of most interest. Because of the small number of deaths and a relatively short observation period the study was inconclusive. Therefore, the study was updated by adding 7 yr of observation increasing the number of deaths in the study cohort from 163 to 295. Mortality from all causes was found to be lower than expected (295 observed versus 318 expected deaths) as well as mortality from all cancers (62 observed versus 80 expected deaths). A statistically significant excess in deaths was observed in the category that includes cancer of the liver (primary and unspecified), gall bladder, and biliary tract (5 observed versus 1.9 expected; $p < 0.05$). Most of this excess was observed in women employed in one plant. [Brown DP; Arch Environ Health 42 (6): 333-9 (1987)] **QC REVIEWED**

HTOX - The possibility of polychlorinated biphenyl-induced porphyria after transplacental exposure was investigated using children born to mothers exposed to contaminated rice oil in central Taiwan in 1979. The exposure was to a mixture of thermally degraded polychlorinated biphenyls, polychlorinated quaterphenyls, & polychlorinated dibenzofurans, which had become mixed with the oil during processing. Women who became pregnant had children with high perinatal mortality and a dysmorphic syndrome. Seventy four controls and 12 siblings of the exposed children were included in the study. Four of the transplacentally exposed children, 2 controls and 1 sib had a type B hepatic porphyria; total porphyrin excretion was elevated in the exposed children as a group (95 ug/l, exposed; 81 ug/l, control); and 8 of the 75 exposed children and 2 controls had total urinary porphyrin

concentrations of >200 ug/l. The children did not appear to have symptoms directly attributable to porphyria, but a mild disturbance in porphyrin metabolism appeared to be related to their intrauterine exposure. [Gladen BC et al; Arch Environ Health 43 (1): 54-8 (1988)] **QC REVIEWED**

HTOX - People occupationally exposed to PCB's have relatively high PCB residue levels. [ENCYC OCCUPAT HEALTH & SAFETY 1983 , p. 1753] **PEER REVIEWED**

HTOX - The Carcinogen Assessment Group (CAG), Office of Health and Environmental Assessment in EPA'S Research and Development Office, has prepared a list of chemical substances for which substantial or strong evidence exists showing that exposure to these chemicals, under certain conditions, causes cancer in humans, or can cause cancer in animal species which in turn, makes them potentially carcinogenic in humans. Substances are placed on the CAG list only if they have been demonstrated to induce malignant tumors in one or more animal species or to induce benign tumors that are generally recognized as early stages of malignancies, and/or if positive epidemiologic studies indicated they were carcinogenic. Polychlorinated biphenyls are on that list. [USEPA/CAG; The Carcinogen Assessment Group's List of Carcinogens (7/14/80)] **PEER REVIEWED**

HTOX - Digestive symptoms such as abdominal pain, anorexia, nausea, vomiting, jaundice, with rare cases of coma and death, may occur. At autopsy, acute yellow atrophy of the liver was found in lethal cases. ... Neurological symptoms such as headache, dizziness, depression, nervousness ... and other symptoms such as fatigue, loss of weight, loss of libido and muscle and joint pains were found in various percentages of exposed people. ... By the study of PCB-associated diseases in the general population, pathological pregnancies (toxemia of pregnancy, abortions, stillbirths, underweight births, etc) were frequently associated with increased PCB serum levels. ... [ENCYC OCCUPAT HEALTH & SAFETY 1983 , p. 1753] **PEER REVIEWED**

HTOX - Mother's milk contaminated with PCB's appears to be a source of exposure for infants. Developmental abnormalities have been observed in PCB-intoxicated infants. Premature eruption of teeth was observed ... and larger frontal and occipital fontanelles, exophthalmos and the maintenance of an abnormally wide sagittal suture were observed. ... [IARC MONOGRAPHS. 1972-PRESENT V18 82 (1978)] **PEER REVIEWED**

HTOX - Skin and mucous membrane changes; swelling of the eyelids, burning of the eye, and excessive eye discharge, burning sensation and edema of face and hands, simple erythematous eruptions with pruritus, acute eczematous contact dermatitis, chloracne, hyperpigmentation of skin and mucous membranes, discoloration of finger nails and thickening of the skin were reported. [ENCYC OCCUPAT HEALTH & SAFETY 1983 , p. 1754] **PEER REVIEWED**

HTOX - CATEGORIES OF KNOWN OR SUSPECTED ORG CHEM CARCINOGENS FOUND IN DRINKING WATER: HIGHEST OBSERVED CONCN IN FINISHED WATER: 3 UG/L; UPPER 95% CONFIDENCE ESTIMATE OF LIFETIME CANCER RISK: 3.1X10-6 UG/L. [NRC. DRINKING WATER & HEALTH 1977 , p. 794] **PEER REVIEWED**

HTOX - Dental records were studied and dental exams given to children living in Taiwan transplacentally exposed to polychlorinated biphenyls (PCB) (Yu-Cheng babies) as confirmed by epidemiological studies in the early

1980s. Nine school aged Yu-Cheng males and 9 females were compared to an unexposed reference group of 26 males and 18 females on the prevalence of missing permanent teeth germ while taking congenital factors into account. Among 9 transplacental Yu-Cheng girls, 4 were missing permanent teeth germ due to congenital factors. Among the 18 girls in the reference group, none were missing permanent teeth germ due to congenital factors. Among 9 transplacental Yu-Cheng boys, 1 was missing permanent teeth germ due to congenital factors. Among the 26 boys in the reference group, 1 was missing permanent teet germ due to congenital factors. [Lan SJ et al; Bull Environ Contam Toxicol 42 (6): 931-4 (1989)] **QC REVIEWED**

HTOX - A job exposure matrix was developed linking the work tasks in the Swedish National Census of population 1960 to exposure to 50 single agents or groups of substances, including polychlorinated biphenyls. All 1,905,660 men (ages 20-64 yr) in 1960, reporting themselves as gainfully employed in the Census, were observed for the occurrence of urothelial cancer during the 1961-1979 period by linkage to the National Swedish Cancer Registry. Only subjects in 1 work task, electricians in electric power stations, were assigned exposure to polychlorinated biphenyls with a moderate predictive value. The relative risk (with 95% confidence interval) for this group was 1.3 (1.0-1.8) for urinary bladder cancer. [Steineck G et al; Am J Ind Med 16 (2): 209-24 (1989)] **QC REVIEWED**

