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Naval Facilities Engineering Command

Norfolk, Virginia

Under The

LANTDIV CLEAN Program

Comprehensive Long-Term Environmental Action Navy

Baker

FOSTER WHEELER ENVIRONMENTAL CORPORATION

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
ARARs	Applicable, Relevant, and Appropriate Regulations
ASTM	American Society of Testing Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
b	saturated thickness
Baker	Baker Environmental, Inc.
BCF	Bioconcentration Factor
BEHP	Bis(2-ethylhexyl)phthalate
BFI	Browning Ferris Industries
bgs	below ground surface
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	Corrective Measures Study
COC	Chemical of Concern
COD	chemical oxygen demand
COPCs	Chemicals of Potential Concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRQL	Contract Required Detection Limit
CS	Confirmation Study
CSF	Cancer Slope Factor
D	duplicate
DAD	Dermally Absorbed Doses
DoN	Department of the Navy
DRMO	Defense Reutilization and Marketing Office
DRO	diesel range organics
EDB	ethylene dibromide
Eh	Oxidation-Reduction Potential
ER	equipment rinsate
ERL	effects range low
ERM	effects range median
ESE	Environmental Science and Engineering, Inc.
FB	field blank
GRO	gasoline range organics
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HSWA	Hazardous and Solid Waste Amendments
HQ	Hazard Quotient

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

HxCDD	Hexachlorodibenzo-p-dioxin
HxCDF	Hexachlorodibenzofuran
IAS	Initial Assessment Study
ICM	Interim Corrective Measure
ID	inside diameter
IDW	investigation derived waste
ILCR	Incremental Lifetime Cancer Risk
IR	Installation Restoration
IRIS	Integrated Risk Information System
K	hydraulic conductivity
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol Water Partition Coefficient
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
MCLs	maximum contaminant levels
MEK	methyl ethyl ketone
MI	mobility index
MIBK	methyl isobutyl ketone
msl	mean sea level
NCEA	National Center for Environmental Assessment
NEESA	Naval Energy and Environmental Support Activity (see NFESC)
NFESC	Naval Facilities Engineering Service Center (Formerly NEESA)
NSRR	Naval Station Roosevelt Roads
OD	outside diameter
OU	Operable Unit
PAH	polyaromatic hydrocarbons
PCB	polychlorinated biphenyls
PCDD	Polychlorinated Dibenzo-p-dioxins
PCDF	Polychlorinated Dibenzofuran
PeCDF	Pentachlorodibenzofuran
PID	photo ionization detector
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QC	quality control
RA	Risk Assessment
RAC	Remedial Action Contractor

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

RAGS	Risk Assessment Guidance for Superfund
RB	rinsate blank
RBCs	Risk Based Concentrations
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RfC	Reference Concentration
RfD	Refernece Dose
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
RPD	relative percent difference
RRRS	Relative Risk Ranking System
SCCRBS	Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening
SOP	standard operating procedures
SSV	sediment screening value
SVOCs	Semivolatile Organic Compounds
SWMU	Solid Waste Mangement Unit
T	transmissivity
TB	trip blank
2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TCDF	Tetradichlorodibenzofuran
TEC	Toxic Equivalent Concentration
TEF	Toxic Equivalent Factor
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSCA	Toxic Substance Control Act
TSS	total suspended solids
95% UCL	95th percent Upper Confidence Level
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compounds
VSI	visual site inspection

1.0 INTRODUCTION

This document presents the results from the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Operable Units (OU) 3 and 5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. This full RFI investigation was conducted during October and November 1996 and during the fall (September/October) 1997. It should be noted that the data obtained during the Confirmation Study (ESE, 1988), the Supplemental Investigation (Baker, 1993), and the Relative Risk Ranking (Baker, 1995b) has been incorporated into this document at the request of United States Environmental Protection Agency (USEPA) Region II. This report has been prepared by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-89-D-4814.

On October 20, 1994, a Final RCRA Part B Permit (RCRA/HSWA Permit No. PR2170027203) was issued by the USEPA Region II to Naval Station Roosevelt Roads (NSRR). This permit contains requirements for RFI activities at 24 solid waste management units (SWMUs) and 3 areas of concern (AOC). Prior to 1993, environmental activities at NSRR, exclusive of underground storage tanks (USTs), were conducted in compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations under the Department of the Navy's (DoN's) Installation Restoration (IR) Program. The RCRA Part B Permit, issued for the Defense Reutilization and Marketing Office (DRMO) at NSRR, included provisions for corrective action under the Hazardous and Solid Waste Amendments (HSWA) provisions of RCRA.

The various SWMUs and AOCs at Roosevelt Roads have been grouped together into Operable Units based on similarity of investigation scope, geography, or similarity of contaminants potentially released (Figure 1-1). This report pertains to OU 3 and OU 5 which are comprised of:

- OU 3: SWMU 1 - Army Cremator Disposal Site
  SWMU 2 - Langley Drive Disposal Site

- OU 5: SWMU 11/45 - Building 38

SWMUs 1 and 2 were grouped together since each are former disposal sites and are relatively close to one another. OU 5 has been divided into two separate but inclusive SWMUs. SWMU 11 pertains to the interior portion of Building 38 (former bomb-proof power plant) while SWMU 45 includes the soil and groundwater surrounding Building 38 including the cooling water tunnels. This report presents the data for SWMU 45. The data for SWMU 11 will be presented in a separate RFI due to the need to recharacterize the Building 38 interior. A fire occurred inside Building 38 following the initial sampling effort which was negated due to the fire. A workplan has been submitted to the EPA to recharacterize the interior of Building 38. Following approval of the workplan the sampling will be conducted as will the development of the RFI report. This report will be submitted as a separate RFI for SWMU 11.

1.1 Purpose and Organization

The purpose and organization of this document is to present the results of the sampling conducted during the field investigations as part of the Confirmation Study and Supplemental Investigation for Sites 5 and 6 (OU 3), and the Relative Risk Ranking for OU 3 and the RFI for OUs 3 and 5. Conclusions regarding the analytical results as well as recommendations for the sites are also presented.

Section 1.0 of ts document includes this introduction and the objectives of this RFI Report. Section 2.0 provides a description of the facility and historical background. Section 3.0 describes the field activities undertaken during the RFI. It also describes the purpose of the study of individual media, sampling procedures, sampling locations for all media, and quality control (QC) conducted during the sampling activities. Section 4.0 provides a description of the physical characteristics (i.e., geology and hydrology) of the individual SMWUs. Section 5.0 describes the nature and extent of contaminants detected in the environmental samples from each media sampled. Section 6.0 presents the human health risk assessment for each SWMU, Section 7.0 presents conclusions and recommendations and the references utilized in this report are provided in Section 8.0.

1.2 Objectives

The objective of this report is to present and evaluate the data collected during the Confirmation Study, Supplemental Investigation, Relative Risk Ranking, and the RFI field investigation at OU's 3 and 5. The evaluation consists of comparing the data to established standards/criteria and performing a human health risk assessment to assess whether any contaminants detected on-site pose an unacceptable risk to human health or a significant adverse risk to possible ecological receptors. This report will assist in assessing if any further action is warranted at any of the sites investigated to assist in mitigating any present or future risks.

2.0 BACKGROUND

This section contains a description of the physical facility, Naval Station Roosevelt Roads background history, and a summary of previous investigations.

2.1 Facility Background

NSRR occupies part of the northern side of the east coast of Puerto Rico, along Vieques Passage with Vieques Island lying to the east about 10 miles off the harbor entrance. The north entrance to NSRR is about 35 miles east along the coast road (Route 3) from San Juan. The closest large town is Fajardo (population approximately 37,000), which is about 10 miles north of NSRR off Route 3. Ceiba (population approximately 17,000) adjoins the west boundary of NSRR (see Figure 2-1).

NSRR occupies over 33,500 acres and has administrative and command responsibilities for some operations separated from the main base on Vieques Island.

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

2.2 Operable Unit 3 Background

Operable Unit 3 consists of two SWMUs. These sites include SWMU 1 - Army Cremator Disposal Site and SWMU 2 - Langley Drive Disposal Site and are discussed in detail in the following sections.

2.2.1 SWMU 1 - Army Cremator Disposal Site

This SWMU is located east of the Navy Lodge (Figure 2-2). The site is bounded to the north by

Kearsage Road leading to the Coast Guard Pier, Ensenada Honda to the east and south, and the Navy Lodge and Bowling Alley to the west.

SWMU 1 encompasses an area of roughly 36 acres with a east-west ridge line that bisects the site. The topography gently slopes to the north, south, and east. Based on previous reports, the Army Cremator Disposal Site operated from the early 1940s until the early 1960s and was the main station landfill during this period. Waste material was disposed of by piling, burning, and compacting (A.T. Kearney, Inc., 1988). An estimated 100,000 tons of waste including scrap metal, inert ordnance, batteries, tires, appliances, cars, cables, dry cleaning solvent cans, paint cans, gas cylinders, construction debris, dead animals, and residential waste was disposed of at this site (NEESA, 1984). No reliable information exists regarding the amounts of material present in the disposal area that could be hazardous; however, in 1984, the Initial Assessment Study (IAS) team estimated that as much as 1,000 tons of hazardous material could be present.

2.2.1.1 Summary of Previous Investigations

In 1984, the Initial Assessment Study team observed several large mounds of drums during an overflight. An on-ground visual inspection was attempted, however; due to dense vegetation the drums could not be located.

A Confirmation Study (CS) conducted by Environmental Science and Engineering, Inc. (ESE) in 1988 evaluated data from two rounds of verification sampling. During each round a total of five sediment and surface water samples, and five groundwater samples were collected. The sediment samples showed isolated, low levels of pesticides, and elevated levels of antimony, selenium, and methylene chloride while the surface water samples showed several metals exceeding ambient water quality criteria. Groundwater samples indicated thallium, copper, arsenic, chromium (total and hexavalent), and selenium at levels exceeding primary drinking water standards. Additionally, low levels of organic compounds were detected in some of the groundwater samples. Based on USEPA Region II review, the quality of the data obtained during the CS is questionable due to the unknown level of laboratory data quality objectives and the apparent lack of independent, third party data validation and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

In 1988, the RCRA Facility Assessment (RFA) Visual Site Inspection (VSI) team observed an oily, silver-toned substance floating at the water's edge. Dead mangroves were observed several feet out from the water's edge and extending up and down the shoreline. Facility representatives indicated this was due to a JP-5 (aviation kerosene) spill in November 1986 which came from a separate, unrelated, site. An area measuring approximately 50 feet in diameter completely devoid of vegetation was found within the boundaries of this SWMU. The area affected by this spill is included in the IR program as Site 14 - Ensenada Honda Shoreline and Mangroves.

Baker conducted a Supplemental Investigation of the site in 1993 which included the performance of a geophysical investigation (electromagnetic terrain profiling and magnotometry) along with the collection of 17 soil samples and one groundwater sample. The geophysical study was conducted along traverses cut by heavy equipment based on the review of photo-interpretation and map analysis. Correlation between the disposal features noted by photo-interpretations and disposal indications found during land-clearing were high (Figure 2-3). The indicated disposal features were found on the southwest side in the locations transferred from the aerial photographs to the maps. Similarly, areas indicated by photo-interpretation not to have been used for disposal appeared undisturbed except for top-stripping (Geo Decisions, Inc. 1993). The geophysical interpretations agreed with both the photo-interpretation and the visual inspection of the ground. It should be noted that the geophysical investigation only covered the horizontal extent of the disposal area. Appendix A contains the geophysical report. Figure 2-3 combines the results from the air photo analysis presented in the Supplemental Investigation with the results from the geophysical investigation provided in Appendix A. The approximate limits of the disposal area interpolated from the geophysical investigation have also been presented on Figure 2-3. In addition all sampling locations to date have been presented on this figure to assist with the site investigations.

The soil and groundwater samples collected from each media detected trace levels of organic contaminants. The concentration of inorganic compounds in each media were found to be in the acceptable range for soil and groundwater developed from a ferromanganous, igneous rock. Results of the risk assessment conducted as part of the Supplemental Investigation indicated that there was no threat to human health or the environment associated with these media.

2.2.2 SWMU 2 - Langley Drive Disposal Site

SWMU 2 is located along Langley Drive approximately 2,000 feet northeast of the Navy Exchange (Figure 2-4). The site extends from Langley Drive to the mangroves and has an estimated length of 1300 feet in a northeast-southwest direction. According to Naval Energy and Environmental Support Activity (NEESA), 1984, this site operated as a landfill from approximately 1939 to 1959. The Navy documents this unit as having been used for the disposal of both hazardous and nonhazardous wastes. The site is characterized as nearly flat lying with a very gradual slope to the east from Langley Drive toward Ensenada Honda.

2.2.2.1 Summary of Previous Investigations

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

The 1988 CS report prepared by ESE evaluated data from two rounds of sampling. During the two rounds a total of 32 soil, six sediment, six surface water, and one groundwater sample were collected. Elevated lead concentrations were reported in some of the soil samples. During Round 2, two soil samples were analyzed for EP Toxicity of lead only. Results from these samples did not exhibit sufficient levels of lead to be classified as hazardous. Elevated levels of total chromium, copper and, selenium were detected in the surface water samples. Based on USEPA Region II review, the quality of the data obtained during the CS is questionable due to the unknown level of laboratory data quality objectives and the apparent lack of independent, third party data validation and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

During the 1988 RFA, the VSI team observed a dump site covering an area of approximately 40 feet by 150 feet. Within this area were lengths of thick cable, broken concrete blocks, ringed

metal hoses, and six severely corroded drums. At least one of the drums was filled with a white, damp chalky substance.

A total of 16 soil samples and one groundwater sample were collected at this SWMU during the Supplemental Investigation (Baker, 1993). Organic contaminants including benzene, 2-butanone, ethylbenzene, methylene chloride, toluene, and xylene were detected in the soil samples while low levels of semivolatile organic compounds (SVOCs) were detected in the groundwater sample. Inorganic compounds detected were in the range expected for soil and groundwater developed from a ferromanganous, igneous rock. The results of a risk assessment conducted indicated that there is no threat to human health or the environment associated with these media.

2.3 Operable Unit 5 Background

Operable Unit 5 consists of one site (Building 38 and surrounding area) divided into two separate SMWUs. SWMU 11 comprises the interior of Building 38 while SWMU 45 relates to the soil and groundwater outside of Building 38. SMWU 45 encompasses the area from the tree line north of Building 38 to the bedrock outcrop to the south and the access road leading to the base landfill (to the east) and the former substation located west of the building. Also included in SWMU 45 are the cooling water tunnels and USTs associated with the former power plant.

2.3.1 SWMU 11/45 - Building 38

Building 38 is located along a dirt access road south of Forrestal Drive opposite Camp Moscrip and north of SWMU 3 - Base Landfill (Figure 2-5). SWMU 11/45 is a former power plant containing a 60-megawatt steam turbine facility that operated from the early 1940s through 1949 (NEESA, 1984). The facility used Bunker C fuel, which was stored in two 50,000-gallon reinforced concrete tanks located directly northeast of the building (NEESA, 1984). Associated with Building 38 are two tunnels used to transfer salt water to and from the building. A cooling water intake tunnel runs from the north end of the building to Puerca Bay to the northeast. The cooling water discharge tunnel originates from the building's east wall and parallels the dirt access road to the landfill (SWMU 3). Apparently the discharge tunnel terminates in Ensenada Honda

(to the south), however, the exact location of the outflow has not been determined.

In 1979, Bunker C fuel was observed in manholes near Building 38 during heavy rainfalls. Bunker C fuel was also discharged to the Enlisted Beach (see Figure 2-5) through the cooling water intake tunnel located in Puerca Bay (NEESA, 1984).

2.3.1.1 Summary of Previous Investigations

The 1988 CS conducted by ESE included the collection of 38 soil samples from the site (9 samples in Round 1 and 29 samples in Round 2). These samples were analyzed for polychlorinated biphenyls (PCBs), oil and grease, volatile organic compounds (VOCs), ethylene dibromide (EDB), xylenes, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK). In Round 2, an EP toxicity test for lead was completed. The analytical results indicated the presence of PCB and lead contamination at
the site. Lead concentrations were less than the EP toxicity standard. Other constituents detected, but not at levels of concern, were MEK as well as oil and grease. Based on USEPA Region II review, the quality of the data obtained during the CS is questionable due to the unknown level of laboratory data quality objectives and the apparent lack of independent, third party data validation and; therefore, no conclusions regarding conditions at the site can be drawn on the basis of this information.

The 1988 RFA report states that a facility representative informed the VSI team that the site is Toxic Substance Control Act (TSCA) regulated. Within Building 38 is a cyclone fence which surrounds a curbed, 8-inch concrete pad. PCB-contaminated items (e.g., old transformers and 55-gallon drums) are temporarily stored on the pad for ultimate disposal by a DRMO contractor. The VSI team observed drums believed to contain PCB contaminated soil outside the cyclone fence as well as oil contaminated sorbent inside the fenced pad. According to a facility representative an oil spill from a non-PCB transformer (<50 ppm PCBs) had occurred and that laboratory results were pending regarding the contents of the drum located outside the fenced pad.

A Remedial Investigation/Feasibility Study (RI/FS) conducted by Versar in 1992 determined that

concrete surfaces, sediments, and soil surrounding Building 38 were contaminated with PCBs at levels exceeding applicable, relevant, and appropriate regulations (ARARs). Additionally, surface water and wipe samples collected from the cooling water tunnel and underground storage tank manways were contaminated and required further investigation as separate operable units (designated IR Site 16). Contamination was reported to a depth of at least one foot; however, the presence of coral prevented deeper sampling. The RI/FS focused on the soil/sediment operable unit. An estimated 986 cubic yards of soil/sediment were reported requiring remediation along with 20,000 square feet of concrete.

Three alternatives were proposed in the FS: soil excavation, shipment, and off-site incineration; soil excavation, shipment, and off-site landfill; and, soil excavation and on-site incineration. Of these three, soil excavation, shipment, and off-site landfill was accepted as the most feasible. Soils outside Building 38 have been remediated and a project close-out report has been submitted (OHM, 1995).

During the Supplemental Investigation (Baker, 1993), seven surface water and six sediment samples were collected. Organic contaminants including toxaphene, endosulfan II, and Aroclor 1260 were detected in both media. The 1993 RFA reinspection indicated conditions within the building were similar to those seen in 1988.

An Interim Corrective Measure (ICM) was performed for SWMU 45 to address the reported discharges of product from the cooling water tunnels. These actions included the breaching and sealing of the intake and discharge cooling water tunnels with cast-in-place concrete, removal of liquids and sludge from the underground storage tanks and tunnels, backfilling the storage tanks with concrete, and the sealing of manway entrances to the storage tanks and cooling water tunnels. Remediation at the site was performed by the Remedial Action Contractor (RAC) OHM, Inc. Work began in May 1996 and was completed in November 1996.

3.0 RCRA FACILITY INVESTIGATION

The following sections present a description of the activities conducted at the various SWMUs during the RFI investigations. These activities included land clearing, surface and subsurface soil sampling, sediment sampling, monitoring well installation, groundwater sampling, wellhead tests, and PCB wipe sampling. Also included is a description of the procedures employed during sampling. All investigations performed and the methodologies used were in accordance with the approved RFI work plans (Baker, 1995a).

Tables 3-1 through 3-3 present a listing of samples collected from each SMWU during the Confirmation Study, Supplemental Investigation, Relative Risk Ranking, and RFI Investigation along with their associated analytical parameters. Table 3-4 provides the same information for the background investigations. Table 3-5 lists those individual parameters included in the Appendix IX list, while Table 3-6 lists those individual parameters included in the RCRA Metals list.

3.1 Land Clearing Activities

3.1.1 1996 RFI Investigation

This section describes the land clearing activities that were required for the performance of the field investigation conducted during the 1996 field work at SWMUs 1 and 2.

In order to gain access to the soil boring and well locations at SWMUs 1 and 2, it was necessary to clear access lanes. Land clearing was performed prior to mobilization of the drilling subcontractor using a single, tracked excavator under the direction of the Baker field team.

At SMWU 1, two access lanes were cleared due to the large size of the site. The first access lane was cut in the same general vicinity as the lane cut during the Supplemental Investigation (Baker, 1993) as shown on Figure 3-1. This lane runs in a southerly direction to provide access to the southwest portion of the site and monitoring well 1MW04. An additional lane was cut from

the initial lane to gain access to monitoring well 5GW03. The second access lane was excavated from the drive leading to the Coast Guard Pier in a southernly direction to well 1MW02. This lane was continued in an easterly direction to provide access to monitoring well 5GW04. At no time was the excavator in close proximity to the mangrove swamp.

A single access lane was cut into SWMU 2 from Langley Drive in a generally east direction with secondary lanes cut in north-south directions. As with SMWU 1, the excavator did not encroach into the mangrove swamp.

Land clearing at both SWMUs included areas of sufficient size for the construction of a decontamination pad and storage of a roll-off box. Land clearing activities were not required at SMWU 11/45 during the 1996 field work.

3.1.2 1997 RFI Investigation

This section describes the land clearing activities that were required for the performance of the field investigation conducted during the 1997 field work at SWMU 1 and SWMU 11/45.

In order to gain access to the soil boring and well locations at SWMU 1 it was necessary to clear access lanes. Land clearing was performed prior to mobilization of the drilling subcontractor using a single, tracked excavator under the direction of the Baker field team.

At SMWU 1, one access lane was cleared to gain access for the installation of monitoring well 5GW03R. This lane runs in a southerly direction to provide access to the southern portion of the site. This access lane was excavated from the drive leading to the Coast Guard Pier in a southernly direction beyond well 1MW02. At no time was the excavator in close proximity to the mangrove swamp.

Land clearing activities were required at SMWU 11/45 to gain access to the water intake tunnel of Building 38. Four access lanes were constructed for the investigation. Two of the lanes were adjacent to the sides of the tunnel while the other two lanes were located approximately 50 feet away from the sides of the tunnel. The disturbance of the tree line along the roadways was kept

to a minimum by clearing a lane inside the trees parallel to the roadway to clear the lanes parallel to the tunnel.

3.2 Sampling Activities at SMWU 1 - Army Cremator Disposal Site

3.2.1 1996 RFI Investigation

Sampling activities during the 1996 field work at SMWU 1 consisted of the collection of surface soil samples (1SS01 through 1SS08), sediment samples (1SD01 through 1SD03), advancement of soil borings (1SB01 through 1SB04) and subsequent subsurface soil sampling, the installation of four new monitoring wells (1MW01 through 1MW04), groundwater sampling of the newly installed wells and three existing wells (5GW01, 5GW03, and 5GW04), and wellhead testing. Locations of the surface soil, sediment, soil borings, and monitoring wells are presented on Figure 3-1.

The approved work plans called for the inspection of the five existing wells at SMWU 1: 5GW01, 5GW02, 5GW03, 5GW04, and 5GW05. During the field investigation each of the existing wells were located with the exception of what was believed to be 5GW02. Well 5GW03 was found at the location where 5GW02 was marked on the map. It was discovered during the revision to the draft RFI report that the labels for wells 5GW02 and 5GW03 were switched on the Workplan figure. This discrepancy is due to a transcription error from transferring the well locations from the CS report to the RFI Workplan. This transcription error along with the wells not being labeled with well tags explains why the field crew made this error. Therefore, it was monitoring well 5GW03 which was not located in the field not 5GW02 as originally believed. All figures and data have been edited to correct this transcription error. Several attempts to locate 5GW03 were unsuccessful. The search included areas along the mangrove east of 5GW02 up to the area near 5GW04. Well 5GW03 was not replaced during the 1996 field investigation because of inaccessibility to the mapped location (small peninsula south of 5GW04) due to soft soil conditions from heavy rains.

Inspection of the existing wells, located in the field, indicated that they were suitable for use as

part of this investigation (i.e., protective casing intact and well casing unobstructed to bottom of well) with the exception of 5GW05 which was measured to be roughly 10 feet shorter in depth than the remaining existing wells. Well 5GW05 was located along the drive to the Coast Guard Pier at the northeast corner of the site. Based on the above observations coupled with the unavailability of well construction logs, this well was abandoned and replaced with 1MW01.

While field locating the new monitoring wells it was believed that the location of 5GW05 coincided with the proposed well to be installed north of 1MW02 along the drive to the Coast Guard Pier. The replacement of 5GW05 with 1MW01 was thought to satisfy both requirements of replacing 5GW05 and the installation of the proposed new well. Following demobilization and receipt of the site survey data, all well locations (new and existing) were plotted on the site map. It was then that it was discovered that well 5GW05 was not coincident with the proposed well north of 1MW02, rather it was located further east than originally thought. Because of this misinterpretation, the proposed monitoring well north of 1MW02 along the roadway was not installed.

3.2.1.1 Soils Investigation

A total of 15 surface soil samples and one duplicate sample were collected as part of this investigation as indicated in Table 3-1 during the 1996 RFI investigation. As can be seen on Figure 3-1, eight of the surface soil samples, 1SS01 through 1SS08, were collected at individual locations while the remaining seven samples were associated with either a soil boring or monitoring well. It should be noted that a surface soil sample was not collected at 1SB04 due to groundwater being present at the ground surface. Each surface soil sample was analyzed for the full Appendix IX parameter list, explosives, and asbestos. Table 3-1 presents a summary of the samples collected and the analytical program. A description of the sampling procedures employed is discussed in Section 3.6.

Eight soil borings were advanced within the limits of the SWMU with four borings ultimately being converted into groundwater monitoring wells. A total of 12 subsurface soil samples and two duplicate samples were collected from these borings and analyzed for the parameters listed on Table 3-1. The work plans called for collection of subsurface samples from each boring. One

sample was to be collected from immediately above the water table and one sample from the vadose zone between the water table and the ground surface. At two locations, 1MW01 and 1SB01, only one subsurface soil sample was collected due to the high groundwater elevation (less than seven feet) negating the need for collection of the sample from the vadose zone. At another location, 1SB04, no surface or subsurface soil samples were collected due to groundwater being encountered at the ground surface.

3.2.1.2 Groundwater Investigation

The groundwater investigation at SMWU 1 during the 1996 investigation involved the sampling of the four newly installed monitoring wells in addition to three existing wells for a total of seven groundwater samples with one duplicate sample. Each of the monitoring wells were sampled for the full Appendix IX list, explosives, asbestos, and sodium (Table 3-1). Monitoring well installation and sampling procedures are discussed in Section 3.7.

Following groundwater sampling, all wells at the SWMU (existing and new) had wellhead (slug) tests performed to assess in-situ hydraulic conductivity.

3.2.1.3 Sediment Investigation

A total of three sediment and surface water samples were proposed for collection from leachate seeps emanating from the landfill slopes. An exhaustive reconnaissance of the SWMU did not detect any seeps from the site even though heavy rainfalls occurred during the investigation; therefore, no surface water samples were collected. The three sediment samples collected (1SD01, 1SD02, and 1SD03) were obtained from surface expressions (e.g., shallow swales) indicating surface flow at one time in the past. These samples were located from areas in close proximity to the mangrove swamps surrounding the SWMU (Figure 3-1). The sediment samples were analyzed for the Appendix IX list, explosives, asbestos, and total organic carbon (TOC) as shown on Table 3-1.

3.2.2 1997 RFI Investigation

Sampling activities at SMWU 1 consisted of the installation of two new monitoring wells (1MW05 and 5GW03R) and subsequent subsurface soil sampling, and groundwater sampling of the newly installed wells during the 1997 RFI investigation. Monitoring well 5GW03R is the replacement well for 5GW03 which was never located as previously discussed in Section 3.2.1. Locations of the monitoring wells are presented on Figure 3-2.

3.2.2.1 Soils Investigation

Two soil borings were advanced within the limits of the SWMU ultimately being converted into groundwater monitoring wells. A total of four subsurface soil samples were collected from these borings and analyzed for the parameters listed on Table 3-1. The work plans called for collection of two subsurface samples from each boring. One sample was to be collected from immediately above the water table and one sample from the vadose zone between the water table and the ground surface. A description of the sampling procedure employed is discussed in Section 3.6.

3.2.2.2 Groundwater Investigation

The groundwater investigation at SMWU 1 involved the sampling of the two newly installed monitoring wells. Each of the monitoring wells were sampled for the full Appendix IX list, explosives, asbestos, and sodium (Table 3-1). Monitoring well installation and sampling procedures are discussed in Section 3.7.

3.3 Sampling Activities at SWMU 2 - Langley Drive Disposal Site

A similar sampling program was performed at SWMU 2 during the RFI investigation and included the collection of surface soil samples, sediment samples, advancement of soil borings, installation of monitoring wells, groundwater sampling, and wellhead testing. Sampling locations are presented on Figure 3-3 while the analytical program is shown in Table 3-2.

3.3.1 Soils Investigation

The soils investigation at SWMU 2 involved the collection of eight surface soil samples and one duplicate sample as shown on Figure 3-3. All of the surface soils were either associated with a soil boring or monitoring well. Three of the samples were from the newly installed monitoring wells while the other five samples were from the soil borings. Each surface soil sample was analyzed for Appendix IX list, explosives, and asbestos. Table 3-2 presents a summary of the samples collected and the analytical program. A description of the sampling procedures employed is discussed in Section 3.6.

A total of four subsurface soil samples and one duplicate sample were collected from the five soil borings. As stated in Section 3.2, the work plans required that two subsurface soil samples be collected from each boring. Due to the shallow depth to groundwater close to the mangrove swamp (five feet or less below ground surface), only one sample from immediately above the water table was collected from soil borings 2SB04 and 2SB05, while no subsurface soil samples were collected from soil boring 2SB02 and 2SB03. Four subsurface soil samples and one duplicate sample were collected from the three monitoring well borings. Due to the shallow depth to groundwater only one sample was collected from soil borings 2MW01 and 2MW03, while both samples were obtained from 2MW02. Each subsurface soil sample was analyzed for Appendix IX list, explosives, and asbestos. Table 3-2 shows those samples collected from each location in addition to the analytical program.

3.3.2 Groundwater Investigation

Three new monitoring wells were installed at SWMU 2 as part of this investigation. Groundwater samples were collected from these three new monitoring wells along with existing well 6GW01. These samples were analyzed for the full Appendix IX list, explosives, asbestos, and sodium. In addition to the above parameters, groundwater collected from 6GW01 was also analyzed for the corrective measures parameters of TOC, chemical oxygen demand (COD), and total suspended solids (TSS) to provide information relative to the screening of specific potential corrective measures. Table 3-2 shows those samples collected in addition to the analytical program.

3.3.3 Sediment Investigation

A total of three sediment samples were collected from the site during the investigation. As with SMWU 1 there were no observed seeps emanating from the site. For this reason, there were no surface water samples collected. Those sediment samples that were collected were obtained from areas where surface water would most likely flow over the landfill towards the mangrove swamp. One of these samples, 2SD01, was collected at a location where the drainage ditch north of SWMU 2 intersects the mangrove swamp east of 2MW01. 2SD02 was collected from a shallow swale located west-northwest of 2SB05 while 2SD03 was located north of 2SB04. Each sediment sample was analyzed for the parameters listed in Table 3-2.

3.4 Sampling Activities at SWMU 11/45 - Building 38

Building 38 has been divided into two separate SMWUs (Figure 3-4). SWMU 11 pertains to the interior portion of the building and was investigated for potential PCB contamination through the collection of 125 wipe samples (Figure 3-5). SWMU 45 encompasses the soils outside the building including the USTs located adjacent to and north of the building. The field work conducted at SWMU 11/45 was conducted in two different phases and will be discussed as such in the following sections.

3.4.1 1996 RFI Investigation

This SMWU was investigated through the collection of 125 PCB wipe samples, surface and subsurface soil samples, installation of four temporary wells, the installation of four permanent monitoring wells and the collection of eight groundwater samples during the 1996 field investigation. This investigation addressed the interior of Building 38 and the underground storage tanks adjacent to Building 38.

3.4.1.1 PCB Investigation - Building 38 Interior

The interior space of Building 38 is divided into two halves (designated north and south) separated

by an interior wall as shown on Figure 3-5. The field investigation at this site involved the collection of 125 PCB wipe samples to determine if the interior portion of the building is contaminated due to past PCB storage practices. Prior to sampling, a 20-foot x 20-foot grid was established within the building interior. The grid was adjusted slightly to avoid wood planking which covered the piping trenches running throughout the building and any stationary equipment. Wipe samples were collected at each floor grid node as well as points along the walls two feet above the floor and at the floor/wall intersection. A total of 59 wipe samples (11WS01 through 11WS59) were collected from the north half of the building and 66 wipe samples (11WS60 through 11WS125) were collected from the southern half.

It should be noted that there was a fire within Building 38 after the wipe samples were collected, which may have negated the data collected from Building 38 interior. Due to this fire, the wipe sample results from this investigation will not be presented in this report since they no longer characterize the interior condition of the building. The results of the initial wipe sampling efforts were provided in, and used to assist in developing, the workplan for the recharacterization of the building interior. This recharacterization workplan along with the analytical data have been provided to the EPA for review.

3.4.1.2 Soils Investigation

The 1996 investigation at SWMU 45 included the collection of four surface soil samples from the four soil borings associated with the installation of the four permanent monitoring wells as shown on Figure 3-4. Each surface soil sample was analyzed for VOCs, SVOCs, PCBs, and RCRA metals. Table 3-3 presents a summary of the samples collected and the analytical program. A description of the sampling procedures employed are discussed in Section 3.6.

Four soil borings were advanced within the limits of the SWMU ultimately being converted into groundwater monitoring wells. A total of eight subsurface soil samples were collected from these borings and analyzed for the parameters listed on Table 3-3. The work plans called for the collection of subsurface samples from each boring. One sample was to be collected from immediately above the water table and one sample from the vadose zone. Each subsurface soil sample was analyzed for VOCs, SVOCs, PCBs, and RCRA metals. Four temporary wells were

installed to obtain groundwater samples as shown on Figure 3-4. Soil samples were not collected for analytical analysis during the installation of the temporary wells.

3.4.1.3 Groundwater Investigation

A total of eight groundwater samples were collected from the four temporary wells and four permanent wells installed as part of this investigation. The temporary wells (designated 45HP01 through 45HP04) were installed along the perimeter of the site as shown on Figure 3-4.

The four permanent wells, 45MW01 through 45MW04, were to be installed through the concrete slab overlying the USTs. During the field investigation a small test pit was excavated adjacent to the northeast corner of the slab to determine its thickness for concrete coring estimates. The slab was observed to be a minimum of three feet thick. Due to the thickness of the slab, the wells were relocated to positions outside the slab area with the permission of the USEPA obtained during a conference call. Three of the wells were installed at locations to the north, east, and west of the slab (Figure 3-4). The fourth well which was initially to be installed south of the USTs was relocated northeast of 45MW03 when product was encountered at that well. The rationale for relocating 45MW04 was to define the extent of possible contamination from 45MW03 in the apparent down gradient direction. A more detailed examination of the conditions at the site are discussed in Section 5.4.

All groundwater samples were analyzed for the parameters shown on Table 3-3 and included VOCs, SVOCs, PCBs, and RCRA metals.

3.4.1.4 Sediment Investigation

A series of three sediment samples were to be collected from the terminus of the cooling water discharge tunnel located in Ensenada Honda during the investigation. Using a small boat, the field team attempted to locate the discharge tunnel terminus in the waters of Ensenada Honda directly off shore from Building 38 and parallel to the Base Landfill (SMWU 3). Since no mapping exists which shows the exact location of the discharge tunnel terminus and because of the extremely dense mangrove vegetation along and some distance from the shore the field team did not locate

the discharge tunnel; therefore, no sediment samples were collected.

3.4.2 1997 RFI Investigation

An Interim Remedial Measure (IRM) was performed at SWMU 45 as indicated previously. During the work around the tunnels while cleaning and backfilling them, a pit was dug next to the tunnel at one point to see if the source of groundwater inflow could be established. This pit discovered the presence of some apparent oil contamination outside the tunnel. To ascertain the extent and severity of the release, an investigation program which included the installation of 27 soil borings, collection of 18 subsurface soil samples, installation of 14 temporary wells, and the collection of 14 groundwater samples was performed. In addition, in response to findings of elevated levels of some constituents in the sediments, nine more sediment samples were collected from Puerca Bay during the 1997 field investigation at SWMU 45.

3.4.2.1 Soils Investigation

The 1997 investigation at SWMU 45 included the installation of 27 soil borings utilizing direct push technology as shown on Figure 3-6. Each boring was advanced to a minimum depth of two feet below the tunnel invert or to the water table. A minimum of one sample was to be collected from every other boring if there was no evidence of contamination present. Samples were to be collected from the suspected contaminated area and/or just above the water table. A total of 18 subsurface soil samples were collected from 17 of the borings. One sample was collected from each of the borings except for 11-SB22 were an additional sample was collected from the saturated zone. This additional sample was collected to assist in determining the properties of the free product since the quantity of free product in the temporary wells was not of sufficient volume for a sample. Each subsurface soil sample was analyzed for VOCs, SVOCs, PCBs, Appendix IX metals, and total petroleum hydrocarbons (TPH) gasoline range organics (GRO) and diesel range organics (DRO) except the sample collected from the saturated zone from boring 11-SB22 which was only analyzed for PCBs. Table 3-3 presents a summary of the samples collected and the analytical program. A description of the sampling procedures employed is discussed in Section 3.6. Fourteen of the soil borings were converted into temporary groundwater monitoring wells.

3.4.2.2 Groundwater Investigation

A total of 14 groundwater samples were collected from the 14 temporary wells installed as part of this investigation. The temporary wells were installed so that the screen spanned across the water table surface to assist in determining the presence of free product. If free product was detected within the well it was to be sampled for analysis. The quantities of free product in the wells was not enough to collect a sample for analysis. This is why an additional sample was collected from 11-SB22 as discussed in the preceding paragraph. All groundwater samples were analyzed for the parameters shown in Table 3-3 and included VOCs, SVOCs, PCBs, Appendix IX metals, TPH GRO and DRO, and TOC. A description of the sampling procedures employed is discussed in Section 3.7.

3.4.2.3 Sediment Investigation

The 1997 field investigation included the collection of sediments from Puerca Bay, which is where the cooling water tunnel is located as shown on Figure 3-6. A total of nine sediment samples were obtained utilizing a petite ponar dredge from a boat. One sediment sample (11-SD01) was obtained from the mouth of the tunnel. Three sediment samples (11-SD02 through 11-SD04) were obtained from an arc approximately 50 feet away from the mouth of the tunnel. An additional three sediment samples (11-SD05 through 11-SD07) were obtained from an arc approximately 100 feet away from the mouth of the tunnel. The remaining two samples (11-SD08 and 11-SD09) were collected from approximately 200 feet away from the mouth of the tunnel. Each sediment sample was analyzed for VOCs, SVOCs, PCBs, Appendix IX metals, and TPH DRO and GRO as indicated in Table 3-3.

3.5 Background

A background investigation was conducted during the OU 2 field activities in March 1996 and included the installation of four background monitoring wells, BGMW01 through BGMW04 located north of Gate 2 between the entrances to the Crash Crew Area and Air Operations (Figure 3-7). The background wells were installed in undisturbed, wooded areas along the east

side of the realigned Boxer Drive. The location of the background monitoring wells was described in the approved RFI work plans (Baker, 1995a) as near the perimeter fence north of Gate 2. It was not possible to locate the wells along the west side of Boxer Drive since the ground had been disturbed during the road realignment; therefore, the wells were positioned in an area east of the road to ensure that they were on undisturbed soil. The area of the background wells is heavily wooded and has historically been used as a buffer zone between the station's northeast perimeter fence and the air field.

The background investigations were completely described in the EPA approved Revised Draft, RFI Report for Operable Unit 2 (SWMU 7/8) submitted in June 1997 and in the OU 1, 6 and 7 RFI Report addendum also submitted in 1997.