HTOX - In Taiwan in 1979, rice oil contaminated with polychlorinated biphenyls (PCBs) and polychlorinated dibenzofurans was ingested by approx 2000 people. Blood samples were taken from 36 women who were potentially exposed, and 24 non-exposed women (controls). The frequency of sister chromatid exchanges in lymphocytes from their heparinized whole blood was assessed after culturing cells in the presence or absence of 40 uM alpha-naphthoflavone for 72 hr. There was no significant difference in baseline sister chromatid exchanges for PCB exposed compared to the control group (7.29 vs 7.61). In contrast, addition of alpha-naphthoflavone resulted in a dramatic induction of sister chromatid exchange frequencies in PCB exposed lymphocytes ($p < 0.01$). PCB exposed frequencies increased to 10.75, while those of the unexposed group only increased to 8.85. [Thompson C et al; Chemosphere 18 (1-6): 687-94 (1989)] **QC REVIEWED**

NTOX - PCB ADMIN HAS BEEN FOUND TO RESULT IN INCREASED SYNTHESIS, HEPATIC CONTENT & EXCRETION OF PORPHYRINS IN RATS, QUAILS & CHICKENS; & THIS HAS BEEN ASSOCIATED WITH AN INCR IN LIVER MITOCHONDRIAL GAMMA-AMINOLEVULINIC ACID SYNTHETASE. [IARC MONOGRAPHS. 1972-PRESENT V18 74 (1978)] **PEER REVIEWED**

NTOX - The carcinogenicity of polychlorinated biphenyls was shown in animal, experimentally exposed. Benign and malignant liver cell tumors, lymphomas and leukemias, and carcinomas of the gastrointestinal tract were obtained. [ENCYC OCCUPAT HEALTH & SAFETY 1983 , p. 1754] **PEER REVIEWED**

NTOX - EXPOSURE OF RATS, RABBITS, MONKEYS, CHICKS AND RAINBOW TROUT TO PCBS RESULTED IN INCREASED ACTIVITY OF ... URIDINE DIPHOSPHOGLUCURONOSYLTRANSFERASE & NITROREDUCTASE, OR A SIGNIFICANT INCR IN THE LEVEL OF CYTOCHROME P450. [IARC MONOGRAPHS. 1972-PRESENT V18 74 (1978)] **PEER REVIEWED**

NTOX - EGGSHELL THINNING, LOSS OF REPRODUCTIVE ABILITY, OR BOTH HAVE BEEN ATTRIBUTED ... TO PCBS /IN BIRDS/. [HAYES. TOX OF PESTICIDES 1975 , p. 498] **PEER REVIEWED**

NTOX - ISOMERICALLY PURE PCBS WERE TESTED AS INDUCERS OF HEPATIC DRUG-METABOLIZING ENZYMES IN THE RAT. THE CHLORINATED BIPHENYL ISOMERS CAN BE CATEGORIZED INTO 2 DISTINCT GROUPS OF INDUCERS, WHILE COMMERCIAL PCB MIXT HAVE CHARACTERISTICS OF BOTH GROUPS. BIPHENYLS CHLORINATED SYMMETRICALLY IN BOTH THE META AND PARA POSITIONS INCREASE THE FORMATION OF CYTOCHROME P448, BUT DECREASE THE AMINOPYRINE N-DEMETHYLASE ACTIVITY. BIPHENYL ISOMERS CHLORINATED IN BOTH THE PARA AND ORTHO POSITIONS INDUCE THE FORMATION OF CYTOCHROME P450 AND N-DEMETHYLASE ACTIVITY. ISOMERS WHICH ARE CHLORINATED IN ONLY 1 RING, OR ARE CHLORINATED IN BOTH RINGS BUT NOT IN THE PARA POSITIONS, HAVE VERY LITTLE ACTIVITY AS INDUCERS OF LIVER ENZYMES. [GOLDSTEIN JA ET AL; CHEM-BIOL INTERACT VOL 17 (1): 69-87 (1977)] **PEER REVIEWED**

NTOX - The most consistent pathological changes occurring in mammals after polychlorinated biphenyls (PCB) exposure are in the liver. In rats, rabbits, and guinea pigs ... fatty deposits after acute injections and similar changes in rabbits and guinea pigs after dermal application /were observed/. In feeding experiments, marked fatty metamorphosis was noted in guinea pig liver with intracellular hyaline bodies observed in rats. Less striking changes were noted in the kidneys, lung, adrenals, and heart of guinea pigs. Rats exposed repeatedly to dietary PCBs showed increased liver weights. [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p.C-37 (1980) EPA 440/5-80-068] **PEER REVIEWED**

NTOX - Hepatic microsomal activity was elevated by single large doses of Aroclor 1242. Monkeys given 300 ppm for 90 days developed alopecia, chloracne, subcutaneous edema, liver hypertrophy, and hypertrophy and hyperplasia of the gastric mucosa. [GOSSELIN. CTCP 5TH ED. 1984 II-171] **PEER REVIEWED**

NTOX - Animal studies have shown that polychlorinated biphenyls (PCBs) can cross the placental barrier and are excreted in the mother's milk. [IARC MONOGRAPHS. 1972-PRESENT V18 37 (1978)] **PEER REVIEWED**

NTOX - GROUPS OF 10 MALE & 10 FEMALE 3-4-WEEK-OLD SHERMAN RATS WERE FED 0, 20, 100, 500 OR 1000 MG AROCLOR 1260/KG DIET ... SEVERAL ... GIVEN THE TWO HIGHEST DOSE LEVELS DIED BEFORE 6 MO. ... LESIONS ... DESCRIBED AS ADENOFIBROSIS OF LIVER OCCURRED IN 2 MALES FED 1000 MG/KG & IN 1, 1 AND 4 FEMALES FED 100, 500, AND 1000 MG/KG ... (KIMBROUGH ET AL, 1972) [IARC MONOGRAPHS. 1972-PRESENT V18 67 (1978)] **PEER REVIEWED**

NTOX - Certain substitution patterns are believed to influence the biological activities of chlorobiphenyls. The presence of two adjacent carbon atoms without chlorine substitution in one or both rings is believed to facilitate metabolism because it permits the formation of arene oxide intermediates. Essentially all chlorobiphenyls with five or fewer chlorine atoms have at least one pair of adjacent unsubstituted carbon atoms because of the rarity of 3,5-substitution in the natural mixtures. ... Chlorobiphenyls with three or four chlorine atoms in the ortho-positions (2- and 6-) are more easily metabolized by humans than those with only one or two ortho- chlorines. ... Chlorobiphenyl isomers with chlorine substitutions in both the 4- and 4'- positions tend to be biologically active and well retained in tissues. [USEPA; Ambient Water

Quality Criteria Doc: Polychlorinated Biphenyls p.A-9-11 (1980) EPA 440/5-80-068] **PEER REVIEWED**

NTOX - In addition to the inhibition of tumor induction by some chemicals, PCBs were also shown to inhibit the growth of experimental tumors in rats. Sprague-Dawley rats were innoculated with Walker 256 carcinosarcoma cells and the effects of PCBs determined. Both dietary and injected aroclor 1254 reduced the size of solid tumors and increased animal life span. [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p.C-75 (1980) EPA 440/5-80-068] **PEER REVIEWED**

NTOX - The time course of induction and inhibition of several enzymes in the liver of male C57BL/6 and ddy mice fed a diet containing Kanechlor-500 (500 ppm) was examined. Controls were maintained without treatment. Four animals/group were killed at 1, 2, 3, 6, and 10 weeks, following a 24 hr fast. In treated C57BL/6 and ddY mice there was an increase in the microsomal p450 level at 1 week. In treated C57BL/6 mice, the activity of mitochondrial delta-aminolevulinic acid synthetase (ALA-S) gradually increased for 2 wk (5.7 times the control value) and then rose rapidly for 3 wk (20 times the control value). These changes were accompanied by the rapid development of porphyria (characterized by increased excretion and hepatic accumulation of uroporphyrin). The activity of uroporphyrinogen decarboxylase (URO-D) was depressed approximately 40% within the first wk and 80% within 3 wk. In treated ddY mice there was a moderate increase of ALA-S (8 times the control at 3 wk); URO-D activity was unaffected for 3 wk and a significant decrease (p value not given) was observed at wk 6. Activities of ALA-S and URO-D in both strains of control mice were constant during the study. The control level (time 0) of URO-D in ddY mice was significantly higher ($p < 0.01$) than that of C57BL/6 mice, whereas control ALA-S activities were similar in the 2 strains. In C57BL/6 mice, the hepatic uroporphyrin level was elevated during the first week of exposure. By the third week, the liver porphyrin level was 2100 times that of the controls. Porphyrin did not accumulate in treated ddy mice at week 3, was slightly increased at week 6, and remained constant at week 10. There were no increases in uroporphyrin levels in untreated mice. /Kanechlor-500/ [Seki Y et al; Toxicol Appl Pharmacol 90 (1): 116-25 (1987)] **QC REVIEWED**

NTOX - Groups of eight female Sprague-Dawley rats were fed 50 ppm Aroclor 1242 or Aroclor 1254 in their normal diets for seven months. One group of animals served as controls. Because (86)Rb mimics K+ in membrane transport, it was used to assess the amount of K+ uptake in erythroid cells. In a culture medium depleted of K+, the uptake of (86)Rb by erythroid cells was significantly lower in the Aroclor 1254-treated group (7.78%) ($p < 0.05$) compared with the control group (21.9%). Uptake of (86)Rb in the Aroclor 1242-treated group was not significantly lower than that of controls. In a sodium-depleted culture medium, erythroid cells from only the Aroclor 1254-treated animals showed a minimal, but significant reduction in (86)Rb uptake (1.16%) ($p < 0.05$) compared with the control group (3.91%). The difference in 86(Rb) uptake between the Na+ and K+-depleted culture media was attributed to the relative saturation of the K+ transport system. When erythroi cells were challenged with ouabain in order to suppress Na+, K+, and ATPase

activity, (86)Rb uptake was depressed in all but the Aroclor 1254 group (this group had already been maximally depressed). [Byrne JJ, Sepkovic DW; Arch Environ Contam Toxicol 16: 573-7 (1987)] **QC REVIEWED**

NTOX - Juvenile rainbow trout (Salmo gairdneri) were fed diets of coho salmon containing polychlorinated biphenyls (PCBs) naturally bioaccumulated from Lake Michigan, Lake Ontario, or the Pacific Ocean for a 20 wk period. Gas chromatographic analysis indicated that the bioaccumulated PCB levels in rainbow trout were similar to the levels in coho salmon used as dietary supplements. Following dietary exposure to control chow or coho salmon from the Pacific Ocean, the rainbow trout contained low PCB levels, whereas trout which were fed Lake Michigan salmon and Lake Ontario salmon contained logarithmically elevated levels of PCBs. The effect on natural resistance was assessed by challenge with a titrated dose of Vibrio anguillarum (VA-58). The ability to mount a protective immune response in trout exposed for a 20-wk period to control or Lake Ontario coho salmon diets was determined by immunization with a VA-58 bacteria followed by challenge with virulent VA-58. A high level of protective immunity was demonstrated in all dietary groups suggesting that the parameters of host resistance of rainbow trout were not compromised following dietary exposure to Great Lakes coho salmon. [Cleland GB et al; Aquatic Toxicol 13 (4): 281-290 (1989)] **QC REVIEWED**

NTOX - Eggs of three seabird species, double-crested cormorant (Phalacrocorax auritus), Leach's storm-petrel (Oceanodroma leucorhoa), and Atlantic puffin (Fratercula artica) were collected at 4-yr intervals from 1968 to 1984, from colonies (4 to 10 eggs/colony) in eastern Canada (A: Great Island, Newfoundland; B: Kent Island C: Manawagonish Island and D: Machias Seal Island, Bay of Fundy; and E: Ile-aux-Pommes, St. Lawrence River) and analyzed for organochlorines. PCBs declined significantly in all species from the Bay of Fundy, and from site A, but not significantly at site E. Over the entire period, PCB residues were highest in the cormorant. [Pearce PA et al; Environ Pollut 56 (3): 217-35 (1989)] **QC REVIEWED**

NTOX - Channel catfish were obtained from Devil's Swamp (exposed fish), a river basin in southern LA heavily impacted by industrial complexes and hazardous waste sites. Reference fish were taken from LA State University's experimental Ben Hur aquaculture facility. The hepatic microsomal mediated O-dealkylation of various substituted alkoxyresorufins by the catfish were compared and correlated with polychlorinated biphenyl (PCB) contents from fat tissues of these fish. The most abundant PCB congeners found were pentachlorinated PCB (3900 ppb) followed by hexachlorinated (2800 ppb), tetrachlorinated (2400 ppb), heptachlorinated (540 ppb), octachlorinated (230 ppb), trichlorinated (130 ppb) and dichlorinated (40 ppb) biphenyls. The monochlorinated, nonochlorinated and decachlorinated biphenyls were represented in trace concn. Fatty tissue from reference fish were essentially devoid of PCB congeners. Specific activities and turnover numbers of 7-methoxyresorufin, 7-ethoxyresorufin, 7-pentoxyresorufin and benzyloxyresorufin O-dealkylases in Devil's Swamp microsomes of both male and female fish were significantly elevated relative to that of reference fish. When expressed per mg of protein, the degree of induction of these activities was notably higher in female catfish than

in male catfish. [Winston GW et al; J Environ Sci Health (B) 24 (3): 277-89 (1989)] **QC REVIEWED**