Surface soil, subsurface soil, and groundwater samples were collected from each location in a manner consistent with those collected at OUs 3 and 5. Each background sample media, designation, depth and analytical parameter is outlined in Table 3-4. All of the background samples were analyzed for the full appendix IX parameter list (Table 3-5) and are discussed further in Section 5.1. The background data was compared with the concentrations reported from SWMUs 1, 2, and 45 for assessment of potential contamination and determining chemicals of potential concern (COPCs) for use in the risk assessment.

3.6 Soils Investigation

The following subsections present a description of the procedures employed in collecting surface and subsurface soil samples during the RFI investigation.

3.6.1 Surface Soil Sampling Procedures

Surface soil samples were collected at SWMUs 1, 2, and 45 during the 1996 investigation. Samples were collected using decontaminated stainless steel spoons. Prior to sample collection, vegetation (grass and roots) was removed from the location. Surface soil samples were collected to a depth of one foot as required by USEPA Region II guidelines. Soil collected for VOC

analysis was placed directly into the laboratory prepared container to prevent volatization. Soil collected for other analyses was placed on sheets of aluminum, homogenized and placed in their respective containers beginning with SVOCs and pesticides/PCBs, dioxin, explosives, and finally inorganic analyses (metals, sulfides, cyanide, TOC, and asbestos). All samples were kept in coolers on ice and under strict chain-of-custody until delivered to the laboratory. Chain-of-custody forms are presented in Appendix B.

3.6.2 Drilling Procedures

Overburden drilling and sampling was accomplished using 3-1/4 inch inside diameter (ID) hollow-stem augers and 3-inch, nominal diameter, split-spoons advanced in accordance with American Society of Testing Materials (ASTM) Method 1586. Subsurface samples were collected continuously beginning at a depth of two feet below ground surface (bgs). Once the borehole was advanced to its target depth at the monitoring well locations, it was reamed with 6-1/4 inch ID hollow-stem augers to allow for the placement of backfill materials (i.e., sand and bentonite). A polyvinyl chloride (PVC) bottom plug or 6-inch center bit was used during reaming to prevent soil cuttings from entering the augers. In some cases these measures did not prevent cuttings from entering the augers which necessitated the removal and cleaning of the augers and redrilling. These procedures were followed during the advancement of borings for the four temporary wells (around the USTs) at SMWU 11/45 during the 1996 investigation except that these locations were not reamed using the 6-1/4 inch ID hollow-stem augers.

Subsequent to sampling activities at the soil borings, each boring was backfilled to the ground surface with a cement-bentonite grout.

Borehole information pertaining to soil classification, environmental sampling depths, and depth to groundwater measurements were recorded on test boring and well construction records (Appendix C). At SMWUs 1 and 2 all soil cuttings and discarded split-spoon samples were removed from the boring location and placed in a roll-off box located at each SWMU during the 1996 work, 55-gallon drums were utilized during the 1997 field investigation. At SMWU 45 all solid investigation derived waste (IDW) was placed in 55-gallon drums, sealed, and labeled. IDW

generated during the investigations at SWMUs 1, 2, and 11/45 was characterized by Baker and disposed by Browning Ferris Industries (BFI).

3.6.3 Direct Push Procedures

An Earthprobe system was used (a double casing system) for this project. A two inch outside diameter (OD) casing with a removable drive point was used to advance the boring. Once the casing was at a desired depth, the drive point was removed through the interior of the casing. Next, a 1-3/4 inch OD sample core tube and rods were placed inside the drive casing. The sample core tube was driven below the tip of drive casing until the desired length of sample was collected (maximum of two feet). The sample core tube was then pulled from the ground. Once at the surface, subcontractor personnel would remove the drive shoe to free a one inch OD by two foot long acetate liner containing the soil sample.

Borehole information pertaining to soil classification, environmental sampling depths, and depth to groundwater measurements were recorded on test boring and well construction records (Appendix C).

3.6.4 Subsurface Soil Sampling Procedures

3.6.4.1 Drilling Sampling

Soil samples from the soil borings and monitoring wells were collected using three inch nominal diameter split-spoons for the drilling. After the split-spoons were removed from the borehole they were opened and immediately screened using a photo ionization detector (PID). Each sample was then tightly wrapped in aluminum foil until soil sampling operations were completed. The samples selected for analysis (based on the criteria contained within the approved work plans) were opened and representative portions placed directly into the container for VOCs using decontaminated stainless steel spoons. The remaining sample was then homogenized in the aluminum foil and placed into their respective containers beginning with the organic analyses and ending with the inorganic analyses. All samples were kept in coolers on ice and under strict

chain-of-custody until delivered to the laboratory. Chain -of-custody forms are presented in Appendix B.

3.6.4.2 Direct Push Sampling

Subsurface soil samples were collected using direct push methodologies. After the one inch OD by two foot long acetate liner was removed from the casing, depth intervals were marked on the exterior of the liner. The soil sample was then removed from the liner and immediately screened using a PID and placed on virgin aluminum foil and sealed. This process was repeated for all soil samples. For laboratory analysis, multiple soil samples were composited due to the volume of soil required by the laboratory. Soils for volatile organic analysis were not physically mixed, but were composited directly into sample jars. Soils for all other analysis were physically mixed before placement into sample jars. All samples were kept in coolers on ice and under strict chain-of-custody until delivered to the laboratory. Chain -of-custody forms are presented in Appendix B.

3.7 Groundwater Investigation

The groundwater investigation included the installation, development, and sampling of monitoring wells along with the performance of wellhead tests. Additionally, 18 temporary wells were installed at SWMU 45 (14 associated with the tunnel subsurface investigation and four associated with the USTs). Each of these activities are discussed below.

3.7.1 Monitoring Well Installation Procedures

Each permanent monitoring well was constructed of 2-inch nominal diameter, Schedule 40, flush-joint and threaded PVC casing, screen, and threaded bottom cap. Screen lengths varied between locations depending on borehole depth and thickness of the water-bearing zone. Screen lengths ranged from a minimum of 10 feet of 0.010-inch, machine slotted, screen to a maximum of 25 feet. Table 3-7 presents a summary of the soil boring and well construction details.

At two locations, 2MW02 and 45MW02, the well casing did not extend the full length of the

borehole. A concern of possible downward migration of contaminants below the saturated zone was expressed if well screens were set to the top of bedrock surface through zones which were not saturated. Groundwater at both locations did not extend from the top of the water table to bedrock; rather the saturated zone was less than ten feet thick. After discussions, and subsequent approval, from USEPA, wells with saturated zones that did not extend to bedrock would be partially backfilled to near the base of the saturated zone. At the above locations, the wells were advanced to their target depths and then backfilled with sand to a point approximately one to two feet below the base of the saturated zone. The remaining annulus to the base of the saturated zone was then backfilled with bentonite to provide an adequate seal before setting the monitoring well.

Monitoring well installation included surrounding the well screen with sand a minimum of one to two feet above the top of the screen. Thickness of the sand pack varied between locations based on screen length and to ensure that the full water table zone was spanned. A bentonite pellet seal, with a minimum thickness of two feet, was placed above the sand pack and hydrated using potable water. The remaining annulus was backfilled to the ground surface with a cement-bentonite grout. An above ground, steel, protective casing was installed at the top of each well and cemented into a 3-foot x 3-foot concrete pad. Additionally, four, 5-foot long, steel, posts were installed in the corners of the pad to prevent damage to the well and protective casing. The posts and pads were painted a bright yellow color.

The four temporary wells installed at SWMU 45 during the 1996 investigation were constructed of 2 inch nominal diameter, Schedule 40, flush-joint and threaded PVC casing, screen, and threaded bottom cap. The well casings were installed directly into the borehole advanced using the 3-1/4 inch ID hollow-stem augers. No backfill materials (i.e., sand, bentonite, or grout) were introduced into the borehole, instead the formation was allowed to collapse around the casing. Following the collection of samples from the temporary wells, the casings were removed and the borehole backfilled with a cement-bentonite grout to the ground surface.

The 14 temporary wells installed along the cooling tunnel route during the 1997 investigation were constructed of 3/4 inch nominal diameter, Schedule 40, flush-joint and threaded PVC casing, 0.01 inch slotted screen, and threaded bottom cap. The well casings were installed directly into the

borehole advanced using the Earthprobe double casing system. No backfill materials (i.e., sand, bentonite, or grout) were introduced into the borehole, instead the formation was allowed to collapse around the casing. Following the collection of samples from the temporary wells, the casings were removed and the borehole backfilled with a cement-bentonite grout to the ground surface.

As previously stated, existing monitoring well 5GW05 was abandoned during this investigation and replaced with well 1MW01. Abandonment of well 5GW05 included the removal of the concrete pad, protective casing, and the well casing itself. The resultant open borehole was backfilled to the ground surface with a cement-bentonite grout.

3.7.2 Well Development Procedures

Following permanent well construction and curing of the bentonite and grout seals (i.e., typically 24 hours or more), each new monitoring well was developed to remove fine-grained sediments from the screen and to establish an interconnection between the well and formation. Well development also was performed at those existing wells scheduled for sampling as part of this investigation. Development was performed using disposable polyethylene bailers and clean rope dedicated to each well to minimize the potential for cross-contamination.

Prior to well development, water levels from each well were measured. The total depth also was recorded from each well to the nearest 0.1-foot using a steel tape. Water level data and total depth measurements were used to calculate the volume of water to be evacuated. A minimum of three to five well volumes were purged from each well with measurements of pH, temperature, and specific conductivity recorded prior to development and after each well volume. Development continued until three consecutive measurements were within 10 percent of each other. All measurements were recorded in field log books and transferred to Well Development Forms provided in Appendix D.

Development water was stored in 55-gallon steel drums and staged at a central location. Samples of the development water were collected from each SWMU and submitted for analyses and disposed by BFI.

3.7.3 Groundwater Sampling Procedures

Prior to groundwater purging, water level and total depth measurements were collected from the well in order to calculate well volumes. A minimum of three and a maximum of five well volumes were purged from each well using a disposable bailer and clean rope prior to sampling. Measurements of pH, temperature, and specific conductance were made prior to purging and after each well volume to ensure the groundwater stabilized before sampling. Purging was considered complete when three successive measurements were within 10 percent of each other or five well volumes were evacuated from the well.

Groundwater samples were introduced into laboratory-prepared containers directly from the sampling device. Sample bottles for VOC analysis were filled first, followed by SVOC, pesticides, op-pesticides, herbicides, dioxins, explosives, and finally the inorganic analyses. Samples analyzed for dissolved metals were collected in laboratory-prepared containers and filtered prior to placement in preserved containers. Samples were filtered and preserved in the field using a peristaltic pump and 45 micron in-line filters. Groundwater samples were kept in coolers on ice and under strict chain-of-custody until delivered to the laboratory. Chain -of-custody forms are presented in Appendix B.

Groundwater samples obtained from SWMU 45 during the 1997 investigation were collected using temporary wells. The temporary wells consisted of 3/4 inch OD PVC casing and 0.01 inch slotted screen. Screen lengths were either 5 or 10 feet based on hydrogeologic conditions. A peristaltic pump and virgin polyethylene tubing was used to draw groundwater from each of the temporary wells. In accordance with the work plans the wells were not purged prior to sample collection. Groundwater samples were collected no sooner than 24 hours, and no later than 48 hours after well installation. Samples were collected in order of relative volatility directly into sample jars. Samples were placed on ice immediately after collection.

Collection of free product samples was attempted at temporary wells where free product was observed in soil samples, by lowering a bailer to the top of the water to measure the amount of free product. Floating free product was observed in temporary wells 11GW01, 11GW05, and 11GW07. The thickness of the free product could not be determined because it smeared on the bailer rather than float on the water surface. Additionally, the free product was too viscous to pump, and not present in sufficient quantity in the bailer to sample.

3.7.4 Wellhead Testing Procedures

Each monitoring well sampled during the 1996 investigation (SWMUs 1, 2, and 45) had in-situ hydraulic conductivity tests ("slug tests") performed after groundwater samples had been collected. These tests allowed for the approximation of aquifer hydraulic conductivities in the vicinity immediately surrounding the wells. Each test was conducted by installing a pressure transducer, attached to an electronic recording device (Hermit ™ data logger), into the well to record the water level data. The first part of the test (falling head) involved introducing the PVC slug into the water table and measurements recorded as the water level fell to its original elevation. Once the static water level in the well stabilized, the slug was removed and the rising head test initiated. Data was recorded in the data logger and later downloaded, in the field, to a personal computer. The slug test data is presented in Appendix E. Results of the slug tests are discussed in further detail in Section 4.4.

3.8 Sediment Investigation

The following subsections present a description of the procedures employed in collecting sediment samples during the 1996 and 1997 investigation.

3.8.1 Sediment Sampling Procedures

Sediment samples were collected at SWMUs 1 and 2 during the 1996 investigation while sediment samples were collected at SWMU 45 during the 1997 investigation. Samples were collected using decontaminated stainless steel spoons at SWMUs 1 and 2. Prior to sample

collection, vegetation (grass and roots) was removed from the location. Sediment collected for VOC analysis was placed directly into the laboratory prepared container without homogenizing to prevent volatization. Sediment collected for other analyses was placed on sheets of aluminum, homogenized and placed in their respective containers beginning with SVOCs followed by pesticides/PCBs, dioxins, explosives, and finally inorganic analyses (metals, sulfides, cyanide, TOC, and asbestos). All samples were kept in coolers on ice and under strict chain-of-custody until delivered to the laboratory. Chain-of-custody forms are presented in Appendix B.

Samples were collected using a petite ponar dredge at SWMU 45. Sediment collected for VOC and TPH gasoline range organics analysis was placed directly into the laboratory prepared container without homogenizing to prevent volatization. Sediment collected for other analyses was placed on sheets of aluminum, homogenized and placed in their respective containers beginning with SVOCs, followed by TPH diesel range organics, PCBs, and finally Appendix IX metals analyses. All samples were kept in coolers on ice and under strict chain-of-custody until delivered to the laboratory. Chain-of-custody forms are presented in Appendix B.

3.9 Quality Assurance/Quality Control Sampling Procedures

Extensive field quality assurance/quality control (QA/QC) samples were collected during the RFI investigation. These samples were obtained to: (1) ensure that decontamination procedures were properly implemented (i.e., equipment rinsate blanks); (2) evaluate field methodology (i.e., duplicate
samples); (3) establish field background conditions (i.e., field blanks); and, (4) evaluate whether cross-contamination occurred during sampling and/or shipping (i.e., trip blanks).

Several types of field QA/QC samples were collected and analyzed including duplicate samples, equipment rinsate samples, field blanks, and trip blanks. These QA/QC samples are defined below:

- Duplicate Sample (D): Two samples collected simultaneously into separate containers from the same source under identical conditions. One duplicate sample was collected for every 10 (10 percent) environmental samples collected

for each media type.

- Equipment Rinsate Sample (ER/RB): Sample obtained by running laboratory supplied deionized water over/through sample collection equipment after it was decontaminated. These samples were used to determine if decontamination procedures were adequate.

- Field Blank (FB): Sample obtained from each water source utilized during the field program. The water sources used during the field program included: laboratory supplied deionized water utilized to collect rinsate blanks; store bought distilled water utilized for decontamination; and, potable water utilized for decontamination.

- Trip Blank (TB): Trip blanks were prepared at the laboratory and shipped with the sample containers. The trip blanks were packaged for shipment with the other VOC samples and sent for analysis. At no time after their preparation were the trip blank sample containers opened before they reached the laboratory. At least one trip blank per shipping cooler was sent to the laboratory for VOC analysis.

3.10 Decontamination Procedures

Decontamination procedures performed in the field were conducted in accordance with USEPA Region II guidelines.

For routine sample collection equipment, the following steps were implemented:

- Clean with potable water and low-phosphate detergent
- Tap water rinse
- 10 percent nitric acid solution rinse
- Tap water rinse
- Methanol followed by a hexane or an acetone rinse
- Analyte-free deionized water rinse

- Air dry
- Wrap in aluminum foil, shiny side out, for storage or transport

This decontamination procedure was performed on stainless steel sampling spoons and the split-spoon samplers used in drilling operations in accordance with Baker's standard operating procedure (SOP) F502. Decontamination of heavy equipment (i.e., hollow-stem augers, and drill rods) was performed by rinsing with potable water to remove soil followed by steam cleaning, in accordance with SOP F501 as contained in the approved work plans.

4.0 PHYSICAL CHARACTERISTICS OF STUDY AREA

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

4.1 Climatology

The climate of the Roosevelt Roads area is characterized as warm and humid, with frequent showers occurring throughout the year. A major factor affecting the weather is the pattern of trade winds associated with the Bermuda High, the center of which is in the vicinity of 30E North, 30E West. The prevailing wind direction reflects the easterly trade winds. The area receives a surface flow varying between the northeast to the southeast about 75 percent of the year, and as much as 95 percent of the time in July when the easterly winds are strongest. The differential heating of the land and sea during the day tends to give a more northerly component to the flow on the northern side of the island and a more southerly component on the southern side. During the night, a land breeze causes a prevailing southeasterly flow in the north and a prevailing northeasterly flow over the southern coast. The mean annual wind velocity is 5.5 knots, with a minimum in November and a maximum in August. Gales associated with westward moving disturbances in the trade winds or hurricanes passing either north or south of the area have the highest probability of occurrence from June through October.

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

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

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

4.2 Topography

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

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

4.3 Geology

The following subsections present a description of the general geology at NSRR as well as site-specific geologic information obtained at SWMUs 1, 2, and 11/45.

4.3.1 Soils

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

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

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

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

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

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

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

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

4.3.2 Regional Geology

The underlying geology of the station area is predominantly volcanic (composed of lava and tuff), as well as sedimentary (rocks derived from discontinuous beds of limestone). These rocks all range in age from early Cretaceous to middle Eocene. The volcanic rocks and interbedded

limestones have been complexly faulted, folded, metamorphosed and variously intruded by dioritic rocks. This complex geological structuring occurred sometime after the deposition of the limestone during the middle Tertiary, when Puerto Rico was separated from the other major Antillean Islands by block faulting, and was arched, uplifted and tilted to the northeast. Culebra, Vieques, and the Virgin Islands are part of the Puerto Rican block; they are separated from the main island simply because of the drowning that resulted from the tilting.

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

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

4.3.3 Site Geology SWMU 1 - Army Cremator Disposal Site

The subsurface conditions at SWMU 1 have been illustrated on four geologic cross sections. Figure 4-1 shows the locations of the monitoring wells and borings used to generate the various sections as well as the hydrogeologic cross sections. Figures 4-2 through 4-5 graphically present subsurface conditions along hydrogeologic cross sections A-A', B-B', C-C', and D-D', respectively.

The soil encountered at SWMU 1 was field classified into primarily four groups: fill, decomposed rock, highly decomposed Gabbro, and residual material. Each of these materials are discussed below.

- Fill material was observed at boring locations 1SB01, 1SB02, 1SB03, 1MW01, 1MW02, and 1MW03. Based on these borings, it appears that fill soils are present in the western portion of the site extending from soil boring 1SB03 north to soil boring 1SB01 and east to 1MW03. Fill material is also present in the northeast portion of the site extending from monitoring well 1MW02 east to

1MW01. Thickness of the fill material in the western portion of the site ranges from 2.25 feet at soil boring 1SB03, to four feet at 1SB01 as presented on Figures 4-2 and 4-3. The soil in this area is a reddish brown to brown silty clay to clayey silt with varying amounts of sand. The thickness of the fill material in the northeastern portion of the site ranges from four feet at 1MW02, to eight feet at 1MW01. The soil in this area is reddish brown to brown silty clay with various sizes of rock fragments. The fill soils in this area are apparently related to the build-up of the road leading to the Coast Guard Pier. Figure 4-4, containing cross-section C-C', illustrates the thickness of the fill at this portion of the site.

- Beneath the fill and residual soils, lies a relatively thick layer of decomposed rock. The decomposed rock was encountered in soil borings 1SB03, 1MW04, 1MW03, 1MW02, 1MW01, 1MW05, and 5GW02. These locations make up the eastern and southwestern portions of the site. The thickness of the decomposed rock in the southwestern portion ranged from 28.5 feet at 1MW03 and 1MW04, to 56.5 feet at 1SB03. The thickness of the decomposed rock in the eastern portion ranged from six feet (1MW01) to 26 feet (1MW02).

- Underlying the fill is a layer of highly decomposed Gabbro consisting primarily of trace fine sand to trace clay. This layer was present in the western portion of the site, at locations 1SB01 and 1SB02 ranging in thickness from 12.5 feet (1SB01) to 25 feet (1SB02).

- Beneath the fill is a relatively thin sequence of possible residual soil, formed by in-place weathering of the local bedrock. This soil consists of a dense silt to clayey silt. The thickness of the residual soil ranged from 1.5 feet at soil boring 1SB03 to four feet at 1MW03.

4.3.4 Site Geology SWMU 2 - Langley Drive Disposal Site

A similar sequence of subsurface soil to that seen at SWMU 1 was encountered at SWMU 2 including fill, decomposed Gabbro, and residual soils. Figure 4-6 shows the locations of the

SWMU 2 wells and borings as well as the hydrogeologic cross sections. Figures 4-7, 4-8, and 4-9 graphically present subsurface conditions along hydrogeologic cross sections A-A', B-B', and C-C', respectively. Each geologic unit is described below.

- Portions of the site are overlain by a zone of fill and/or reworked native soil that extends eastward from monitoring well 2MW02 to soil boring 2SB02 (Figure 4-7). This material is also present in the southern part of the site at soil boring 2SB05 (Figure 4-9). This material consists of a stiff, brown to reddish brown silty clay with an approximate thickness of four feet.

- Underlying the fill soil at this site is a thick zone of decomposed Gabbro consisting of varying amounts of silt to clayey silt which is moist and very dense. The decomposed Gabbro ranged in thickness from 17.5 feet at 2SB02 to 42.5 feet at 2SB04 (Figure 4-9).

- Beneath fill soil lies a relatively thin zone of residual soil. Residual soil was encountered primarily between monitoring well 2MW02 and soil boring 2SB02, which consisted mainly of hard, fine grained silts and clays. The residual zone extended to the top of the decomposed Gabbro zone, which appears around monitoring well 2MW02 at an approximate thickness of five feet.

4.3.5 Site Geology SWMU 11/45 - Building 38

The natural stratigraphy underlying SWMU 11/45 represents a transitional depositional zone (ie., a zone containing both marine and non-marine sediments). This transitional zone is underlain by residual soil and bedrock. Some filling is also evident in the western portions of the site. Figure 4-10 shows the locations of the hydrogeologic cross sections. Figures 4-11 through 4-16 show subsurface conditions along cross sections A-A', B-B', C-C', D-D', E-E', and F-F'. Each unit or zone can be described as follows:

- The fill material generally consists of brown sand and gravel and silt. The horizontal extent of the fill is limited to the area around Building 38 and the

wooded area directly across the access road. The fill material is generally thin (approximately 4 feet thick), but was observed to be approximately 10 feet thick at 11-SB01.

- Marine sediments were observed in an area east of a line represented by borings 11-SB19, 11-SB03, 11-SB08, and 11-SB27. These sediments consist of fine sands and coral, shell, and rock fragments. The fragmented nature of the coral and shells suggests that the area was a littoral zone (ie., shallow surf). These sediments extent to a depth of at least 14 feet below the ground surface. The soil borings and wells did penetrate below the marine sediments.

- The non-marine sediments were observed in an area west of a line represented by borings 11-SB19, 11-SB03, 11-SB08, and 11-SB27. These sediments consist of fine to coarse sands interbedded with silts and clays. Based on the wells and borings installed in 1996, the non-marine sediments appear as wedge-shaped deposits which begin north and west of Building 38 and thicken in a generally north-northeast direction, toward Puerca Bay.

- Residual soil was observed underlying non-marine sediments in the vicinity of Building 38. Additionally, residual soil only was encountered east of Building 38 at 45HP03 and 45HP04 (Figure 4-13). This zone consists of olive, white, and black silt to silty sand, is generally damp to moist, and dense to very dense. The top of bedrock surface (gabbro) slopes from the large outcrop south and west of Building 38 north-northeast toward Camp Moscrip and Puerca Bay.

4.4 Hydrology

The following subsections present a description of the hydrologic conditions that exist at NSRR. Both regional conditions and site specific conditions at SMWUs 1, 2, and 45 are discussed.

4.4.1 Regional Hydrology

The surface waters that flow across the northeastern plain of Puerto Rico, where the Station is located, originate on the eastern slopes of the Sierra de Luquillo mountains. Surface runoff is channeled into various rivers and streams which eventually flow into the Caribbean Sea. The Daguao River and Quebrada Seca Stream (a tributary to Rio Daguao) collect surface waters from the hills immediately north of the station, and in periods of heavy rain, on-station flooding occurs. The Daguao-Quebrada Seca watershed comprises an area of approximately 7.6 square miles (4,900 acres), and the river falls some 700 feet from its source to sea level. Increased development in the Town of Ceiba, especially in areas adjacent to the station's northern boundary, has significantly increased the surface runoff reaching the station, causing ponding and erosion in the Boxer Drive area. Boxer Drive, for a major portion of its length, is subject to surface water flooding, as are Hangar 200 and AIMD Hangar 379 and adjacent apron areas. This condition has been alleviated by the construction of the new highway (Route 3) immediately outside the fence and the realignment of Boxer Drive both with attendant stormwater management features.

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

Little information exists concerning the geohydrology of NSRR. The only known potential sources of groundwater lie in lenticular beds of clay, sand and gravel, and rock fragments which occur at a depth of less than 30 meters. No wells have been developed on-base from these layers. Some wells had been developed upgradient of the station in Ceiba, some three kilometers from base headquarters, but were abandoned due to high levels of salinity.

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

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

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

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

The base has been served for over 30 years by the present treatment facility. The plant (Building 88) has a capacity of 4.0 million gallons per day (mgd). Water flows by gravity into a 45 million gallon raw water storage basin from which the plant draws its supply at a rate of 1.3 mgd on average. Treatment consists of pre-chlorination, coagulation, sedimentation, filtration and post-chlorination.

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

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

4.4.2 SWMU 1 - Hydrogeology

Groundwater at SMWU 1 was encountered in both the residual and alluvial soil depending upon location within the site. In the upland portions, groundwater was encountered in the residual soil, described as a silt to sandy silt, at depths ranging from 4 feet bgs at 1MW02 and 1SB03 to 26 ft

bgs at 1SB02. Within the low lying areas adjacent to the mangrove areas, groundwater was encountered in a silty clay alluvial soil at depths ranging from 7 feet bgs at 1MW01 to immediately below ground surface at 1SB04.

Groundwater elevation measurements from November and December 1996 are presented in Table 4-1. For SWMU 1, groundwater elevation variations ranged from 6.84 to 7.13 feet between wells across the site. A groundwater elevation contour map for the shallow aquifer in November 1996 is presented on Figure 4-17. The contours are shown in two separate areas due to the well locations across the rather large site and the differences in the undulating topography. The represented groundwater surface in the eastern portion of the site generally follows the topography of the land from the higher elevations to the mangroves at shore edge. The measured hydraulic gradient of the groundwater in the eastern portion of the site between monitoring wells 1MW02 and 5GW04 to the southeast is 0.0033 ft/ft. The hydraulic gradient measured between 1MW02 and 1MW01 to the northeast is 0.0044 ft/ft. This gives an average estimated hydraulic gradient for the eastern portion of the site of 0.00385 ft/ft.

The represented groundwater surface in the southern portion of the site generally follows the topography of the land from the higher elevations to the mangroves at shore edge. The measured hydraulic gradient of the groundwater in the southern portion of the site between monitoring wells 1MW03 and 5GW03 to the south is 0.0022 ft/ft. The hydraulic gradient measured between 1MW04 and 5GW03 to the east is 0.005 ft/ft. This gives an average estimated hydraulic gradient for the southern portion of the site of 0.0036 ft/ft.

The hydraulic properties of the shallow aquifer were characterized by performing in situ rising and/or falling head slug tests in existing groundwater monitoring wells. The tests were performed in November 1996. An electronic data logger (In Situ Hermit Model 1000C) and pressure transducer assembly were used to record the recovery of groundwater in the monitoring wells to static level. All data was recorded in logarithmic scale to more closely monitor initial changes in groundwater elevation. The data resulting from the slug tests were converted into time (in minutes) and the corresponding change in water level displacement (in feet). Results from the slug tests were analyzed using Geraghty & Miller's AQTESOLV (ver. 2.01) computer program for performing quantitative groundwater assessments. The Bouwer and Rice solution for slug

tests in unconfined aquifers was used to evaluate all test data (Bouwer and Rice, 1989)(Bouwer and Rice 1976). Table 4-2 presents a summary of slug test data obtained from the SWMU 1 wells. The input parameters and plots generated from the slug tests are contained in Appendix E.

Hydraulic conductivity (K) values from the falling head test ranged from 4.10 ft/day in well 5GW03 to 27.50 ft/day in well 5GW01. An estimated transmissivity (T) value can be obtained by multiplying the hydraulic conductivity by the saturated thickness (b) of the aquifer. Assuming an average saturated thickness of 20 feet, estimated T values range from 82 ft^2/day (615 gallons/day/ft) to 550 ft^2/day (4,125 gallons/day/ft).

Hydraulic conductivity values from the rising head test ranged from 1.20 ft/day in well 1MW02 to 32.60 ft/day in well 5GW01. Assuming an average saturated thickness of 20 feet, estimated T values range from 24 ft^2/day (180 gallons/day/ft) to 652 ft^2/day (4,890 gallons/day/ft).

4.4.3 SWMU 2 - Hydrogeology

As with SMWU 1, groundwater at this SMWU was encountered in the residual and alluvial soil, which appear to be hydraulically connected. Along the western portion of the site at 2MW02, groundwater was intersected in the residual soil consisting of silty clay to clayey silt at a depth of 14 feet bgs to 12 feet bgs at 2SB01. Within the alluvial soil along the eastern perimeter, adjacent to the mangroves, groundwater was encountered in predominantly silty clays at depths ranging from 2.5 ft bgs at 2SB02 and 2SB03 to 6 ft bgs at 2SB05.

Groundwater elevation measurements from November and December 1996 are presented in Table 4-1. For SWMU 2, groundwater elevation variations range from 2.56 to 2.77 feet between wells across the site. A groundwater elevation contour map for the shallow aquifer in November 1996 is presented on Figure 4-18. The represented groundwater surface of the site generally follows the topography of the land from the higher elevations to the mangrove swamps. The measured hydraulic gradient of the groundwater of the site between monitoring wells 6GW01 and 2MW01 to the east is 0.0101 ft/ft. The hydraulic gradient measured between 2MW02 and 2MW03 to the south is 0.0131 ft/ft. This gives an average estimated hydraulic gradient for SWMU 2 of 0.0116 ft/ft.

The hydraulic properties of the shallow aquifer were characterized by performing in situ rising and/or falling head slug tests in existing groundwater monitoring wells as described in the previous section. The tests were performed in November 1996. Table 4-2 presents a summary of slug test data obtained from the SWMU 2 wells. The input parameters and plots generated from the slug tests are contained in Appendix E.

Hydraulic conductivity values from the falling head test ranged from 1.30 ft/day in well 2MW03 to 17.20 ft/day in well 2MW01. Assuming an average saturated thickness of 20 feet, estimated T values range from 26 ft^2/day (195 gallons/day/ft) to 344 ft^2/day (2,580 gallons/day/ft).

Hydraulic conductivity values from the rising head test ranged from 6.00 ft/day in well 6GW01 to 17.90 ft/day in well 2MW01. Assuming an average saturated thickness of 20 feet, estimated T values range from 120 ft^2/day (900 gallons/day/ft) to 358 ft^2/day (2,685 gallons/day/ft).

4.4.4 SWMU 45 - Hydrogeology

Groundwater north of Building 38 was encountered in the alluvial soil consisting of fine grained silty sands at depths ranging from 4 ft bgs at 45MW02 to 9 ft bgs at 45MW03. East of Building 38 groundwater was intercepted in a residual soil comprised of sand to silty sand at depths of 10 ft bgs at 45HP03 to 12 ft bgs at 45HP04.

Groundwater elevation measurements from November and December 1996 are presented in Table 4-1. For SWMU 45, groundwater elevation variations range from 0.43 to 0.62 feet between wells across the site. A groundwater elevation contour map for the shallow aquifer in November 1996 is presented on Figure 4-19. The represented groundwater surface of the site generally follows the topography of the land from the higher elevations in an easterly direction toward Puerca Bay. The measured hydraulic gradient of the groundwater of the site between monitoring wells 45MW02 and 45MW04 to the east is 0.005 ft/ft.

The hydraulic properties of the shallow aquifer were characterized by performing in situ rising and/or falling head slug tests in existing groundwater monitoring wells as described in the previous section. The tests were performed in November 1996. Table 4-2 presents a summary of slug

test data obtained from the SWMU 45 wells. The input parameters and plots generated from the slug tests are contained in Appendix E.

Hydraulic conductivity values from the rising head test ranged from 0.90 ft/day in well 45MW02 to 24.30 ft/day in well 45MW04. Assuming an average saturated thickness of 20 feet, estimated T values range from 18 ft^2/day (135 gallons/day/ft) to 486 ft^2/day (3,645 gallons/day/ft).

5.0 NATURE AND EXTENT OF CONTAMINATION

This section presents an overview of the chemical analytical results obtained as part of the OU3/5 RFI field investigation. It should be noted that the analytical results from the Confirmation Study, Supplemental Investigation, and Relative Risk Ranking are also presented and discussed in this section of the report at the request of the EPA Region II. Details on the sampling and methodologies from each of these investigations can be found in their respective reports and will not be included in this report. The objective of this section is to characterize the nature and delineate the extent of potential site contamination. COPCs will be selected as part of the human health risk assessment presented in Section 6.0. SWMU characterization data was obtained through sample collection and analysis of the surface and subsurface soil, surface water, sediment, and groundwater.

SWMU-specific sample results presented in the following sections have been compared to several criteria. Organic compounds detected in soil samples were compared to their respective risk based concentrations (RBCs) for both residential and industrial conditions as determined by USEPA Region III (October 1, 1998)(USEPA, 1998b). Inorganic compounds were compared to the RBCs (USEPA, 1998b) as well as two times the average detected background levels in accordance with recent EPA guidance (USEPA, 1995b). Compounds detected in the groundwater samples were compared to USEPA Region III tap water RBCs (USEPA, 1998b) as well as the federal maximum contaminant levels (MCLs) (USEPA, 1996b). Organic compounds, as well as inorganic compounds detected in sediment samples were compared to the effects range low (ERL) and effects range median (ERM) sediment screening value (Long, et.al, 1995). Compounds detected in the surface water samples were compared to Federal Ambient Water Quality Criteria (USEPA, 1992b) and the USEPA Region III BTAG Screening levels (USEPA, 1995a). Isopleth maps are provided on a media and constituent specific basis, for all constituents which were detected in a given media at four or more sampling points at concentrations equaling or exceeding the appropriate criteria.

Appendix B presents the chain-of-custody forms from the RFI investigation while Appendices F and G present the analytical results and QA/QC results, respectively.

5.1 Background Conditions

Background samples collected during this investigation included surface soil, subsurface soil, and groundwater. These samples were obtained from a series of four background monitoring wells installed along Boxer Drive northwest of the Crash Crew area (see Figure 3-7). [Note: the full rationale for background locations was provided in the approved RFI report for SWMUs 7/8 (Tow Way Fuel Farm) (Baker, 1997). The background samples were analyzed for the full Appendix IX parameter list. Tables 5-1 through 5-6 present the positive detections of the analytical results of the analytical testing of background samples. These results are discussed in the following sections.

5.1.1 Surface Soil

Table 5-1 presents those organic compounds detected in the surface soil samples collected from the four background monitoring wells. There were no VOCs, pesticides/PCBs, dioxins, chlorinated herbicides, or op-pesticides detected in this sample set, however, three SVOCs [butylbenzylphthalate, bis(2-ethylhexyl) phthalate, and fluoranthene] were detected in sample BGMW01-00. These concentrations did not exceed their respective RBCs (residential or industrial).

Of the inorganic compounds detected in the surface soil samples, (Table 5-2) only the compound arsenic exceeded the residential RBC for soil (0.43 mg/kg). A review of Table 5-2 shows that exceedances occurred in samples BGMW01-00, BGMW03-00, and BGMW04-00. Arsenic concentrations in excess of the residential RBC ranged from 1.2 mg/kg at BGMW01-00 to 1.8 mg/kg at BGMW04-00. Further review shows that these concentrations are below the industrial RBCs for soil. No other compound in the sample set exceeded either the residential or industrial RBC for soil.

5.1.2 Subsurface Soil

Trace concentrations of organic compounds (VOCs, SVOCs, dioxins, and chlorinated herbicides) were detected in the background subsurface soil sample set as shown in Table 5-3. Detected compounds included xylene, di-n-butyl phthalate, total Hexachlorodibenzo-p-dioxin (HxCDD), and 2,4,5-T. Of these compounds, only total HxCDD exceeded the residential RBC for soil of 0.043 µg/kg in sample BGMW03-03 with a concentration of 0.31J µg/kg. This concentration was below the industrial soil

RBC. No other compound in the sample set exceeded either the residential or industrial RBC for soil.

A comparison of background subsurface soil inorganic concentrations to the residential RBCs show that arsenic is the only compound detected to exceed the screening criteria (Table 5-4). Arsenic concentrations exceeded the screening criteria in all of the samples except BGMW01-06 (nondetect). Concentrations ranged from 0.71J mg/kg at BGMW02-05, to 2.4J mg/kg at BGMW03-03. All inorganic concentrations in this sample set were below their respective industrial RBCs for soil.

5.1.3 Groundwater

As presented in Table 5-5, there were no VOCs present above their respective method detection limits. Three SVOCs were above their method detection limits in this sample set, including acetophenone, bis(2-ethylhexyl)phthalate, and dimethylphthalate). Acetophone exceeded the tap water RBC in sample BGMW03, with a concentration of 1J Fg/l. The concentration of bis(2-ethylhexyl)phthalate in sample BGMW03 (7J Fg/l) exceeded both the Federal MCL and the EPA Region III Tap Water RBC. There were no pesticides/PCBs, dioxins, chlorinated herbicides, or op-pesticides detected in any of the groundwater samples in this set.

Table 5-6 presents those inorganic compounds detected in the background groundwater samples for total inorganics. A total of twelve inorganic constituents were detected in this sample set. Three of these twelve (arsenic, cadmium, and vanadium) exceeded at least one of the listed criteria. The concentrations of arsenic ranged from 1.7J Fg/l in sample BGMW03, to 3.6 Fg/l in sample BGMW04 which are above the Tap Water RBC of 0.04 Fg/l, but below the Federal MCL. Cadmium exceeded the Federal MCL of 5 Fg/l in sample BGMW01, with a concentration of 7.5 Fg/l. The concentration of vanadium (549 Fg/l) in sample BGMW04 was detected in excess of the tap water RBC. No other constituent in this sample set exceeded either of the listed criteria.

Table 5-6 presents concentrations of dissolved inorganics which were above their method detection limits. Seven inorganic constituents were detected in this sample set. However, none of the seven constituents exceeded any of the listed criteria.

5.2 SWMU 1 - Army Cremator Disposal Site

Sampling activities at SWMU 1 were conducted under the Confirmation Study, Supplemental Investigation, Relative Risk Ranking, and the RFI Investigation. The results from these investigations have been combined together into one unified database to assist in evaluating the environmental impact, if any, to this SWMU.

Sampling activities at SWMU 1 (Site 5) during the Confirmation Study, involved the collection of 11 surface water samples , 11 sediment samples, and 10 groundwater samples. These samples were submitted to the laboratory for analysis of VOCs, SVOCs, pesticides/PCBs, and inorganics. In addition to this parameter list, the surface water and half of the sediment samples were also analyzed for hexavalent chromium.

Sampling activities at SWMU 1 (Site 5) during the Supplemental Investigation, involved the collection of six surface soil samples and six subsurface soil samples with two duplicate samples and one groundwater sample. The soil samples were analyzed for VOCs, SVOCs, pesticides/PCB, and inorganics. The groundwater sample was analyzed for SVOC, pesticides/PCBs, and total and dissolved inorganics.