NTOX - To study the chronic effects of contaminated sediments on mortality, growth, gonad production and bioaccumulation in the urchin, Lytechinus pictus, urchins were exposed to 3 of the most contaminated sediment types in southern California and to a control sediment in the laboratory for 60 days in flow through experiments. Initial concentrations of polychlorinated biphenyls in the sediments used were very high (1118-3484 ng/g vs < 59 ng/g dry wt in the control), as were those of other contaminants. The sediments caused significant mortality and reduction of growth. Both male and female gonad production was also significantly decreased. Gonads accumulated up to 7.4 ppm polychlorinated biphenyls during the 60 day exposure period, but their concentrations of Cd, Cu and Zn were greatly reduced. [Thompson BE et al; Environ Toxicol Chem 8 (7): 629-37 (1989)] **QC REVIEWED**

NTOX - In order to investigate interspecific responses to pollutants, physiological and biochemical parameters were studied in 2 sp of Gobiidae under both natural and experimental conditions. In addition to higher mixed function oxidase activity, Gobius niger, collected in a heavily polluted port, had higher polychlorinated biphenyls residues (0.45 ug/g dry wt vs 0.23 ug/g dry wt) than another sp, Zosterisessor ophiocephalus, collected from a relatively clean lagoon. After 20 days of acclimatization to clean water, the 2 sp exhibited practically identical levels of mixed function oxidase activity and polychlorinated biphenyls residues. Subsequent exposure to polychlorinated biphenyls (Arochlor 1260) at 10 ug/l resulted in considerably higher mixed function oxidase activity in G niger than in Z ophiocephalus and the polychlorinated biphenyls residue level was 4 times higher in G niger than in Z ophiocephalus after 20 days of exposure. [Fossi C et al; Ecotoxicol Environ Safety 18 (1): 11-4 (1989)] **QC REVIEWED**

NTOX - Two groups of 12 female common seals (Phoca vitulina) were fed fish having high levels of polychlorinated biphenyl (PCB) contamination from the Wadden Sea (Group 1), or fish having low PCB contamination from the northeast Atlantic (Group 2) for almost 2 yr. Seals in Group 1 had a drastic reduction in plasma retinol concn as compared to those in Group 2 (30 to 55% reduction). The PCB-induced reduction in plasma retinol levels disappeared when seals were subsequently fed low-PCB Atlantic Ocean fish for 6 mo. Significant reductions of total and free thyroxine and triiodothyronine were also observed in Group 1. [Brouwer A et al; Aquatic Toxicol 15 (1): 99-106 (1989)] **QC REVIEWED**

NTOX - Regeneration experiments on the liver of flounder (Platichthys flesus L.) were performed to identify the role of diverse pollutants (chlorinated hydrocarbons including polychlorinated biphenyls) in the pathogenesis of the liver abnormalities observed during a 3-yr multidisciplinary survey in the Elbe estuary (Federal Republic of Germany). Flounder kept under contaminant-free conditions and fed ad libitum with uncontaminated food indicated initial and complete liver regeneration in 50% of the individuals after 20 days, and in 70% after 40 days. Signs of regeneration, diagnosed at the light and electron microscope level were accompanied by a significant decr in the concn of chlorinated hydrocarbons in the liver. Livers of flounder without regenerative signs maintained their high levels of contaminants. The

ultrastructural findings indicated that transfer of Elbe flounder into a contaminant-free environment induced incr activity of biotransformation and detoxification in the hepatocytes (tubular smooth endoplasmic reticulum, lysosomes). [Kohler A; Aquat Toxicol 14 (3): 203-32 (1989)] **QC REVIEWED**

NTOX - Rhesus monkeys exposed to polychlorinated biphenyl mixtures during gestation and lactation were tested on two-choice discrimination-reversal learning (DR). In the first experiment, offspring of mothers fed 1.0 ppm Aroclor 1248 (avg exposure 20.7 + or - 3.1 mo), and offspring born 1.5 yr after maternal exposure to 2.5 ppm Aroclor 1248 ended (avg exposure 18.2 + or - 1.7 mo) did not differ from controls on spatial, color or shape discrimination-reversal problems. In the second experiment, offspring of mothers fed 0.25 or 1.0 ppm Aroclor 1016 (avg exposure of 21.8 + or - 2.2 mo) and offspring born 3 yr after maternal exposure to 2.5 ppm Aroclor 1248 ended were tested on the same spatial, color and shape problems, but a spatial problem with color and shape as irrelevant cues was inserted after the initial spatial problem. Performance of the high dose Aroclor 1016 offspring was impaired on the initial spatial problem, and facilitated on the shape problem. Performance of the Aroclor 1248 postexposure offspring was facilitated on the shape problem. [Schantz SL et al; Neurotoxicol Teratol 11 (3): 243-50 (1989)] **QC REVIEWED**

NTOX - Different combinations of 2,5,2',5'- and 3,4,3',4'-polychlorinated biphenyls and Aroclor 1254 were applied to human lymphocyte cultures, which were subsequently examined for chromosome breakage, rearrangements, sister-chromatid exchange, and mitotic delay. Results were compared to similar cultures treated with the known mutagen cyclophosphamide. In one experiment, parallel cultures were exposed to a final culture concn of either 10-4, 10-3, 10-2, or 10-1 ug/ml of 3,4,3',4' or to a 1.0 ug/ml dose of 2,4,2',5' and to either 10-3 ug/ml or 10-5 ug/ml of cyclophosphamide or to 25, 20, 10 or 5 ng/ml mitomycin C. Cells were also exposed to combinations of 2,5,2',5'- and 3,4,3',4'-polychlorinated biphenyl using either a combination of 1 ug/ml 2,5,2'5'- with 10-2, 10-3, 10-4 or 10-5 ug/ml 3,4,3',4'-polychlorinated biphenyl or a combination of 10-5 ug/ml 3,4,3'4'-polychlorinated biphenyl with 10-1, 10-2, or 10-3 ug/ml 2,5,2'5'-polychlorinated biphenyl. In other experiments, parallel cultures were treated with either 1 ug/ml or 10-1 ug/ml 2,4,5,2',4',5'-polychlorinated biphenyl as well as to a combination of 10-5 ug/ml 3,4,3',4' and 10-1 ug/ml 2,4,5,2',4',5'-polychlorinated biphenyl. In addition, either Aroclor 1254 or a fish extract containing Aroclor 1254 was added to parallel cultures at 1.1 ug/ml, 1.1X10-1 ug/ml or 1.1X10-2 mg/ml. Results showed that one planar polychlorinated biphenyl congener, 3,4,3',4'-tetrachlorobiphenyl, caused dose-related chromosome breakage in human lymphocytes exposed in vitro to 0.1-10-4 ug/ml. In contrast, the non-planar 2,5,2'5'- polychlorinated biphenyl, did not cause chromosome damage in comparable tests even at concn as high as 1 ug/ml. When the 3,4,3',4' congener at a concn lower than that which causes chromosome breakage (10-5 ug/ml) was combined with a non-clastogenic concn of the 2,5,2'5' congener, the chromosomal damage observed was far in excess of what one would expect from higher doses of the 3,4,3',4' congener alone. [Sargent L et al; Mutat Res 224 (1):