Sampling activities at SWMU 1 during the Relative Risk Ranking, involved the collection of three sediment samples all of which were analyzed for VOCs, SVOCs, pesticides/PCBs, op-pesticides, dioxins, chlorinated herbicides, inorganics, and sulfide.

Sampling activities at SWMU 1 during the 1996 RFI investigation, involved the collection of 15 surface soil, 12 subsurface soil, 3 sediment samples, and 7 groundwater samples. These samples were submitted to the laboratory for analysis of the full appendix IX list, explosives, and asbestos. In addition to this parameter list, the sediment samples were also analyzed for TOC, and the groundwater samples were additionally analyzed for sodium.

Sampling activities at SWMU 1 during the 1997 RFI investigation, involved the collection of four subsurface soil and two groundwater samples. These samples were also submitted to the laboratory

for analysis of the full appendix IX list, explosives, and asbestos. In addition to this parameter list, the groundwater samples were also analyzed for sodium.

The results from the Confirmation Study, Supplemental Investigation, Relative Risk Ranking, and the RFI have been combined together and are discussed by media in the following subsections.

5.2.1 Surface Soil

Surface soil samples were collected during both the supplemental investigation and the RFI investigation. The results of which are included in the following subsections. A complete set of the analytical data is presented in Appendix F.

5.2.1.1 Supplemental Investigation

A total of six surface soil samples (05SS126, 05SS128, 05SS130, 05SS132, 05SS135, and 05SS138) were collected in this area during the supplemental investigation. Within the surface soil organic sample set, a total of three VOCs were detected in the samples as shown in Table 5-7. These VOCs included acetone in four samples, carbon disulfide in four samples, and methylene chloride in sample 05SS135. The three detected VOCs in the supplemental investigation, were below both residential and industrial soil RBCs.

One semivolatile organic compound (bis(2-ethylhexyl)phthalate) was detected in surface soil sample 05SS130 at a concentration of 430J Fg/kg as shown in Table 5-7. The detected SVOC is below both residential and industrial soil RBCs.

Six pesticides (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endrin, heptachlor, and methoxychlor) were detected in the surface soil samples as indicated in Table 5-7. These reported concentrations did not exceed the residential or industrial RBCs in any of the samples except for sample 05SS130 (Site ID 05SS103). 4,4'-DDE was detected at a concentration of 3,500CD Fg/kg which exceeds the Residential RBC as shown on Figure 5-1.

Nineteen inorganic compounds were detected in the supplemental investigation surface soil samples as shown in Table 5-8. All six samples had levels of inorganics which exceeded at least one of the three criteria. A total of six compounds exceeded two-times the average detected background concentrations. These included antimony, beryllium, cadmium, lead, nickel, and silver. Three of the detected constituents (antimony, cadmium, and silver) were not detected in the background soils. One compound exceeded the residential RBC standard including iron. Iron exceeded the residential RBC in four of the six samples ranging from 31,700 to 69,900 mg/kg. None of the industrial RBCs were exceeded in these samples. Exceedances of the screening criteria are also presented on Figure 5-1.

5.2.1.2 RFI Investigation

A total of fifteen surface soil samples and one duplicate sample were collected in this area during the RFI investigation. Within the surface soil organic sample set, a total of four VOCs were detected in two samples as shown in Table 5-7. These VOCs included acetone in sample 1MW02-00, ethyl benzene, tetrachloroethene, and xylene in sample 1SB01-00. The four detected VOCs were below both residential and industrial soil RBCs. It should be noted that acetone is a common laboratory contaminant and was identified in the QA/QC samples for this SWMU (see Section 5.5), and therefore is not believed to be site related.

Fifteen semivolatile organic compounds were detected in four of the surface soil samples as shown in Table 5-7. The majority of which are classified as polynuclear aromatic hydrocarbons (PAHs). The majority of the detections were from three of the samples (1SS06, 1SS07, and 1SB03-00,). These three samples are limited to the southwest portion of the site where the majority of disposal activity occurred. The residential RBCs for soil were exceeded for benzo(a) anthracene, benzo(a) pyrene, benzo(b) fluoranthene, and dibenzo(a,h) anthracene in sample 1SS06. Benzo(a) pyrene also exceeded the residential RBC in sample 1SB03-00 at a concentration of 260 J µg/kg. No industrial RBCs were exceeded in any of the samples. Figure 5-1 displays the exceedances of the screening criteria.

Two pesticides (4,4'-DDE and 4,4'-DDT) were detected in the surface soil samples with the exception of samples 1SS01, 1SS03, 1SS08 1MW01-00, and 1MW02-00, as indicated in Table 5-7. Those samples reporting pesticide detections are limited to the western portion of the site where the majority of disposal activity occurred. These reported concentrations did not exceed the residential or

industrial RBCs. Additionally, there were no PCBs, dioxins, chlorinated herbicides, op-pesticides, explosives, or asbestos reported above the method detection limits in this sample set.

Seventeen inorganic compounds were detected in the RFI surface soil samples as shown in Table 5-8. All fifteen samples had levels of inorganics which exceeded at least one of the three criteria. A total of eleven compounds exceeded two-times the average detected background concentrations. These included antimony, arsenic, beryllium, cadmium, copper, lead, nickel, silver, sulfide, tin, and zinc. Four of the detected constituents (antimony, cadmium, silver, and sulfide) were not detected in the background soils. Two compounds exceeded the residential RBC standard including arsenic and cadmium. Arsenic exceeded the residential RBC in three samples ranging from 0.67 to 2.8 mg/kg, while cadmium exceeded the residential RBC in one sample at a concentration of 83.8 mg/kg. None of the industrial RBCs were exceeded in this sample set. Exceedances of the screening criteria are also presented on Figure 5-1. It should also be noted that cyanide was not detected in this sample set.

5.2.1.3 Summary

The only organics constituents detected above the screening criteria were from three sampling locations in the southwestern portion of the site. These locations fall within the approximate extent of the disposal area identified from the geophysical survey and aerial photo analysis (see Figure 2-3) and to the areas where possible fill was encountered during drilling operations at the site. The SVOCs detected were above the residential RBCs but below the industrial RBCs and they are all classified as PAHs. Only one pesticide was detected above the residential RBC at one location from the southwestern portion of the site. This detection was from the sampling performed during the supplemental investigation. It should be noted that no other exceedances of pesticides have occurred in any of the investigations conducted after the Supplemental Investigation. This detection along with the low levels of 4,4'-DDE and 4,4'-DDT (below screening levels) reported in the samples collected from the western portion of the site may be attributed to former routine application of pesticides at the site.

Inorganics compounds were detected across the site consistently for antimony, beryllium, and cadmium as presented on the isopleth maps for these constituents (Figures 5-2, 5-3, and 5-4, respectively). The isopleth maps of antimony and beryllium in surface soil (Figures 5-2 and 5-3) present those

concentrations which exceed two times the average detected background concentrations. It should be noted that antimony and beryllium were not detected above their respective residential or industrial RBC values. The isopleth for cadmium has a similar pattern as that of the antimony and beryllium concentrations. The cadmium detections were above the background concentrations with one of the 22 samples being detected in excess of the residential RBC. Iron was detected above the residential RBC at isolated locations from the southwestern portion of the site as shown on the isopleth map presented on Figure 5-5. The iron concentrations exceeded the residential RBC in four of the six samples. Lead was also detected in the surface soils above the background concentrations from the southwestern portion of the site as presented on Figure 5-6. The antimony and beryllium concentrations were not detected in the background surface soil samples.

5.2.2 Subsurface Soil

Subsurface soil samples were collected during both the supplemental investigation and the RFI investigation. The results of which are included in the following subsections.

5.2.2.1 Supplemental Investigation

A total of six subsurface soil samples (05SS127, 05SS129, 05SS131, 05SS133, 05SS136, and 05SS139), and two duplicate samples (05SS134 and 05SS137) and three background subsurface soil samples were collected in this area during the supplemental investigation. Within the subsurface soil organic sample set, a total of two VOCs were detected in the samples as shown in Table 5-9. These VOCs included acetone in three samples and carbon disulfide in five samples. The two detected VOCs in the supplemental investigation, were both below both residential and industrial soil RBCs.

One semivolatile organic compound (bis(2-ethylhexyl)phthalate) was detected in subsurface soil samples 05SS136 and 05SS139 at concentrations ranging from 400 J to 420 J Fg/kg as shown in Table 5-9. The detected SVOC is below both residential and industrial soil RBCs.

Eight pesticides (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, gamma-chlordane, delta-BHC, endrin, endrin aldehyde, and methoxychlor) were detected in four of the six subsurface soil samples as indicated in Table 5-9. These reported concentrations did not exceed the residential or industrial RBCs in any of

the samples. The four samples with the pesticide detections are located in the western side of the SWMU.

Twenty inorganic compounds were detected in the supplemental investigation subsurface soil samples as shown in Table 5-10. All nine samples had levels of inorganics which exceeded at least one of the three criteria. A total of eight compounds exceeded two-times the average detected background concentrations. These included antimony, barium, beryllium, cadmium, cobalt, lead, selenium, and silver. Two of the detected constituents (antimony and silver) were not detected in the background soils. One compound exceeded the residential RBC standard including iron. Iron exceeded the residential RBC of 23,464 mg/kg in four of the nine samples ranging from 25,900 to 48,800 mg/kg. None of the industrial RBCs were exceeded in this sample set. Exceedances of the screening criteria are also presented on Figure 5-7.

5.2.2.2 RFI Investigation

A total of sixteen subsurface soil samples and two duplicate samples were submitted for laboratory analysis from SWMU 1 during the RFI investigation. Three VOCs were detected in two of the subsurface soil samples, including 1,2-Dibromo-3-chloropropane, and tetrachloroethene in sample 1SB01-02/05 and benzene in sample 1SB03-06 as presented in Table 5-9; however, none exceeded their respective residential or industrial soil RBCs.

One SVOC (di-n-butylphthalate) was detected in three samples ranging in concentration from 45 J Fg/kg to 90 J Fg/kg. All of the SVOC detections were below the screening criteria as indicated in Table 5-9. Three pesticides (4,4'-DDT, dieldrin, and endosulfan I) were detected in subsurface soil sample 1MW04-04 as shown in Table 5-9. None of the detected concentrations exceeded the industrial or residential RBCs.

Dioxins [total HxCDD, total Hexachlorodibenzofuran (HxCDF), and total Tetradichlorodibenzofuran (TCDF)] were detected in three of the sixteen samples (1MW01-02, 1MW05-05, and 1SB03-03) and exceeded the residential RBC as presented in Table 5-9 and shown on Figure 5-7. Sample 1MW01-02 is situated along Kearsage Road leading to the Coast Guard Pier near the perimeter of the mangrove swamp and reported total TCDF at 0.09 J µg/kg. Soil boring 1SB03-03 is located near the southwest

portion of the site in the general vicinity of the former trenches. In the uppermost subsurface sample at this location (6 to 8 feet bgs), total HxCDD was reported at 0.3 J µg/kg and total HxCDF was reported at 0.17 J µg/kg. Sample 1MW05-05 is located adjacent to the access roadway off of Kearsage Road. Additionally, there were no chlorinated herbicides, op-pesticides, explosives, or asbestos reported above the method detection limits for this sample set.

Sixteen inorganic compounds were detected in the RFI subsurface soil samples as indicated in Table 5-10. Thirteen of the sixteen sample locations reported inorganic concentrations which exceeded at least one of the three criteria. There were no reported concentrations of cyanide or sulfide above the method detection limits. There were eleven compounds which exceeded two-times the average detected background concentration. These included antimony, barium, beryllium, cobalt, copper, lead, mercury, selenium, silver, tin, and zinc. None of the detected compounds exceeded the residential or industrial RBCs. All exceedances of the screening criteria are presented on Figure 5-7.

5.2.2.3 Summary

Analytical results from the subsurface soil sample set shows that this media has been minimally impacted by past operations. The only organic constituents detected above the screening criteria were dioxins from three of the sampling locations as identified on Figure 5-7. The dioxin detections were located from two of the monitoring wells along Kearsage Road in the northeastern portion of the site and from one of the soil borings west of the Navy Lodge. There presence along roadways indicate the possibility that they are related to former applications of herbicides to keep the road shoulders clear. Dioxins are known to have been present in some herbicides. Research on herbicide use at NSRR is ongoing in response top comments received on other documents.

Inorganic compounds were detected consistently across the site except for antimony as presented on the isopleth map generated for antimony (Figure 5-8). Antimony was detected in excess of two times the average detected background concentration but less than the residential and industrial RBCs. These areas are from the western and northeastern portions of the site and correspond well with antimony in surface soil (see Figure 5-2). Beryllium and iron were detected in the southwestern portion of the site as shown on Figures 5-9 and 5-10. Beryllium was detected above the background concentrations but below the RBC values while iron was detected above the residential RBC in five

of the eleven samples. The beryllium and iron detections in the surface soil correspond well with those detected in the surface soil (see Figures 5-3 and 5-5).

It should be noted that the areas identified in the isopleth maps presenting positive detections above the screening criteria correspond well with the results from the geophysical survey and the areas identified during the aerial photo interpretation analysis (see Figure 2-3).

5.2.3 Sediment

Sediment samples were collected during the confirmation study, relative risk ranking, and the RFI investigation. The results of which are discussed in the following subsections.

5.2.3.1 Confirmation Study

A total of ten sediment samples were collected in this area during the confirmation study. Within the sediment organic sample set, one VOC (methylene chloride) was detected in five of the ten samples as shown in Table 5-11. There are no criteria established for this constituent. It should be noted that the detection of methylene chloride was from the samples obtained during the second round of sediment sampling under this investigation.

Three semivolatile organic compounds [bis(2-ethylhexyl)phthalate, di-n-octylphthalate, and phenols] were detected in the sediment samples. Bis(2-ethylhexyl)phthalate was detected in one sample (5SE1) at a concentration of 100 Fg/kg. Di-n-octylphthalate was detected in four samples at concentrations ranging from 500 to 4,000 Fg/kg. Phenols were detected in four samples at concentrations ranging from 2,500 to 29,800 Fg/kg as shown in Table 5-11. No ERL or ERM sediment screening values have been established for any of these constituents.

Two pesticides (4,4'-DDE and delta-BHC) were detected in the sediment samples as indicated in Table 5-11. These reported concentrations of 4,4'-DDE exceeded the ERL and ERM sediment screening values in both of the samples which it was detected during the second round of sampling. No ERL or ERM sediment screening values have been established for delta-BHC which was detected in two of

the sediment samples from the first round of sampling. Exceedances of the screening criteria are also presented on Figure 5-11.

Twelve inorganic compounds were detected in the confirmation study sediment samples as shown in Table 5-12. All ten of the samples had levels of inorganics which exceeded the ERL sediment screening value. Six constituents exceeded the ERL screening criteria. These included arsenic, cadmium, copper, lead, nickel, and silver. None of the ERM sediment screening values were exceeded in this sample set. Exceedances of the screening criteria are also presented on Figure 5-11

5.2.3.2 Relative Risk Ranking

A total of three sediment samples were collected in this area during the relative risk ranking. Within the sediment organic sample set, one VOC (tetrachloroethene) was detected in two of the three samples at a concentration of 2J Fg/kg as shown in Table 5-11. There are no criteria established for this constituent.

One semivolatile organic compounds (bis(2-ethylhexyl)phthalate) was detected in two of the three sediment samples (1SD01 and 1SD03) at concentrations of 130J and 110J Fg/kg, respectively as shown in Table 5-11. No ERL or ERM sediment screening values have been established for this constituent. No pesticides/PCBs, dioxins, chlorinated herbicides, or op-pesticides were detected in the sediment samples.

Twelve inorganic compounds were detected in the relative risk ranking sediment samples as shown in Table 5-12. One of the three samples exceeded the ERL sediment screening value for copper. Only one compound (copper) exceeded the ERL screening criteria at a concentration of 110 mg/kg in sediment sample 1SD02. None of the ERM sediment screening values were exceeded in this sample set. Exceedances of the screening criteria are also presented on Figure 5-11

5.2.3.3 RFI Investigation

According to the approved work plans, three sediment samples were to be collected if leachate seepage and/or ponded surface water was observed. These surface features were not observed during the field

investigation resulting in three sediment samples being collected from shallow swales where surface runoff would most likely occur. Sample 1SD01 was collected just south-southeast of well 5GW03; 1SD02 was collected southeast of 1MW04 adjacent to the mangrove swamp; and, 1SD03 was collected adjacent to the mangrove south-southwest of 5GW04 (Figure 5-11). Each of these samples were analyzed for the full appendix IX list, explosives, asbestos, and TOC.

Xylene was the only VOC detected in the sediment samples. It was detected in one sample (1SD03) at a concentration of 2 J µg/kg. Ten SVOCs were detected in sample 1SD01 as shown in Table 5-11. Pyrene was detected in sample 1SD02. It should be noted that the majority of the SVOCs, detected are PAHs. None of the VOCs or SVOCs detected in the sediment samples exceeded any of the established screening criteria.

Three pesticides (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT) and one PCB (Aroclor-1260) were detected in the sediment samples as presented in Table 5-11. 4,4'-DDE was detected at two locations above the ERL and ERM sediment screening value ranging from 370 µg/kg (1SD02) to 930 µg/kg (1SD01). 4,4'-DDT was detected in two samples above the ERM sediment screening value ranging from 63 µg/kg (1SD02) to 130 µg/kg (1SD01). Aroclor 1260 was detected in sample 1SD02 at a concentration of 440 µg/kg which was above the ERM sediment screening value. The exceedances of the screening criteria are shown on Figure 5-11.

Four dioxins (total HxCDD, total HxCDF, total PeCDF, and total TCDF) were also detected in the sediment samples as shown in Table 5-11. All four of the dioxins were detected in sample 1SD02 while two of the four dioxins were detected in sample 1SD01. There are no sediment screening values for these constituents. Additionally, there were no chlorinated herbicides, op-pesticides, explosives, asbestos, or TOC reported above the method detection limits for the sediment samples.

A total of 16 different inorganic compounds were detected in the sediment samples. All three sample locations reported at least one inorganic compound which exceeded the ERL, ERM, or both sediment screening values (Table 5-12). There was a total of six compounds which exceeded the ERL sediment screening value in two of the samples (1SD01 and 1SD02). These included cadmium, copper, lead, mercury, nickel, and zinc. There was a total of five compounds which exceeded the ERM sediment screening value. These included copper, lead, mercury, nickel, and zinc as shown on Figure 5-11.

5.2.3.4 Summary

Four of the eleven sediment samples appear to be affected by past site operations. This is evidenced by the detections of pesticides above the screening criteria. These four samples were collected near the mangrove swamp along the southern edge of the site with the majority of them along the southwestern edge of the site. The detections of the pesticides along the southwestern edge of the mangrove swamps are located in the general vicinity of a similar detection in one of the surface soil samples (4,4'-DDT in 05SS103). 4,4'-DDE was the most commonly detected pesticide above the screening criteria. An isopleth map presenting the approximate extent of organic sediment contamination is presented on Figure 5-12. No other organic constituents were detected in the sediment samples above the screening criteria.

The majority of the inorganic detections in excess of the screening criteria have occurred in the southwestern portion of the site as presented on Figure 5-11. Arsenic, cadmium, and copper were detected in excess of the screening criteria along the southern boundary of the site as indicated on Figures 5-13, 5-14, and 5-15, respectively.

The locations of the constituents of concern correspond well to the approximate extent of the site identified through the geophysical survey and aerial photo analysis interpretation.

5.2.4 Groundwater

Groundwater samples were collected during the confirmation study, supplemental investigation, and the RFI investigation. The results of which are included in the following subsections.

5.2.4.1 Confirmation Study

A total of ten groundwater samples were collected from SMWU 1 during two rounds of groundwater sampling from monitoring wells (5GW01, 5GW02, 5GW03, 5GW04, and 5GW05) during the confirmation study.

Chloroform and 1,1,2,2-tetrachloroethane were the only VOCs detected at concentrations of 0.54 and 1.1 µg/L, respectively from sample 5GW1. These detections only occurred during the first round of groundwater sampling. Both of these values exceed the tap water RBC but are below the federal MCL as shown in Table 5-13.

Two SVOCs (pentachlorophenol and bis(2-ethylhexyl)phthalate) were detected in the groundwater samples from the first round of sampling as presented in Table 5-13. The detected concentration of pentachlorophenol exceeded both the tap water RBC and federal MCL in all four samples in which it was detected. The detection of bis(2-ethylhexyl)phthalate occurred in monitoring wells 5GW04 and 5GW05 during both rounds of sampling. Only the sample obtained during the second round of sampling from 5GW05 exceeded the screening criteria for bis(2-ethylhexyl)phthalate as shown in Table 5-13. Phenols were detected in all five samples obtained during the second round of groundwater sampling as presented in Table 5-13. The positive detections of phenol were below the tap water RBC. The exceedances of the screening criteria are spatially presented on Figure 5-16.

Two pesticides (aldrin and beta-BHC) were detected in the groundwater samples collected from the first round of groundwater sampling. Aldrin was detected in sample 5GW1 at a concentration of 0.045 µg/L which exceeds the tap water RBC as indicated in Table 5-13 and on Figure 5-16. Beta-BHC was detected in sample 5GW2 at a concentration of 0.02 µg/L which is below the tap water RBC as shown in Table 5-13.

A total of ten different inorganic constituents were detected in the total fraction of the groundwater samples as presented in Table 5-14. Six of the 10 detected inorganic (total) compounds were reported at concentrations in excess of at least one of the screening criteria. There were six compounds which exceeded their respective federal MCLs. These include arsenic, beryllium, chromium, copper, selenium, and thallium. The federal MCL for thallium was exceeded in six of the samples ranging from 9.64 to 4.310 µg/L. Arsenic, chromium, and selenium exceeded the federal MCL in three samples, while copper exceeded the federal MCL in two samples and beryllium in one sample. There were five compounds which exceeded the tap water RBC. These include arsenic, chromium, copper, selenium, and thallium. Thallium exceeded the tap water RBC in six samples, arsenic in five samples, chromium in three samples , and copper and selenium in two samples as shown on Figure 5-16.

5.2.4.2 Supplemental Investigation

One groundwater sample (05GW101) was collected from SMWU 1 during the groundwater sampling from monitoring well 5GW01 during the Supplemental Investigation.

VOCs were not analyzed for sample 05GW101. One SVOC (bis(2-ethylhexyl)phthalate) was detected in the groundwater sample at a concentration of 3 J Fg/l, which is below the listed criteria as presented in Table 5-13.

One pesticide (heptachlor) was detected in sample 05GW101 at a concentration of 0.0032 J µg/L, which exceeds the tap water RBC as indicated in Table 5-13 and on Figure 5-16. It should be noted that this constituent was not detected during the previous two rounds of sampling performed during the confirmation study.

A total of 10 different inorganic constituents were detected in the total fraction of the groundwater sample obtained during this investigation as presented in Table 5-14. However, none of these 10 constituents exceeded either of the listed criteria.

Nine different inorganics were detected in the dissolved fraction of the groundwater sample. One of the nine detected inorganic (dissolved) compounds was detected in excess of both the federal MCLs and tap water RBCs (Table 5-15). Thallium was detected in sample 05GW101 at a concentration of 16.5J Fg/l. It should be noted that thallium was not detected in the total fraction of the inorganic analysis for this sample. The reason for this occurrence is unknown since this data set was from a previous investigation. None of the other eight dissolved fraction inorganics exceeded the screening criteria.

5.2.4.3 RFI Investigation

A total of nine groundwater samples and one duplicate sample were collected from SMWU 1 including six newly installed wells (1MW01, 1MW02, 1MW03, 1MW04, 1MW05, and 5GW03R) and three existing wells (5GW01, 5GW02, and 5GW04) during the RFI Investigation.

Chloroform was the only VOC detected at a concentration of 2J µg/L from sample 1MW04, which exceeds the tap water RBC as shown in Table 5-13. Chloroform is a common potable water chlorination artifact and is not believed to be site related due to its low concentration. It should also be noted that chloroform was detected in the QA/QC samples for SWMU 1 (see Section 5.5). Two pesticides (4,4'-DDE and aldrin) were detected in the groundwater samples. 4,4'-DDE was detected in sample 1MW02 at a concentration of 0.056J µg/L. Aldrin was detected in three samples ranging in concentration from 0.02 µg/L (1MW01D), to 0.1J µg/L (1MW02), all of which exceed the tap water RBC as indicated in Table 5-13 and on Figure 5-16.

The dioxin, total HxCDD, was detected in sample 5GW02 at a concentration of 0.0005J µg/L, which exceeded the tap water RBC as shown on Figure 5-16. Two chlorinated herbicides [2,4,5-TP (Silvex) and 2,4,5-T] were detected in the groundwater samples as indicated in Table 5-13. 2,4,5-TP (Silvex) was detected in sample 1MW03 at a concentration of 0.081J µg/L, and 2,4,5-T was detected at a concentration of 0.26 µg/L in sample 1MW02. Neither of the concentrations exceeded the listed criteria. Additionally, there were no SVOCs, PCBs, OP pesticides, explosives, or asbestos reported above the method detection limits for the groundwater samples.

A total of 15 different inorganic constituents were detected in the total fraction of the groundwater samples obtained during this investigation as presented in Table 5-14. Nine of the 15 detected inorganic (total) compounds were reported at concentrations in excess of at least one of the screening criteria. There were eight compounds which exceeded their respective federal MCLs. These include antimony, beryllium, cadmium, chromium, copper, lead, mercury, and nickel. The federal MCL for cadmium was exceeded in five of the samples ranging from 5.5J Fg/l (5GW01) to 30.9J µg/L (1MW01). Antimony, chromium, copper, and lead exceeded the federal MCL in two samples, while beryllium, mercury, and nickel exceeded the federal MCL in one sample each. There were five compounds which exceeded the tap water RBC. These include antimony, cadmium, chromium, copper, and vanadium. Vanadium exceeded the tap water RBC in five samples, cadmium in four samples, antimony, chromium, and copper in two samples as shown on Figure 5-16.

Ten different inorganics were detected in the dissolved fraction of the groundwater samples. Two of the ten detected inorganic (dissolved) compounds were detected in excess of both the federal MCLs and tap water RBCs (Table 5-15). Cadmium was detected in six samples with a range from 4.3J Fg/l

in sample 1MW04, to 42.1J Fg/l in sample 1MW01. Four of the detections exceeded both of the listed criteria. Copper was detected in seven of the ten samples, with sample 5GW02 containing the only exceedances with a concentration of 1,680 Fg/l. This concentration of copper exceeded both of the listed criteria. None of the other eight dissolved fraction inorganics exceeded the screening criteria.

5.2.4.4 Summary

Groundwater samples located within the southwest portion of the site appear to be somewhat affected by past site operations as evidenced by the presence of pesticides, chlorinated herbicides, dioxins, and inorganics. Monitoring wells 5GW01, 5GW02, 5GW03, 5GW04, and 5GW05 were sampled during multiple rounds of groundwater sampling. This provides a trend in site contaminants in the groundwater from these wells. Due to the dynamics of the groundwater media, the data from the RFI investigation will be weighted since it represents the most recent conditions of the groundwater.

Two different VOCs were detected during the initial groundwater sampling event but were not detected again. Therefore it is not believed that VOCs have any continuing impact at the site. An isopleth map displaying pentachlorophenol in groundwater from the initial round of groundwater sampling is presented on Figure 5-17. The SVOCs which were detected in the first two rounds of groundwater sampling were not detected in the final round of groundwater sampling; therefore it is not believed that SVOCs have impacted the site. Pesticides have impacted the groundwater above the tap water RBCs but below the Federal MCL in two of the wells in the northeastern portion of the site from monitoring wells 1MW01 and 1MW02 as shown on Figure 5-16. Chlorinated herbicides are also present in the groundwater at low levels in monitoring wells 1MW02 and 1MW03. It should be noted that the levels detected are below the screening criteria. One dioxin was detected above the tap water RBC from monitoring well 5GW02 which is located in the southern portion of the site. It should be noted that dioxins were only analyzed for during the RFI investigation.

Inorganic compounds (total fraction) consistently were found above the tap water RBCs and federal MCLs included arsenic, cadmium, thallium and vanadium. Isopleth maps presenting these trends are presented on Figures 5-18, 5-19, 5-20, 5-21 respectively. The arsenic and thallium detections were detected across the site while the cadmium concentrations are along the northern, eastern, and southern edges of the site. The vanadium exceedances were isolated to the southwestern and northeastern areas

of the site. Dissolved inorganic compounds reported above these criteria included cadmium and thallium. Cadmium was detected in the total fraction while thallium was not detected in the total fraction. It should be noted that the detection of thallium in the dissolved fraction was from an earlier investigation and was not detected above the screening criteria during the RFI investigation.

5.2.5 Surface Water

Surface Water samples were only collected during the Confirmation Study Investigation. The results of which are included in the following subsections.

5.2.5.1 Confirmation Study

A total of ten surface water samples were collected during two rounds of sampling from the confirmation study. Within the surface water organic sample set, no VOCs or pesticides/PCBs were detected in any of the ten samples as shown in Table 5-16. Three SVOCs [bis(2-ethylhexyl)phthalate, di-n-octylphthalate, and phenols] were detected in the surface water samples. Di-n-octylphthalate was the only one of the three constituents which exceeded the applicable criteria in two samples, with a range of 4 Fg/L (5SW3) to 7 Fg/l in sample 5SW2. These detections exceeded the EPA Region III BTAG Screening Levels as presented on Figure 5-22. The other two constituents were detected at levels below their listed criteria. It should be noted that the Federal Ambient Water Quality for these three constituents is not established.

Eight inorganic compounds were detected in the surface water samples as shown in Table 5-17. Five of the eight constituents contained levels of inorganics which exceeded the Federal Ambient Water Quality, which included arsenic, chromium, copper, selenium, and silver. Four of these constituents (arsenic, copper, selenium, and silver) also exceeded the EPA Region III BTAG Screening Values, as presented on Figure 5-22. Zinc also exceeded the BTAG Screening Values, with concentrations of 19.9 Fg/ in sample 5SW4, to 20.8 Fg/l in sample 5SW03.

5.2.5.2 Summary

The exeedances of the screening criteria which were detected during the initial round of surface water sampling were not detected during the second round of surface water sampling. Therefore it is not believed that SWMU 1 has impacted the surface waters with organics.

The only inorganic constituent which was detected above the screening criteria with any consistency was arsenic as shown on Figure 5-13. It should be noted that these detections correspond to the arsenic detected in the sediment during the same sampling event. It should also be noted that arsenic was not detected in the surface water samples during the second round of surface water sampling and the detections of arsenic in the second round of sediment samples were below the screening criteria. It is possible that the exceedances of arsenic in the surface water samples may be due to sediment in the water. This could be caused by poor field sampling techniques. Since this sampling was performed during a prior investigation and there is no indication of the sampling methodology used, this scenario is possible. Figure 5-24 presents the thallium which was detected in the surface water during the first round of surface water sampling. It should be noted that none of these detections are above the screening criteria.

The analytical data presented for the surface water media does not indicate that SWMU 1 has impacted the media.

5.3 SWMU 2 - Langley Drive Disposal Site

Sampling activities were conducted at SWMU 2 under the Confirmation Study, Supplemental Investigation, Relative Risk Ranking, and the RFI Investigation. The results from these investigations have been combined together into one unified database to assist in evaluating the environmental impact, if any, to this SWMU.

The Confirmation Study involved two rounds of sampling. The first round was held in December of 1985, and involved the collection of 15 surface soil samples, four surface water samples, and four sediment samples. These samples were submitted to the laboratory for analysis of VOCs, SVOCs, pesticides, PCBs, and inorganics. The second round was held in November of 1987, and involved the

collection of one groundwater sample, 13 surface soil samples, two subsurface soil samples, and three surface water and sediment samples. All of these samples except for the surface soil were submitted to the laboratory for analysis of VOCs, SVOCs, Pesticides/PCBs, and inorganics. The surface soil samples were only analyzed for lead. Surface soil samples R6S10A, R6S09A, R6S010A, and R6S011A were also analyzed for EP TOX lead.

The Supplemental Investigation was performed in November of 1992. During this investigation, one groundwater sample, seven surface soil samples, and seven subsurface soil samples were collected. All of these samples except two soil samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics. Surface soil sample 06SS155D was only analyzed for pesticides/PCBs and inorganics while subsurface soil sample 06SS152, was only analyzed for pesticides/PCBs.

The Relative Risk Ranking was performed during October of 1995. Four sediment samples were collected during this investigation and analyzed for VOCs, SVOCs, pesticides/PCBs, sulfide and inorganics.

Sampling activities at SWMU 2 also occurred during the RFI investigation, and involved the collection of nine surface soil samples, ten subsurface soil samples, three sediment samples, and four groundwater samples. These samples were submitted to the laboratory for analysis of the full appendix IX list, explosives, and asbestos. In addition to this parameter list, the sediment samples were also analyzed for TOC, and the groundwater samples were additionally analyzed for sodium. Groundwater sample 6GW01, was also analyzed for TOC, COD, and TSS.

5.3.1 Surface Soil

Surface soil samples were collected during the confirmation study, supplemental investigation, and the RFI investigation. The results of which are included in the following subsections. A complete set of the analytical data is presented in Appendix F.

5.3.1.1 Confirmation Study

Round 01

A total of fifteen surface soil samples were collected from SWMU 2 during the first round of the Confirmation Study. There were no positive detections of VOCs or pesticides/PCBs in any of the surface soil samples. Eleven SVOCs were detected in the surface soil samples, with the majority of the detections from two of the samples (R6S5A and R6S6A) as presented in Table 5-18. Benzo(a)pyrene was the only constituent exceeding the residential RBC in sample R6S6A, with a concentration of 200 µg/kg as shown on Figure 5-25.

Eleven inorganic compounds were detected in the surface soil samples as indicated in Table 5-19. All fifteen sample locations reported inorganic concentrations which exceeded at least one of the screening criteria. All eleven compounds had exceedances of two-times the average detected background concentration. Arsenic exceeded the industrial RBCs in fourteen of the fifteen samples ranging from 12.7 mg/kg (R6S6A) to 134 mg/kg (R6S7A). Three compounds exceeded the residential RBC which included arsenic (14 samples), antimony and selenium (one sample each). The rest of the inorganic detections were below the respective screening criteria. Sample R6S10A was also analyzed for EP TOX lead, which had a positive detection of 2.8 mg/kg as presented in Table 5-19.

Round 02

A total of thirteen surface soil samples were collected from SWMU 2 during the second round of sampling of the confirmation study. These samples were only analyzed for lead, with three of the samples additionally analyzed for EP TOX lead as presented in Table 5-19.

All thirteen samples exceeded two times the average detected background for lead. These exceedances ranged from 35.1 mg/kg in sample R6S011A, to 988 mg/kg in sample R6S09A as presented on Figure 5-25. There are no industrial or residential RBCs established for lead.

Samples R6S09A, R6S011A, and R6S12A had positive detections of EP TOX lead. These levels ranged from 2.8 mg/kg (R6S012A), to 10.6 mg/kg (R6S09A and R6S011A).

5.3.1.2 Supplemental Investigation

A total of seven surface soil samples were collected from SWMU 2 during the Supplemental Investigation. Four VOCs were detected in the samples as shown in Table 5-18. The VOCs included acetone and methylene chloride in five of the six samples and carbon disulfide and toluene each detected in one sample. The four detected VOCs in the supplemental investigation, were below both residential and industrial soil RBCs.

Four SVOCs were detected in one of the six surface soil samples (06SS145), with benzo(a)pyrene being the only compound to exceed any of the listed criteria as shown in Table 5-18. Benzo(a)pyrene exceeded the residential RBC in sample 06SS145 (sampling location 06SS103), with a concentration of 180J Fg/kg as indicated on Figure 5-25. A total of seventeen pesticides were detected which were all below the listed criteria for this sampling set.

Twenty inorganic compounds were detected in the supplemental investigation surface soil samples as shown in Table 5-19. All seven samples had levels of inorganics which exceeded at least one of the three criteria. A total of 13 compounds exceeded two-times the average detected background concentrations. These included antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, vanadium, and zinc. Two of the detected constituents (antimony and cadmium) were not detected in the background soils. Arsenic was the only compound to exceed the industrial RBC in three of the seven samples, with a range from 6.9 mg/kg (06SS153) to 19.6 mg/kg (06SS145). Three compounds exceeded the residential RBC standard, including arsenic, copper, and iron. Arsenic exceeded the residential RBC in four of the seven samples ranging from 3.3 mg/kg in sample 06SS147, to 19.6 mg/kg in sample 06SS145. Copper exceeded the residential RBC in sample 06SS141, with a concentration of 5,850 mg/kg. Iron exceeded the residential RBC in each of the seven samples with the exception of 06SS147 and 06SS153, with concentrations ranging from 38,000 mg/kg (06SS145) to 168,000 mg/kg (06SS141). Exceedances of the screening criteria are also presented on Figure 5-25. The rest of the inorganic detections were below the respective screening criteria.

5.3.1.3 RFI Investigation

A total of eight surface soil samples and one duplicate sample were collected from SWMU 2 during the RFI investigation. Within the surface soil organic sample set, one VOC (1,1,1-Trichloroethane) was detected in two samples as shown in Table 5-18. Samples 2MW01-00 and 2SB02-00 reported concentrations of 1,1,1-Trichloroethane above the method detection limits, but below both the residential and industrial soil RBCs.

Eleven semivolatile organic compounds were detected in the surface soil samples as shown in Table 5-18. The majority of which are classified as polynuclear aromatic hydrocarbons (PAHs). The majority of the detections were from four of the samples (2MW02-00, 2SB03-00, 2SB04-00, and 2SB05-00,). These four samples are limited to the southwest portion of the site. The residential RBCs for soil was exceeded for Benzo(a) pyrene in samples 2SB03-00 and 2SB04-00, with concentrations ranging from 150J Fg/kg (2SB04-00) to 340J Fg/kg (2SB03-00). No industrial RBCs were exceeded in any of the samples. Figure 5-25 displays these exceedances of the screening criteria.

Two pesticides (4,4'-DDE and 4,4'-DDT) were detected in four of the nine surface soil samples as indicated in Table 5-18. These reported concentrations did not exceed the residential or industrial RBCs.

Dioxins (total HxCDD and total HxCDF) were detected in one of the nine samples (2SB03-00), which exceeded the residential RBC as presented in Table 5-18 and shown on Figure 5-25. Sample 2SB03-00 is situated inside the site boundary and reported total HxCDD at a concentration of 0.37J Fg/kg, and total HxCDF at a concentration of 0.17J Fg/kg. Additionally, there were no chlorinated herbicides, op-pesticides, explosives, or asbestos reported above the method detection limits in this sample set.

Fifteen inorganic compounds were detected in the RFI surface soil samples as shown in Table 5-19. All nine samples reported levels of inorganics which exceeded at least one of the three criteria. A total of thirteen compounds exceeded two-times the average detected background concentrations. These included antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, tin, and zinc. Two of the detected constituents (antimony, and cadmium) were not detected in

the background soils. One compound (arsenic) exceeded the residential RBC standard of 0.43 mg/kg in eight samples ranging from 1.1mg/kg (2MW03-00) to 18.6 mg/kg (2SB03-00). Arsenic also contained concentrations which were reported above the industrial RBC of 3.82 mg/kg, with a range from 4.7 mg/kg (2SB02-00D) to 18.6 mg/kg (2SB03-00). Exceedances of the screening criteria are also presented on Figure 5-25. The remaining inorganic detections were below the respective screening criteria.

5.3.1.4 Summary

The only organic constituents detected above the screening criteria were from four sampling locations in the southeastern portion of the site. The SVOC detected (benzo(a)pyrene was above the residential RBC but below the industrial RBC. Figure 5-26 presents an isopleth map of the benzo(a)pyrene concentrations in excess of the residential RBC. Two dioxins were detected in one of the samples at concentrations in excess of the residential RBC. The impact of organic constituents are limited across the site as presented on Figure 5-25.