79-88 (1989)] **QC REVIEWED**
HTXV - ND
NTXV - ND
ETXV - ND
NTP - ND
IARC - ND
POPL - Persons with skin diseases and chronic liver diseases and women of child-bearing age /are at special risk in facilities/ manufacturing or using PCBs. [ENCYC OCCUPAT HEALTH & SAFETY 1983 , p. 1755] **PEER REVIEWED**
POPL - Those groups at particular risk for PCB exposure include ... individuals consuming large amounts of contaminated fish, such as sport fishermen, and nursing infants who, per kg body weight, may accumulate significant body burdens from the levels in human breast milk. [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p.C-79 (1980) EPA 440/5-80-068] **PEER REVIEWED**
ADE - DURING MARCH 1964 AND FEBRUARY 1970, 48 OF 169 GOLDEN EAGLES FROM 22 STATES WERE FOUND TO CONTAIN PCBS IN EITHER BRAIN, HEART, KIDNEY, LIVER, MUSCLE, OR FAT, IN CONCN RANGING FROM LESS THAN 1 TO 19 UG/G ON A WET BASIS. [IARC MONOGRAPHS. 1972-PRESENT V18 63 (1978)] **PEER REVIEWED**
ADE - /IN 1970/ ... THE MEAN PCB LEVEL IN HUMAN MILK IN TWO CALIFORNIA CITIES WAS ABOUT 0.06 UG/ML OF WHOLE MILK. ... ANALYSIS OF LIPID FRACTION OF 80 SAMPLES OF HUMAN MILK FROM VARIOUS AREAS OF THE USA SHOWED THAT ALL EXCEPT 2 HAD CONCN ... FROM 0.4-10.6 UG/G. THE AVERAGE CONCN IN ALL SAMPLES WAS APPROX 1.7 UG/G. [IARC MONOGRAPHS. 1972-PRESENT V18 64 (1978)] **PEER REVIEWED**
ADE - FORTY-THREE PERCENT OF 723 PLASMA SAMPLES FROM PERSONS IN SOUTH CAROLINA NOT OCCUPATIONALLY EXPOSED TO PESTICIDES WERE FOUND TO CONTAIN PCBS, WITH A MAXIMUM OF 0.029 UG/ML. [IARC MONOGRAPHS. 1972-PRESENT V18 65 (1978)] **PEER REVIEWED**
ADE - Polychlorinated biphenyls are stored in body fat and not readily excreted except in breast milk and possibly through the placenta. [MARTINDALE. EXTRA PHARMACOPEIA 28TH ED 1982 , p. 831] **PEER REVIEWED**
ADE - Polychlorinated biphenyls (PCBs) are readily absorbed through the gut, respiratory system and skin. /PCBs/ may initially concentrate in the liver, blood, and muscle mass, but long-term storage in mammals is primarily in adipose tissue and skin. ... [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p.C-31 (1980) EPA 440/5-80-068] **PEER REVIEWED**
ADE - PCBs which are readily metabolized are also rapidly excreted in the urine and bile. Excretion in urine is most prominent for the least chlorinated, while bile becomes the more significant route of excretion for more highly chlorinated isomers. Those isomers which are most refractory to metabolism accumulate for increasing periods of time in fatty tissues. Highly chlorinated isomers are accumulated almost indefinitely. [USEPA; Ambient Water Quality Criteria Doc: Polychlorinated Biphenyls p.C-32 (1980) EPA 440/5-80-068] **PEER REVIEWED**
ADE - Animal studies have shown that PCB's can cross the placental barrier and are excreted in the mother's milk. [IARC MONOGRAPHS. 1972-PRESENT

RR-00207-03.13-05/15/92

WILLIAMS ENVIRONMENTAL SERVICES, INC.

Material Profile Sheet

WILLIAMS PROPOSAL No. _____ DATE _____
(for Williams use only)

INSTRUCTIONS:

A completed Material Profile Sheet must be filled out and submitted before a written price quotation can be issued. Please note that customer is the party responsible for payment. Answers must be typewritten or printed in ink.

(1) GENERATOR Name: US NAVY
Address:
Contact: Telephone: ( )

(2) CUSTOMER Name: US NAVY
Address:
Contact: Telephone: ( )

(3) CONSULTANT Name: VERSAR INC – KENNETH SALEM
Address: 6850 VERSAR CENTER SPRINGFIELD VA 22151
Contact: Telephone: (703) 642 6722

(4) SITE LOCATION Name: PUERTO RICO
Address:
Contact: Telephone: ( )

(5) ANTICIPATED QUANTITY 2500 (tons) _____ (volume)

(6) TYPE OF CONTAMINATION _____ Gasoline, _____ No. 2 Fuel Oil
_____ Heavy Oil, _____ Other: PCB 0-1500 ppm w 200 ppm AVG

(7) ANALYTICAL DATA (attach hard copy of Engineering Report)

Benzene _____ ppm Toluene _____ ppm Total Lead _____ ppm
Xylene _____ ppm Ethyl Benzene _____ ppm % Moisture _____
TPH (Method _____) _____ ppm
Average Concentration _____ ppm

(8) SOIL CHARACTERISTICS

Type: _____ Clay, _____ Sandy Clay, X Sand, _____ Silty Sand
Texture: X Dry, _____ Moist, _____ Wet, _____ Saturated

(9) CLEAN-UP LEVELS 10 ppm by Method _____

(10) ESTIMATED START DATE SPRING '92

(11) ADDITIONAL INFORMATION

I hereby certify that the above description is complete and accurate to the best of my knowledge.

SIGNED: [signature] CHEMICAL ENGINEER
(Title)

2078 West Park Place Stone Mountain, Georgia 30087 404/498-2020

C

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HazLabs Incorporated

a HazWaste Company

Date: 9.4.91 Time: 4:55 No. of Pages (incl. this one): 8

To: Mr. Ken Sulen Fax No.: (703) 642-6810

Company: Versar, Inc.