Inorganics were detected across the site consistently for antimony, arsenic, beryllium, cadmium, copper, lead, nickel, selenium, and zinc as presented on the isopleth maps for these constituents (Figures 5-27, 5-28, 5-30, 5-31, 5-33, 5-35, 5-37, 5-38, and 5-39, respectively). The isopleth maps for antimony, barium, beryllium, cadmium, chromium, cobalt, lead, mercury, nickel, selenium, and zinc present those concentrations which exceeded two times the detected background concentrations. It should be noted that only the arsenic and iron isopleth maps present those exceedances above the residential RBCs. The detections of barium, chromium, iron, and mercury are isolated across the site as presented on Figures 5-29, 5-32, 5-34, and 5-36, respectively.

5.3.2 Subsurface Soil

Subsurface soil samples were collected during the confirmation study, supplemental investigation, and RFI investigation. The results of which are included in the following subsections.

5.3.2.1 Confirmation Study

Two subsurface soil samples (R6S010B and R6S010C) were collected during the second round of sampling of the confirmation study. These samples were only analyzed for lead, as presented in Table 5-21.

Both sample locations reported inorganic concentrations of lead, which exceeded the two times the average background screening criteria. Lead exceeded the background screening criteria of 8.7 mg/kg, with concentrations of 63.6 mg/kg (R6S010C) and 199 mg/kg (R6S010B). Neither the industrial nor the residential RBCs were exceeded in this sample set. Exceedances of the background screening criteria are also presented on Figure 5-40.

5.3.2.2. Supplemental Investigation

A total of five subsurface soil samples (06SS142, 06SS146, 06SS148, 06SS151, and 06SS154), and two duplicate samples (06SS149-DUP and 05SS152-DUP) were collected in this area during the supplemental investigation. Within the subsurface soil organic sample set, a total of nine VOCs were detected in the samples as shown in Table 5-20. The detected VOCs in the supplemental investigation were below both the residential and industrial soil RBCs.

A total of fifteen semivolatile organic compounds were reported above their method detection limits in the subsurface soil samples, the majority of which were detected in sample 06SS146. The concentrations of benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, and dibenzo(a,h)anthracene in sample 06SS146, were the only constituents which exceeded the residential RBCs as shown in Table 5-20 and on Figure 5-40. No other detections exceeded any of the criteria.

Fourteen pesticides were detected in the subsurface soil samples as indicated in Table 5-20. The majority of the detections were from two of the samples (06SS142 and 06SS151). These reported concentrations of pesticides did not exceed the residential or industrial RBCs in any of the samples. Additionally, there were no detections of PCBs, chlorinated herbicides, op-pesticides, explosives, or asbestos.

Twenty-one inorganic compounds were detected in the subsurface soil samples as shown in Table 5-21. All six samples had levels of inorganics which exceeded at least one of the three criteria. A total of eleven compounds exceeded two-times the average detected background concentrations. These included antimony, arsenic, barium, beryllium, cadmium, copper, lead, mercury, nickel, selenium, and zinc. Antimony was not detected in the background soils. Two compounds exceeded the residential RBC standard including arsenic and iron. Arsenic exceeded the residential RBC of 0.4 mg/kg in all six samples, with concentrations ranging from 0.95B mg/kg (06SS148) to 21.4 mg/kg (06SS142). Iron exceeded the residential RBC of 23,464 mg/kg in four of the six samples, with concentrations ranging from 24,400J mg/kg (06SS154) to 238,000 mg/kg (06SS142). Concentrations of arsenic in three of the samples (06SS142, 06SS146, and 06SS154) exceeded the industrial RBCs with a range from 10.5 mg/kg to 21.4 mg/kg. Exceedances of the screening criteria are also presented on Figure 5-40.

5.3.2.3 RFI Investigation

A total of eight subsurface soil samples and two duplicate samples were submitted for laboratory analysis from SWMU 2 during the RFI investigation. Two VOCs were detected in two of the subsurface soil samples, including acetone in sample 2SB04-02 and carbon disulfide in sample 2MW03-01D as presented in Table 5-20; however, these concentrations did not exceed their respective residential or industrial soil RBCs. Acetone is a common laboratory artifact, therefore it is unlikely that it is site related.

Four SVOCs (2-methylnaphthalene, fluorene, phenanthrene, and bis(2-ethylhexyl)phthalate) were reported above the method detection limits in one sample (2SB01-02). These SVOC detections were below both the screening criteria as indicated in Table 5-20. No other SVOCs were detected in any of the other samples.

Dioxins (total HxCDD and total TCDF) were detected in two of the eight samples (2SB04-02 and 2SB05-01/02), which exceeded the residential RBC of 0.043 Fg/kg as presented in Table 5-20 and shown on Figure 5-40. Sample 2SB04-02 is situated along the southwest edge of the site boundary and reported total TCDF and total HxCDD concentrations of 0.28 JS µg/kg and 0.21 JS Fg/kg, respectively. Sample 2SB05-01/02 is located in the southwest portion of the site and reported total

TCDF at a concentration of 0.07 JS Fg/kg. Additionally, there were no pesticides/PCBs, op-pesticides, chlorinated herbicides, explosives, or asbestos reported above the method detection limits for this sample set.

Seventeen inorganic compounds were detected in the RFI subsurface soil samples as indicated in Table 5-21. All ten samples reported inorganic concentrations which exceeded at least one of the three criteria. Eleven compounds exceeded the two-times the average detected background concentration, including antimony, arsenic, barium, cobalt, copper, lead, selenium, silver, sulfide, tin, and zinc. One compound (arsenic) exceeded the residential and industrial RBCs. Arsenic exceeded the residential RBC of 0.4 mg/kg in six of the ten samples, with a range from 0.73J mg/kg to 4.2 J mg/kg. Arsenic exceeded the industrial RBC in sample 2MW03-01, with a range of 4.2 J mg/kg. All exceedances of the screening criteria are presented on Figure 5-40.

5.3.2.4 Summary

Analytical results from the subsurface soil sample set shows that this media has been minimally impacted by past operations. The only organic constituents detected above the screening criteria were four SVOCs above the residential RBC in one sample and dioxins from two of the samples as identified on Figure 5-40. The dioxin detections were located from two of the soil borings in the southwestern portion of the site. The SVOC detections were from one subsurface soil sample location in the eastern portion of the site.

Arsenic was detected consistently across the site as presented on the isopleth map (Figure 5-42). Antimony, iron, lead, selenium, and zinc detections were isolated more to eastern portion of the site as displayed on Figures 5-41, 5-43 through 5-46. The only constituents which exceeded the RBC screening criteria were arsenic (residential and industrial RBCs) and iron (residential RBCs) as shown on Figures 5-42 and 5-43.

5.3.3 Sediment

Sediment samples were collected during the confirmation study, relative risk ranking, and the RFI investigation. The results of which are included in the following subsections.

5.3.3.1 Confirmatory Study

Round 01

A total of three sediment samples were collected in this area during round one of the confirmation study. Within the sediment organic sample set, one VOC (2-butanone) was detected in one of the four samples as shown in Table 5-22. There are no criteria established for this constituent.

Two semivolatile organic compounds (bis(2-ethylhexyl)phthalate and di-n-octylphthalate) were detected in the sediment samples. Bis(2-ethylhexyl)phthalate was detected in one sample (R6SE1) at a concentration of 90 Fg/kg. Di-n-octylphthalate was detected in three samples at concentrations ranging from 200 to 300 Fg/kg as shown in Table 5-22. No ERL or ERM sediment screening values have been established for either of these constituents. Additionally, there were no pesticides/PCBs above their method detection limits.

Nine inorganic compounds were detected in the Round 01 confirmation study sediment samples as shown in Table 5-23. Two of the three samples had levels of arsenic which exceeded the ERL sediment screening value. The concentration of arsenic ranged from 15.1 mg/kg in sample R6SE2, to 16.4 mg/kg in R6SE3. None of the ERM sediment screening values were exceeded in this sample set. Exceedances of the screening criteria are also presented on Figure 5-47.

Round 02

A total of three sediment samples were collected in this area during Round 02 of the confirmation study. Within the sediment organic sample set, no VOCs were detected in the samples collected as shown in Table 5-22.

One semivolatile organic compounds (bis(2-ethylhexyl)phthalate) was detected in two of the three sediment samples. The concentration of bis(2-ethylhexyl)phthalate ranged from 10,000 Fg/kg (R6SE03) to 13,000 Fg/kg (R6SE01) as shown in Table 5-22. No ERL or ERM sediment screening values have been established for this constituent. Additionally, there were no pesticides/PCBs above their method detection limits.

Seven inorganic compounds were detected in the Round 02 confirmation study sediment samples as shown in Table 5-23. Two of the three samples had levels of inorganics which exceeded the ERL sediment screening value. A total of two compounds exceeded the ERL sediment screening value, including cadmium and copper. Cadmium exceeded the ERL sediment screening value in sample R6SE01 with a concentration of 1.71 mg/kg. Copper exceeded the sediment screening value in two samples with concentrations of 35.9 mg/kg (R6SE01) and 57.5 mg/kg (R6SE03). None of the ERM sediment screening values were exceeded in this sample set. Exceedances of the screening criteria are also presented on Figure 5-47.

5.3.3.2 Relative Risk Ranking

A total of three sediment samples (2SD01, 2SD02, and 2SD03) and one duplicate sample (2SD03D) were collected in this area during the relative risk ranking. Within the sediment organic sample set, one VOC (2-butanone) was detected in the duplicate sample, at a concentration of 11J Fg/kg as shown in Table 5-22. There are no criteria established for this constituent.

Fifteen semivolatile organic compounds were detected in the sediment samples as shown in Table 5-22. Eight of the fifteen constituents exceeded the ERL sediment screening values including anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, and pyrene. Three constituents (benzo(a)anthracene, benzo(a)pyrene, and pyrene) also exceeded their respective ERM sediment screening values from the duplicate sample.

Two pesticides (beta-BHC and 4,4'-DDE) were detected in the sediment samples as presented in Table 5-22. 4,4'-DDE was detected in the environmental sample and it's duplicate above the ERL and ERM sediment screening values ranging from 29 Fg/kg (2SD03) to 33 Fg/kg (2SD03D) as presented on Figure 5-47.

Three dioxins (total HxCDD, total HxCDF, and total PeCDD) were detected in the sediment samples as shown in Table 5-22. All three dioxins were detected in duplicate sample 2SD03D, while total HxCDD and total HxCDF were also detected in the corresponding environmental sample 2SD03. No ERL or ERM sediment screening values are established for these dioxins.

Fourteen inorganic compounds were detected in the relative risk ranking sediment samples as shown in Table 5-23. Three of the four samples (2SD02, 2SD03, and 2SD03D) had levels of inorganics which exceeded at least two of the listed criteria. Sample 2SD02 detected copper, lead, mercury, and zinc above the ERL and ERM sediment screening values. Samples 2SD03 and it's duplicate sample 2SD03D reported detections above both screening criteria for copper and mercury, while concentrations of lead and zinc only exceeded the ERL screening values as shown on Figure 5-47.

5.3.3.3 RFI Investigation

A total of three sediment samples were collected from SWMU 2 during the RFI investigation. Within the sediment organic sample set, no VOCs were detected in any of three samples collected as shown in Table 5-22.

One SVOC (benzo(b)fluoranthene) was detected in one of the three sediment samples (2SD02) at a concentration of 63J Fg/kg, as shown in Table 5-22. No ERL or ERM sediment screening values have been established for this constituent. Additionally, there were no pesticides/PCBs or dioxins detected in the sediment samples. The samples were also analyzed for total organic carbon (TOC) which was positively detected in all three samples ranging in concentration from 2.4% (2SD02 and 2SD03) to 3.3% (2SD01).

A total of fifteen different inorganic compounds were detected in the sediment samples. Two of the three samples reported concentrations of inorganic compounds which exceeded at least two of the listed criteria (Table 5-23). There was a total of five compounds which exceeded the ERL sediment screening values. These included cadmium, copper, lead, nickel, and zinc. There was a total of three compounds which exceeded the ERM sediment screening values from sample 2SD02. These included copper, lead, and zinc as shown on Figure 5-47.

5.3.3.4 Summary

Two of the nine sediment sample locations appear to be minimally affected by past site operations. This is evidenced by the detections of SVOCs above the screening criteria as presented on Figure 5-47. These two samples were collected near the mangrove swamp along the southeastern edge of the site.

The detections of the SVOCs along the southeastern edge of the mangrove swamps are located in the general vicinity of similar detections in three of the surface soil samples (benzo(a)pyrene) and one of the subsurface soil samples (06SS146 from sampling location 06SS103). In addition to the SVOCs one pesticide (4,4'-DDE) was detected above the ERL and ERM sediment screening criteria. No other organic constituents were detected in the sediment samples above the screening criteria.

The majority of the inorganic detections in excess of the screening criteria have occurred in the southeastern portion of the site as presented on Figure 5-47. Isopleth maps presenting a minimum of at least four exceedances of the screening criteria have been developed for copper and lead (Figure 5-48 and 5-49, respectively). No other inorganic constituents were detected four or more times above the screening criteria.

5.3.4 Groundwater

Groundwater samples were collected during the confirmation study, supplemental investigation, and the RFI investigation. The results of which are included in the following subsections.

5.3.4.1 Confirmation Study

One groundwater sample (06GW01) was collected from SMWU 2 during the confirmation study.

Chloroform was the only VOC detected at a concentration of 1.7 µg/L, which exceeded the tap water RBC of 0.15 Fg/l. The concentration of chloroform was below the federal MCL of 100 Fg/l as shown in Table 5-24. Chloroform is a common potable water chlorination artifact and is not believed to be site related due to it's low concentration.

Three SVOCs [bis(2-ethylhexylphthalate, pentachlorophenol, and phenols) were detected in the groundwater sample from the second round of sampling as presented in Table 5-24. The detected concentration of pentachlorophenol was the only compound which exceeded the listed criteria. Pentachlorophenol exceeded both the tap water RBC and federal MCL, with a concentration of 11 Fg/l. The exceedances of the screening criteria are spatially presented on Figure 5-50.

Aldrin was the only pesticide detected in the groundwater sample collected from the second round of groundwater sampling. The concentration of aldrin (0.006 µg/l) exceeded the tap water RBC as indicated in Table 5-24 and on Figure 5-50. Additionally, there were no PCBs reported above the method detection limit for this groundwater sample.

A total of three different inorganic constituents (copper, lead, and zinc) were detected in the total fraction of the groundwater samples obtained during the second round of the investigation as presented in Table 5-25. Lead was the only compound of the three previously mentioned which exceeded at least one of the screening criteria. The concentration of lead (121 Fg/l) exceeded its respective federal MCL of 15 Fg/l as shown on Figure 5-50.

5.3.4.2 Supplemental Investigation

One groundwater sample (06GW101) was collected from SMWU 2 during the Supplemental Investigation.

There were no reported VOCs above the method detection limit in this sample. One SVOC [bis(2-ethylhexyl)phthalate], was detected in the groundwater sample at a concentration of 2 J Fg/l, which is below both of the listed criteria as presented in Table 5-24. One pesticide (heptachlor) was detected in the groundwater sample at a concentration of 0.0017NJ µg/L, which did not exceed either of the listed criteria as presented on Figure 5-50. Additionally, there were no PCBs reported above the method detection limits for the groundwater sample.

A total of nine different inorganic (total) constituents were detected in the groundwater sample obtained during this investigation as presented in Table 5-25. However, none of these nine constituents exceeded either of the listed criteria.

A total of eight different inorganic (dissolved) constituents were detected in the groundwater sample obtained during this investigation as presented in Table 5-26. However, none of these eight constituents exceeded either of the listed criteria.

5.3.4.3 RFI Investigation

A total of four groundwater samples (2MW01, 2MW02, 2MW03, and 6GW01) and one duplicate sample (2MW02D) were collected from SMWU 2 during the RFI Investigation.

Chloroform and trichloroethene were the only VOCs detected at levels exceeding at least one of the listed criteria. Chloroform was detected in three of the five samples, with concentrations ranging from 4J Fg/l (2MW01) to 7 Fg/l (2MW02). All three detections were reported at levels exceeding the tap water RBC as shown in Table 5-24. Chloroform is a common potable water chlorination artifact and is not believed to be site related due to its low concentration. Trichloroethene was also detected in three of the five samples, with concentrations ranging from 5 Fg/l (2MW02D) to 7 Fg/l (6GW01). These three concentrations exceeded the tap water RBC, with samples 2MW02 and 6GW01 also exceeding the federal MCL for trichloroethene.

Two SVOCs (isodrin and pentachlorophenol) were detected in the groundwater samples. Isodrin was detected in four of the five samples, but at concentrations below the listed criteria as presented in Table 5-24. Pentachlorophenol was detected in one of the five samples with a concentration of 5J Fg/l (6GW01). This detection exceeded both the federal MCL and the tap water RBC.

Two pesticides (aldrin and heptachlor epoxide) were detected in the groundwater samples. Aldrin was detected in samples 2MW01 and 2MW03, with concentrations of 0.13 µg/l and 0.084 µg/l, respectively. Heptachlor epoxide was detected in one sample (2MW01), with a concentration of 0.04 µg/l. These pesticide concentrations only exceed the tap water RBC as indicated in Table 5-24 and on Figure 5-50.

One chlorinated herbicide (2,4,5-T) was detected in sample 2MW03 at a concentration of 0.13 µg/l, which did not exceed the listed criteria as shown in Table 5-24. Sample 6GW01 was also analyzed for COD, TOC, and TSS, with concentrations consisting of 210,000 mg/l, 46,000 mg/l, and 63,000 mg/l, respectively. Additionally, there were no PCBs, op-pesticides, dioxins, explosives, or asbestos reported above the method detection limits for the groundwater samples.

A total of fifteen different inorganic constituents were detected in the total fraction of the groundwater samples obtained during this investigation as presented in Table 5-25. Four of the fifteen detected inorganic (total) compounds were reported at concentrations in excess of at least one of the listed screening criteria. There were two compounds which exceeded their respective federal MCLs, including antimony and lead. The federal MCL for antimony was exceeded in two of the samples, ranging from 16.1J Fg/l (2MW02) to 19.6J µg/L (2MW03). The federal MCL for lead was exceeded in one sample, with a concentration of 16.9 Fg/l (2MW02). There were three compounds which exceeded their respective tap water RBC, including antimony, arsenic, and vanadium. The tap water RBC for antimony was exceeded in two samples, with a range from 16.1J Fg/l (2MW02) to 19.6J Fg/l (2MW03). The tap water RBC for arsenic was exceeded in two samples with a range from 2.7 Fg/l (2MW02) to 2.8 Fg/l (2MW03). Vanadium exceeded the tap water RBC in two samples, with concentrations ranging from 539 Fg/l (2MW02D) to 631 Fg/l (2MW02) as shown on Figure 5-50.

Ten different inorganics were detected in the dissolved fraction of the groundwater samples. Only one of the ten detected inorganic (dissolved) compounds was detected in excess of at least one of the listed criteria (Table 5-26). The concentration of antimony (21.2J Fg/l) in sample 2MW02D, exceeded both the federal MCL and the tap water RBC.

5.3.4.4 Summary

Groundwater samples located within SWMU 2 appear to be somewhat affected by past site operations as evidenced by the limited presence of VOCs, SVOCs, pesticides, and inorganics.

Chloroform which was detected during the initial groundwater sampling event but was not detected again during the following two sampling events from monitoring well 6GW01. Therefore it is not believed that chloroform has any impact to the site groundwater. Trichloroethene was detected upgradient of the site in two monitoring wells located northwest of the site boundary during the RFI investigation. It should be noted that these detections are below the Federal MCL and above the tap water RBC.

Pentachlorophenol was detected in monitoring well 6GW01 during the initial and final groundwater sampling event but not during the intermediate groundwater sampling event. Both detections were in

excess of the Federal MCL and tap water RBC. Two pesticides were detected above the tap water RBC in two of the monitoring wells. These included aldrin and heptachlor epoxide. These detections were from monitoring wells along the eastern portion of the site. All positive detections in excess of the screening criteria are presented on Figure 5-50.

Inorganic compounds (total fraction) in excess of the screening criteria were randomly detected above the screening criteria as presented on Figure 5-50. Antimony and arsenic were the only two constituents which were similar to the site. Antimony was detected in only one sample above the screening criteria for the dissolved portion of the inorganic analysis. This detection was from monitoring well 2MW02. Antimony was also detected in the total fraction from the same monitoring well.

5.3.5 Surface Water

Surface water samples were only collected during the Confirmation Study Investigation.

Round 1

A total of three surface water samples were collected during the first round of the confirmation study. Within the surface water organic sample set, no VOCs or pesticides/PCBs were detected in any of the three samples as shown in Table 5-27. Two SVOCs [bis(2-ethylhexyl)phthalate, and di-n-octylphthalate] were detected in the surface water samples, but at concentrations below the EPA Region III BTAG Screening Levels. It should be noted that the Federal Ambient Water Quality Criteria for these two constituents is not established.

Ten inorganic (total) compounds were detected in the sediment samples as shown in Table 5-28. Seven of the ten constituents contained levels of inorganics which exceeded the Federal Ambient Water Quality, including chromium, copper, lead, mercury, nickel, selenium, and zinc. Six of these constituents (copper, lead, mercury, nickel, selenium, and zinc) also exceeded the EPA Region III BTAG Screening Values, as presented on Figure 5-51.

Round 02

A total of three surface water samples were collected during the second round of the confirmation study. Within the surface water organic sample set, no VOCs or pesticides/PCBs were detected in any of the three samples as shown in Table 5-27. Two SVOCs [bis(2-ethylhexyl)phthalate, and phenols] were detected in the surface water samples, but at concentrations below the EPA Region III BTAG Screening Levels. It should be noted that the Federal Ambient Water Quality for these two constituents is not established.

Five inorganic (total) compounds were detected in the sediment samples as shown in Table 5-28. Four of the five constituents contained levels of inorganics which exceeded the Federal Ambient Water Quality, including chromium, copper, selenium, and silver. Four of the five constituents (copper, selenium, silver, and zinc) exceeded the EPA Region III BTAG Screening Values, as presented on Figure 5-51.

Summary

The analytical data presented for the surface water media at SWMU 2 does not indicate that the site has impacted the media.

The only organic constituents detected were three SVOCs all of which were well below their respective screening criteria.

Only three inorganic compounds were consistently detected above the screening levels from the initial round of sampling to the final round of sampling. These consisted of chromium, selenium, and silver and are spatially presented on Figure 5-51.

5.4 SWMU 45 - Building 38 Exterior

Sampling activities at SMWU 45 was performed during two field investigations (fall of 1996 and the fall of 1997) in accordance with the SWMU 45 RFI. The 1996 RFI Investigation involved the collection of five surface soil samples, nine subsurface soil samples, and nine groundwater samples

from four hydropunch and four monitoring well locations. These samples were submitted to the laboratory for analysis of VOCs, SVOCs, PCBs, and RCRA Metals.

The sampling conducted at SWMU 45 during the 1997 RFI Investigation involved the collection of 20 subsurface soil, 11 sediment, and 16 groundwater samples. These samples were analyzed for VOCs, SVOCs, PCBs, appendix IX metals, and TPH DRO and GRO. In addition to the parameters just mentioned, groundwater samples were also analyzed for TOC. Sample 11-SB22-06 was only analyzed for PCBs during this investigation.

5.4.1 1996 RFI Investigation

This investigation was limited to the general area of the USTs associated with Building 38 and the area where PCB contaminated soils were removed. The purpose was to assess whether releases had occurred to soil and/or groundwater around the UST, and whether PCBs had migrated to groundwater. Compounds detected in the SWMU 45 samples obtained during the 1996 investigation are shown in Table 5-29 through 5-35, and the results of which are included in the following subsections. A graphical presentation of those compounds detected at concentrations in excess of the screening criteria are shown on Figures 5-52 and 5-53. A complete set of the analytical data is presented in Appendix F.

5.4.1.1 Surface Soil

A total of four surface soil samples (45MW01-00, 45MW02-00, 45MW03-00, and 45MW04-00), and one duplicate sample (45MW04-00D) were collected during the 1996 investigation. There were no VOCs or SVOCs present within the surface soil organic sample set. One PCB (Aroclor-1260) was detected in two of the four surface soil samples and the duplicate sample as indicated in Table 5-29. These reported concentrations did not exceed the residential or industrial RBCs in any of the samples collected.

Six RCRA metals were detected in the samples collected as shown in Table 5-30. All six samples reported levels of inorganics which exceeded at least one of the three criteria. A total of three constituents exceeded two-times the average detected background concentrations, including arsenic, barium, and cadmium. Arsenic also exceeded the residential RBC standard in three of the four

samples, with a range from 1.1J (45MW04-00D) to 3.3J mg/kg (45MW02-00) and the duplicate sample. None of the industrial RBCs were exceeded in this sample set. Exceedances of the screening criteria are also presented on Figure 5-52.

5.4.1.2 Subsurface Soil

A total of eight subsurface soil samples (45MW01-02, 45MW01-03, 45MW02-01, 45MW02-02, 45MW03-03, 45MW03-04, 45MW04-01, and 45MW04-02), and one duplicate samples (45MW03-03D) were collected from SWMU 45 during this investigation. Within the subsurface soil organic sample set, acetone was the only VOC reported above its method detection limit as shown in Table 5-31. Acetone was detected in sample 45MW03-04, but at a level below both the residential and industrial soil RBCs. It should be noted that acetone is a common laboratory artifact and may not be site related.

One semivolatile organic compound (benzo(g,h,i)perylene) was detected in subsurface soil duplicate sample 45MW03-03D at a concentration of 61 J Fg/kg as shown in Table 5-31. This detected SVOC is below both the residential and industrial soil RBCs. Additionally, there were no PCBs reported above the method detection limits for this sample set.

Five RCRA Metal compounds were detected in the subsurface soil samples during this investigation as shown in Table 5-32. All eight samples had levels of inorganics which exceeded at least one of the three criteria. Only one compound (arsenic) exceeded two-times the average detected background concentration. Arsenic exceeded the background concentration of 2.05 mg/kg in six of the eight samples, with a range from 2.4J mg/kg (45MW03-04) to 3.9J mg/kg (45MW04-01). This compound also exceeded the residential RBC of 0.43 mg/kg in all the samples, with concentrations ranging from 0.49J mg/kg (45MW01-03) to 3.9J mg/kg (45MW04-01). The concentration of arsenic (3.9J mg/kg) in sample 45MW04-01, was the only constituent detected in excess of the listed industrial RBC. Exceedances of the screening criteria are also presented on Figure 5-52.

5.4.1.3 Groundwater

A total of eight groundwater samples (45HP01, 45HP02, 45HP03, 45HP04, 45MW01, 45MW02, 45MW03, and 45MW04) and one duplicate sample (45MW01D) were collected from SMWU 45 during the 1996 investigation.

Acetone was the only VOC reported above the method detection limit, with a concentration of 12J Fg/l in sample 45MW04. This detection did not exceed the tap water RBC as shown in Table 5-33. It should be noted that no federal MCL has been established for acetone. It should also be noted that acetone is a common laboratory artifact and may not be site related.

Three SVOCs (acenaphthene, bis(2-ethylhexyl)phthalate, and phenol) were detected in the groundwater samples during this investigation as presented in Table 5-33. The concentration of bis(2-ethylhexylphthalate in sample 45MW02 (64J Fg/l), was the only compound of the three which exceeded at least one of the listed criteria. This detection exceeded both the federal MCL and the tap water RBC. The concentrations of acenaphthene and phenol were both below the listed criteria. The exceedances of the screening criteria are spatially presented on Figure 5-53.

One PCB (aroclor-1260) was reported above the method detection limit for this sampling set. The concentration of aroclor-1260 (0.35 Fg/l) in sample 45HP02 exceeded the tap water RBC as indicated in Table 5-33 and on Figure 5-53 but was below the Federal MCL.

A total of six different RCRA metals (total) were detected in the groundwater samples obtained during this investigation as presented in Table 5-34. Four of the six detected RCRA metals compounds were reported at concentrations in excess of at least one of the listed screening criteria. A total of four compounds exceeded their respective federal MCLs, including arsenic, cadmium, chromium, and lead. The federal MCL for chromium was exceeded in five of the samples ranging from 104Fg/l (45MW02) to 182 µg/l (45MW01). Cadmium exceeded the Federal MCL in five samples, while lead exceeded the Federal MCL in four samples and arsenic exceeded the federal MCL in two samples. A total of three compounds exceeded their respective tap water RBCs, including arsenic, cadmium, and chromium. Arsenic exceeded the tap water RBC in six samples, chromium in four samples, and cadmium in one sample as shown on Figure 5-53.

A total of four different RCRA metals (dissolved) were detected in the groundwater samples obtained during this investigation as presented in Table 5-35. Two of the four RCRA metals(dissolved) compounds were reported at concentrations in excess of at least one of the screening criteria. Cadmium was the only compound to exceed the Federal MCL, with a concentration of 5.6 µg/l in sample 45HP01. Arsenic was the only compound to exceed the tap water RBC in four samples, ranging in concentration from 2.5J µg/l (45MW01) to 16.1J µg/l (45HP01) as shown on Figure 5-53. It should be noted that all of the dissolved fractions of RCRA metals detected were also detected in the total fraction.

5.4.2 1997 RFI Investigation

The 1997 investigation focussed on the cooling water tunnel leading to Puerca Bay. This investigation was in response to the discovery of oil contamination in a single test pit dug along the tunnel during the performance of the ICM. Sediment samples were obtained in response to previous sampling results in Puerca Bay. The samples collected from SWMU 45 during this investigation included twenty subsurface soil samples, and sixteen groundwater samples along the cooling water tunnel route, and eleven sediment samples in Puerca Bay. The compounds detected in these samples are presented in Tables 5-36 through 5-42. A graphical presentation of those compounds detected at concentrations in excess of the screening values are shown on Figures 5-54 through 5-56. A complete set of the analytical data is presented in Appendix F.

5.4.2.1 Subsurface Soil

A total of 18 subsurface soil samples and two duplicate samples were collected from SWMU 45 during the 1997 RFI Investigation. Within the subsurface soil organic sample set, five VOCs were reported above the method detection limits, as shown in Table 5-36. All five constituents were detected at levels below both the residential and industrial soil RBCs.

Ten different SVOCs were detected in the subsurface soil samples, with benzo(a)pyrene being the only compound to exceed the residential RBC as indicated in Table 5-36. The concentration of benzo(a)pyrene ranged from 110J µg/kg (11SB01-02), to 260J µg/kg (11SB09-02) as shown on Figure 5-54. The rest of the semivolatiles were below the respective screening criteria.

TPH DRO and/or GRO were detected in seven of the eighteen subsurface soil samples, including 11SB01-02, 11SB06-02, 11SB07-02, 11SB09-02, 11SB11-02, 11SB22-04, and 11SB26-01. DRO detections ranged from 6,700 Fg/kg to 250,000 Fg/kg. The GRO detections ranged from 32J Fg/kg to 540 Fg/kg as presented on Table 5-36. It should be noted that there is no criteria established for these two compounds.

Aroclor-1260 was the only PCB reported above the method detection limit in this sample set. Concentrations of aroclor-1260 were detected in five of the eighteen samples collected in this sample set, with a range from 46 µg/kg (11SB18-02) to320J µg/kg (11SB01-02). The concentration of aroclor-1260 (320J µg/kg) in sample 11SB01-02, was the only detection above its respective residential RBC. It should be noted that this sample was collected adjacent to the cooling water tunnel near Building 38.

Fifteen inorganic compounds were detected during this investigation in the subsurface soil samples as shown in Table 5-37. All seventeen samples had levels of inorganics which exceeded at least one of the three criteria. A total of six compounds exceeded two times the average detected background concentration, including antimony, arsenic, cadmium, chromium, silver, and zinc. Arsenic was the only compound which exceeded the industrial RBC of 3.82 mg/kg, with concentrations of 4.5J mg/kg in sample 11SB05-02 and 5.4 mg/kg in duplicate sample 11SB11-02D. A total of two compounds exceeded the residential RBC criteria, including arsenic and chromium. Exceedances of the screening criteria are also presented on Figure 5-54.

5.4.2.2 Sediment

A total of nine sediment samples and two duplicate samples were collected at SWMU 45 during the 1997 RFI Investigation. Within the organic sample set, one VOC (acetone) was detected in all of the samples as shown in Table 5-38. It should be noted that there is no criteria established for this constituent. It also should be noted that acetone is a common laboratory artifact and may not be site related.

A total of seventeen semivolatile organic compounds were detected in the sediment samples collected. Eight of the constituents were reported at levels which exceed the ERL sediment screening value as

presented in Table 5-38. These include acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, and pyrene. Benzo(a)pyrene also exceeded the ERM sediment screening value in sample 11SD03 and it's duplicate 11SD03D, with concentrations of 1,800 Fg/kg and 3,200 Fg/kg, respectively.

Aroclor-1260 was the only PCB reported above the method detection limit in this sample set. All of the samples contained detections of aroclor-1260 which exceeded the ERL sediment screening value of 22.7 Fg/kg. These concentrations ranged from 28J Fg/kg (11SD01) to 130 Fg/kg (11SD09) as presented in Table 5-38 and on Figure 5-55. Eight of the nine samples contained concentrations of TPH diesel range organics above their method detection limit ranging in concentration from 18,000 Fg/kg to 65,000 Fg/kg. It should be noted that the criteria for this compound has not been established.

Sixteen inorganic compounds were detected during the 1997 RFI Investigation as shown in Table 5-39. Three of the nine samples had levels of inorganics which exceeded the ERL sediment screening criteria. A total of three compounds exceeded the ERL sediment screening criteria, including arsenic, copper, and mercury. None of the ERM sediment screening values were exceeded in this sample set. Exceedances of the screening criteria are also presented on Figure 5-55.

5.4.2.3 Groundwater

A total of fourteen groundwater samples and two duplicate samples were collected from SMWU 45 during this investigation.

Acetone was the only VOC reported above the method detection limit in six of the samples ranging in concentration from 12 Fg/l (11GW13) to 34 Fg/l (11GW10). None of these detections exceed the tap water RBC as shown in Table 5-40. It should be noted that the federal MCL criteria for acetone is not established. It also should be noted that acetone is a common laboratory artifact and may not be site related.

A total of fifteen SVOCs were detected in the groundwater samples during this investigation as presented in Table 5-40. Two of the fifteen compounds (benzo(a)pyrene and bis(2-ethylhexylphthalate) were detected at levels which exceeded both federal MCL and the tap water

RBCs. Two other compounds also exceeded the tap water RBCs, including benzo(a)anthracene and chrysene. The exceedances of the screening criteria are spatially presented on Figure 5-56. Additionally, there were no PCBs reported above the method detection limits for this sample set.

TPH DRO and GRO were reported in this sample set above the method detection limit as presented in Table 5-40. TPH DRO was detected in five of the 14 samples at concentrations ranging from 130J Fg/l to 68,000 Fg/l. TPH GRO was detected in four of the 14 samples at concentrations ranging from 54 Fg/l to 2,000 Fg/l. It should be noted that the criteria for these compounds has not been established. This sample set was also analyzed for TOC, however the criteria for this analysis is not established as indicated in Table 5-40.

A total of thirteen different inorganic (total) constituents were detected in the groundwater samples obtained during this investigation as presented in Table 5-41. Only one of the thirteen detected inorganic (total) compounds (arsenic) was reported at concentrations in excess of at least one of listed the screening criteria. The concentrations of arsenic detected above the tap water RBC ranged from 1.7J Fg/l (11GW05) to 18.9 Fg/l (11GW19) as shown on Figure 5-56.

A total of twelve different inorganic (dissolved) constituents were detected in the groundwater samples obtained during this investigation as presented in Table 5-42. Two of the twelve detected inorganic (dissolved) compounds (arsenic and mercury) were reported at concentrations in excess of one of the screening criteria. Mercury exceeded the federal MCL in one of the fourteen samples, with a concentration of 2.6 µg/l in sample 11GW16. Arsenic exceeded the tap water RBC in ten of the fourteen samples, with concentrations ranging from 1.3J µg/l (11GW02) to 15J µg/l (11GW19) as shown on Figure 5-56.

Summary

A review of the analytical data collected from SWMU 45 during the RFI investigations indicates that the media sampled have not been significantly affected by past site operations. Within the surface soil samples collected there were no VOCs or SVOCs detected above their respective detection limits. One SVOC, benzo(a)pyrene was detected above the residential RBC in subsurface soil samples 11SB01-01 and 11-SB27.

Low levels of Aroclor-1260, below the residential and industrial soil RBCs, were detected in three of the surface soil samples, whereas, one subsurface soil sample (11SB01-01) detected Aroclor-1260 above the residential RBC. It should be noted that this is the same sample which also detected the above mentioned benzo(a)pyrene.

Inorganic compounds reported in the soil samples exceeding the screening criteria included arsenic, barium, and cadmium in the surface soil samples and arsenic, cadmium, chromium, silver, and zinc in the subsurface soil samples. Arsenic was the only compound to exceed the industrial soil RBC, which occurred in two subsurface soil samples. Elevated inorganic compound concentrations in the surface soil samples may be inherent to the fill material used in the remediation of the site and not indicative of site conditions. Additionally, the alluvial sediments in which monitoring wells, 45MW01 through 45MW04 were installed, may have naturally higher inorganic concentrations than reported in the background samples which were derived from residual soil.

Bis(2-ethylhexyl)phthalate was detected in one monitoring well and one hydropunch boring above the Federal MCL and tap water RBC. The detection of bis(2-ethylhexyl)phthalate in the sample 45MW02, although exceeding both screening criteria, is believed to be a laboratory artifact since this compound is not associated with fuels or PCBs. These are the primary constituents to be expected given the materials managed/disposed at the site. Three different SVOCs (benzo(a)anthracene, benzo(a)pyrene, and chrysene) were detected above the screening criteria as presented on Figure 5-56 from hydropunch sample location 11-SB05. All three of these locations are on the northeast side of Building 38.

Arsenic was the only inorganic constituent consistently detected across the entire site as shown on Figures 5-53 and 5-56. Inorganic compounds (both total and dissolved) reported in excess of the screening criteria mainly occurred at the locations were wells were installed in the alluvial sediments. The locations of the two hydropunches, 45HP03 and 45HP04, reported far fewer exceedances than those locations within the alluvial sediments. Based on this observation, it appears that the alluvial sediments and its associated groundwater contain naturally higher inorganic concentrations and do not suggest widespread inorganic contamination at the site.

Acetone was detected in all nine of the sediment samples, but no exceedances exist due to criteria not established. Seventeen different SVOCs were detected in the sediment samples, the majority of which being PAHs. Three of the nine samples exceeded one or both of the screening criteria. Eight of the seventeen compounds detected exceeded the ERL sediment screening value. These included acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, and pyrene. Benzo(a)pyrene also exceeded the ERM sediment screening value in one sample. Aroclor-1260 was detected above the ERL sediment screening value in all of the sediment samples collected during this investigation. TPH DRO was detected in all but one of the samples. It should be noted that the screening criteria for this compound is not established.

Three inorganic compounds (arsenic, copper, and mercury) were detected above one of the listed criteria in the sediment sample set. These concentrations only exceeded the ERL Sediment Screening Value.

5.5 Quality Assurance/Quality Control Sample Results

A portion of the QA/QC sampling efforts consisted of equipment rinsates, field blanks, and trip blanks. Tables 5-43 through 5-50 present the detected constituents in the QA/QC samples. The complete set of the analytical results from the QA/QC sampling is presented in Appendix G.

5.5.1 SWMU 1 - QA/QC Sample Results

5.5.1.1 1996 RFI Investigation

During the 1996 RFI Investigation, the equipment rinsate samples and field blank samples were analyzed for full Appendix IX parameters, explosives, and sulfide. The trip blanks were analyzed for Appendix IX VOCs.

5.5.1.1.1 Equipment Rinsate Samples

Five equipment rinsate samples (1RB01 through 1RB05) were collected during the 1996 RFI Investigation for SWMU 01. Sample 1RB01 was collected while pouring lab grade deionized water

over a stainless steel spoon. Samples 1RB02 through 1RB05 were collected while pouring lab grade deionized water over split spoons. One VOC (acetone) was detected in rinsate sample 1RB05, with a concentration of 21 Fg/l as presented in Table 5-43. It should be noted that acetone is a common laboratory artifact and may not be related to the equipment rinsate. Three SVOCs were detected in the equipment rinsate samples, including bis(2-ethylhexyl)phthalate in two samples, diethylphthalate in two samples, and phenol in one sample. Additionally, there were no pesticides/PCBs, chlorinated herbicides, op-pesticides, dioxins, or explosives reported above the method detection limit.

Five inorganic compounds were reported above the method detection limit in this sample set. These compounds include chromium, copper, lead, mercury, and zinc as indicated in Table 5-43.

It should be noted that the majority of the detections in the equipment rinsate samples were also detected in the field blank samples.

5.5.1.1.2 *Field Blank Samples*

Two field blank samples (FB01 and FB02) were collected during the 1996 RFI Investigation for SWMU 01. The water analyzed included NSRR potable water supply (fire hydrant next to McDonalds near the NEX) (FB01) and store bought distilled water (FB02). A total of five VOCs were detected above the method detection limit, including acetone, bromodichloromethane, chloroform, methylene chloride, and toluene. Concentrations of bromodichlormethane (11 µg/l) and chloroform (66 µg/l) were detected in FB01 as shown in Table 5-44. It should be noted that chloroform is commonly identified in potable water supplies. Concentrations of acetone (25 µg/l), methylene chloride (6 µg/l), and toluene (1J µg/l) were detected in FB02. Bis(2-ethylhexyl)phthalate (1 J µg/l) was the only SVOC reported above the method detection limit in FB02. Additionally, there were no pesticides/PCBs, chlorinated herbicides, op-pesticides, dioxins, or explosives reported above the method detection limit.

Five different inorganic compounds were detected in the field blank samples as shown in Table 5-44. Barium, copper, lead, mercury, and zinc were detected in FB01, while copper, lead, and zinc were detected in FB02.

5.5.1.1.3 *Trip Blank Samples*

A total of nine trip blanks (TB1, TB001, and TB02 through TB07) were analyzed as part of the 1996 RFI Investigation for SWMU 01. Two different VOCs (acetone and trichlorofluoromethane) were detected in the trip blanks from this sample set. Acetone was detected in trip blank TB04 with a concentration of 10 µg/l, while trichlorofluoromethane was detected in TB001 with a concentration of 6 J µg/l as presented in Table 5-45. Acetone is a common laboratory artifact.

5.5.1.2 1997 RFI Investigation

During the 1997 RFI Investigation the equipment rinsates and field blanks were analyzed for full Appendix IX parameters, TPH, DRO and GRO, asbestos, and explosives. Sample FB01 was also analyzed for RCRA metals. The trip blanks were analyzed for Appendix IX VOCs.

5.5.1.2.1 *Equipment Rinsate Samples*

One equipment rinsate sample (1ER01) was collected during the 1997 RFI Investigation for SWMU 01. Sample 1ER01 was collected while pouring lab grade deionized water over a split spoon. One SVOC [bis(2-ethylhexyl) phthalate] (a common laboratory contaminant) was detected in this rinsate sample at a concentration of 24 µg/L as indicated in Table 5-46. Additionally, there were no VOCs, pesticides/PCBs, chlorinated herbicides, op-pesticides, dioxins, explosives, asbestos, or TPH reported above the method detection limit.

A total of four inorganic compounds were detected in this equipment rinsate sample. These compounds include barium, chromium, lead, and zinc as indicated in Table 5-46.

5.5.1.2.2 *Field Blank Samples*

One field blank sample (FB01) was collected during the 1997 RFI Investigation for SWMU 01. The water analyzed included NSRR potable water supply (garden hose from spigot at the Tow Way Fuel Farm (TWFF)). A total of three VOCs, acetone (20 J µg/l), bromodichloromethane (13 J µg/l), and chloroform (160 J µg/l) were detected in FB01 as shown in Table 5-47. Two SVOCs (acetophenone

and phenol) were detected in the sample set at concentrations of 2 J Fg/l and 3 J Fg/l, respectively. TPH GRO was detected in FB01, with a concentration of 25 J µg/l. It should be noted that the garden hose utilized for the water was from the TWFF and may be the source of the GRO detection. Additionally, there were no pesticides/PCBs, chlorinated herbicides, op-pesticides, explosives, dioxins, and asbestos reported above the method detection limit.

Four different inorganic compounds were detected in the field blank sample as shown in Table 5-47. These compounds include barium, chromium, vanadium, and zinc. Two RCRA metals (barium and cadmium) were also detected in FB01 sample as shown in Table 5-47.

5.5.1.2.3 *Trip Blank Samples*

A total of three trip blanks (1TB01, TB02 and 13TB01) were analyzed as part of the 1997 RFI Investigation for SWMU 01. There were no VOCs reported above the method detection limits in this sample set, as presented in Table 5-48.

5.5.2 SWMU 2 - QA/QC Sample Results

During the 1996 RFI Investigation, the equipment rinsates and field blanks were analyzed for full Appendix IX parameters, explosives, and sulfide. The trip blanks were analyzed for Appendix IX VOCs.

5.5.2.1 Equipment Rinsate Samples

Five equipment rinsate samples (2RB01 through 2RB05) were collected during the 1996 RFI Investigation at SWMU 2. Samples 2RB01 and 2RB02 were collected while pouring lab grade deionized water over split spoons. Samples 2RB03 through 2RB05 were collected while pouring lab grade deionized water over stainless steel spoons. A total of two VOCs (acetone and toluene) were reported above the method detection limits. Acetone (a common laboratory artifact) was detected in rinsate samples 2RB01, 2RB03, and 2RB05 at concentrations ranging from 11 µg/l to 33J µg/l as presented in Table 5-49. Bis(2-ethylhexyl) phthalate was the only SVOC reported above the method detection limit. The concentration of bis(2-ethylhexyl)phthalate ranged from 1J µg/l (2RB02) to 2J

µg/l (2RB04). Additionally, there were no pesticides/PCBs, chlorinated herbicides, op-pesticides, dioxins, or explosives reported above the method detection limits.

A total of four inorganic compounds were detected in the equipment rinsate samples, including chromium, copper, sodium, and zinc as indicated in Table 5-49.

5.5.2.2 Field Blank Samples

See Section 5.5.1.1.2 for a discussion on the 1996 RFI Investigation field blank sample results.

5.5.2.3 Trip Blank Samples

A total of six trip blanks (TB001, TB002, and TB09 through TB12) were analyzed as part of the 1996 RFI Investigation for SWMU 02. A total of two VOCs (acetone and trichlorofluoromethane) were detected in the trip blank samples during this investigation. Sample TB12 contained the only detection of acetone within the SWMU 02 sample set, with a concentration of 12 µg/l. Sample TB001 contained the only detection of trichlorofluoromethane within the SWMU 02 sample set, with a concentration of 6 J µg/l as presented in Table 5-45.

5.5.3 SWMU 45 - QA/QC Sample Results

5.5.3.1 1996 RFI Investigation

During the 1996 RFI Investigation the equipment rinsate samples and field blank samples were analyzed for VOCs, SVOCs, PCBs, and RCRA metals. The trip blanks were analyzed for VOCs.

5.5.3.1.1 Equipment Rinsate Samples

Two equipment rinsate samples (45RB01 and 45RB02) were collected during the 1996 RFI Investigation for SWMU 45. The samples were collected while pouring lab grade deionized water over stainless steel spoons. Two VOCs (acetone and toluene) were detected in rinsate samples 45RB01 and 45RB02 as presented in Table 5-50. The concentration of acetone ranged from 22 J Fg/l in sample

45RB02, to 23 J Fg/l in sample 45RB01. Toluene was detected in both samples with a range from 3 J Fg/l (45RB02) to 4 J Fg/l (45RB01). Additionally, there were no SVOCs or PCBs reported above the method detection limits.

Two RCRA metals were detected in this sample set, including barium and lead. The concentration of barium was 1.5 Fg/l in sample 45RB02, while the concentration of lead was 0.83 Fg/l in sample 45RB02 as indicated in Table 5-50.

5.5.3.1.2 *Field Blank Samples*

One field blank sample (FB03) was collected during the 1996 RFI Investigation for SWMU 45. The water analyzed included NSRR potable water supply from the fire hydrant near the station landfill access road. A total of two VOC compounds (bromodichloromethane and chloroform) were detected in this sample, with concentrations of 8 Fg/l and 78 Fg/l, respectively. Bis(2-ethylhexyl)phthalate was the only SVOC reported above the method detection limit, with a concentration of 10 Fg/l as shown in Table 5-44. Additionally, there were no PCBs reported above the method detection limit.

Barium was the only RCRA metal detected in the field blank sample, with a concentration of 5.3 Fg/l as shown in Table 5-44.

5.5.3.1.3 *Trip Blank Samples*

Two trip blanks (TB13 and TB14) were analyzed as part of the 1996 RFI Investigation for SWMU 45. There were no VOCs reported above the method detection limit in either of the samples as presented in Table 5-45.

5.5.3.2 1997 RFI Investigation

During the 1997 RFI Investigation the equipment rinsate samples and field blank samples were analyzed for VOCs, SVOCs, PCBs, Appendix IX metals, and TPH, DRO and GRO. The trip blanks were analyzed for VOCs.

5.5.3.2.1 Equipment Rinsate Samples

A total of seven equipment rinsate samples (11ER01, 11ER02, 11EB03, and 11ER04 through 11ER07) were collected during the 1997 RFI Investigation for SWMU 45. Sample 11ER01 was collected while pouring lab grade deionized water through an acetate liner. Sample 11ER02 and 11ER05 were obtained while pouring lab grade deionized water over stainless steel spoons. 11EB03 and 11ER06 were collected from peristaltic pump tubing used for groundwater sampling. An aluminum pie pan was rinsed for rinsate sample 11ER04. The ponar dredge utilized for the sediment sampling in Puerca Bay made up 11ER07. The concentration of 2-butanone (40 J Fg/l) in sample 11ER05 was the only reported VOC above the method detection limit. A total of four SVOC compounds were detected above the method detection limit. These include 4-chloroaniline, benzoic acid, phenol, and pyridine. Sample 11ER01 was the only sample out of the seven to have detections of the previously listed SVOCs as shown in Table 5-46. Additionally, there were no PCBs, or TPH compounds reported above the method detection limit.

A total of six inorganic compounds were reported above the method detection limit, including antimony, barium, chromium, lead, mercury, and zinc as indicated in Table 5-46.

5.5.3.2.2 Field Blank Samples

Two field blank samples (11FB01 and 11FB02) were collected during the 1997 RFI Investigation for SWMU 45. The water analyzed included deionized water from the direct push subcontractor (11FB01), and NSRR potable water supply (garden hose from Forrestal Wastewater Treatment Plant construction site) (11FB02). A total of seven VOC compounds [1,1-dichloroethane, benzene, bromodichlormethane, chloroform, dibromochloromethane, ethylbenzene, and xylene (total)] were reported above their method detection limits as shown in Table 5-47. Sample 11FB01 contained detections of three of the seven compounds including bromodichlormethane, chloroform, and dibromochloromethane. Sample 11FB02 contained detections of six of the seven compounds listed above, including 1,1-dichloroethane, benzene, bromodichlormethane, chloroform, ethylbenzene, and xylene (total). Additionally, there were no PCBs, or TPH compounds reported above the method detection limit.

Six different inorganic compounds were detected in the field blank samples for SWMU 45 as shown in Table 5-47. These compounds include barium, chromium, copper, lead, vanadium, and zinc.

5.5.3.2.3 *Trip Blank Samples*

A total of eight trip blanks (TB01, TB02, 11TB01 through 11TB04, 13TB01 and 13TB02) were collected during the 1997 RFI Investigation for SWMU 45. There were no VOC compounds detected above the method detection limit in this sample set as shown in Table 5-48.

5.6 Determination/Demonstration of Statistical Representativeness

This section presents the statististical analysis performed on the SWMU 1 and SWMU 2 data sets. This statistical analysis was performed at the request of the USEPA Region II to assist in determining whether or not the data sets are statistically represented of the areas potentially impacted. The purpose of the statistical analysis is to identify any data gaps which may be present and to recommend actions to resolve these data gaps if identified.

5.6.1 Statistical Representativeness Methodology

Two different guidance documents were utilized in performing the statistical analysis. These included the Methods for Evaluating the Attainment of Cleanup Standards (EPA 230/02-89-042, February 1989) and Test Methods for Evaluating Solid Waste (EPA Publication SW-846, Third Edition, November 1986, as amended by updates I (July 1992), II (September 1994), IIA (August 1993), and IIB (January 1995). These documents were utilized to assess the statistical representativeness of the surface soil, subsurface soil, sediment, groundwater, and surface water data sets for SWMU 1 and SWMU 2.

The Methods for Evaluating the Attainment of Cleanup Standards was utilized to calculate the confidence intervals of each constituent detected within each data set by media. This was performed by performing the procedures outlined in Chapter 6 (Determining Whether the Mean Concentration of the Site is Less than a Cleanup Standard). It was determined that the sampling which was

performed during the past investigations fell into the simple random sampling category. Therefore the proceures for simple random sampling were utilized.

The first step was to calculate the sample mean (average sample concentration), sample variance, and the standard deviation. These items were calculated using the following formulas:

Since the data are a random sample of n observations (i.e. the sample size is n), designate the data as $x_1, x_2 \ldots, x_i, \ldots$ to x_n.

The sample mean (or average), indicated by θ, was calculated as:

$$s^2 = \frac{\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}}{n-1}$$

The formula for the sample variance, s^2, is:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

The formula for the standard deviation is:

$$s = \sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}}{n-1}}$$

The upper one sided confidence limit was calculated using the following formula:

$$m_{Ua} = \overline{X} + t_{1-a,\mathrm{df}} \frac{s}{\sqrt{n}}$$

The value of *t* was obtained from the statistical Table A.1 found in Appendix A of the above referenced document. The default alpha utilized was 0.05 which yielded a 95% confidence mean sample concentration.

To determine whether the site meets the screening criteria established for these sites the following rule was utilized to determine whether or not the site attains the screening criteria:

If $\mu_{Uá}$<Cs, conclude that the area is clean.
If $\mu_{Uá}$$Cs, conclude that the area is dirty.
Cs = The Screening Criteria

The exact percent confidence in the analytical results was calculated for each constituent utilizing the above equations. These results were plotted on bar graphs for ease of presentation. The graphs present the results by media and analytical suite for each SWMU.

The results from this portion of the statistical analysis are presented in Section 5.6.2 of this document.

Following the calculation to determine if the site meets the screening criteria the data was evaluated according to the Test Methods for Evaluating Solid Waste to determine if a sufficient quantity of samples were obtained for each data set by media on a per constituent basis. This was performed utilizing chapter nine of the above mentioned document.

It is assumed that the investigation is complete at the sites and therefore the sample set was analyzed to determine if a sufficient quantity of samples were collected to characterize the site. This was done by utilizing the following equations:

The appropriate number of samples to collect from a waste

$$n_2 = \frac{t^2_{.20} s^2}{\Delta^2}$$

where:

$$\Delta = RT - \bar{x}$$

and RT = the applicable screening criteria (i.e. EPA Region III Industrial Soil RBCs)

Following the determination of the number of samples required was the development of the confidence interval that the number of samples were enough. This confidence interval was calculated utilizing the following equation:

$$CI = \bar{x} \pm t_{.20} s_{\bar{x}}$$

The confidence interval was then compared against the screening interval to determine if a re-estimation of the number of samples is required. If additional samples were required than the above equation for determing the number of samples was utilized to calculate such quantity recomended.

The results from this portion of the statistical analysis are presented in Section 5.6.2 of this document.

5.6.2 Statistical Representativeness Results

This sections contain the results of the statistical analysis which was performed on the data sets for SWMU 1 and SWMU 2. The results include a discussion of the percent confidence that the analytical results meet the established screening criteria and wether or not a sufficient quantity of samples were collected for each site. These results are discussed by SWMU in the following sections.

5.6.2.1 SWMU 1

The statistical representativeness was performed on the surface soil, subsurface soil, sediment, groundwater, and surface water data sets. The results of which are discussed below.

Surface Soil

The screening criteria utilized for the evaluation of the statistical representativeness of the surface soil were the EPA Region III Residential and Industrial Soil RBCs.

The percent confidence in the organic data set for the surface soils at SWMU 1 was at 95% for all but four of the SVOC constituents as presented on Table 5-51. All of the VOC and pesticide detections

yielded a 99.9% confidence that the site meets the residential and industrial soil RBCs as presented on Figures 5-57 and 5-58. Figure 5-59 shows that all but benzo(a)pyrene and dibenzo(a,h)anthracene were at 99.9% with respect to meeting the industrial RBCs. The percent confidence for benzo(a)pyrene was 78% and dibenzo(a,h)anthracene was 81.3% for meeting the industrial RBCs. The residential portions of these two constituents could not be calculated due to the analytical method detection levels being greater than the RBC. The calculation for determining the percent confidence takes a non detection at the detection level of the constituent. This skews the result of the equation since these values which are greater then the standard are compared against the standard. Three of 22 samples were positively detected for benzo(a)pyrene with two of them in excess of the residential RBC. One of the 22 samples were positively detected for dibenzo(a,h)anthracene with one of the detections in excess of the residential RBC. It was noticed that high detection levels from the non detect samples occurred from the samples collected during the Supplemental Investigation. Due to this the four constituents which were impacted by the high detection levels were recalculated without the supplemental Investigation data as presented on page 4 of 4 of Table 5-51. This recalculation yielded 99.9% confidence in all of the industrial RBC scenarios and two of the four residential RBC scenarios.

Additional samples are not required to be collected for the surface soil sample set except for benzo(a)pyrene and dibenzo(a,h)anthracene as presented on Table 5-51. It was determined that additional samples were required for these two constituents when compared to the industrial RBCs but not compared to the residential RBCs. The large quantity of samples estimated to be collected are unreasonable for this site. It should be noted that only three detections of benzo(a)pyrene and two detections of dibenzo(a,h)anthracene were detected in the surface soil sample set. Due to the limited amount of detections of these constituents additional samples are not required for these constituents.

The percent confidence in the inorganic data set for the surface soils at SWMU 1 was at least 95% for all but two of the inorganic constituents as presented on Table 5-52. All of the inorganics detections except three of them yielded a 99.9% confidence that the site meets the residential and industrial soil RBCs as presented on Figure 5-60. Figure 5-60 shows that all of the inorganic constituents were at 99.9% with respect to meeting the industrial RBCs. All but three of the inorganics were at 99.9% for meeting the residential RBCs. These included manganese (99.75%) and arsenic and iron whose detection levels in the non-detects being greater than the residential RBCs caused a zero percent confidence for these two inorganics.

Additional samples are not required to be collected for the surface soil inorganic sample set as presented on Table 5-51.

Subsurface Soil

The screening criteria utilized for the evaluation of the statistical representativeness of the subsurface soil were the EPA Region III Residential and Industrial Soil RBCs.

The percent confidence in the organic data set for the subsurface soils at SWMU 1 was at 95% for all but three dioxin constituents as presented on Table 5-53. All of the VOC, SVOC, and pesticide detections yielded a 99.9% confidence that the site meets the residential and industrial soil RBCs as presented on Figures 5-61 through 5-63. Figure 5-64 shows that all the dioxins were at 99.9% with respect to meeting the industrial RBCs. The residential portions of the dioxins could not be calculated due to the analytical method detection levels being greater than the residential RBC. The calculation for determining the percent confidence takes a non detection at the detection level of the constituent. This skews the result of the equation since these values which are greater then the standard are compared against the standard. Total HxCDD was detected in one of the 18 samples while total HxCDF was detected in two of the 18 samples and total TCDF was detected in one of the 18 samples in excess of the residential RBCs.

Additional samples are not required to be collected for the organic subsurface soil sample set except for total TCDF as presented on Table 5-53. The large quantity of samples estimated to be collected are unreasonable for this site. It should be noted that only one detection of total TCDF was detected in the surface soil sample set. Due to the limited amount of detections of these constituents additional samples are not required for this constituent.

The percent confidence in the inorganic data set for the subsurface soils at SWMU 1 was at least 95% for all but two of the inorganic constituents as presented on Table 5-54. All of the inorganics detections except two of them yielded a 99.9% confidence that the site meets the residential and industrial soil RBCs as presented on Figure 5-65. Figure 5-65 shows that all of the inorganic constituents were at 99.9% with respect to meeting the industrial RBCs. All but two of the inorganics were at 99.9% for meeting the residential RBCs. These included arsenic and iron whose detection

levels in the non-detects being greater than the residential RBCs caused a zero percent confidence for these two inorganics.

Additional samples are not required to be collected for the inorganic subsurface soil sample set except for iron as presented on Table 5-54. The large quantity of samples estimated to be collected are unreasonable for this site. It should be noted that only five detections exceeded the residential RBCs.

Sediment

The screening criteria utilized for the evaluation of the statistical representativeness of the sediment were the ERL and ERM Sediment Screening Values.

The percent confidence in the organic data set for the sediment at SWMU 1 was at 95% for all but four of the constituents as presented on Table 5-55. It should be noted that no criteria have been established for a majority of the constituents. All of the constituents with established criteria were at 99.9% confidence except for benzo(a)anthracene (ERL), 4,4'-DDE (ERL and ERM), 4,4'-DDT (ERM), and Aroclor 1260 (ERM) as presented on Figures 5-66 and 5-67.

Additional samples are not required to be collected for the sediment sample set except for benzo(a)anthracene as presented on Table 5-55. It was determined that additional samples were required for this constituent when compared to the ERL but not compared to the ERM. It should be noted that only one detection of benzo(a)anthracene was detected in the sediment sample set which was below the screening criteria. Due to this fact additional samples are not required for these constituents.

The 95 percent confidence in the inorganic data set for the sediment at SWMU 1 is presented on Table 5-56. All of the inorganics detections were at least 92.3 % confidence for meeting the ERM criteria as presented on Figure 5-68. Six of the nine constituents did not meet the 95% confidence in meeting the ERL sediment screening criteria due to the criteria value being less then the method detection limit.

Additional samples are required to be collected for the sediment inorganic sample set as presented on Table 5-56. A more in depth evaluation of the sediment associated with this SMWU is planned to be conducted under the CMS being proposed for this site.

Groundwater

The screening criteria utilized for the evaluation of the statistical representativeness of the groundwater were the Federal MCLs and the EPA Region III Tap Water RBCs.

The 95 percent confidence in the organic data set for the groundwater at SWMU 1 is presented on Table 5-57. All of the chlorinated herbicide detections yielded a 99.9% confidence that the site meets the Federal MCL and tap water RBC as presented on Figure 5-72. Figures 5-69 through 5-73 present the percent confidence levels for those organic constituents detected in the groundwater. The majority of the constituents that do not meet the 95% confidence in the tap water RBC were minimally detected on the site. The method detection levels for many of the non detect constituents were above the criteria tap water RBC. The calculation for determining the percent confidence takes a non detection at the detection level of the constituent. This skews the result of the equation since these values which are greater then the standard are compared against the standard.

Additional samples are not required to be collected for the groundwater sample set except for bis(2-ethylhexyl)phthalate and beta-BHC as presented on Table 5-57. It was determined that additional samples were required for these two constituents when compared to one of the criteria but not the other. The large quantity of samples estimated to be collected are unreasonable for this site. It should be noted that only one detection of bis(2-ethylhexyl)phthalate was detected above the screening criteria while the only detection of beta-BHC was not above either of the criteria. Due to the limited amount of detections and exceedances of the respective criteria additional samples are not required for these constituents.

The 95 percent confidence in the inorganic data set for the groundwater at SWMU 1 is presented on Tables 5-58 and 5-59. Figures 5-74 and 5-75 present the percent confidence levels for those inorganic constituents detected in the groundwater. The majority of the constituents that do not meet the 95% confidence were minimally detected on the site. The method detection levels for many of the non detect

constituents were either above the criteria or the criteria was not established for the respective constituent. The calculation for determining the percent confidence takes a non detection at the detection level of the constituent. This skews the result of the equation since these values which are greater then the standard are compared against the standard.

Additional samples are not required to be collected for the groundwater sample set except for selenium and vanadium as presented on Table 5-58. It was determined that additional samples were required for these two constituents when compared to one of the criteria but not the other. The large quantity of samples estimated to be collected are unreasonable for this site. It should be noted that only 14.3% of the samples analyzed for selenium was detected above the Federal MCL. Due to these facts it is unreasonable to obtain additional groundwater samples for this site.

Surface Water

The screening criteria utilized for the evaluation of the statistical representativeness of the groundwater were the Federal Ambient Water Quality Criteria and the EPA Region III BTAG Screening Values.

The 95 percent confidence in the organic data set for the surfacewater at SWMU 1 is presented on Table 5-60. All of the SVOC detections yielded at least a 96.9% confidence that the site meets the BTAG screening levels as presented on Figure 5-76. Bis(2-ethylhexyl)phthalate and phenols yielded 99.9% confidence.

Additional samples are not required to be collected for the surface water organic sample set as presented on Table 5-60.

The 95 percent confidence in the inorganic data set for the surface water at SWMU 1 is presented on Table 5-61. Figure 5-77 presents the percent confidence levels for those inorganic constituents detected in the surface water. The majority of the constituents that do not meet the 95% confidence were minimally detected on the site. The method detection levels for many of the non detect constituents were either above the criteria or the criteria was not established for the respective constituent. The calculation for determining the percent confidence takes a non detection at the

detection level of the constituent. This skews the result of the equation since these values which are greater then the standard are compared against the standard.

Additional samples are required to be collected for the surfacewater sample set for arsenic, copper, and selenium as presented on Table 5-61. It should be noted that a more in depth evaluation of the ecological habitats is scheduled to be conducted for this SWMU. This will provide a better determination of wether or not additional surfacewater sampling is required for this site.

5.6.2.2 SWMU 2

The statistical representativeness was performed on the surface soil, subsurface soil, sediment, groundwater, and surface water data sets. The results of which are discussed below.

Surface Soil

The screening criteria utilized for the evaluation of the statistical representativeness of the surface soil were the EPA Region III Residential and Industrial Soil RBCs.

The percent confidence in the organic data set for the surface soils at SWMU 2 was at least 95% for all but one of the SVOC constituents (dibenzo(a,h)anthracene 90%) for industrial RBCs as presented on Table 5-63. The majority of the organic detections were at least 95% when compared to the residential RBCs. Figures 5-78 through 5-81 present a visual display of the actual percent confidence for each of the organic constituents detected in the surface soil.

Additional samples are not required to be collected for the surface soil sample set except for heptachlor as presented on Table 5-62. It was determined that 18 additional samples were required for this constituent when compared to the residential RBCs but not when compared to the industrial RBCs. It should be noted that only 3 out of thirty one samples positively detected heptachlor. Furthermore none of the detections were above the any of the screening criteria. Due to this fact it is not a reasonable assumption that additional samples are required for this sample set.

The percent confidence in the inorganic data set for the surface soils at SWMU 2 was at least 95% for all but two of the inorganic constituents as presented on Table 5-63. All of the inorganics detections except two of them yielded a 99.9% confidence that the site meets the residential and industrial soil RBCs as presented on Figure 5-82. Figure 5-82 shows that all but one of the inorganic constituents were at 99.9% with respect to meeting the industrial RBCs. All but two of the inorganics were at 99.9% for meeting the residential RBCs.

Additional samples are not required to be collected for the surface soil inorganic sample set as presented on Table 5-63.

Subsurface Soil

The screening criteria utilized for the evaluation of the statistical representativeness of the subsurface soil were the EPA Region III Residential and Industrial Soil RBCs.

The percent confidence in the organic data set for the subsurface soils at SWMU 1 was at least 95% for all the VOCs and pesticides/PCBs and the majority of the SVOCs as presented on Table 5-64. All of the VOC, pesticide, and dioxin detections yielded a 99.9% confidence that the site meets the industrial soil RBCs as presented on Figures 5-83 through 5-86. The residential portions of the dioxins could not be calculated due to the analytical method detection levels being greater than the residential RBC. The calculation for determining the percent confidence takes a non detection at the detection level of the constituent. This skews the result of the equation since these values which are greater then the standard are compared against the standard. Total HxCDD was detected in one of the eight samples while total TCDF was detected in two of the eight samples in excess of the residential RBCs.

Additional samples are required to be collected for a handful of the SVOC constituents and one dioxin as presented on Table 5-64. The large quantity of samples estimated to be collected are unreasonable for this site. Due to the limited amount of detections of these constituents additional samples are not required for this constituent.

The percent confidence in the inorganic data set for the subsurface soils at SWMU 2 was at least 95% for all but two of the inorganic constituents as presented on Table 5-65. All of the inorganics detections except two of them yielded a 99.9% confidence that the site meets the residential and industrial soil RBCs as presented on Figure 5-87. Figure 5-87 shows that all of the inorganic constituents except arsenic were at 99.9% with respect to meeting the industrial RBCs. All but two of the inorganics (arsenic and iron) were at 99.9% for meeting the residential RBCs. These included arsenic and iron whose detection levels in the non-detects being greater than the residential RBCs caused a zero percent confidence for these two inorganics.

Additional samples are not required to be collected for the inorganic subsurface soil sample set except for arsenic and iron as presented on Table 5-65. The large quantity of samples estimated to be collected are unreasonable for this site.

Sediment

The screening criteria utilized for the evaluation of the statistical representativeness of the sediment were the ERL and ERM Sediment Screening Values.

The percent confidence in the organic data set for the sediment at SWMU 2 was at least 95% for all but one of the constituents when compared with the ERM criteria as presented on Table 5-66. It should be noted that no criteria have been established for a majority of the constituents. All of the constituents with established criteria were at 99.9% confidence except for fluorene (99.5%) and 4,4'-DDE for meeting the ERM criteria as displayed on Figures 5-88 and 5-89.

Additional samples are not required to be collected for the sediment sample set when compared to the ERM criteria as presented on Table 5-66.

The 95 percent confidence in the inorganic data set for the sediment at SWMU 2 is presented on Table 5-67. The majority of the inorganic detections were at least 91.3 % confidence for meeting the ERM criteria as presented on Figure 5-90. Five of the eight constituents did not meet the 95% confidence in meeting the ERL sediment screening criteria due to the criteria value being less then the method detection limit.

Additional samples are required to be collected for the sediment inorganic sample set as presented on Table 5-67. A more in depth evaluation of the sediment associated with this SMWU is planned to be conducted under the CMS being proposed for this site.

Groundwater

The screening criteria utilized for the evaluation of the statistical representativeness of the groundwater were the Federal MCLs and the EPA Region III Tap Water RBCs.

The 95 percent confidence in the organic data set for the groundwater at SWMU 2 is presented on Table 5-68. The chlorinated herbicide detection yielded a 99.9% confidence that the site meets the tap water RBC as presented on Figure 5-94. Figures 5-91 through 5-94 present the percent confidence levels for those organic constituents detected in the groundwater. The majority of the constituents that do not meet the 95% confidence in the tap water RBC were minimally detected on the site. The method detection levels for many of the non detect constituents were above the criteria tap water RBC. The calculation for determining the percent confidence takes a non detection at the detection level of the constituent. This skews the result of the equation since these values which are greater then the standard are compared against the standard.

Additional samples are not required to be collected for the groundwater sample set except for trichloroethene (346 samples) and bis(2-ethylhexyl)phthalate (2 samples) as presented on Table 5-68. It was determined that additional samples were required for these two constituents when compared to the Federal MCL but not the more conservative tap water RBC. The large quantity of samples estimated to be collected for trichloroethene is unreasonable for this site. It should be noted that only two detections of bis(2-ethylhexyl)phthalate was detected above the screening. Due to the limited amount of detections and exceedances of the respective criteria additional samples are not required for these constituents.

The 95 percent confidence in the inorganic data set for the groundwater at SWMU 2 is presented on Tables 5-69 and 5-70. Figures 5-95 and 5-96 present the percent confidence levels for those inorganic constituents detected in the groundwater. The majority of the constituents that do not meet the 95% confidence were minimally detected on the site. The method detection levels for many of the non detect

constituents were either above the criteria or the criteria was not established for the respective constituent. The calculation for determining the percent confidence takes a non detection at the detection level of the constituent. This skews the result of the equation since these values which are greater then the standard are compared against the standard.

Additional samples are not required to be collected for the groundwater sample set except for antimony, lead and vanadium as presented on Table 5-69 and 5-70. It was determined that additional samples were required for these constituents when compared to one of the criteria but not the other for the total fraction. The large quantity of samples estimated to be collected are unreasonable for this site. It should be noted that only 33.3% of the samples analyzed for vanadium were detected above the tap water RBC. Due to these facts it is unreasonable to obtain additional groundwater samples for this site.

Surface Water

The screening criteria utilized for the evaluation of the statistical representativeness of the groundwater were the Federal Ambient Water Quality Criteria and the EPA Region III BTAG Screening Values.

The 95 percent confidence in the organic data set for the surfacewater at SWMU 2 is presented on Table 5-71. All of the SVOC detections yielded at least a 99.9% confidence that the site meets the BTAG screening levels as presented on Figure 5-97.

Additional samples are not required to be collected for the surface water organic sample set as presented on Table 5-71.

The 95 percent confidence in the inorganic data set for the surface water at SWMU 1 is presented on Table 5-72. Figure 5-98 presents the percent confidence levels for those inorganic constituents detected in the surface water.

Additional samples are not required to be collected for the surfacewater sample set as presented on Table 5-72.

6.0 HUMAN HEALTH RISK ASSESSMENT

A baseline human health risk assessment (RA) was performed, as part of a Resource Conservation Recovery Act (RCRA) facility investigation being conducted at operable units (OUs) 3 and 5 at Naval Station Roosevelt Roads (NSRR), Puerto Rico. OU 3 consists of two Solid Waste Management Unit (SWMUs), including the Army Cremator Disposal Site (SWMU 1) and the Langley Drive Disposal Site (SWMU 2). OU 5 (SWMU 45) includes the soil and groundwater surrounding Building 38.

This risk assessment evaluated samples collected from Confirmation Study (Environmental Science and Engineering [ESE], 1988), Supplemental Investigation (Baker Environmental, Incorporated [Baker], 1993), Relative Risk Ranking System (RRRS) (Baker, 1995b), and this RCRA Facility Investigation (RFI). The Confirmation Study (ESE, 1988) evaluated groundwater, surface water, and sediment at SWMU 1, and surface soil, subsurface soil, groundwater, surface water, and sediment at SWMU 2. The Supplemental Investigation (Baker, 1993) evaluated surface soil, subsurface soil, and groundwater at both SWMUs 1 and 2. The RRRS (Baker, 1995b) evaluated sediment at both SWMUs 1 and 2. This RFI evaluated surface soil, subsurface soil, groundwater and sediment at SWMU 45. Descriptions and historical background for each SWMU were provided in previous sections of this RFI report.

The purpose of the baseline RA is to evaluate the potential risks associated with exposures to contaminants in environmental media assuming no remedial action(s) is undertaken (i.e., baseline conditions). The baseline RA considers the most likely routes of potential human exposure for both current and future risk scenarios and was conducted in accordance with the following documentation: Interim Final RCRA Facility Investigation Guidance, Volume I of IV: Development of an RFI Work Plan and General Considerations for the RCRA Facility Investigations, May 1989 (United States Environmental Protection Agency [USEPA], 1989c); Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A), Interim Final, December 1989 (USEPA, 1989b); Selecting Exposure Routes and Contaminants of Concern, by Risk-Based Screening (SCCRBS), dated January 1993 (USEPA, 1993) and the USEPA Region III Risk-Based Concentration Table, October 1998 (USEPA, 1998b).

This baseline RA is comprised of seven sections: Section 6.1 presents the selection of chemicals of potential concern (COPCs); Sections 6.2 and 6.3 present the exposure assessment and toxicity assessment, respectively; the risk characterization is pr esented in Section 6.4; Section 6.5 presents sources of uncertainty inherent in the estimation of inferential potential human health effects; and a summary of the baseline RA is provided in Section 6.7.

6.1 Identification of Chemicals of Potential Concern

The selection of COPCs was based primarily on comparisons of analytical results with appropriate human health-based criteria. In conjunction with concentration comparisons to screening values, a comparison to concentrations detected in field and laboratory blanks was conducted to ensure that only site-related contaminants were evaluated in the quantitative estimation of human health effects. The prevalence of each detected chemical was used not as selection criteria, but for purposes of re-inclusion if necessary. Exceedence of criteria by a chemical concentration resulted in the selection of that chemical as a COPC in the given medium for further quantitative assessment. A more detailed discussion of COPC selection criteria is provided in the following section.

6.1.1 COPC Selection Criteria

The primary criteria used in selecting a chemical as a COPC at OUs 3 and 5 included comparing the maximum detected soil and groundwater concentrations to corresponding risk-based USEPA Region III chemicals of concern (COC) screening values, as presented in the Region III COC Screening Table (USEPA, 1994a), in accordance with USEPA Region III SCCRBS guidance (USEPA, 1993). In addition, detected groundwater concentrations were also compared with corresponding USEPA Federal Safe Drinking Water Act maximum contaminant levels (MCLs). Surface water concentrations were compared to Federal Ambient Water Quality Criteria (AWQC) for both water and organisms and organisms only (USEPA, 1992). Sediment concentrations were compared to sediment screening effects range-medium (ER-M) values (Long, et al, 1995) and Region III residential soil COC screening values.

USEPA Region III COC Screening Concentrations - Risk-Based COC Screening Concentrations (COC screening concentrations) were derived by USEPA Region III in January of 1993, and provided in tabular format to support selection of COPCs. COC screening concentrations address two major limitations in the COPC selection process presented in RAGS. First, using COC screening concentrations prioritizes chemical toxicity and focuses the risk assessment on those COPCs and potential exposure routes. Second, using the COC screening concentrations provides an absolute comparison of potential risks associated with the presence of a COPC in a given medium.

The principle of using risk-based criteria such as COC screening values is consistent with methodologies described in Interim Final RCRA Facility Investigation Guidance, Volume I of IV: Development of an RFI Work Plan and General Considerations for the RCRA Facility Investigations, May 1989 (USEPA, 1989c). COC screening concentrations were derived using conservative, USEPA-promulgated, default values and the most recent toxicological criteria available. COC screening concentrations for potentially carcinogenic and noncarcinogenic chemicals were individually derived based on a target incremental lifetime cancer risk (ILCR) of 1×10^{-6} and a target hazard quotient (HQ) of 0.1, respectively. An HQ of 0.1, rather than 1.0, is targeted for derivation of noncarcinogenic COC screening values for protection from cumulative effects of multiple chemical exposures. For potential carcinogens, the toxicity criteria applicable to the derivation of COC screening concentrations are chronic oral and inhalation cancer slope factors; for noncarcinogens, they are oral and inhalation reference doses. These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. Therefore, the use of toxicity criteria in the derivation of COC screening concentrations requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria.

In March of 1994, the USEPA Region III published a second COC Screening Table which was also based on an ILCR of 1×10^{-6} and a target HQ of 0.1. Subsequent semi-annual publications of the table (i.e., Risk-Based Concentration [RBC] Tables) have included an ILCR of 1×10^{-6} but an HQ of 1.0, rather than 0.1. However, since the RBCs are derived using similar equations and USEPA promulgated default exposure assumptions that were used to derive the original sets of COC screening concentrations, updated COC values can be obtained by using the carcinogenic RBCs

issued semi-annually by USEPA Region III and dividing the accompanying noncarcinogenic RBCs by a factor of 10. An updated set of COC values can, therefore, be obtained each time the RBC Tables are updated. The COC values used in this baseline RA were derived from the RBC values issued by the USEPA Region III for October 1998 (USEPA, 1998b).