Subject:

Comments:

From: Maurizio Gaskar

HazLabs Incorporated
[illegible] Northwest Parkway
Suite F
[illegible]

Fax No. 404-933-8155
Office No. 404-988-8184

If you do no receive all pages, please call us immediately. Thank you.

HazWaste

HazLabs Incorporated

A HazWaste Company

September 4, 1991

Mr. Ken Salen
Versar, Inc.
6800 Versar Center
Springfield, VA 22151

Dear Mr. Salen,

Please find enclosed the information you requested on HazLab's "Treatability Studies for the Aerobic Bioremediation of Contaminated Soils". This document presents our approach to the evaluation of the potential for using biological treatment as a remediation technology.

We apologize for the delay in submitting this information. If you have any questions please contact me or Jack Mizner at (404) 988-8184.

Sincerely,

Maurizio F. Giabbai, PhD.
President

MFG/tow

cc: Mr. Jack Mizner, Jr., Senior Environmental Engineer

B07/aerbiore.cp

2264 NORTHWEST PARKWAY • SUITE F • MARIETTA, GEORGIA 30067
404-988-8184
ATLANTA • ORLANDO • RICHMOND

HazWaste®

TREATABILITY STUDIES FOR AEROBIC BIOREMEDIATION OF CONTAMINATED SOILS

SUBMITTED TO: Versar, Inc.
6800 Versar Center
Springfield, VA 22151
Attn: Mr. Ken Salen

SUBMITTED BY: HazLabs, Inc.
2264 Northwest Parkway
Suite F
Marietta, GA 30067

September 4, 1991

TREATABILITY STUDIES FOR AEROBIC BIOREMEDIATION OF CONTAMINATED SOILS

I. INTRODUCTION

Biodegradation is an important environmental process which occurs naturally and results in the breakdown of organic compounds either aerobically or anaerobically into by-products of microbial metabolism such as CO_2, H_2O, CH_4, and inorganic salts. Microorganisms (bacteria, actinomycetes, and fungi) make up the most significant group of organisms involved in biodegradation.

Soil environments contain a diverse microbial community, which, under the proper conditions, can degrade a wide variety of organic compounds, including those considered toxic or recalcitrant. Degradation of these toxic or recalcitrant compounds, however, may be slow, especially when these compounds are introduced into the soil environment in large quantities (i.e. accidental releases such as spills or ruptured tanks). In such cases the microbial community is not adapted to the particular substrate and requires an acclimation period to develop the necessary enzyme systems to degrade the substrate. This process is slow and may take many years to develop a population capable of reducing organic contaminants to regulatory levels. Additionally, the proper physical and chemical conditions must be present to develop a microbial community capable of degrading recalcitrant compounds, such as pesticides, petroleum products, and aromatic compounds. However, by applying scientific principles and good engineering practices, conditions can be created in which the majority of organic wastes can be degraded by soil microorganisms through a process of bioremediation in a reasonable amount of time.

Bioremediation is a term which describes the use of microorganisms to degrade or detoxify environmental contamination to concentrations below regulatory limits. Aerobic, anaerobic or facultative pathways may be utilized. A variety of systems exist to accomplish this, and range from simple to in situ systems such as soil tilling and composting to more complicated designs such in-vessel slurry reactors. The ultimate goal is convert organic wastes into biomass and harmless byproducts of microbial metabolism.

The advantages of soil bioremediation are:

1) It is often more cost-effective than other remediation methods.
2) Less liability (i.e., transportation) is incurred if the waste is treated on-site.
3) The soil is rendered non-hazardous, and can be used for other purposes.

The chief disadvantages of soil bioremediation is the length of time that may be required to reduce contamination to necessary levels.

Bioremediation, like any other technology, is not a panacea for the treatment of all contaminated soils. A thorough characterization of the contaminant, the soil, and site must be conducted, and laboratory and field investigations should be performed before a decision can be made to apply this approach to site restoration.

This report presents a simple tiered approach to conducting treatability studies to determine if bioremediation is an appropriate technology, and if so to develop the necessary design parameters to insure that it is successfully applied. This four phased approach consists of: 1) Soil Characterization, 2) Bioremediation screening Tests, 3) Optimization Studies, 4) Pilot-scale Testing. Each of these phases and a range of costs is presented below.

II. MAJOR PHASES OF BIOREMEDIATION TREATABILITY STUDY

IIa. Phase I- Soil and Waste Characterization

Before proceeding with treatability experiments, the extent and degree of the contamination must be assessed. This includes analyses to identify and quantify the hazardous materials, and to establish the physical and chemical characteristics of the soil matrix. These analyses include:

- NUTRIENTS CONCENTRATIONS - (phosphorus, nitrogen, potassium, carbon, trace elements).
- ORGANIC CONSTITUENTS CHARACTERIZATION - The characterization will include the qualitative and quantitative analysis of toxic organic compounds (e.g., BTEX, Chlorinated Solvents, PAHs Phenols, etc.) that will be tested for biodegradability. Additional analyses will be conducted to gather information on the other organic constituents present in the soil matrix (e.g., TOC, TOX, etc.)
- BACTERIAL CONCENTRATIONS - Estimates of the type and numbers of indigenous bacteria provide an indication of whether cultured micro-organisms are required to remediate the site.
- HEAVY METALS CHARACTERIZATION - This analysis determines the presence of any toxic metals.
- PHASE ANALYSIS OF CONTAMINANTS - This analysis will reveal to what extent the contamination is present in the solid, liquid, or vapor phases.

- SOIL CHARACTERISTICS
  - % moisture
  - pH
  - REDOX potential
  - Oxygen concentration
  - Soil type
  - Temperature

Based upon the above analyses a decision will be made as to whether bioremediation is a feasible option, and, if so, how best to proceed with its evaluation.

Costs for this phase varies depending on the type and extent of the contamination and the number of samples required for a full characterization. Typical costs vary from $2,000 - $10,000.

IIb. Phase II- Bioremediation Screening Tests

In this phase several options are evaluated to determine how to proceed with biological treatment of the soil. These tests will be conducted in Biometer flasks.

A Biometer flask is an unmixed, aerated batch reactor, in which bacterial respiration is determined by quantifying CO_2 production. Cumulative respiration of a bacterial population is related to its growth, reproduction, and ability to metabolize a particular substrate (food) source). By varying factors such as nutrients, the ability of a microbial population to degrade a contaminated soil can be investigated.

At a minimum 4 treatments consisting of 4 biometer flasks per treatment are required for this screening process. The 4 treatments are:

1) ABIOTIC CONTROL = contaminated soil & mercuric chloride. This treatment is necessary to determine if there is non-biological production of CO_2 which could lead to false conclusions about the biotreatability potential.