Region III COC screening concentrations used in this baseline RA include those derived for tap water (based on ingestion and inhalation pathways) and soil (based on the ingestion pathway residential and industrial land use scenarios). Both the residential and industrial soil COC screening values are presented in this baseline RA; however, in text, the residential values were actually used in selecting COPCs, since they are lower, and consequently, more conservative than the industrial values. Industrial COC screening values are presented because future land use at OUs 3 and 5 is expected to remain industrial. The soil RBCs protective of direct contact exposures under both industrial and residential scenarios are similar to those derived and presented in USEPA's Soil Screening Guidance (USEPA, 1996a).

Total polychlorinated dibenzo-p-dioxins (PCDDs) and total polychlorinated dibenzofurans (PCDFs) were detected in the media investigated at OUs 3 and 5. However, COC screening values are only available for the 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) congener. In order to derive a COC value for a dioxin or furan congeners other than 2,3,7,8-TCDD, a 2,3,7,8-TCDD toxic equivalent concentration (TEC) was estimated for each compound. This was done by dividing the COC value for 2,3,7,8-TCDD by the appropriate 2,3,7,8-TCDD toxic equivalence factor (TEF) established for each congener. TEF values were acquired from USEPA's Estimating Exposures to Dioxin - Like Compounds, Volume I: Executive Summary (USEPA, 1994c). However, 2,3,7,8-TCDD TEFs are not generally established for the calculation of TECs for total PCDDs and PCDFs, but rather, for specific congeners. Therefore, the most conservative TEFs for the 2,3,7,8-congeners (cited in Section 6.2.3.5) corresponding to detected total PCDDs and PCDFs were applied to the Region III industrial and residential soil RBCs for 2,3,7,8-TCDD to give the following toxic equivalent dioxin/furan RBCs (µg/kg): total hexachlorodibenzo-p-dioxin (HxCDD) - 0.38/0.043; total tetrachlorodibenzofuran (TCDF) - 0.38/0.043; total pentachlorodibenzofuran (PeCDF) - 0.076/0.0086; and total hexachlorodibenzofuran (HxCDF) - 0.38/0.043. The calculation of 2,3,7,8-TCDD TECs for various dioxin/furan congeners is discussed in greater detail in Section 6.3.4.

Maximum Contaminant Levels (MCLs) - Federal USEPA MCLs are potentially enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs have been adopted as enforceable standards for public drinking water systems and apply to drinking water supplies consumed by a minimum of 25 persons. They have been developed for the prevention of human health effects associated with lifetime exposure (70 year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical and economic feasibility of removing the constituent from a public water supply. The MCLs applied in this baseline RA for OUs 3 and 5 were published in October 1996 (USEPA, 1996). It should be noted that since MCLs are not entirely risk-based, especially since they consider technical and economic feasibility, these were only presented in this baseline RA for informational purposes. MCLs were used to select or eliminate COPCs only in the absence of corresponding COC screening values.

Ambient Water Quality Criteria (AWQC) - AWQCs (USEPA, 1992b and USEPA, 1991c) are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). The human health AWQCs for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 (i.e., the 10^{-7} to 10^{-5} range).

Sediment Screening Values - At present, promulgated sediment COC values or quality criteria do not exist to protect human health. However, sediment screening values (SSVs) have been published (Long, et al., 1995) for evaluating the potential for chemical constituents in sediment to cause adverse biological effects. This screening method was developed through evaluation of biological effects data for aquatic (marine and freshwater) organisms that were obtained through equilibrium partitioning calculations, spiked-sediment bioassays, and concurrent biological and chemical field surveys. For each constituent having sufficient data available, the concentrations causing adverse biological effects were arrayed and the lower 10 percentile (called an Effects Range-Low, or ER-L) and the median

(called an Effects Range-Median, or ER-M) were determined. If contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable.

Since this baseline RA evaluates exposures to human receptors, which are less toxicologically sensitive than ecological receptors, exceedences of the ER-M constituted a chemical's retention as a COPC. Therefore, constituents detected in sediment samples collected from SWMUs 1, 2, and 45 were compared to the ER-M s to determine if any criteria were exceeded.

Prevalence - The prevalence of a chemical in an environmental medium can be described by the frequency and concentration with which it is detected. Prevalence has been provided in the text for comparison, but was not used to select COPCs. Prevalence could be used to re-include COCs eliminated by comparison to COC screening concentrations if necessary.

Blank Concentrations - If a chemical is detected in both the environmental sample and a blank sample, it may not be retained as a COPC in accordance with RAGS depending on the concentration of the chemical in the media. Therefore, blank data were compared with results from environmental samples. If the blanks contained detectable results for common laboratory contaminants (i.e., acetone, 2-butanone, methylene, chloride, toluene, and phthalate esters), environmental sample results were considered as positive results only if they exceed 10 times the maximum amount detected in the associated blank. If the chemical detected in the blank(s) is not a common laboratory contaminant, environmental sample results were considered as positive results only if they exceeded five times the maximum amount detected in the associated blank(s). Furthermore, the elimination of an environmental sample result would directly correlate to a reduction in the prevalence of the contaminant in that media.

When assessing soil and sediment concentrations, the Contract Required Quantitation Limits (CRQLs) and percent moisture are accounted for in order to correlate solid and aqueous quantitation limits. For example, when assessing semivolatile, pesticide, polychlorinated biphenyls (PCB), and nitramine contaminants the CRQL for solid samples is 33 to 66 times (depending on the contaminant) that of the aqueous samples. This correction is not necessary for the evaluation of volatile COPCs. Therefore, in order to assess contaminant levels in solid samples using an aqueous blank

concentration, the concentration was multiplied by 5 or 10 (noncommon or common laboratory contaminants, respectively) and then multiplied by 33 to correct for the variance in the CRQL. Accounting for multipliers greater than 33 or the percent moisture was not necessary for this data set. Associated blanks for SWMUs 1, 2, and 45 included: field blanks, trip blanks, and rinsate blanks. It is important to note that the aforementioned methodologies for evaluating blanks are usually implemented during third party analytical data validation prior to the selection of COPCs in the RA.

Essential Nutrients - Despite their potential toxicity, certain inorganic constituents are essential nutrients. Essential nutrients need not be considered further in the baseline RA if they are present in relatively low concentrations (i.e., slightly elevated above naturally occurring levels), or if the constituent is toxic at doses much higher than those which could be assimilated through exposures at the site. Essential nutrients include calcium, magnesium, potassium and sodium.

6.1.2 Selection of COPCs

Tables 6-1 through 6-14 present the selection of COPCs for each environmental medium based on the criteria discussed previously in Section 6.1.1. A list of the individual samples collected at each SWMU and associated analyses is presented in Tables 3-1 through 3-3. In general, the following analytical parameters were specified: volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), RCRA metals, Appendix IX metals, explosives, and individual inorganics. Analyses for specific media are presented below:

Surface and subsurface soil:

Confirmation Study (SWMU 2): VOCs, SVOCs, Pesticides/PCBs, Inorganics and Lead

Supplemental Investigation (SWMUs 1 & 2): VOCs, SVOCs, Pesticides/PCBs and Inorganics

1996 RFI (SWMU 45): VOCs, SVOCs, PCBs and RCRA metals

1997 RFI (SWMU 45): VOCs, SVOCs, PCBs and Appendix IX metals

RFI (SWMUs 1 & 2): Appendix IX List and Explosives

Groundwater:

Confirmation Study (SWMUs 1 & 2): VOCs, SVOCs, Pesticides/PCBs and Inorganics

Supplemental Investigation (SWMU 1): SVOCs, Pesticides/PCBs and Inorganics

Supplemental Investigation (SWMU 2): VOCs, SVOCs, Pesticides/PCBs and Inorganics

1996 RFI (SWMU 45): VOCs, SVOCs, PCBs and RCRA metals

1997 RFI (SWMU 45): VOCs, SVOCs, PCBs and Appendix IX metals

RFI (SWMUs 1 & 2): Appendix IX List, Explosives and Sodium

Surface water:

Confirmation Study (SWMU 1): VOCs, SVOCs, Pesticides/PCBs, Inorganics and Chromium

Confirmation Study (SWMU 2): VOCs, SVOCs, Pesticides/PCBs and Inorganics

Sediment:

Confirmation Study (SWMUs 1 & 2): VOCs, SVOCs, Pesticides/PCBs and Inorganics

RRRS (SWMUs 1 & 2): Appendix IX List

1997 RFI (SWMU 45): VOCs, SVOCs, PCBs and Appendix IX metals

RFI (SWMUs 1 & 2): Appendix IX List and Explosives

The following paragraphs present the rationale for selecting COPCs at SWMUs 1, 2 and 45 at NSRR. Frequencies on detection (i.e., the number of positive detects / the number of samples analyzed) are also provided in the following paragraphs in parentheses. It should also be noted that although background values (representing the arithmetic mean concentration for each chemical plus two times the standard deviation) are presented in the tables, they were not used to select COPCs, as a conservative measure. Sample locations, analytical results, and corresponding figures are presented in previous sections of this RFI report.

6.1.2.1 <u>SWMU 1 - Army Cremator Disposal Site</u>

Environmental media investigated at SWMU 1 included surface soil, subsurface soil (i.e., greater than 1 foot bgs), groundwater, surface water and sediment. Data and COPC selection summaries for these media are presented in Tables 6-1 through 6-5 respectively. The following paragraphs present the rationale for selecting COPCs in each investigated medium at SWMU 1.

Surface Soil

Table 6-1 indicates that 21 surface soil samples were collected at SWMU 1. VOCs were detected at concentrations less than USEPA Region III industrial and residential soil COC screening values. Therefore, they were not retained as surface soil COPCs at SWMU 1.

Fifteen SVOCs were detected in the SWMU 1 surface soil samples. Of these 15 compounds, four polynuclear aromatic hydrocarbons (PAHs) exceeded their respective USEPA Region III residential soil COC screening values: benzo(a)anthracene (3/21), benzo(b)fluoranthene (3/21), benzo(a)pyrene (3/21), and dibenzo(a,h)anthracene (2/21). Therefore, these four compounds were retained as surface soil COPCs. All other SVOCs were detected at concentrations less than their respective criteria and were not retained as surface soil COPCs.

Six pesticides were detected in the surface soil. One concentration of 4,4'-DDT (15/21) exceeded the corresponding residential soil COC screening value. Therefore, 4,4'-DDT was retained as a surface soil COPC. All other pesticides were detected at concentrations less than their respective criteria and were not retained as surface soil COPCs.

Inorganics were also detected in each of the surface soil samples collected. Detected concentrations of aluminum (6/6), antimony (11/21), arsenic (3/21), cadmium (14/21), chromium (21/21), copper (21/21), iron (6/6), manganese (6/6) and vanadium (21/21) exceeded their corresponding USEPA Region III residential soil COC values. In addition, there was no comparison criteria for mercury (13/21). Therefore, these inorganics were retained as surface soil COPCs for quantitative evaluation in the baseline RA. The remaining thirteen inorganics were considered essential nutrients or were detected at concentrations below their respective criteria and were therefore not retained as COPCs.

Subsurface Soil

Table 6-2 indicates that 22 subsurface soil samples were collected from SWMU 1 and analyzed. Five VOCs, two SVOCs, and seven pesticides were detected in the subsurface soil samples at

concentrations less than corresponding USEPA Region III industrial and residential soil COC screening values and, therefore, were not retained as subsurface soil COPCs.

Total dioxins/furans were detected in the subsurface soil samples collected. Results were conservatively reported as totals for hexachlorinated dioxins and furans and a single tetrachlorinated furan moiety. Total HxCDD was reported in one of sixteen subsurface soil samples. HxCDF was detected in two of sixteen samples and TCDF was detected in one of sixteen samples. All three of these compounds exceeded residential soil COC screening values and, therefore, were retained as COPCs.

Inorganics also were detected sporadically in each of the subsurface soil samples. Aluminum (6/6), antimony (12/22), chromium (22/22), copper (22/22), iron (6/6), manganese (6/6), and vanadium (22/22) exceeded the corresponding USEPA Region III residential soil COC screening values; therefore, they were retained as subsurface soil COPCs for quantitative evaluation in the baseline RA. In addition, there was no comparison criteria for mercury (2/22); therefore, it was also retained as a possible COPC. The remaining fifteen inorganics were considered essential nutrients or were detected at concentrations below their respective criteria and were therefore not retained as COPCs.

Groundwater

Table 6-3 indicates that twenty groundwater samples were collected from SWMU 1. Two VOCs, chloroform (2/19) and 1,1,2,2-tetrachloroethane (1/19), were detected in groundwater samples exceeding their corresponding USEPA Region III COC screening values for tap water and were retained as a groundwater COPCs at SWMU 1.

Three SVOCs were detected in the groundwater at SWMU 1. Pentachlorophenol (4/20) and bis(2-ethylhexyl)phthalate (6/19) were detected at concentrations which exceeded the USEPA Region III COC screening value for tapwater and were therefore retained as COPCs at SWMU 1. Phenols were detected at concentrations less than corresponding screening criteria and were not retained as groundwater COPCs.

Four pesticides and two herbicides were detected in the groundwater samples collected at SWMU 1. Of these compounds, the pesticides heptachlor (1/20) and aldrin (3/20) exceeded corresponding USEPA Region III COC screening values for tapwater and were retained as COPCs.

Total HxCDD (1/9), was detected in one sample at a concentration above the COC screening value for tapwater and was therefore retained as a COPC.

Twenty-four total (unfiltered) inorganics were detected in the groundwater samples collected. Of these, 18 inorganics were detected at levels above criteria. Antimony (3/20), arsenic (5/13), barium (10/10), cadmium (4/20), chromium (15/20), chromium VI (3/10), cobalt (7/10), copper (18/20), manganese (1/1), nickel (13/20), selenium (5/13), silver (5/20), thallium (6/20), vanadium (8/10) and zinc (19/20) exceeded USEPA Region III tapwater COC screening values. Antimony, arsenic, cadmium, chromium, chromium VI, copper, nickel, selenium, and thallium also exceeded the Federal MCLs. Beryllium (4/20) and mercury (3/20) exceeded the Federal MCLs. Lead (4/15) exceeded its corresponding action level in two samples. All of these total inorganics were retained as groundwater COPCs. The remaining six total inorganics were considered essential nutrients or were detected at concentrations below their respective criteria and were therefore not retained as COPCs.

Fifteen dissolved (filtered) inorganics also were detected in the groundwater samples collected. Detected concentrations of cadmium (5/10), copper (7/10), manganese (1/1), nickel (3/10), thallium (1/10) and vanadium (7/10) exceeded their corresponding USEPA Region III tapwater COC screening values. In addition, the maximum detected concentration of cadmium, copper and thallium exceeded the respective Federal MCLs. Therefore, cadmium, copper, manganese, nickel, thallium and vanadium were retained as dissolved groundwater COPCs for quantitative evaluation in the baseline RA.

Surface Water

Table 6-4 indicates that ten surface water samples were collected from SWMU 1. Three SVOCs were detected in the surface water. Detected concentrations of bis(2-ethylhexyl)phthalate (BEHP) (8/10) exceeded Federal AWQCs; therefore, BEHP was retained as a surface water COPC for SWMU 1. Due to lack of comparison criteria, di-n-octylphthalate (4/10) was retained as a possible surface water COPC. The concentrations of phenols (5/5) were detected at concentrations below corresponding screening values and were not retained as surface water COPCs.

Eight total (unfiltered) inorganics were also detected in the surface water at SWMU 1. Detected concentrations of arsenic (5/10), thallium (5/10), and zinc (6/10) exceeded Federal AWQCs and were therefore retained as a surface water COPCs for SWMU 1. The remaining five inorganics were detected at concentrations below their respective criteria and were therefore not retained as COPCs.

Sediment

Table 6-5 shows that seventeen sediment samples were collected at SWMU 1. Three VOCs were detected in samples at a level that did not exceed the SSVs or USEPA Region III residential soil COC screening values. Therefore, VOCs were not retained as a COPCs for sediment.

Twelve SVOCs were detected in sediment samples. Benzo(a)pyrene (1/16), was detected at a concentration exceeding the USEPA Region III residential soil COC screening values in one sample. Benzo(a)pyrene was, therefore, retained as a COPC. The remaining SVOCs were detected at concentrations below screening values and were not retained as sediment COPCs.

Four pesticides and one PCB were detected in sediment samples collected from SWMU 1. Of the pesticides, 4,4'-DDE (4/16) and 4,4'-DDT (2/16) exceeded ER-M values and delta-BHC (2/16) exceeded the corresponding USEPA Region III residential soil COC screening value. Therefore, 4,4'-DDE, 4,4'-DDT, and delta-BHC were retained as sediment COPCs. Aroclor-1260 (1/16) was detected in one sample at a concentration that exceeded both the ER-M value and the USEPA Region III residential soil COC screening value and was also retained as a sediment COPC.

Four total dioxin/furan compounds were reported by the laboratory as detected in sediments at SWMU 1 at levels that exceeded residential soil COC screening values. These included total HxCDD (2/5), total TCDF (1/5), total PeCDF (1/5), and total HxCDF (2/5). Total dioxin/furan compounds were therefore retained as sediment COPCs for SWMU 1.

Sixteen inorganics were detected in sediment samples collected at SWMU 1. Ten of these inorganics were detected at levels exceeding the USEPA Region III residential soil COC screening values: antimony (7/16), arsenic (14/16), chromium (16/16), copper (16/16), lead (12/17), selenium (12/16) and vanadium (6/6). Copper and lead also exceeded ER-M values. Three additional inorganics, mercury (3/16), nickel (13/16), and zinc (16/16) exceeded ER-M values. Therefore, these ten inorganics were retained as sediment COPCs.

6.1.2.2 SWMU 2 - Langley Drive Disposal Site

The environmental media investigated at SWMU 2 included surface and subsurface soils, groundwater, surface water and sediment. Data and COPC selection summaries for these media are presented in Tables 6-6 through 6-10. The following paragraphs present the rationale for selecting COPCs in each investigated medium at SWMU 2.

Surface Soil

Table 6-6 shows that twenty-nine surface soil samples were collected from the 0- to 1-foot interval. Five VOCs were detected at concentrations below screening values; therefore, VOCs were not retained as surface soil COPCs.

Thirteen SVOCs were detected in the SWMU 2 surface soil samples. Concentrations of twelve of these SVOCs were less than the respective industrial and residential COC screening values and, therefore, were not retained as surface soil COPCs. One SVOC, benzo(a)pyrene (7/29), was detected at levels above the residential COC value in four samples. Therefore, benzo(a)pyrene was retained as a COPC for surface soils.

Seventeen pesticides were detected in the surface soil at concentrations less than corresponding USEPA Region III industrial and residential COC screening values. Therefore no pesticides were retained as surface soil COPCs.

Two dioxin/furan compounds were each detected in one soil sample collected at SWMU 2. Both of these compounds, total HxCDD (1/8) and total HxCDF (1/8), were detected at levels above the residential COC screening values. Therefore, both of these compounds were retained as surface soil COPCs.

Twenty-two inorganics were detected in the surface soil samples collected. Aluminum (6/6), antimony (21/29), arsenic (25/29), barium (14/14), cadmium (17/29), chromium (29/29), copper (29/29), iron (6/6), lead (37/42), manganese (6/6), nickel (27/29), selenium (16/29), vanadium (14/14) and zinc (29/29) exceeded the corresponding Region III residential COC value. In addition, arsenic and iron were detected above the industrial COC values. Also, mercury was retained as a possible COPC because of the uncertainties associated with the lack of comparison criteria. Therefore, aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium and zinc were retained as inorganic surface soil COPCs for quantitative evaluation in the baseline RA.

Subsurface Soil

Table 6-7 shows that thirteen subsurface soil samples were collected from SWMU 2. Nine VOCs were detected in the subsurface samples at concentrations less than corresponding USEPA Region III industrial and residential COC screening values and were not retained as surface soil COPCs.

Seventeen SVOCs were detected in the subsurface soil samples collected from SWMU 2. Concentrations of benzo(a)anthracene (1/13), benzo(b)fluoranthene (1/13), benzo(a)pyrene (1/13), and dibenzo(a,h)anthracene (1/13) exceeded the USEPA Region III residential COC screening value and were therefore retained as subsurface soil COPCs.

Fourteen pesticides were detected in the subsurface soil at SWMU 2 at concentrations less than their corresponding industrial and residential COC screening values. Therefore no pesticides were retained as subsurface soil COPCs.

Two dioxin/furan compounds were each detected in subsurface soil samples collected at SWMU 2. Total HxCDD (1/6) and total TCDF (2/6) were detected at concentrations exceeding residential COC screening values; therefore, total HxCDD and total TCDF were retained as subsurface soil COPCs.

Twenty-two inorganics were detected in the subsurface soil samples collected at SWMU 2. Aluminum (5/5), antimony (10/13), arsenic (11/13), cadmium (10/13), chromium (13/13), copper (13/13), iron (5/5), lead (13/13), manganese (5/5), and vanadium (13/13) exceeded corresponding Region III residential soil COC values. In addition, arsenic and iron exceeded corresponding industrial COC values. Also, mercury was retained as a possible COPC because of uncertainties associated with the lack of comparison criteria. Therefore, aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury and vanadium were retained as SWMU 2 subsurface soil COPCs for quantitative evaluation in the baseline RA.

Groundwater

Table 6-8 shows that six groundwater samples were collected at SWMU 2. Two VOCs, chloroform (3/6), and trichloroethene (2/6) were detected in these samples exceeding the USEPA Region III tapwater COC values. In addition, two detections of trichloroethene exceeded the Federal MCL. Therefore, chloroform and trichloroethene were retained as groundwater COPCs.

Four SVOCs were detected in groundwater samples collected at SWMU 2. Both detections of pentachlorophenol (2/6) exceeded the USEPA Region III tapwater COC value and the Federal

MCL. Due to the uncertainties associated with the lack of comparison criteria, isodrin (the endo,endo isomer of the pesticide aldrin) (3/4) was retained as a possible COPC. Therefore, pentachlorophenol and isodrin were retained as groundwater COPCs for SWMU 2.

Three pesticides and one herbicide were detected in groundwater samples. The pesticides aldrin (3/6) and heptachlor epoxide (1/6) exceeded USEPA Region III tapwater COC values and were therefore retained as groundwater COPCs for SWMU 2.

Nineteen total (unfiltered) inorganics were detected in the groundwater samples collected at SWMU 2. Nine of these nineteen were detected at levels that exceeded criteria. Antimony (2/4), arsenic (2/6), barium (4/5), cadmium (2/6), chromium (3/6), copper (4/6), iron (1/1), lead (4/6) and vanadium (5/5) exceeded USEPA Region III tapwater COC values. In addition, antimony and lead exceeded the Federal MCL in two samples. Therefore, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, and vanadium were all retained as total inorganic groundwater COPCs.

Twelve dissolved (filtered) inorganics were detected in the filtered groundwater samples collected at SWMU 2. Of these twelve only three were detected at levels that exceeded criteria. Barium (4/5), cadmium (2/5) and vanadium (5/5) exceeded USEPA Region III tapwater COC values; therefore, these three inorganics were retained as dissolved inorganic COPCs for groundwater at SWMU 2.

Surface Water

Table 6-9 indicates that six surface water samples were collected from SWMU 2. Three SVOCs, bis(2-ethylhexyl)phthalate (5/6), di-n-octylphthalate (2/6) and phenol (3/6) were detected in the surface water. The concentrations of bis(2-ethylhexyl)phthalate exceeded Federal AWQCs and was therefore retained as a surface water COPC for SWMU 1. Due to uncertainties associated with the lack of comparison criteria, di-n-octylphthalate was also retained as a possible surface water COPC. The concentrations of phenol were detected at concentrations below corresponding screening values; therefore, phenol was not retained as a surface water COPC.

Eight total (unfiltered) inorganics were detected in the surface water at SWMU 2. Detected concentrations of beryllium (3/6), chromium (6/6), mercury (3/6), selenium (5/6), and thallium (3/6) exceeded Federal AWQCs and were therefore retained as a surface water COPC for SWMU 1. In addition, lead (3/7) and zinc (4/6) were retained as possible COPCs because of lack of comparison criteria. Therefore, beryllium, chromium, lead, mercury, selenium, thallium and zinc were retained as surface water COPCs at SWMU 2. The remaining four total inorganics were detected at concentrations below their respective criteria and were therefore not retained as COPCs.

Sediment

Thirteen samples of sediment were collected at SWMU 2 (Table 6-10). One VOC, 2-butanone (1/13) was detected at a concentration below the corresponding screening values and was therefore not retained as a sediment COPC.

Twelve SVOCs were detected in the sediment at SWMU 2. Benzo(a)anthracene (2/12), benzo(a)pyrene (1/12) and benzo(b)fluoranthene (2/12) were detected at concentrations which exceeded the USEPA Region III residential soil COC screening values, and were therefore retained as sediment COPCs.

4,4'-DDE was detected in one sediment sample collected from SWMU 2 at concentrations exceeding the ER-M value, and was therefore retained as a sediment COPC.

Total HxCDD (1/6) and total HxCDF (1/6) were detected in sediments at SWMU 2 at levels that exceeded residential soil COC screening values; therefore, these compounds were retained as sediment COPCs for SWMU 2.

Fifteen inorganics were detected in the sediment samples, eight of which were detected at levels that exceeded residential soil COC values and/or ER-Ms. Antimony (5/12), arsenic (12/12), chromium (12/12), copper (12/12), and vanadium (6/6) exceeded residential soil COC values. In addition, copper exceeded the ER-M in three samples. Lead (9/13), mercury (6/12) and zinc (12/12) exceeded their ER-Ms. Therefore, antimony, arsenic, chromium, copper, lead, mercury, vanadium and zinc were retained as sediment COPCs for the baseline RA at SWMU 2.

6.1.2.3 SWMU 45 - Building 38

The environmental media investigated at SWMU 45 included surface soil, subsurface soil, groundwater and sediment. Data and COPC selection summaries for these media are presented in Tables 6-11 through 6-14, respectively. The following paragraphs present the rationale for selecting COPCs in each investigated medium at SWMU 45.

Surface Soil

Table 6-11 indicates that four surface soil samples were collected from the 0- to 1-foot interval. Only one organic compound, Aroclor-1260 (2/4), was detected in surface soil samples at concentrations less than the corresponding COC screening values; therefore, no organics were retained as surface soil COPCs at SWMU 45.

Six inorganics were detected in the surface soil samples collected at SWMU 45. Of these inorganics, arsenic (3/4) and chromium (4/4) exceeded the corresponding Region III residential soil COC value; therefore, arsenic and chromium were retained as surface soil COPCs for quantitative evaluation in the baseline RA. In addition, mercury (4/4) was retained as a possible COPC because of lack of comparison criteria. The remaining three inorganics were detected at concentrations below their respective criteria and were therefore not retained as COPCs.

Subsurface Soil

Twenty-five subsurface soil samples were collected from SWMU 45 and analyzed for organic and inorganic constituents (Table 6-12). Four VOCs were detected at concentrations less than USEPA Region III industrial and residential soil COC screening values. Therefore, VOCs were not retained as subsurface soil COPCs at SWMU 45.

Ten SVOCs were detected in the subsurface soil samples at SWMU 45. Of these 10 compounds, benzo(a)pyrene (4/25) was the only SVOC which exceeded its respective USEPA Region III residential soil COC screening values. Therefore, benzo(a)pyrene was retained as a subsurface soil COPC. All other SVOCs were detected at concentrations less than their corresponding COC screening concentrations and were not retained as subsurface soil COPCs.

Aroclor-1260 was detected in five of the subsurface soil samples collected at SWMU 45 at concentrations less than the corresponding COC screening values; therefore, Aroclor-1260 was not retained as a subsurface soil COPC at SWMU 45.

Fifteen inorganics were detected in the subsurface soil samples collected at SWMU 45. Arsenic (22/25), chromium (25/25), and vanadium (17/17) exceeded corresponding Region III residential soil COC values. Arsenic also exceed the industrial COC value in three samples. Mercury was also retained as a possible COPC despite the lack of comparison criteria. Therefore, arsenic, chromium, mercury and vanadium were retained as SWMU 45 subsurface soil COPCs for quantitative evaluation in the baseline RA. The remaining eleven inorganics were detected at concentrations below their respective criteria and were therefore not retained as COPCs.

Groundwater

Twenty-two groundwater samples were collected from SWMU 45 (Table 6-13). One VOC was detected in the groundwater samples at concentrations less than the corresponding groundwater criteria; therefore, VOCs were not retained as a groundwater COPC.

Sixteen SVOCs were detected in the groundwater samples from SWMU 45. Of these compounds, benzo(a)anthracene (1/22), benzo(a)pyrene (1/22), bis(2-ethylhexyl)phthalate (8/22), and chrysene (1/22) exceeded their respective USEPA Region III tapwater COC screening values. Benzo(a)pyrene and bis(2-ethylhexyl)phthalate also exceeded their respective Federal MCLs. Therefore, benzo(a)anthracene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, and chrysene were retained as groundwater COPCs.

One PCB, Aroclor-1260 (1/22), was detected in a groundwater sample which exceeded its corresponding Region III tapwater COC value. Therefore, Aroclor-1260 was retained as a groundwater COPC.

Thirteen total (unfiltered) inorganics were detected in the groundwater samples collected from SWMU 45. Detected concentrations of antimony (11/16), arsenic (17/25), barium (25/25), cadmium (10/25), chromium (22/25), lead (10/24) and vanadium (14/16) exceeded their corresponding Region III tap water COC values. In addition, two detections of arsenic, four detected concentrations of cadmium, six detections of chromium, and five detections of lead exceeded the respective Federal MCLs. Therefore, antimony, arsenic, barium, cadmium, chromium, lead, and vanadium were retained as total groundwater COPCs for quantitative evaluation in the baseline RA.

Twelve dissolved (filtered) inorganics were detected in the groundwater samples collected. Detected concentrations of antimony (5/14), arsenic (14/22), barium (22/22), cadmium (4/22), mercury (5/22), and vanadium (7/14) exceeded their corresponding Region III tap water COC values. In addition, one detection of dissolved cadmium and one detection of dissolved mercury exceeded their respective Federal MCLs. Therefore, antimony, arsenic, barium, cadmium, mercury, and vanadium were retained as dissolved groundwater COPCs for quantitative evaluation in the baseline RA.

Sediment

A total of nine samples of sediment were collected at SWMU 45. A single VOC, acetone (9/9) was detected in the samples collected but at levels below criteria. Therefore, it was not retained as a sediment COPC (Table 6-14).

Sixteen SVOCs were detected in the SWMU 45 sediment samples. Of these compounds, benzo(a)pyrene (7/9), benzo(b)fluoranthene (7/9), dibenzo(a,h)anthracene (3/9), and indeno(1,2,3-cd)pyrene (7/9) exceeded their respective USEPA Region III residential soil COC screening values. In addition, one detection of benzo(a)pyrene and dibenzo(a,h)pyrene exceeded their ER-M values. Therefore, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were retained as sediment COPCs.

One PCB, Aroclor-1260 (9/9) was detected in the sediment at concentrations less than the SSV or USEPA Region III residential soil COC screening values; therefore, PCBs were not retained as a sediment COPCs.

Sixteen inorganics were detected in the sediment samples. Arsenic (11/11) and vanadium (11/11) were detected at levels that exceeded their respective residential soil COC values. Therefore, these inorganics were retained as sediment COPCs for the baseline RA at SWMU 45.

6.1.3 Summary of COPCs

The following summarizes the COPCs identified for each SWMU to be quantitatively evaluated in this baseline RA. Italicized COPCs are those that do not exceed station background values. Table 6-15 provides a summary of the COPCs by SWMU and media.

SWMU 1 - Army Cremator Disposal Site

SURFACE SOIL: Benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, 4,4-DDT, aluminum, antimony, arsenic, cadmium, *chromium,* copper, iron, manganese, *mercury* and *vanadium*

SUBSURFACE SOIL: Total HxCDD, total HxCDF, total TCDF, aluminum, antimony, *chromium*, copper, iron, manganese, mercury and *vanadium*

TOTAL GROUNDWATER: Chloroform, 1,1,2,2-tetrachloroethane, pentachlorophenol, bis(2-ethylhexyl)phthalate, heptachlor, aldrin, total HxCDD, antimony, arsenic, barium, beryllium, cadmium, chromium, chromium VI, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium and zinc

FILTERED GROUNDWATER: Chloroform, 1,1,2,2-tetrachloroethane, pentachlorophenol, bis(2-ethylhexyl)phthalate, heptachlor, aldrin, total HxCDD, cadmium, copper, manganese, nickel, thallium and vanadium

SURFACE WATER: Bis(2-ethylhexyl)phthalate, di-n-octylphthalate, arsenic, thallium, and zinc

SEDIMENT: Benzo(a)pyrene, 4,4'-DDE, 4,4'-DDT, delta-BHC, Aroclor-1260, total HxCDD, total TCDF, total PeCDF, Total HxCDF, antimony, arsenic, chromium, copper, lead, mercury, nickel, selenium, vanadium, and zinc

SWMU 2 - Langley Drive Disposal Site

SURFACE SOIL: Benzo(a)pyrene, total HxCDD, total HxCDF, aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium and zinc

SUBSURFACE SOIL: Benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, Total HxCDD, total TCDF, aluminum, antimony, arsenic, cadmium, *chromium,* copper, iron, lead, manganese, mercury, and *vanadium*

TOTAL GROUNDWATER: Chloroform, trichloroethene, isodrin, pentachlorophenol, aldrin, heptachlor epoxide, antimony, *arsenic*, *barium, cadmium, chromium, copper,* iron, lead, and vanadium

FILTERED GROUNDWATER: Chloroform, trichloroethene, isodrin, pentachlorophenol, aldrin, heptachlor epoxide, barium, cadmium, and vanadium

SURFACE WATER: Bis(2-ethylhexyl)phthalate, di-n-octylphthalate, beryllium, chromium, lead, mercury, selenium, thallium, and zinc

SEDIMENT: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, 4,4'-DDE, total HxCDD, total HxCDF, antimony, arsenic, chromium, copper, lead, mercury, vanadium, and zinc

SWMU 45 - Building 38

SURFACE SOIL: Arsenic, *chromium*, and *mercury*

SUBSURFACE SOIL: Benzo(a)pyrene, arsenic, chromium, *mercury* and *vanadium*

TOTAL GROUNDWATER: Benzo(a)anthracene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, chrysene, Aroclor-1260, antimony, arsenic, *barium*, cadmium, chromium, lead, and *vanadium*

FILTERED GROUNDWATER: Benzo(a)anthracene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, chrysene, Aroclor-1260, antimony, arsenic, barium, cadmium, mercury, and vanadium

SEDIMENT: Benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, and vanadium

6.2 Exposure Assessment

The exposure assessment addresses each potential current and future exposure pathway in soil, groundwater, surface water, sediment, and air. To determine whether human exposure could occur at SWMUs 1, 2, and 45 in the absence of remedial action, an exposure assessment was conducted to identify potential exposure pathways and receptors. The following four elements were considered to ascertain whether a complete exposure pathway was present (USEPA, 1989b):

- A source and potential mechanism of chemical release
- An environmental retention or transport medium
- A point of potential human contact with the contaminated medium
- An exposure route (e.g., ingestion) at the contact point

The exposure scenarios presented in the following sections are used to estimate individual risks. The reasonable maximum exposure (RME) was evaluated for each scenario utilized in this baseline RA. Relevant equations for assessing intakes and exposure factors were obtained from RAGS (USEPA, 1989b), Exposure Factors Handbook (USEPA, 1997a), Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992a), and Standard Default Exposure Factors. Interim Final (USEPA, 1991a). Unless otherwise noted, all the statistical data associated with the factors used in the dose evaluation equations for assessing exposure were obtained from the Exposure Factors Handbook (USEPA, 1997a) and the accompanying guidance manuals.

6.2.1 Chemical Fate and Transport

This section discusses the potential release, migration and ultimate fate of COPCs detected at OUs 3 and 5. The potential for a chemical to migrate spatially and its persistence in environmental media is important in the estimation of exposure and potential risks posed by conditions at a site.

The distribution relationships for a chemical between air, water, and soil can be evaluated using equilibrium constants. By utilizing the physio-chemical properties of a constituent, it is possible to estimate a chemical's expected environmental distribution and environmental fate.

The mobility and persistence of a chemical will be influenced primarily by its physical and chemical properties and the chemistry of the medium in which it occurs. Table 6-16 presents the physical and chemical properties associated with the organic COPCs including: vapor pressure, water solubility, octanol-water partition coefficient, soil adsorption coefficient, specific gravity, Henry's Law constant, and mobility index. Calculated values, obtained using approximation methods, are presented when literature values are unavailable. A discussion of the environmental significance of each of these properties follows.

- Vapor pressure is an indication of the rate at which a chemical will volatilize. It is of primary significance as a removal mechanism at environmental interfaces such as shallow (surface) soil-air and surface water-air. In general, vapor pressures for volatile organics, would be higher than vapor pressures for semivolatiles or pesticides. Chemicals with higher vapor pressures are expected to enter the atmosphere more readily than chemicals with lower vapor pressures. Therefore, volatilization can be a significant loss process for VOCs in shallow (surface) soil and surface water.

- Water solubility measures how much of a chemical can be solubilized and potentially leached from soil by infiltrating precipitation. In general, more soluble chemicals, such as VOCs, are more readily leached than less soluble chemicals.

- The octanol-water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of chemicals between octanol and water. The coefficient also is useful in characterizing the sorption of compounds by organic soil where experimental values are not available. The octanol water partition coefficient also is used to estimate bioconcentration factor (BCFs) in aquatic organisms.

- The organic carbon adsorption coefficient (K_{oc}) is an indication of the tendency of a chemical to adhere to soil particles containing organic carbon. Chemicals with high soil or sediment adsorption coefficients generally have low water solubilities (and vice versa), as evidenced by the semivolatiles. For example, chemicals such as PAHs are preferentially bound to the soil and are not subject to aqueous transport to the extent as compounds with higher water solubilities, such as VOCs.

- Specific gravity is the ratio of the weight of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a constituent will have a tendency to float or sink (as an immiscible liquid) in water if it is present as a pure compound or at concentrations which exceed its water solubility.

Both vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and from groundwater. The ratio of these two parameters (Henry's Law constant) is used to calculate the equilibrium constituent concentrations in the vapor (air) phase versus the liquid (water) phase for the dilute solutions commonly encountered in environmental settings.

A quantitative assessment of mobility has been developed that uses water solubility (S), vapor pressure (VP), and organic carbon partition coefficient (K_{oc}) (Laskowski, 1983). This value is referred to as the Mobility Index (MI) and defined as:

$$MI = \log((S*VP)/K_{oc})$$

A scale to evaluate MI is presented by Ford and Gurba (1984):

Relative MI	Mobility Description
> 5	extremely mobile
1 to 5	very mobile
-5 to 0	slightly mobile
-10 to -6	immobile
< -10	very immobile

The MIs for the COPCs area also presented in Table 6-16. The following paragraphs summarize the fate and transport data for the chemical classes of COPCs identified at OUs 3 and 5.

6.2.1.1 Volatile Organic Compounds

Volatile organics tend to be very mobile in environmental media. Their inherent mobility and relatively high MIs (see Table 6-16) result from high water solubilities, high vapor pressures, and low K_{oc} and K_{ow} values. The MIs estimated for the volatile COPCs identified at OUs 3 and 5 range from 3 to 5 (very mobile). Volatile organics do not tend to persist in environmental media because photolysis, oxidation, and biodegradation figure significantly in their removal. They are seldom detected in shallow (surface) soil where volatilization and other removal processes predominate.

6.2.1.2 Semivolatile Organic Compounds

In general, SVOCs are less mobile than the VOCs by virtue of their lower vapor pressures and lower water solubilities. K_{oc} and K_{ow} values for SVOCs are generally greater in magnitude than those for the VOCs, indicating the tendency for this class of compounds to adsorb strongly to soil. The semivolatile COPCs identified for OUs 3 and 5 were predominantly PAHs. PAHs, are ubiquitous in the environment, since they are produced naturally by plants, and are products of the incomplete combustion of fossil fuels. PAHs tend not to migrate appreciable distances in environmental media. Their MIs indicate that they are relatively immobile in the environment based primarily on their relatively low water solubilities. The MIs estimated for the semivolatile COPCs identified at OUs 3 and 5 range from -20 (very immobile) to 3 (very mobile).

Transport of soil particulates containing PAHs is most likely the primary migration mechanism. Surface water may carry entrained particles upon which PAHs are sorbed. PAHs generally lack adequate vapor pressures to be transmitted via vaporization and subsequent airborne transport. However, PAHs adsorbed to particulates can be transported by wind as fugitive dust.

PAHs are somewhat persistent in the environment, although several processes do contribute to their in-situ degradation. Half-lives range from 10 years (pyrene) to 1 day (naphthalene) in groundwater. Photolysis and oxidation may be important removal mechanisms in surface water and shallow (surface) soil, while biodegradation is an important fate process in groundwater and soil.

6.2.1.3 Pesticides/PCBs

Pesticides, such as DDT and DDE, are common environmental contaminants due to their wide spread use in insect control. DDT can no longer be used in the United States except in cases of public health emergency. Studies have shown prolonged persistence of these pesticides in soil. These compounds undergo extensive adsorption to soil particulates, as predicted by their K_{oc} values. DDT and DDE are only slightly soluble in water. Therefore, loss of these compounds in runoff is primarily due to transport of particulates to which these compounds are bound. Since they are bound strongly to soil, they are not easily displaced from their site of application, nor do they tend to leach to groundwater. DDT and DDE are highly lipid soluble, as reflected by their log K_{ow} values. This property, combined with an extremely long half-life, has resulted in bioaccumulation.

The Aroclors, such as Aroclor-1260, are no longer produced or used in the production of new products in the United States and industrial effluent discharges from production sources no longer occur. Current sources of PCB release to the environment include releases from landfills containing transformers, capacitors, and other PCB wastes. The environmental persistence of PCBs generally increases with an increase in the degree of chlorination of the congener. The Aroclors with a high degree of chlorination (1248, 1254, and 1260) are resistant to biodegradation and appear to be degraded very slowly in the environment. Volatilization is an important environmental fate process for the PCBs that exist in natural water in the dissolved state. The values of the estimated Henry's law constants for the Aroclors are indicative of significant volatilization from environmental waters. The low water solubility, high octanol-water partition coefficients of the PCBs and demonstrated

strong adsorption of PCBs to soils and sediment indicate that significant leaching should not occur in soil under most conditions.

6.2.1.4 Dioxins/Furans

Significant advances in analytical methodologies for identification and quantification of PCDDs and PCDFs has resulted in several studies that have confirmed that these chemicals are ubiquitous in the environment (DeVault et al., 1989). Based on information available for 2,3,7,8-TCDD, the fate of dioxins in air, water, and soil is not understood with certainty. The biodegradation of 2,3,7,8-TCDD in water is probably slow. The two processes that may be important for the removal of 2,3,7,8-TCDD are volatility and photodegradation. 2,3,7,8-TCDD is expected to be immobile in most soils by irrigation and rainfalls. The ultimate environmental sink of airborne particulate 2,3,7,8-TCDD is likely to be sediments of surface waters.

6.2.1.5 Inorganics

Different inorganic species behave differently in various environmental media. In general, inorganics can be transported through air, adhering to blowing dust, or move through surface water and groundwater as dissolved salts. Inorganics can also be carried with flowing water on suspended solids or attached to colloidal materials. The most complicated pathway for inorganic chemicals is migration in subsurface soil and groundwater, where oxidation-reduction potential (Eh) and pH may play critical roles.

6.2.2 Potential Migration Pathways

This section identifies the potential migration routes of COPCs at SWMUs 1, 2, and 45. These mechanisms were identified through an evaluation of the analytical results and known site characteristics.

6.2.2.1 Soil

Inorganic and organic compounds were detected in both surface and subsurface soil at OUs 3 and 5. COPCs present in soil at OUs 3 and 5 can migrate by leaching of infiltrating precipitation, advective transport in the direction of surface drainage (runoff), or by suspension of soil particulates in ambient air (dust).

The factors which control contaminant migration through soil, and then to groundwater, are dependent on the chemical and physical nature of the contaminants and of the soil and site hydrology. Some of the factors which influence the migration of chemicals in soil include: pH, Eh, particle size distribution, pore size or voids volume, lime content, content of organic matter, concentration of ions or salts, oxic and anoxic conditions, presence or absence of hydrous oxides, vegetative cover, topography, and climate.

6.2.2.2 Groundwater

Contaminants which come into contact with groundwater can migrate under the influence of groundwater flow. Migration through groundwater is dependent on the chemical nature of the contaminant and the chemical and physical nature of the aquifer. Groundwater flow velocity (a function of hydraulic gradient and conductivity), groundwater chemistry, porosity of the aquifer, and the chemical make up of the aquifer are all factors which affect contaminant migration. Mobility of a contaminant in groundwater is particularly influenced by its water solubility and the organic carbon content of the substrate, as well as the nature of the aquifer materials (subsurface soil) through which the groundwater flows. In general, compounds that have high solubility and low K_{oc} values tend to be more mobile in groundwater than those with low solubility and high K_{oc} values.

6.2.3 Potential Human Receptors and Exposure Pathways

NSRR currently operates, and will continue to operate, as a key Naval Station providing full support for Atlantic Fleet Weapons training and development activities. Current potential human receptors being evaluated in this baseline RA for possible exposures to COPCs detected in environmental media are limited to on-site adult workers and adult and adolescent trespassers.

The on-site workers are assumed to be civilian and/or military personnel who may perform various maintenance and manual labor activities at NSRR. These activities may result in direct contact exposures to surface soil at SWMUs 1, 2, and 45. Potential exposures to COPCs in the surface soil may occur via the pathways of accidental ingestion, dermal contact and the inhalation of fugitive dusts emanating from areas of low vegetative cover and no pavement. Through incidental ingestion and dermal contact, on-site workers may also be exposed to COPCs in surface water and sediment in SWMUs 1 and 2, or they may be exposed to sediment at SWMU 45.

Another receptor group considered for evaluation under current exposures scenarios in this baseline RA are adult and adolescent (ages 7 - 15 years old) trespassers. Trespassers were evaluated for potential exposures to COPCs in the surface soil via the pathways of accidental ingestion, dermal contact and the inhalation of fugitive dusts in SWMUs 1, 2, and 45. Through incidental ingestion and dermal contact, trespassers may also be exposed to COPCs in surface water and sediment in SWMUs 1 and 2, or they may be exposed to sediment at SWMU 45.

Currently, there are no facilities for personnel housing located within the boundaries of any of the SWMUs evaluated in this study. However, a Navy lodge is currently located next to SWMU 1. This lodge houses transient naval personnel who temporarily reside there for up to a week. Exposures to these individuals at SWMU 1 are highly unlikely and are not evaluated in this baseline RA. In addition, housing construction for naval personnel is being planned for a location across the road from SWMU 2. However, it is highly unlikely that personnel from this housing complex will be exposed to soil and sediment COPCs by venturing into SWMU 2 due to the presence of highly dense vegetation. Therefore, these individuals are not being evaluated in this baseline RA.

The areas within the SWMUs being evaluated in this baseline RA will not be developed for personnel housing in the future because of the Station's mission and the need to maintain the predominantly industrial land use patterns for areas in close proximity to the Ensenada Honda for continued support of the fleet. Although future residential development of any SWMU is highly unlikely, future residential exposures to adult and young child (ages 1 through 6 years old) receptors were evaluated as the most conservative (worst-case) scenario. Future residents are being evaluated for accidental ingestion, dermal and inhalation (fugitive dusts) exposures to surface soil (all SWMUs); ingestion and dermal exposures to groundwater used as drinking water (all SWMUs); inhalation exposures to

groundwater used in showering (only adult residents were evaluated for this exposure because young children typically do not shower); accidental ingestion and dermal exposures to surface water and sediment (SWMUs 1 and 2); and accidental ingestion and dermal exposures to sediment (SWMU 45). It should be noted that groundwater at Roosevelt Roads is not used a source of potable water due to poor quality and low yields. A dedicated water pipeline extends from the base into the nearby mountains and associated rainforest. This water is treated on base and this serves as the sole source of water for the base. There is sufficient capacity in the system to support future station use scenarios; therefore, the use of groundwater as a potable source is not envisioned; however, it will be conservatively assumed that child and adult residents will be exposed to organic, total inorganic and dissolved inorganic COPCs identified in the groundwater at SWMUs 1, 2, and 45.

Future construction workers that may perform excavation and related construction activities, were evaluated as potential receptors at SWMU 1, 2, and 45. Generally, it was assumed that the majority of COPC exposures to this receptor would be due to direct contact with excavated subsurface soil. It was also assumed that direct contact exposures to surface soil COPCs would occur; however, these exposures are assumed to be insignificant, relative to the subsurface soil exposures. Therefore, future construction workers were only evaluated for subsurface soil exposures, via the pathways of accidental ingestion, dermal contact and the inhalation of fugitive dusts emanating from excavated subsurface soils at a construction site. Uncertainties associated with evaluating only subsurface soil exposures for this receptor are discussed in Section 6.5.3.

In summary, based on information available regarding the physical features, site setting, site historical activities, and current and expected land uses, the following potential human receptor groups and exposure pathways were evaluated in this human health RA:

Current on-site adult workers:

- Accidental ingestion of surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)
- Dermal contact with surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)
- Inhalation of fugitive dust emanating from surface soil (all SWMUs)

Current adult and adolescent trespassers:

Accidental ingestion of surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Dermal contact with surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Inhalation of fugitive dust emanating from surface soil (all SWMUs)

Future on-site adult construction workers:

Accidental ingestion of subsurface soil (all SWMUs)

Dermal contact with subsurface soil (all SWMUs)

Inhalation of fugitive dust emanating from excavated subsurface soil (all SWMUs)

Future on-site adult and child (1-6 years old) residents:

Accidental ingestion of surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Dermal contact with surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Inhalation of fugitive dusts emanating from surface soil (all SWMUs)

Ingestion of groundwater used as drinking water (all SWMUs)

Dermal contact with groundwater while bathing (all SWMUs)

Inhalation of volatilized organics from groundwater used for showering (all SWMUs - adult residents only)

6.2.4 Conceptual Site Model

Development of a conceptual site model of potential exposure is critical in evaluating all potential exposures for the aforementioned human receptors. The conceptual site model describes the area of concern in terms of potential sources of contamination, release mechanisms, affected media, and all potential routes of migration of the contaminants present.

The primary sources of contamination are the possible spills and releases into the environment that occurred at SWMUs 1, 2 and 45 that are being evaluated in this baseline RA. The primary current and future release mechanisms being considered in this baseline RA include: surface runoff from SWMUs to surface soil in other areas, leaching and vertical migration of contaminants from surface to subsurface soils and groundwater; horizontal contaminant migration through groundwater; fugitive dust generation from surface soil and future excavated subsurface soil; and volatilization of organic contaminants from groundwater. However, it should be noted that current surface generation of fugitive dusts may be hindered to a great extent by existing vegetation

6.2.5 Quantification of Exposure

6.2.5.1 Concentrations Used in the Estimate of Exposure

The chemical concentrations used in the estimation of chronic daily intakes (CDIs) and dermally absorbed doses (DADs) for each medium are considered to be representative of the types of potential exposure encountered by each receptor.

Exposure can occur discretely or at a number of sampling locations depending on the type of scenario considered for a given receptor. Furthermore, certain environmental media such as groundwater are migratory and chemical concentrations detected in this medium change frequently over time. Soil, by nature, is less transitory. The manner in which environmental data are represented also depends on the number of samples and sampling locations available for a given area and a given medium.

To quantify exposure, analytical data must be evaluated to determine its distributional nature. In general, two types of distributions are applied to environmental data; these are the normal and log-normal distributions. For example, most large data sets from soil sampling are log-normally distributed rather than normally distributed. The geometric mean is the best estimator of central tendency for a log-normal data set (USEPA, 1992c). However, most Agency health criteria are based on the long-term average exposure which is expressed as the sum of all daily intakes divided by the total number of days in the averaging period. The geometric mean of a set of sampling results may not

adequately represent random exposure and the cumulative intake that would result from long-term contact with site contaminants.

Potential exposure to soil, groundwater, and sediment at SWMUs 1, 2 and 45, regardless of location, is considered as having an equal probability of occurrence as an individual moves randomly across the site. Therefore, for these media, the exposure point concentration for a constituent in the intake equation can be reasonably estimated as the arithmetic average concentration of site sampling data. USEPA supplemental risk assessment guidance (USEPA, 1992c) states that the average concentration is an appropriate estimator of the exposure concentration for two reasons: 1) carcinogenic and chronic noncarcinogenic toxicity criteria are based on lifetime average exposures; and 2) the average concentration is most representative of the concentration that would be contacted over time. However, uncertainty is inherent in the estimation of the true average constituent concentration at the site.

In order to account for this uncertainty and to be health protective, USEPA risk assessment guidance (USEPA, 1989b) requires the use of an upper bound estimate of the arithmetic mean concentration to calculate the CDI. This estimate, which should be in the high end of the concentration frequency distribution, is called the reasonable maximum exposure (RME) concentration. The RME concentration is defined as the highest concentration that could reasonably be expected to be contacted via a given pathway over a long-term exposure period.

A conservative estimate that best represents the RME is the 95-percent upper confidence limit of the arithmetic mean concentration (95% UCL). In order to estimate the 95% UCL for soil, groundwater, and sediment data sets, a normal distribution was assumed to represent the occurrence of all COPC-detected concentrations for sample data sets greater than or equal to five. However, if the 95% UCL concentration exceeded the maximum detected concentration in a given data set, the maximum detected concentration was used to represent the concentration term for that COPC.

The USEPA recommended use of the 95%UCL (normal or lognormal) as the RME concentration (in addition to RME assumptions) is designed to overestimate actual risks expected to result from "real-world" exposures. As can be seen in Appendix H, the lognormal 95%UCLs are generally greater in value than the normal 95%UCLs. The normal 95%UCL was used as the exposure

concentration, rather than the lognormal 95%UCL, in order to further reduce the potential for the overestimation of risks.

The 95% UCL was calculated using the following equation (USEPA, 1992c):

$$95\%\ UCL \quad \bar{x} \quad t(s/\sqrt{n})$$

Where:

= mean

t = Student t-statistic (Gilbert, 1987)

s = standard deviation

n = number of samples

Maximum detected values and 95%UCLs derived for data sets acquired for SWMUs 1, 2 and 45 are presented in Appendix H.

For results reported as "nondetect" (i.e., results flagged with the following validation qualifiers: U, UJ, UL, and UK), a value of one half of the sample-specific detection limit was used to calculate the 95% UCL. A value of half the detection limit was assigned to nondetects when estimating the 95% UCL because the actual value could be between zero and a value just below the detection limit. Ninety-five percent UCLs were calculated only for the constituents detected in at least one sample collected from the environmental medium of interest. Estimated concentrations also were used to calculate the 95% UCL, such as "J"-qualified (estimated), "L"-qualified (estimated, biased low) and "K"-qualified (estimated, biased high) data. "N"-qualified (tentatively identified) data were also used to estimate the exposure concentration. Reported concentrations qualified with an "R" (rejected) were not used in the statistical evaluation.

For constituents considered by RAGS to be common laboratory blanks, chemicals were deemed positive detects only if their concentration exceeded 10 times the maximum blank concentration. For constituents not considered to be laboratory blanks, chemicals were considered as positive detects only if their concentration exceeded 5 times the maximum blank concentration.

6.2.5.2 Calculation of Chronic Daily Intakes

In order to numerically estimate the risks for current and future human receptors at the various SWMUs, a CDI or DAD must be estimated for each COPC in every retained exposure pathway. Both the CDI and DAD are chemical intakes, expressed in terms of dose; however, the different terms refer to different pathways of exposure. The CDI term is used to describe chemical intake via the oral and inhalation pathways; the DAD term is used to describe chemical intake via dermal absorption. The CDI/DAD for each COPC is calculated by combining the concentration term with assumed or known conservative exposure factors that describe the rates, frequency and duration of exposure. Since the CDI/DAD is a dose term, body weight of the receptor is also incorporated into the calculation, and the long-term exposure is divided by the total number of days in the averaging period. Thus, the unit obtained for the CDI/DAD resulting from chemical exposure is mg/kg/day. Appendix I contains the specific CDI/DAD calculations for each exposure scenario of interest. These equations were adopted from USEPA's Risk Assessment Guidance for Superfund, Volume I (USEPA, 1989b).

CDIs/DADs for potential carcinogens, which tend exhibit non-threshold effects (e.g., tumor development) following long-term exposure, were calculated so that the duration of exposure is averaged over the course of a lifetime (70 years, or 25,550 days).

Exposures to noncarcinogens, on the other hand, tend to result in observable threshold effects. Therefore, CDIs/DADs for noncarcinogens were estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency that represent the number of hours per day and the number of days per year that exposure occurs. In general, noncarcinogenic risks for many exposure routes (e.g., soil ingestion) are greater for children than adults because of the differences in body weights, similar exposure frequencies, and higher ingestion rates.

The subsections which follow present the equations and input parameters used in the calculation of CDIs/DADs for each potential exposure pathway being evaluated for the various SWMUs. Input parameters were taken from USEPA's default exposure factors guidelines where available and

applicable. All inputs not defined by USEPA were derived from USEPA documents concerning exposure or were the result of best professional judgment.

6.2.5.2.1 Soil and Sediment

Accidental Ingestion of Soil or Sediment

The daily intake associated with the potential accidental ingestion of COPCs detected in soil or sediment were calculated using the following equation (USEPA, 1989b):

$$CDI \quad \frac{Cs \ x \ IR \ x \ FI \ x \ CF \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, milligram per kilogram day (mg/kg-day)
Cs	=	Chemical concentration in soil or sediment, mg/kg
IR	=	Ingestion rate, mg/day
FI	=	Fraction Ingested, unitless
CF	=	Conversion factor, 10^{-06} kg/mg
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

CDI calculations using the above equation are presented in Appendix I.

Dermal Contact with Soil or Sediment

The absorbed dose associated with the potential dermal contact of COPCs in soil or sediment were calculated using the following equation (USEPA, 1989b):

$$DAD \quad \frac{CS \ x \ AF \ x \ ABS \ x \ CF \ x \ SA \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

DAD	=	Dermally absorbed dose, mg/kg-day
CS	=	Chemical concentration in the soil or sediment, mg/kg
AF	=	Adherence factor, milligram per square centimeter day (mg/cm^2-d)
ABS	=	Absorbed fraction, unitless
CF	=	Conversion factor, 10^{+06} mg/kg
SA	=	Surface area of exposed skin, cm^2
EF	=	Exposure frequency, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

CDI calculations using the above equation are presented in Appendix I.

Inhalation of Fugitive Dust

The daily intake resulting from the inhalation of soil COPCs adsorbed onto fugitive dust particulates was estimated using the following equation (USEPA, 1989b):

$$CDI \quad \frac{Ca \ x \ RR \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Ca	=	Chemical concentration in air as fugitive dust,(mg/m^3)
RR	=	Respiration rate, m^3/day
ET	=	Exposure time, hours/day
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

The air concentration (Ca) of a chemical in fugitive dust emissions was estimated from the following equation, as determined by Cowherd (1985), and provided by the USEPA (1991b).

$$Ca = Cs \ x \ 1/PEF$$

Where:

Cs	=	Concentration of chemical in the soil, mg/kg
PEF	=	Particulate emission factor, 1.32 x 10^{+9} m^3/kg (USEPA, 1996)

CDI calculations using the above equations are presented in Appendix I.

6.2.5.2.2 Groundwater

Ingestion of Potable Groundwater

The daily intake associated with the direct potential ingestion of the COPCs in groundwater under a potable use scenario was calculated using the following equation (USEPA, 1989b):

$$CDI \quad \frac{Cw \ x \ IR \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Cw	=	Chemical concentration in groundwater, mg/L
IR	=	Ingestion rate, L/day
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

Dermal Contact with Groundwater

The absorbed dose associated with potential dermal contact with COPCs in groundwater (while bathing) was calculated using the following equation (USEPA, 1989b):

$$DAD \quad \frac{Cw \ x \ SA \ x \ PC \ x \ ET \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT}$$

Where:

DAD	=	Dermally absorbed dose, mg/kg-day
Cw	=	Concentration in water, mg/L
SA	=	Surface area of exposed skin, cm^2
PC	=	Permeability constant, cm/hr
ET	=	Exposure time, hours/day
EF	=	Exposure frequency, days/year
ED	=	Exposure duration, years
CF	=	Conversion factor, 1 L/1000 cm^3
BW	=	Average body weight, kg
AT	=	Averaging time, days

Inhalation of Volatile COPCs in Groundwater while Showering

The daily intake associated with the potential inhalation of the volatile COPCs in groundwater while showering was calculated using the following equation (USEPA, 1989b):

$$CDI \quad \frac{Ca \ x \ RR \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Ca	=	Chemical concentration in air, mg/m^3 (Foster and Chrostowski Shower Model, 1986)
RR	=	Respiration rate, m^3/day
ET	=	Exposure time, hours/day
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

Calculation spreadsheets for the derivation of Ca using the Foster and Chrostowski Shower Model (1986) and CDI using the above equations are presented in Appendices J and I, respectively.

6.2.5.3 Exposure Factors Used To Derive Chronic Daily Intakes

Tables 6-17 through 6-20 present the exposure factors used in the estimation of potential CDIs/DADs for COPCs retained for current on-site workers, current adult and older child trespassers, future construction workers, and future on-site adult and child residents, respectively. USEPA promulgated exposure factors are used in conjunction with USEPA standard default exposure factors for the RME scenarios. Furthermore, when USEPA exposure factors are not available, best professional judgment and site-specific information are used to derive a conservative and defensible value.

6.3 Toxicity Assessment

Section 6.2 presented potential exposure pathways and receptors for this baseline RA. This section will review the available toxicological information for COPCs retained for quantitative evaluation.

An important component of the RA process is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. Standard reference doses (RfDs) and/or carcinogenic slope factors (CSFs) have been developed for many of the COPCs. This section provides a brief description of these parameters.

6.3.1 Reference Doses

The RfDs and Reference Concentrations (RfCs) for inhalation are developed for chronic and/or subchronic human exposure to chemicals and are based solely on the noncarcinogenic effects of chemical substances. These values are defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk

of adverse effects during a lifetime. The RfD is expressed as dose (mg) per unit body weight (kg) per unit time (day). The RfC is expressed as dose (mg) per cubic meter of air (m^3).

6.3.2 Carcinogenic Slope Factors

CSFs are used to estimate an upper bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989b). This factor is reported in units of $(mg/kg/day)^{-1}$ and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the 95% UCL.

CSFs can also be derived from USEPA promulgated unit risk values for air and/or water. CSFs derived from unit risks cannot, however, be applied to environmental media other than the medium considered in the unit risk estimate.

Slope factors are also accompanied by corresponding weight-of-evidence classifications which designate the strength of the evidence that the COPC is a potential human carcinogen.

Quantitative indices of toxicity and USEPA weight-of-evidence classifications are presented in Table 6-21 for the COPCs identified at SWMUs 1, 2 and 45. In addition, more detailed toxicological profiles of the COPCs are presented in Appendix K. The hierarchy (USEPA, 1989b) for choosing these values was:

- Integrated Risk Information System (IRIS) (USEPA, 1998)
- Health Effects Assessment Summary Table (HEAST) (USEPA, 1997b)
- National Center for Environmental Assessment (NCEA)

The IRIS data base is updated monthly and contains both verified RfDs, RfCs and CSFs. The USEPA has formed an RfD work group to review existing data used to derive RfDs and RfCs. Once
this task has been completed the verified RfD appears in IRIS. Like the RfD Work Group, the USEPA has also formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work group to review and validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they also appear in the IRIS data base.

HEAST, on the other hand, provides both interim (unverified) and verified RfDs, RfCs and CSFs. This document is published quarterly and incorporates any applicable changes to its data base.

6.3.3 Dermal Absorption Efficiency

Many of the RfDs and CSFs are derived from oral toxicological studies based on administered dose and do not account for the amount of a substance that can penetrate exchange boundaries after contact (e.g., absorbed dose). As a result, there is very little information available regarding dermal toxicity criteria. Therefore, in order to account for a difference in toxicity between an administered dose and an absorbed dose, the RfDs and CSFs (that were based on an administered dose) were adjusted, as described by the USEPA (USEPA, 1989b), using experimentally-derived oral absorption efficiencies. The adjustment for the oral RfD that would correspond to a dermally absorbed dose is represented by multiplying the RfD by an oral absorption efficiency. The adjustment for the oral CSF that would correspond to the dermally absorbed dose is represented by dividing the CSF by an oral absorption efficiency. The oral absorption efficiencies were obtained from sources such as the NCEA, IRIS, Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, toxicology publications, toxicology references, and USEPA Regional Offices. In some instances, published information was not available to determine the absorption efficiency. On these occasions, adjustments to the toxicity value were conducted using the following USEPA Region IV default values:

- VOCs - 80%
- SVOCs/Pesticides/PCBs - 50%
- Dioxins - 90%
- Inorganics - 20%

The absorption efficiencies used in this baseline RA for SWMUs 1, 2, and 45 are also presented in Table 6-21.

6.3.4 Evaluation of Dioxins/Furans

Dioxins are a class of compounds that contain the dibenzo-p-dioxin nucleus; furans are a class of compounds that contain the dibenzofuran nucleus. The chlorinated dioxins and furans, which are of toxicological concern, are those compounds where the nuclei are substituted with chloride ions at different positions in the benzene and furan rings, respectively. As many as eight positions are available for chlorine substitution on each of the dibenzo-p-dioxin and dibenzofuran nuclei. The chlorinated compounds are called pentachlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Approximately 75 congeners of the PCDDs and 135 congeners of the PCDFs are known to exist. Of these, seven of the PCDDs and ten of the PCDFs are considered to be carcinogens of the greatest toxicological concern, with the lesser chlorinated compounds being the most carcinogenically potent. The compound 2378-TCDD is the most studied and is considered the most carcinogenically potent of all the PCDDs and PCDFs.

Exposure to 2378-TCDD, which is classified as a class B2 carcinogen by the U.S. EPA, results in adverse effects to the liver and adipose tissue, with the liver being the most sensitive target organ. 2378-TCDD also impacts the immune system, causes reproductive effects, and is teratogenic (Lappenbusch, 1988). Currently, the oral and inhalation CSF established by the U.S. EPA for 2378-TCDD is 1.50×10^5 $(mg/kg/day)^{-1}$. This slope factor was derived based upon the development of respiratory system and liver tumors in laboratory rats.

Since CSFs have not been derived by the U.S. EPA for the remaining six PCDDs and ten PCDFs that are also of toxicological significance, a procedure has been developed which incorporates the cancer potencies of these compounds relative to that of 2378-TCDD to obtain 2378-TCDD TECs. This is done by multiplying the measured concentration of each congener by its established relative potency factor, or TEF.

Although analyses of individual congeners were not performed for samples collected from the sites included in this study, concentrations of total PCDDs/PCDFs were detected in surface soil, subsurface soil, groundwater, and sediment samples collected from SWMUs 1 and 2. The total PCDDs/PCDFs (and respective TEFs) detected at these SWMUs included total HxCDD; TEF = 0.1, total TCDF; TEF = 0.1, total PeCDF; TEF = 0.5, and total HxCDF; TEF = 0.1.

6.43 Risk Characterization

The risk characterization combines COPCs, potential exposure, and toxicity, to produce a quantitative estimate of current and future potential human health risks associated with SWMUs 1, 2, and 45. Excess ILCRs and hazard indices (HIs) discussed in this section include those estimated for the receptors and pathways identified in Section 6.2.3.

6.4.1 Carcinogenic Compounds

Quantitative risk calculations for potentially carcinogenic compounds estimate inferentially (versus probabilistically) the potential ILCR for an individual in a specified population. This unit of risk refers to a potential cancer risk that is above the background cancer risk in unexposed individuals. For example, an ILCR of 1×10^{-6} indicates that an exposed individual has an increased probability of one in one million of developing cancer subsequent to exposure over the course of their lifetime.
The potential lifetime ILCR for an individual was estimated from the following relationship:

$$ILCR = \sum_{i=1}^{n} (CDI_i \text{ or } DAD_i) \times CSF_i$$

where the CSF_i is expressed as $(mg/kg/day)^{-1}$ for compound i, and the CDI_i and dermally absorbed dose (DAD_i) is expressed as mg/kg/day for compound i. Since the units of CSF are $(\text{mg chemical/kg body weight-day})^{-1}$ and the units of intake or dose are [mg chemical/kg body weight-day], the ILCR value is dimensionless. The aforementioned equation was derived assuming that cancer is a nonthreshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

For quantitative estimation of risk, it is assumed that cancer risks from various exposure routes are additive. Estimated ILCR values will be compared to 1×10^{-6} to 1×10^{-4} which represents the target risk range of ILCR values considered by the USEPA to represent an acceptable (i.e., de minimis) risk (USEPA, 1990).

6.4.2 Noncarcinogenic Compounds

Noncarcinogenic compounds assume that a threshold toxicological effect exists. Therefore, the potential for noncarcinogenic effects is calculated by comparing (i.e., dividing) CDI_i or DAD_i levels with RfDs for each COPC.

Noncarcinogenic effects are estimated by calculating the hazard quotient (HQ) for individual chemicals and the hazard index (HI) for overall chemicals and pathways by the following equation:

$$HI = \sum_{i=1}^{n} HQ_i$$

where: $HQ_i = (CDI_i \text{ or } DAD_i)/RfD_i \text{ or } RfC_i$

A HQ is the ratio of the daily intake or absorbed dose to the reference dose (or reference concentration for inhalation exposure). CDI_i is the chronic daily intake (mg/kg/day) of contaminant i; DAD_i is the dermally absorbed dose (mg/kg/day) of contaminant i; and RfD_i is the reference dose (mg/kg/day) of contaminant i over a prolonged period of exposure. RfC is the reference concentration used when determining exposure due to inhalation. Since the units of RfD are mg/kg-day and the units of CDI or DAD are mg/kg-day, the HQ and HI are dimensionless. To account for the additivity of noncarcinogenic risk following exposure to numerous chemicals, the HI, which is the sum of all the HQs, will be calculated. A ratio of 1.0 is used for examination of the HQ and HI. Ratios less than 1.0 indicate that adverse noncarcinogenic health effects are unlikely. Ratios greater than or equal to 1.0 indicate the potential for adverse noncarcinogenic health effects to occur at that exposure level and caution should be exercised. However, this does not mean that adverse effects will definitely be observed since the RfD incorporates safety and modifying factors to ensure that it is well below that dose for which adverse effects have been observed. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect.

6.4.3 Potential Human Health Effects

Potential carcinogenic and noncarcinogenic human health risks were estimated for human receptors under RME scenarios previously identified in Section 6.2.3. For each receptor, total site carcinogenic and total site noncarcinogenic risks were estimated by SWMU and are presented in Table 6-22. Those scenarios that resulted in unacceptable risks, i.e., those scenarios for which carcinogenic and/or noncarcinogenic risks were estimated to exceed USEPA acceptable risk criteria (the target risk range of 1×10^{-6} to 1×10^{-4} and the target HI value of 1.0, respectively) are shaded in the table. Additional tables (Tables 6-23 through 6-29), which are presented by receptor and SWMU, summarize the medium and pathway risks that resulted in the unacceptable total site risks. Again, as in Table 6-22, those subtotal and total risks in Tables 6-23 through 6-29 that exceed USEPA acceptable risk criteria are shaded. No risk summary tables or text are presented for those scenarios not associated with unacceptable risks; rather, tables are presented in Appendix L. The risk calculation spreadsheets showing the calculation of all CDIs, DADs, ILCRs, and HIs, by receptor, SWMU and pathway, are presented in Appendix I.

The discussions in the subsections that follow focus only on the SWMUs which may pose a potential adverse human health risk. The risks associated with each SWMU are discussed by receptor. It should be noted that potentially unacceptable risks were estimated for current on-site commercial/maintenance workers, future construction workers and future on-site residents. Prior to the more detailed discussion of risks, the following list briefly summarizes receptors and SWMUs associated with unacceptable risks (tables presenting the corresponding medium and pathway risks are also shown in parentheses):

Current On-site Commercial/Maintenance Workers

- SWMU 1 (Table 6-23)
- SWMU 2 (Table 6-24)

Future Construction Workers

- SWMU 1 (Table 6-25)
- SWMU 2 (Table 6-26)

Future On-site Residents

SWMU 1 (Table 6-27)

SWMU 2 (Table 6-28)

SWMU 45 (Table 6-29)

6.4.3.1 Current On-site Commercial/Maintenance Workers

The following subsections describe the resultant risk values derived for exposures of current on-site workers. Potentially unacceptable risks were estimated for surface soil and surface water exposures to this receptor at SWMUs 1 and 2.

SWMU 1 - Army Cremator Disposal Site

Table 6-23 shows that the total ILCR (1.3×10^{-4}) estimated for on-site worker exposures to surface soil, surface water and sediment in SWMU 1 exceeded USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. The risks from exposures to these media are due to cumulative effects. The individual ILCRs for each media and each pathway were within USEPA's acceptable target risk range. The exceedence, however, is due to predominantly to dermal exposures to total HxCDD and total HxCDF in sediment (45% and 40% risk contributions, respectively).

The total HI values estimated for on-site worker exposures (3.7) to noncarcinogenic COPCs at SWMU 1 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to exposures to surface water (subtotal HI = 2.3) and surface soil (subtotal HI = 1.3). The surface water exceedance is primarily due to dermal exposures to thallium (95% risk contribution), and ingestion exposures to thallium and arsenic (81% and 19% risk contributions, respectively). It should be noted that thallium does not have a promulgated RfD in the IRIS database because of the low confidence in toxicity studies and uncertainty in results. A chronic oral RfD value of 7×10^{-5} mg/kg/day was used to evaluate thallium as a soluble salt for the purpose of this report. This number was last cited in the 1991 Annual Health Effects Summary Table (HEAST, 1991). Thallium HQ results must therefore be evaluated with caution.

The surface soil exceedance is primarily due to dermal exposures to manganese, iron, and cadmium (39%, 32%, and 16% risk contributions, respectively). The individual HQ for dermal exposures to thallium in surface water was greater than 1.0. All other individual HQs were less than 1.0.

SWMU 2 - Langley Drive Disposal Site

Table 6-24 shows that the total ILCR (1.2×10^{-4}) estimated for on-site worker exposures to surface soil, surface water and sediment in SWMU 2 exceeded USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. The risks from exposures to these media are due to cumulative effects. The individual ILCRs for each media and each pathway were within USEPA's acceptable target risk range. The exceedence, however, is due to predominantly to dermal exposures to surface soil (subtotal ILCR = 7.8×10^{-5}) and sediment (subtotal ILCR = 4.0×10^{-5}). The surface soil exceedance is primarily due to dermal exposures to arsenic, total HxCDD and total HxCDF (43%, 26% and 20% risk contributions, respectively). The sediment exceedance is primarily due to dermal exposures to total HxCDD and total HxCDF (64% and 24% risk contributions, respectively).

The total HI values estimated for on-site worker exposures (4.8) to noncarcinogenic COPCs at SWMU 1 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to exposures to surface water (subtotal HI = 2.8) and surface soil (subtotal HI = 2.0). The surface water exceedance is primarily due to ingestion exposures to thallium, chromium, and selenium (60%, 24% and 13% risk contributions, respectively). The surface soil exceedance is primarily due to dermal exposures to iron and manganese (47% and 25% risk contributions, respectively). The individual HQ for ingestion exposures to thallium in surface water was greater than 1.0. All other individual HQs were less than 1.0.

6.4.3.2 Future Construction Workers

SWMU 1 - Army Cremator Disposal Site

Table 6-25 shows that the total ILCR (3×10^{-6}) estimated for future construction worker exposures to subsurface soil in SWMU 1 was within the USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. However, the total HI values estimated for future construction worker exposures (1.9) to noncarcinogenic COPCs at SWMU 1 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to ingestion exposures to iron, manganese, and aluminum in subsurface soil (54%, 18% and 11% risk contributions, respectively). Since the individual HQs for all COPCs were

less than 1.0, and they impact different target organs, the cumulative risk is actually less than an HI of 1.0, indicating no adverse effects are expected subsequent to exposure.

SWMU 2 - Langley Drive Disposal Site

Table 6-26 shows that the total ILCR (6×10^{-6}) estimated for future construction worker exposures to subsurface soil in SWMU 2 was within the USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. However, the total HI values estimated for future construction worker exposures (5.2) to noncarcinogenic COPCs at SWMU 2 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to ingestion exposures to iron (76% risk contributions) and dermal contact with iron and manganese (67% and 17% risk contributions, respectively) in the subsurface soil. The individual HQs for ingestion and dermal exposures to iron were greater than 1.0. All other individual HQs were less than 1.0.

6.4.3.3 Future On-site Residents

The following subsections describe the resultant risk values derived for exposures of future adult and young child (ages 1 - 6 years old) residents. Although dissolved inorganics are more indicative of the conditions at the tap, total inorganics were also examined as a conservative measure. Potentially unacceptable risks were estimated for exposures to these receptors at SWMUs 1, 2, and 45. These risks are summarized in Tables 6-27, 6-28, and 6-29.

SWMU 1 - Army Cremator Disposal Site

Organics and Total Inorganics

Table 6-27 shows that the total ILCRs estimated for adult and young child residential exposures (6.2×10^{-4} and 1.3×10^{-3}, respectively) to surface soil, groundwater, surface water and sediment in SWMU 1 exceeded USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. This risk is due to dermal exposures to total HxCDD (97% risk contribution) and ingestion exposures to total HxCDD and arsenic (53% and 44% risk contributions, respectively) in groundwater. With the exception of adult ingestion exposures to total arsenic, the individual ILCR values for the above mentioned COPCs were greater than the USEPA's acceptable risk range.

The total HI values estimated for adult and young child residential exposures (474 and 1,101, respectively) to noncarcinogenic COPCs at SWMU 1 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to ingestion and dermal exposures to total thallium in groundwater (98% risk contribution for both ingestion and dermal exposures), accidental ingestion of iron and manganese in the surface soil (55% and 17% risk contributions, respectively), dermal contact with manganese and iron in the surface soil (39% and 32% risk contributions, respectively) and accidental ingestion of thallium and arsenic in surface water (81% and 19% surface water ingestion risk contribution, respectively). The individual HQs for total thallium in groundwater (both ingestion and dermal, both adult and young child), young child ingestion of iron in surface soil, young child dermal contact with manganese and iron in surface soil, and young child ingestion of thallium in surface water were greater than 1.0. Thallium HQ results should be evaluated with caution because of the uncertainty associated with the oral RfD used in this baseline RA. All other individual HQs were below the target risk value of 1.0.

Organics and Dissolved Inorganics

Table 6-27 shows that the total ILCRs estimated for adult and young child residential exposures (5.2×10^{-4} and 1.1×10^{-3}, respectively) to surface soil, groundwater, surface water and sediment in SWMU 1 exceeded USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. This risk is due to dermal and ingestion exposures to total HxCDD in the groundwater (97% and 95% risk contributions, respectively). The individual ILCR values for total HxCDD were greater than the USEPA's acceptable risk range.