2) CONTROL = contaminated soil only. This treatment measures the ability of the indigenous bacterial population to degrade the contaminants.

3) NUTRIENT TREATMENT = contaminated soil & nutrients. This treatment measures the effect that nutrient addition has on bacterial degradation of the contaminants.

4) BACTERIAL TREATMENT = contaminated soil & nutrients & cultured bacteria. This treatment measures the effect that the addition of an acclimated bacterial strain has in the degradation of the contaminants.

For each treatment 4 identical biometer flasks are prepared. The 16 biometer flasks are then incubated under identical conditions. Table 1 below presents a matrix for this experimental protocol. The Xs in Table 1 indicate the time when each flask within a particular treatment will be sacrificed. At this time the soil mixture within each flask will be analyzed. This analysis will include the concentration of contaminants, and the nutrient concentration. Bacterial numbers, if desired by the client, can also be measured at this time. For each flask CO_2 production will be measured every 2 to 3 days depending in the rate of metabolism. This experimental approach will provide information on: 1) respiration rate, 2) degradation rate of the contaminants, 3) nutrient utilization, and 4) change in bacterial population.

By comparing different treatments one can evaluate conditions which will promote the quickest degradation of the soil contamination.

Costs for this phase of study vary between $ 5,000.00 and $ 10,000.00.

Table 1. Experimental Matrix for Screening Tests

DAYS	ABIOTIC CONTROL				CONTROL				NUTRIENT TREATMENT				BACTERIAL TREATMENT			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
7	X				X				X				X			
14		X				X				X				X		
21			X				X				X				X	
28				X				X				X				X

IIc. Phase III Optimization Studies

Based on the results obtained from Phase II testing, additional experiments will be conducted during Phase III to optimize variables, such as nutrient addition, pH, bacterial addition, and soil moisture. Data gathered during this phase of experimentation will permit us to establish the relationship between the variables which affect biodegradation of the soil contamination, to optimize this process, and to predict removal rates and removal efficiencies of the soil contaminants.

Testing will be conducted in biometer flasks, as described in Phase II, and in specially designed lysimeters. These lysimeters are larger volume reactors that will be used to verify the efficiency at the selected " best" treatment.

Costs associated with this phase will vary with the clients needs, the results from phases I, and II the complexity of the soil matrix and environmental conditions. Costs will vary from $7,000.00 to $ 15,000.00.

IId. Phase IV Pilot Testing

On site pilot testing will be conducted, based on the results from the first three phases, to verify the laboratory derived operating parameters. The pilot scale unit will be specially designed based on the proposed full scale remediation design.

Cost proposals will be submitted at the end of Phase III testing for the pilot scale study.

III. COST PROPOSAL SUMMARY

The cost associated for each phase identified above are summarized hereafter. These include labor, analysis, and material/supplies costs and fees. Upon request, a detailed cost proposal will be prepared by taking into account the specific needs of each project (e.g., sample disposal, etc.). The following cost proposal is presented in dollar ranges for each phase and should be used only as an estimate:

Phase I	$ 2,000 - $10,000
Phase II	$ 5,000 - $10,000
Phase III	$ 7,000 - $15,000
Phase IV	QUOTE

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Company CLEAN EARTH INC. / TCI Company _____

Phone _____ Phone _____

Comments:

SAUL EXCAVATE → LANDFILL NEVADA

(BARGE HOLDS ___ CU YDS
___ TO

ROLLOFF ~ 20 TONS

LOAD ONTO ROLLOFFS,
ROLLOFFS ONTO BARGES,
ROLLOFFS FROM BARGES ONTO TRUCKS.

TRUCKING 6.50/TON
E COAST → NEVADA

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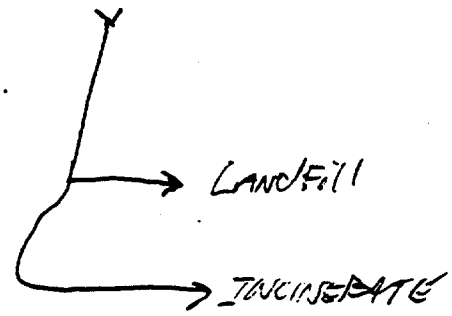

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RR-00207-03.13-05/15/92

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Versar, Inc. Technical Services Group	Phase II	☐	Telefax Phone No. Confirming Phone No.	(703)642-6810 (703)750-3000, Ext. _____

C

Tri County Industries

(301) 937-8611
Fax # 937-8028
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5005 Powder Mill Road
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Beltsville, MD 20705

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NOTES:

Price for PCB contaminated soil disposal in Puerto Rico. (SD)
Price based on pcb levels and no other listed wasts involved. (metals, Solvents)

Price per Ton $696.00
plus barge transfer fee (minimal)

Versar INC.

APPENDIX E

Feasibility Study Documentation

Naval Station Roosevelt Roads
Site 16
Project No. 5295.4.1
st Worksheet for Remediation Options

CAPITAL COST ITEMS	UNIT COST	QUANTITY	SUBTOTAL COST	HEALTH AND SAFETY PROTECTION	CAPITAL COSTS	PRIMARY REFERENCE
Alternative A: Excavation and Transport to Incineration Facility						
Excavation	$3.00 /ton	1,480 tons	$4,440	C	$4,440	Vendor Quote
Transportation	$500.00 /ton	1,480 tons	$740,000	none	$740,000	Vendor Quote
Disposal at Licensed Incineration Facility	$2,000.00 /ton	1,480 tons	$2,960,000	none	$2,960,000	Vendor Quote
Backfill, installed	$10.00 /ton	1,480 tons	$14,800	none	$14,800	Vendor Quote
Concrete Gritblasting	$10,000 /job				$10,000	Vendor Quote
SUBTOTAL CAPITAL COSTS					$3,729,240	
QA/QC (5%)					$186,462	
TOTAL CAPITAL COSTS					$3,915,702	
Alternative B: Excavation and Transport to Licensed Landfill Facility						
Excavation	$3.00 /ton	1,480 tons	$4,440	C	$4,440	Vendor Quote
Transportation	$500.00 /ton	1,480 tons	$740,000	none	$740,000	Vendor Quote
Disposal at Licensed Landfill Facility	$196.00 /ton	1,480 tons	$290,080	none	$290,080	Vendor Quote
Backfill, installed	$10.00 /ton	1,480 tons	$14,800	none	$14,800	Vendor Quote
Concrete Gritblasting	$10,000 /job				$10,000	Vendor Quote
SUBTOTAL CAPITAL COSTS					$1,059,320	
QA/QC (5%)					$52,966	
TOTAL CAPITAL COSTS					$1,112,286	
ternative C: On-Site Incineration						
Excavation	$3.00 /ton	1,480 tons	$4,440	C	$4,440	Vendor Quote
Thermal Treatment	$2,000.00 /ton	1,480 tons	$2,960,000	C	$2,960,000	Vendor Quote
Concrete Gritblasting	$10,000 /job				$10,000	Vendor Quote
SUBTOTAL CAPITAL COSTS					$2,974,440	
QA/QC (5%)					$148,722	
TOTAL CAPITAL COSTS					$3,123,162	

Naval Station Roosevelt Roads
Site 16
Project No. 5295.4.1
Cost Worksheet for Remediation Options

CAPITAL COST ITEMS	COSTS
Alternative A: Excavation and Transport to Incineration Facility	
SUBTOTAL CAPITAL COSTS	$3,729,240
QA/QC (5%)	$186,462
TOTAL CAPITAL COSTS	$3,915,702
ENGINEERING DESIGN (10%)	$391,570
CONSTRUCTION MANAGEMENT (15%)	$587,355
STARTUP (10%)	$391,570
BONDS AND PERMITS (2.5%)	$97,893
LEGAL FEES (3%)	$117,471
CONTINGENCIES (20%)	$783,140
TOTAL ADJUSTED CAPITAL COSTS	$6,284,702
Alternative B: Excavation and Transport to Licensed Landfill Facility	
SUBTOTAL CAPITAL COSTS	$1,059,320
QA/QC (5%)	$52,966
TOTAL CAPITAL COSTS	$1,112,286
ENGINEERING DESIGN (10%)	$111,229
CONSTRUCTION MANAGEMENT (15%)	$166,843
STARTUP (10%)	$111,229
BONDS AND PERMITS (2.5%)	$27,807
LEGAL FEES (3%)	$33,369
CONTINGENCIES (20%)	$222,457
TOTAL ADJUSTED CAPITAL COSTS	$1,785,219
Alternative C: On-Site Incineration	
SUBTOTAL CAPITAL COSTS	$2,974,440
QA/QC (5%)	$148,722
TOTAL CAPITAL COSTS	$3,123,162
ENGINEERING DESIGN (10%)	$312,316
CONSTRUCTION MANAGEMENT (15%)	$468,474
STARTUP (10%)	$312,316
BONDS AND PERMITS (2.5%)	$78,079
LEGAL FEES (3%)	$93,695
CONTINGENCIES (20%)	$624,632
TOTAL ADJUSTED CAPITAL COSTS	$5,012,675

V18 37 (1978)] **PEER REVIEWED**

ADE - In a plant in the United States the PCB plasma levels of workers assembling capacitors and transformers ranged from 10.0-2500 ppb. The plasma concentration increased with the intensity and duration of exposure. [ENCYC OCCUPAT HEALTH & SAFETY 1983 , p. 1753] **PEER REVIEWED**

ADE - Polychlorinated biphenyl (PCB) concentrations in the blood of mothers who were occupationally exposed to PCBs in the capacitor manufacturing facility, and their children, were analyzed from 1975 to 1979. The factory terminated PCB use in 1972, and environmental PCBs were eliminated artificially. Despite this, blood PCB levels of the mothers were very high, ie, 10-100 times higher than that of non-occupationally exposed persons. ... By a present investigation which continued during a 5 yr period, the PCB levels in blood of children were influenced greatly by the duration of breast-feeding, but showed little relationship to the PCB levels in maternal blood. The PCB exposure period of the mothers, time of birth, and age of the children were less clearly related to the PCB levels in the children. The PCB concentration in the children's blood decreased at a constant rate and was independent of their blood PCB levels. A similar result was noted for their mothers' PCB levels. A slight difference, however, was found in the rate of decrease of blood PCB levels between the mothers and children. The results of questionnaire research on the health conditions and the medical examinations for the children showed that frequency of complaints, eg, red eye, fever, itchy skin, and carious teeth, related favorably to the duration of breast-feeding. Less severe findings, ie, decay of nails, pigmentation, mottled enamel, carious teeth, which were typical symptoms in Yusho patients, were observed in some children. ... [Kunita N, Hara I; Arch Environ Health 39 (5): 368-75 (1984)] **PEER REVIEWED**

ADE - Mayflies (Hexagenia limbata) collected from May to Nov 1986 from Lake St. Clair at temperatures of 10 to 20 deg C were exposed in 200 ml test chambers to a polychlorinated biphenyl, (14)C-2,4,5,2',4',5'-hexachlorobiphenyl, in flow-through water and sediment exposure tests. In the water exposure tests where the animals were in artificial burrows of stainless steel screen, the infusion rate was 100 ml/hr of dosed water, with no sediment present. Animals were removed after 1, 2, 4, and 6 hr exposure for radioanalysis. Animals remaining in the exposure chamber after the uptake phase were removed and placed in uncontaminated sediment for elimination for studies for 1, 3, 5, 7, and 14 days. The accumulation from sediment was measured by sorbing the radiolabeled compounds onto sediment in an aqueous slurry overnight. Exposed organisms were removed from the sediment at approximately 1, 3, 5, 7, and 14 days and were radioanalyzed by scintillation counting. The seasonal uptake and elimination rate constants for H limbata, respectively, were: 47.5 + or - 23.9 ml/g/hr and 0.007 + or - 0.001/ hr in May (10 deg C); 44.2 + or - 8.0 ml/g/hr and 0.005 + or - 0.002/hr in Jun (15 deg C); 40.8 + or - 37.3 ml/g/hr and 0.005 + or - 0.001/hr in Jul (15 deg C); 40.8 + or - 37.3 ml/g/hr and 0.007 + or - 0.001/hr in Aug (20 deg C); 128.7 + or - 20.3 ml/g/hr and 0.015 + or - 0.003/hr in Sept (20 deg C); 95.0 + or - 17.3 ml/g/hr and 0.017 + or - 0.002/hr in Sept 30 (20 deg C); and 45.5 + or - 16.1

ml/g/hr and 0004 + or - 0.0006/hr in Nov (10 deg C). Reported values for seasonal uptake rate constants have been corrected for sorption to dissolved organic carbon. Seasonal uptake clearance rate constants from sediment for H limbata for Jun and Aug, respectively, were: 0.030 + or - 0.01/hr (15 deg C) and 0.015 + or - 0.003/hr (20 deg C). [Landrum PF, Poore R; J Great Lakes Res 14 (4): 427-37 (1988)] **QC REVIEWED**

ADE - The uptake of polychlorinated biphenyl (PCB) congeners was investigated in leaf composites and final fruits of four crop species at two alluvial mud sites (a control plot in the flood plain of the Normanskill, NY, and an experimental plot on Patroon Island, Albany, NY).