The total HI values estimated for adult and young child residential exposures (9.8 and 25, respectively) to noncarcinogenic COPCs at SWMU 1 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to ingestion of dissolved thallium and dissolved cadmium in groundwater (67% and 20% risk contributions, respectively), accidental ingestion of iron and manganese in the surface soil (55% and 17% risk contributions, respectively), dermal contact with manganese and iron in the surface soil (39% and 32% risk contributions, respectively) and accidental ingestion of thallium and arsenic in surface water (81% and 19% risk contributions, respectively). The individual HQs for dissolved thallium and dissolved cadmium in groundwater (both adult and young child), young child ingestion of iron in surface soil, young child dermal contact with manganese

and iron in surface soil, and young child ingestion of thallium in surface water were greater than 1.0. All other individual HQs were below the target risk value of 1.0.

SWMU 2 - Langley Drive Disposal Site

Organics and Total Inorganics

Table 6-28 shows that the total ILCRs estimated for adult residential exposures (5.2×10^{-5}) to surface soil, groundwater, surface water and sediment in SWMU 2 were within the USEPA's acceptable target risk range of 1×10^{-6} to 1×10^{-4}. Young child residential exposures (1.9×10^{-4}), however, exceeded USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. This risk to the young child is due to accidental ingestion of arsenic, total HxCDD, and total HxCDF in surface soil (47%, 29%, and 22% risk contributions, respectively).

The total HI values estimated for adult and young child residential exposures (9.1 and 26, respectively) to noncarcinogenic COPCs at SWMU 2 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to accidental ingestion of total vanadium and total antimony in groundwater (39% and 30% risk contributions, respectively), accidental ingestion of iron and arsenic in the surface soil (55% and 17% risk contributions, respectively), and dermal contact with iron and manganese in the surface soil (47% and 25% risk contributions, respectively). The individual HQs for groundwater ingestion exposures to total vanadium and total antimony (both adult and child), young child ingestion exposures to iron and arsenic in surface soil, adult dermal exposures to iron, and young child dermal exposures to iron and manganese in surface soil were greater than 1.0. All other individual HQs were below the target risk value of 1.0.

Organics and Dissolved Inorganics

Table 6-28 shows that the total ILCRs estimated for adult residential exposures (4.6×10^{-5}) to surface soil, groundwater, surface water and sediment in SWMU 2 were within the USEPA's acceptable target risk range of 1×10^{-6} to 1×10^{-4}. Young child residential exposures (1.7×10^{-4}), however, exceeded USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. This risk is due to accidental ingestion of arsenic, total HxCDD, and total HxCDF in surface soil (47%, 29%, and 22% risk contributions, respectively).

The total HI values estimated for adult and young child residential exposures (5.1 and 17, respectively) to noncarcinogenic COPCs at SWMU 2 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to accidental ingestion of iron and arsenic in the surface soil (55% and 17% risk contributions, respectively), dermal contact with iron and manganese in the surface soil (47% and 25% risk contributions, respectively), and accidental ingestion of dissolved cadmium, dissolved vanadium, and dissolved barium in groundwater (27%, 25% and 16% risk contributions, respectively). The individual HQs for young child ingestion exposures to iron and arsenic in surface soil, adult dermal exposures to iron in surface soil, and young child dermal exposures to iron and manganese in surface soil were greater than 1.0. All other individual HQs were below the target risk value of 1.0.

SWMU 45- Building 38

Organics and Total Inorganics

Table 6-29 shows that the total ILCRs estimated for adult and young child residential exposures (4.5×10^{-4} and 9.0×10^{-4}, respectively) to surface soil, groundwater and sediment in SWMU 45 exceeded USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. This risk is associated with dermal exposures to benzo(a)pyrene in groundwater (93% risk contribution), and ingestion exposures to benzo(a)pyrene and total arsenic in groundwater (48% and 46% risk contributions, respectively). The individual ILCRs for adult ingestion exposures to benzo(a)pyrene and total arsenic were less than 1×10^{-4}. All others were greater than 1×10^{-4}.

The total HI values estimated for adult and young child residential exposures (3.5 and 8.3, respectively) to noncarcinogenic COPCs at SWMU 45 exceeded USEPA's acceptable target value of 1.0. This exceedance is due to ingestion exposures to total arsenic and total chromium in groundwater (68% and 18% risk contributions, respectively). The individual HQ for adult ingestion exposures to total chromium in groundwater was below the target risk value of 1.0. All other individual HQs exceeded 1.0.

Organics and Dissolved Inorganics

Table 6-29 shows that the total ILCRs estimated for adult and young child residential exposures (4.0×10^{-4} and 8.0×10^{-4}, respectively) to surface soil, groundwater and sediment in SWMU 45

exceeded USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4}. This risk is due to dermal exposures to benzo(a)pyrene in groundwater (93% risk contribution), and ingestion exposures to benzo(a)pyrene and dissolved arsenic in groundwater (74% and 17% risk contributions, respectively). The individual ILCR for adult ingestion exposures to benzo(a)pyrene exceeded 1×10^{-4}. All others were less than 1×10^{-4}.

The total HI values estimated for adult residential exposures (0.96) to surface soil, groundwater and sediment in SWMU 45 were below the target risk value of 1.0. Young child residential exposures (2.45), however, exceeded USEPA's target risk value of 1.0. This exceedance is due to ingestion exposures to dissolved arsenic, dissolved antimony, and dissolved cadmium in groundwater (63%, 16% and 11% risk contributions, respectively). The individual HQ for young child ingestion exposures to dissolved arsenic in groundwater exceeded the target risk value of 1.0. All other individual HQs were less than 1.0.

6.5 Sources of Uncertainty

Uncertainties are encountered throughout the process of performing a risk assessment. This section discusses the sources of uncertainty inherent in the following elements of the baseline human health risk assessment prepared for SWMUs 1, 2, and 45 at OUs 3 and 5, NSRR:

- Sampling and analysis
- Selection of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Compounds not Quantitatively Evaluated

Uncertainties associated with this baseline RA are discussed in the following paragraphs. Table 6-30 summarizes the potential effects of certain uncertainties on the estimation of human health risks.

6.5.1 Sampling and Analysis

The development of a risk assessment depends on the reliability of, and uncertainties associated with, the analytical data available to the risk assessor. These, in turn, are dependent on the operating procedures and techniques applied to the collection of environmental samples in the field and their subsequent analyses in the laboratory. To minimize the uncertainties associated with sampling and analysis at OUs 3 and 5, USEPA approved sampling and analytical methods were employed. Data were generated following RCRA methods of analysis for organics and inorganics, and were validated in accordance with USEPA Region II procedures. Samples were taken from locations specified in the approved Work Plan along with the necessary Quality Assurance/Quality Control (QA/QC) samples.

Analytical data are limited by the precision and accuracy of the methods of analysis which are reflected by the Relative Percent Difference (RPD) of duplicate analyses and the percent recovery of spikes, respectively. In addition, the statistical methods used to compile and analyze the data (mean concentrations, detection frequencies) are subject to the overall uncertainty in data measurement. Furthermore, chemical concentrations in environmental media fluctuate over time and with respect to sampling location. Analytical data must be sufficient to consider the temporal and spatial characteristics of contamination at the site with respect to exposure.

6.5.2 Selection of COPCs

The selection of COPCs is performed in a risk assessment following the evaluation of data. Analytical data also must be comprehensive in order to address the COPCs associated with the site. Types of organic COPCs encountered at SWMUs 1, 2, and 45 include:

- VOCs in the groundwater at SWMUs 1 and 2

- SVOCs in the surface soil at SWMUs 1 and 2; subsurface soil at SWMUs 2 and 45; groundwater at all SWMUs; surface water at SWMUs 1 and 2; and sediment at all SWMUs

- Pesticides in the surface soil at SWMU 1; groundwater at SWMUs 1 and 2; and sediment at SWMUs 1 and 2

- PCBs in the groundwater at SWMU 45 and sediment at SWMU 1

- Dioxins/furans in the surface soil at SWMU 2; subsurface soil at SWMUs 1 and 2; groundwater at SWMU 1; and sediment at SWMUs 1 and 2

Inorganic constituents were detected in every medium investigated. A summary of the COPC selection criteria for chemicals detected in soil, groundwater, and sediment is presented below.

- Soil COPCs were selected based on comparisons of the detected concentration with USEPA Region III risk-based industrial and residential soil COC screening values.

- Groundwater COPCs were selected based on comparisons of the detected concentrations with USEPA Region III risk-based tap water COC screening values and Federal MCLs (as a secondary criterion).

- Surface Water COPCs were selected based on comparisons of the detected concentrations with Federal AWQCs.

- Sediment COPCs were selected based on comparisons of the detected concentration with USEPA Region III risk-based residential soil COC screening values and SSV ER-Ms.

USEPA Region III risk-based COC screening values are based on exposure assumptions and equations that are intended to introduce conservatism in the risk assessment process by changing the COPC screening method from a relative toxicity screen as presented in RAGS, to an absolute comparison of risk. However, the use of the Region III COC values which incorporate a set of conservative non-site-specific assumptions in the selection of COPCs at OUs 3 and 5, adds conservatism to the baseline RA. Also, use of ecological ER-Ms adds conservatism.

Currently, no Station closures are planned for NSRR and future residential development of the land is not expected. The application of the residential COC values to soil, groundwater, and sediment COPC selections would, therefore, tend to result in a list of COPCs that could be considered conservative for a military base. The use of conservative COPC selections in the baseline RA ensures the protection of public health in that the results of the baseline RA are incorporated into the determination of remedial alternatives and remedial action objectives in the Corrective Measures Study (CMS).

6.5.3 Exposure Assessment

In performing exposure assessments, uncertainties arise from two main sources. First, uncertainties arise in estimating the fate of a compound in the environment, including estimating release and transport in a particular environmental medium. Second, uncertainties arise in the estimation of chemical intakes resulting from contact by a receptor with a particular medium. An example of uncertainty introduced by the latter source is the estimation of potential intakes to construction workers as a result of direct contact exposures to subsurface soil during excavation/construction activities. Here, the uncertainty lies in the assumption that the only medium of concern for this receptor is subsurface soil. Construction worker exposures to surface soil could also occur; however, it is assumed in this baseline RA that at surface soil exposures are insignificant at an excavated construction site relative to subsurface soil exposures. Intakes due to direct contact exposures to surface soil were estimated for the much more conservative residential scenario. The resulting residential risks are expected to be greater than those that would be estimated for the construction worker scenario, and would most likely drive the surface soil remedial efforts. It should be noted again that future residential development of any SWMU is highly unlikely because of the Station's mission and the need to maintain the predominantly industrial land use patterns and that the residential receptors were evaluated as the most conservative (worst-case) scenario.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of constituents by the receptor. Exposure factors have been generated by the scientific community and have undergone review by the USEPA. The USEPA has published an Exposure Factors Handbook (USEPA, 1997a) which contains the best and latest values. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited numbers of individuals. In all instances, values used in this risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA.

The USEPA recommended use of the 95%UCL (normal or lognormal) as the RME concentration (in addition to RME assumptions) is designed to overestimate actual risks expected to result from “real-world” exposures. The W-Test (Gilbert, 1987) was performed on all data sets of the draft report in order to determine the underlying distribution (normal or lognormal)of each data set, and consequently, to determine whether the normal or lognormal 95%UCL would be more appropriate

to use as an exposure concentration. The results of the W-Test, which are presented in Appendix H, indicate that some data sets consist of normally distributed data; some are lognormally distributed data; some data sets could be described by both distributions; while others could be described by neither distribution. As can be seen in Appendix H, the lognormal 95%UCLs are generally greater in value than the normal 95%UCLs. As discussed in the previous paragraph, the 95%UCL for the arithmetic mean versus the maximum detected concentration was used for risk calculations (i.e., assuming all data sets are normally distributed) to reduce the potential for the overestimation of risks. Likewise, the normal 95%UCL was used as the exposure concentration, instead of the lognormal95%UCL in order to reduce the potential for the overestimation of risks. Therefore, in this risk assessment, the use of the normal 95%UCL reduces the uncertainty resulting from overestimation of actual exposures assumed to occur randomly across SWMUs 1, 2, and 45.

6.5.4 Toxicological Assessment

In making quantitative estimates of the toxicity for varying dosages of compounds to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are at all available. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used, and new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental subjects, high doses of a compound are often used. In this situation, a high dose means that high exposures are used in the experiment with respect to most environmental exposures. Therefore, when applying the results of the animal experiment to the human condition, the effects at the high doses must be extrapolated to approximate effects at lower doses. In extrapolating effects from high doses in animals to low doses in humans, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose-response calculations, the following factors are considered:

- Studies are preferred where the animal closely mimics human toxicokinetics.

- Studies are preferred where dose intake most closely mimics the intake route and duration for humans.

- Studies are preferred which demonstrate the most sensitive response to the compound in question.

For compounds believed to cause threshold effects (i.e., noncarcinogens) safety factors are employed in the extrapolation of effects from animals to humans and from high doses to low doses. In deriving carcinogenic potency factors, the 95% UCL value is promulgated by the USEPA to prevent underestimation of potential risk and in the case of PCDDs and PCDFs, further conservatism is applied to congeners to extrapolate the toxicity of tetra-chlorinated dibenzo-dioxin to higher chlorinated dioxins and dibenzo-furans.

Further conservatism in the baseline RA is also introduced through the use of experimentally-derived oral absorption efficiencies to account for a difference in the degree of toxicity between an administered dose and an absorbed dose. Equating the absorption efficiency of the dermal bi-phasic barrier to the absorption efficiency of the gastrointestinal lining is a very conservative approach that tends to overestimate the potential risk to human health.

In summary, the use of conservative assumptions results in quantitative indices of toxicity that are not expected to underestimate potential toxic effects, but may overestimate these effects by an order of magnitude or more.

6.5.5 Risk Characterization

The risk characterization bridges the gap between potential exposure and the possibility of systemic or carcinogenic human health effects, ultimately providing impetus for the remediation of the site or providing a basis for no remedial action.

Uncertainties associated with risk characterization include the assumption of chemical additivity and the inability to predict synergistic or antagonistic interactions between COPCs. These uncertainties are inherent in any inferential risk assessment. To account for this, USEPA- promulgated inputs to the quantitative risk assessment and toxicological indices are calculated to be protective of the human receptor and to err conservatively, so as to not underestimate the potential human health risks.

Also, there is a measure of uncertainty in the dermally absorbed doses for organic compounds. A nonsteady-state approach is suggested in the EPA document entitled Dermal Exposure Assessment: Principles and Applications (USEPA, 1992a) for evaluating these dermal exposures. However, the use of the nonsteady state model for estimating dermal absorption is not recommended for use in these risk calculations which are presented in Appendix I. This approach is overly conservative because it is based on a mono-phasic approach that assumes absorption soley by skin lipids and ignores movement across the proteinaceous stratum corneum layer. This often times produces risks that are equivalent to or greater than those estimated for the ingestion pathway, which is counterintuitive for many chemicals (e.g., some semivolatiles) for which this has been observed. In addition, the steady-state model has been used and accepted consistently by USEPA on past NSRR risk assessments. Introduction of the nonsteady state model into the dermal intake calculations would not only be unrealistically conservative, but would be inconsistent with past risk assessments conducted for NSRR

6.5.6 Constituents Not Quantitatively Evaluated

No risk levels were quantitatively estimated for isodrin, mercury, or lead in this baseline RA. Isodrin was retained as a COPC in the groundwater at SWMU 2. Mercury was retained as a COPC in surface and subsurface soil in all SWMUs, groundwater in SWMUs 1 and 45, surface water at SWMU 2, and sediment at SWMUs 1 and 2. Lead was retained as a COPC in the surface soil, subsurface soil and surface water at SWMU 2, the groundwater at all SWMUs, and the sediment at SWMUs 1 and 2. Lead is currently considered a B2 - probable human carcinogen, as well as a developmental toxin in young children.

This risk assessment has been performed using conservative exposure point concentrations, exposure scenarios (use of the groundwater aquifer as a drinking water source), and available toxicological information. Based on the conservative nature of the risk assessment, it is unlikely that the lack of promulgated toxicological indices for isodrin, mercury, or lead will result in the underestimation of risk.

6.6 Summary of Risk Assessment Results

This section summarizes the results of the baseline RA, and identifies SWMUs that are associated with COPCs in environmental media that may pose potential human health and ecological risks. The OUs 3 and 5 RFI was conducted at SWMUs 1 (the Army Cremator Disposal), 2 (the Langley Drive Disposal Site) and 45 (Building 38) at NSRR, Puerto Rico. Descriptions and historical background for each SWMU were provided in the previous sections of this RFI report. The purpose of the baseline RA is to evaluate the potential human health risks posed by the presence of COPCs detected in the environmental media investigated at each designated SWMU. Further action is recommended for a SWMU if the results of this baseline RA demonstrate that potentially unacceptable risks may be associated with an environmental medium within the boundary of that SWMU.

6.6.1 Summary of Results of the Baseline Human Health Risk Assessment

COPCs were identified for each SWMU based on exceedences of health-based standards/criteria, as discussed in Section 6.1.2, and as summarized in Tables 6-1 through 6-14. The following summarize COPCs that were identified from surface soil, subsurface soil, groundwater, surface water and sediment samples collected throughout OUs 3 and 5. Italicized COPCs are those that do not exceed the background values presented in the tables.

SWMU 1 - Army Cremator Disposal Site

SURFACE SOIL: Benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, 4,4-DDT, aluminum, antimony, arsenic, cadmium, *chromium,* copper, iron, manganese, *mercury* and *vanadium*

SUBSURFACE SOIL: Total HxCDD, total HxCDF, total TCDF, aluminum, antimony, *chromium,* copper, iron, manganese, mercury and *vanadium*

TOTAL GROUNDWATER: Chloroform, 1,1,2,2-tetrachloroethane, pentachlorophenol, bis(2-ethylhexyl)phthalate, heptachlor, aldrin, total HxCDD, antimony, arsenic, barium, beryllium, cadmium,

chromium, chromium VI, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium and zinc

FILTERED GROUNDWATER: Chloroform, 1,1,2,2-tetrachloroethane, pentachlorophenol, bis(2-ethylhexyl)phthalate, heptachlor, aldrin, total HxCDD, cadmium, copper, manganese, nickel, thallium and vanadium

SURFACE WATER: Bis(2-ethylhexyl)phthalate, di-n-octylphthalate, arsenic, thallium, and zinc

SEDIMENT: Benzo(a)pyrene, 4,4'-DDE, 4,4'-DDT, delta-BHC, Aroclor-1260, total HxCDD, total TCDF, total PeCDF, Total HxCDF, antimony, arsenic, chromium, copper, lead, mercury, nickel, selenium, vanadium, and zinc

SWMU 2 - Langley Drive Disposal Site

SURFACE SOIL: Benzo(a)pyrene, total HxCDD, total HxCDF, aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium and zinc

SUBSURFACE SOIL: Benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, Total HxCDD, total TCDF, aluminum, antimony, arsenic, cadmium, *chromium,* copper, iron, lead, manganese, mercury, and *vanadium*

TOTAL GROUNDWATER: Chloroform, trichloroethene, isodrin, pentachlorophenol, aldrin, heptachlor epoxide, antimony, *arsenic*, *barium, cadmium, chromium, copper,* iron, lead, and vanadium

FILTERED GROUNDWATER: Chloroform, trichloroethene, isodrin, pentachlorophenol, aldrin, heptachlor epoxide, barium, cadmium, and vanadium

SURFACE WATER: Bis(2-ethylhexyl)phthalate, di-n-octylphthalate, beryllium, chromium, lead, mercury, selenium, thallium, and zinc

SEDIMENT: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, 4,4'-DDE, total HxCDD, total HxCDF, antimony, arsenic, chromium, copper, lead, mercury, vanadium, and zinc

SWMU 45 - Building 38

SURFACE SOIL: Arsenic, *chromium*, and *mercury*

SUBSURFACE SOIL: Benzo(a)pyrene, arsenic, chromium, *mercury* and *vanadium*

TOTALGROUNDWATER: Benzo(a)anthracene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, chrysene, Aroclor-1260, antimony, arsenic, *barium*, cadmium, chromium, lead, and *vanadium*

FILTERED GROUNDWATER: Benzo(a)anthracene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, chrysene, Aroclor-1260, antimony, arsenic, barium, cadmium, mercury, and vanadium

SEDIMENT: Benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, and vanadium

Constituents identified as COPCs in each SWMU were retained for quantitative evaluation in the baseline RA. The baseline RA estimated potential carcinogenic and noncarcinogenic risks to potential current and future human receptors that would result from exposures to COPCs in the investigated environmental media at each SWMU. Current receptor groups evaluated included on-

site adult workers and adult and adolescent trespassers; future receptor groups evaluated included construction workers and on-site adult and child (ages 1-6 years old) residents. The human exposure pathways evaluated for each receptor are summarized below.

Current on-site adult workers:

Accidental ingestion of surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Dermal contact with surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Inhalation of fugitive dust emanating from surface soil (all SWMUs)

Current adult and adolescent trespassers:

Accidental ingestion of surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Dermal contact with surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Inhalation of fugitive dust emanating from surface soil (all SWMUs)

Future on-site adult construction workers:

Accidental ingestion of subsurface soil (all SWMUs)

Dermal contact with subsurface soil (all SWMUs)

Inhalation of fugitive dust emanating from excavated subsurface soil (all SWMUs)

Future on-site adult and child (1-6 years old) residents:

Accidental ingestion of surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Dermal contact with surface soil and sediment (all SWMUs) and surface water (SWMUs 1 and 2)

Inhalation of fugitive dusts emanating from surface soil (all SWMUs)

Ingestion of groundwater used as drinking water (all SWMUs)

Dermal contact with groundwater while bathing (all SWMUs)

Inhalation of volatilized organics from groundwater used for showering (all SWMUs, adult residents only)

However, it should be noted that currently, there are no facilities for personnel housing within OUs 3 and 5, nor are there any likely to be developed. It is highly improbable that any of the SWMUs will be developed for residential/ military personnel housing in the future since the mission of NSRR is that of a key naval station providing full support for Atlantic Fleet Weapons training and development activities, and the area surrounding Ensenada Honda (the harbor) is needed to support the mission. Although future residential development of any SWMU within OUs 3 and 5 is highly unlikely, future residential exposures were evaluated as the most conservative (worst-case) scenario.

A quantitative risk evaluation of SWMUs 1, 2, and 45 was performed for the COPCs, receptors and exposure pathways previously outlined. The following subsections briefly summarize the environmental media and exposure pathways associated with adverse risks estimated for each of the SWMUs, as well as the potentially affected receptor groups.

6.6.1.1 SWMU 1 - Army Cremator Disposal Site

Potentially unacceptable carcinogenic risks were estimated for current on-site workers that would result predominantly from the cumulative effect of dermal exposures to total HxCDD and total HxCDF in sediment. It should be noted that the media-specific subtotal ILCRs for this receptor were within USEPA's acceptable target risk range of 1×10^{-4} to 1×10^{-6}.

Potentially unacceptable noncarcinogenic risks were estimated for current on-site workers that would result predominantly from dermal and ingestion exposures to thallium in surface water, ingestion exposures to arsenic in surface water, and dermal exposures to manganese, iron, and cadmium in surface soil. The individual HQs for arsenic in surface water and manganese, iron, and cadmium in surface soil were less than one. Also, arsenic, manganese, iron, and cadmium target different organs in the human body. Consequently, since these COPCs were inorganics and the target organs and critical effects vary, it is unlikely that the HQs for the analytes in the surface water and surface soil are additive. However, the individual HQ for dermal exposures to thallium was greater than 1.0. It must be noted that the HQ for thallium was calculated using an oral RfD that was withdrawn from

EPA's toxicological database (IRIS and HEAST) because of uncertainties in the database from which it was derived.

Potentially unacceptable noncarcinogenic risks were estimated for future construction workers that would result predominantly from accidental ingestion of iron, manganese, and aluminum in subsurface soil. It should be noted, however, that the individual HQs for these analytes were less than the USEPA's acceptable target risk value of 1.0. Also, iron, manganese and aluminum target different organs in the human body. Consequently, since these COPCs were inorganics and the target organs and critical effects vary, it is unlikely that the HQs for the analytes in the subsurface soil are additive. Therefore, no adverse health effects are expected to occur subsequent to exposure.

Potentially unacceptable carcinogenic risks were estimated for future residents that would result predominantly from ingestion and dermal exposures to total HxCDD and total arsenic in groundwater. The individual ILCR values for total arsenic was within the USEPA's target risk range of 1.0×10^{-4} to 1.0×10^{-6}, while the individual ILCRs for total HxCDD was outside of the USEPA's target risk range. It should be note that dissolved metals (which demonstrated no risk) are more indicative of conditions at the tap, and that total metals were evaluated as a conservative measure only. Also, due to naturally poor groundwater quality and low yield capacity of the aquifer being investigated, it is highly improbable that the aquifer will ever be used as a potable source.

In addition, potentially unacceptable noncarcinogenic risks were estimated for future residents that would result predominantly from ingestion and dermal exposures to thallium in groundwater (both total and dissolved), ingestion and dermal exposures to iron and manganese in surface soil, and accidental ingestion of thallium and arsenic in the surface water. The individual HQs for groundwater exposures were greater than 1.0. It should be noted again, however, that because of the naturally poor groundwater quality and low yield capacity of the aquifer being investigated, it is highly improbable that the aquifer will ever be used as a potable source. The individual HQs for surface soil and surface water exposures were also generally greater than 1.0.

6.6.1.2 SWMU 2 - Langley Drive Disposal Site

Potentially unacceptable carcinogenic risks were estimated for current on-site workers that would result predominantly from the cumulative effect of dermal exposures to arsenic, total HxCDD and total HxCDF in surface soil and dermal exposures to total HxCDD and total HxCDF in sediment. It should be noted that PCDDs and PCDFs may or may not be site related because they tend to occur ubiquitously in environmental media. Their sporadic occurrence may also indicate that they are not site related. It should also be noted that the media-specific subtotal ILCRs for this receptor were within USEPA's acceptable target risk range of 1×10^{-4} to 1×10^{-6}.

Potentially unacceptable noncarcinogenic risks were estimated for current on-site workers that would result predominantly from ingestion exposures to thallium, chromium, and selenium in surface water and dermal exposures to iron and manganese surface soil. The individual HQs for chromium and selenium in surface water and iron and manganese in surface soil were all less than one. Also, chromium, selenium, iron and manganese target different organs in the human body. Consequently, since these COPCs were inorganics and the target organs and critical effects vary, it is unlikely that the HQs for the analytes in the surface water and surface soil are additive. However, the individual HQ for ingestion exposures to thallium in surface water was greater than 1.0. HQs for thallium must be considered with caution because they were generated using an RfD that has been withdrawn from USEPA databases.

Potentially unacceptable noncarcinogenic risks were estimated for future construction workers that would result predominantly from ingestion and dermal exposures to iron, and dermal exposures to manganese in the subsurface soil. The individual HQs for dermal and ingestion exposures to iron were greater than the USEPA's acceptable target risk value of 1.0.

Potentially unacceptable carcinogenic risks were estimated for future young child residents that would result predominantly from accidental ingestion of arsenic, total HxCDD and total HxCDF in surface soil. It should be noted, however, that the individual pathway ILCRs for this receptor were within USEPA's acceptable target risk range of 1×10^{-4} to 1×10^{-6}.

In addition, potentially unacceptable noncarcinogenic risks were estimated for both adult and young child future residents that would result predominantly from accidental ingestion of total vanadium, total thallium, dissolved cadmium, dissolved vanadium, and dissolved barium in groundwater, ingestion of iron and arsenic in surface soil, and dermal exposures to iron and manganese in surface soil. The individual HQs for groundwater exposures to total inorganics were greater than 1.0. It should be noted again, however, that dissolved metals are more indicative of conditions at the tap, and that total metals were evaluated as a conservative measure only. Also, because of the naturally poor groundwater quality and low yield capacity of the aquifer being investigated, it is highly improbable that the aquifer will ever be used as a potable source. The individual HQs for surface soil exposures were also generally greater than 1.0.

6.6.1.3 SWMU 45 - Building 38

Potentially unacceptable carcinogenic risks were estimated for future adult and child residents that would result predominantly from dermal and ingestion exposures to benzo(a)pyrene in SWMU 45 groundwater, and ingestion of total and dissolved arsenic in groundwater. Again, however, it should be noted that due to naturally poor groundwater quality and low yield capacity of the aquifer being investigated, it is highly improbable that the aquifer will ever be used as a potable source.

Potentially unacceptable noncarcinogenic risks were estimated for future residents that would result predominantly from ingestion exposures to total arsenic, total chromium, dissolved arsenic, dissolved antimony, and dissolved cadmium in SWMU 45 groundwater. Generally, the individual HQ for exposures to total inorganics were greater than 1.0, while exposures to dissolved inorganics were less than 1.0. Again, dissolved metals are more indicative of conditions at the tap, and that total metals were evaluated as a conservative measure only. It should be noted again that due to naturally poor groundwater quality and low yield capacity of the aquifer being investigated, it is highly improbable that the aquifer will ever be used as a potable source.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This section of the report provides overall conclusions regarding the various SWMUs which comprise OUs 3 and 5 based on analysis of the RFI findings. Recommendations are provided in response to the conclusions. It should be noted that detailed summaries of investigation results and risk assessment conclusions are provided in Sections 5.0 and 6.0, respectively.

7.2 Conclusions by SWMU

The various SWMUs comprising OUs 3 and 5 are discussed separately in the subsections that follow.

7.2.1 SWMU 1

Confirmation Study, supplemental Investigation, Relative Risk Ranking, and the RFI data indicates that the site has been minimally impacted by former landfilling operations. This conclusion is supported for the environmental media discussed below.

Surface Soils

Semivolatile constituents were found in three surface soil samples above screening criteria. These were PAHs located in the southwestern portion of the site. One pesticide was detected above the screening criteria in one sample. It should be noted that the exceedances only appeared in the samples at levels above the residential but below the industrial RBCs. Numerous inorganic species were detected above screening levels largely characterized by the suite of antimony, beryllium, cadmium, iron, and lead. Only cadmium and iron exceeded residential RBCs at sporadic locations. In some cases, the concentrations of cadmium exceed both residential RBCs and two times the average detected background concentration. Antimony, beryllium, and lead only exceeded the two times the average detected background concentration. Given the

widespread occurrence, wide ranging concentrations, and presence in the background data set, it appears that the inorganics are the result of long-term leaching of soils of volcanic origin that has resulted in the immobile metals and metalloids being left in the soil.

Subsurface Soils

Data from the subsurface soil investigations indicate similar results. The only organics detected above screening levels were dioxins in three samples above the residential RBCs. Inorganics, characterized by the suite antimony, beryllium, and iron were detected above screening levels in the subsurface soil samples. It should be noted that none of the exceedances were in excess of the industrial RBCs. As with the surface soil, the presence of these species at the concentrations seen is likely the result of leaching activity on volcanic origin soils rather than site waste management activities.

Groundwater

Minimal impact is seen in the groundwater. As would be expected given the concentrations of metals seen in the surface and subsurface soils, the same metals show up in the groundwater, often exceeding screening criteria. Given that the inorganics are attributed to natural conditions (not waste management activities) in the soils, the same can be said of the groundwater.

Pesticides exceeded the tap water RBCs but below the Federal MCLs in two of the monitoring wells in the northeastern portion of the site. One dioxin was detected above the tap water RBC in one monitoring well. Reviewing the occurrence and concentrations of these organic constituents would appear to indicate that they may be site related but that there is no pattern to their occurrence and no obvious significant source.

Sediments

Eleven sediment samples were obtained. The pesticide 4,4'-DDE was detected above the sediment screening values in four of the samples but is probably reflective of past pesticide application as opposed to waste management activities. These four samples were obtained from

the southern portion of the site. Inorganics in the sediments were generally reflective of the site soils from which they were derived. There was one detection above screening criteria of PCBs (1SD02 at 440 µg/L) that is unexplained but does not appear to indicate a pattern of contamination.

Surface Water

The exceedances of the organic screening criteria which were detected during the initial round of surface water sampling were not detected during the second round of surface water sampling. Therefore it is not believed that SWMU 1 has impacted the surface water with organics. Arsenic was only detected in the initial round of sampling and not the second of sampling.

Statistical Representativeness

The majority of all the data obtained for the different media of interest for SWMU 1 reflect a 99.9% confidence that the site is below the screening criteria. For certain constituents the confidence interval was lower since the method detection levels were above the screening criteria. The majority of the number of samples that were collected for each constituent were sufficient to characterize the site.

Risk Assessment

The risk assessment performed on the site data indicated that there were potential unacceptable health risks posed to:

- Current on-site commercial/maintenance workers
- Future on-site residents

The risk assessment indicates that there is no imminent risk posed by SWMU 1.

The presentation of the aerial photo analysis, geophysical report, all the analytical data from the history of the site, the statistical analysis, and the human health risk assessment indicate that SWMU 1 is adequately characterized.

7.2.2 SWMU 2

SWMU 2, separated from SWMU 1 by an access road, shows a similar pattern of site impact evidence. Each of the environmental media sampled is discussed briefly below.

Surface Soils

The inorganic occurrence above screening levels shows a similar pattern to SWMU 1 with antimony, arsenic, beryllium, cadmium, copper, lead, nickel, selenium, and zinc being the most commonly seen species. This would appear to lend credence to the conclusion that the inorganics are present at the levels seen as a result of long-term leaching of soils derived from volcanic rocks. This is especially indicated considering the wide areal spacing of the samples and the fact that many of them were collected at locations outside of the suspected waste disposal areas.

Only two organics were detected above screening criteria. There was one detection of benzo(a)pyrene above the residential RBC and one detection of dioxins (detecting two species HxCDD and HxCDF) above the residential RBCs. Based on this finding, there does not appear to be a widespread occurrence or pattern of organic contamination at this site.

Subsurface Soils

The same pattern of inorganic exceedances of screening criteria is seen in the subsurface soil as was present in the surface soils. This again would appear to support the conclusion that the inorganics are naturally occurring and not related to site waste management activities.

Dioxins in two adjacent borings (2SB04 and 2SB05) were detected at extremely low levels but above the residential RBC. Four SVOCs were detected above the residential RBC in one

sample. Their absence at other locations and the absence of other organics above screening criteria would indicate that there is no pattern of organic contamination in the subsurface soils.

Groundwater

There does not appear to be impact to the groundwater at this site only trichloroethene was detected. It was found in three of the four wells at levels below the Federal MCL and tap water RBC. While this is the case, the levels are very low (single digit parts per billion). Two pesticides were detected above the tap water RBCs in two different, widely separated wells. These are likely the result of past applications of pesticides rather than being related to waste management practices.

The inorganic species exceeding screening levels include those which would be expected given their concentrations in the soil above the water table. Based on this, they appear to be naturally occurring and not related to site activities.

Sediment

Two of the sediment samples collected appear to be minimally affected by past site operations. This is evidenced by the detections of SVOCs above the screening criteria along the southeastern edge of the mangrove swamps. One pesticide (4,4'-DDE) was also detected above the ERL and ERM Sediment Screening criteria. The metals and metalloids seen compare to those found in the surface soils indicating that the sediment findings are reflective of site soil conditions rather than past management activities.

It should be noted that the sediment samples obtained on site compare well to those obtained off-shore during investigations for OU 7 (Ensenada Honda Sediments). The inorganic constituents seen were comparable to those in the onshore samples which would only make sense given their derivation. The presence of PAHs in the off-shore sediments is likely the result of the one major and, probably many minor, oil/fuel spills to the Honda.

Surface Water

The analytical data presented for the surface water media at SWMU 2 does not indicate that the site has impacted the media. The only organic constituents detected were three SVOCs all of which were well below their respective screening criteria. Only three inorganic compounds, chromium, selenium, and silver were consistently detected above the screening levels from the initial round of sampling to the final round of sampling.

Statistical Representativeness

The majority of all the data obtained for the different media of interest for SWMU 2 reflect a 99.9% confidence that the site is below the screening criteria. For certain constituents the confidence interval was lower since the method detection levels were above the screening criteria. The majority of the number of samples that were collected for each constituent were sufficient to characterize the site.

Risk Assessment

The risk assessment performed on the site data indicated that there were unacceptable health risks posed to:

- Current on-site commercial/maintenance workers
- Future on-site residents

The risk assessment indicates that there is no imminent risk posed by SWMU 2.

The presentation of the aerial photo analysis, the geophysical report, all the analytical data from the history of the site, the statistical analysis, and the human health risk assessment indicate that SWMU 2 is adequately characterized.

7.2.3 SWMU 45

This section only addresses SWMU 45 which is defined in the permit as the outside areas surrounding Building 38. The interior of Building 38 is SWMU 11 which was originally intended to be included in this report. All sampling of the building's interior was completed in accordance with the approved RFI workplan but the results were negated by a fire in the building. For this reason, the results are not included herein. All original sampling results were provided, along with a workplan describing the investigations needed to recharacterize the building's interior, in a submission to the EPA on March 31, 1998. After the investigations to recharacterize are performed, a report will be submitted detailing the results of the work and providing conclusions and recommendations for further actions as an addendum to this OU 3/5 RFI report.

SWMU 45 for the purposes of this report, is actually comprised of three separate areas. These are:

- The area outside of Building 38 including the USTs
- The soils around the tunnel leading to Puerca Bay
- The Puerca Bay sediments

Each of these areas is discussed separately in the subsections which follow.

7.2.3.1 Building 38 UST Area

The surface and subsurface soils showed no significant impact from site activities. Only arsenic, and occasionally barium and cadmium, exceeded screening levels. As has been seen at other sites, these are ubiquitous in the near seawater areas of the base and are naturally occurring as the result of leaching of soils derived from volcanic rock.

Groundwater appears to be minimally impacted. The inorganics are largely what would be expected given the concentrations seen in the overlying soils. There was one detection of a phthalate over the screening criteria; however, this is a common laboratory and sampling artifact and is not a constituent of oil (which is the material managed at the site) which would indicate that

its occurrence is not site related. One PCB was detected above the tap water RBC at 0.35 µg/L. This is likely from the soils above which, at one time, contained significant levels of PCBs. An ICM was conducted in the area which removed the contaminated soils. The single detection would appear to indicate that the groundwater is not significantly affected.

7.2.3.2 Cooling Water Tunnel Soils

The investigatory data indicates that there have been significant releases of petroleum related compounds from the tunnels. While this is the case, no free product was found at any location and the zone of contamination is confined to the area immediately adjacent to the tunnels. This is evidenced by the fact that organics were not detected in any of the borings made at a distance of approximately 50 feet from the tunnels.

Supporting the conclusion that the contamination is only around the tunnel is the lack of organic constituents found in the groundwater. The only finding of note for groundwater is the ubiquitous presence of arsenic above the tap water RBC. Given that it is found in soils, attributed to natural conditions, it is not surprising that it is present in groundwater.

7.2.3.3 Puerca Bay Sediments

The sediments within Puerca Bay show obvious impact from tunnels discharges. Aroclor 1260 is found in every sample at levels exceeding the ERL sediment screening value. PAHs are found in only one sample which may be indicative of extensive weathering of released petroleum products which has essentially only left behind the persistent PCBs.

7.2.3.4 Risk Assessment

A human health risk assessment was performed for all of SWMU 45 with the exception of the Puerca Bay sediments for which there was no complete pathway for exposure. The findings indicated that the only risk was to possible future on-site residents.

It should be noted that the USTs and the cooling water tunnel had an ICM conducted as previously agreed to by the EPA and therefore no further action is required for these areas.

7.3 Recommendations by Area

The subsections which follow present the recommendations for each area based on the results of the RFI.

7.3.1 SWMU 1

Recommendation

It is recommended that further actions at SWMU 1 be limited to the placement of institutional controls related to land use restrictions. This will be accomplished through the development of a CMS for SWMU 1. An ecological risk evaluation will also be performed as part of the CMS. The workplan for the performance of such CMS has been coincidentally submitted with this report.

Rationale

The only unacceptable human health risks calculated were for "Current On-site Commercial/ Maintenance Workers" and for "Future On-site Residents." There are no site workers now; the site being a heavily vegetated area with no need for maintenance. It is highly unlikely that the area would be developed for housing given its topography and location. Also, groundwater would not be used due because the base has a potable water supply derived in the mountains which has excess capacity. To ensure that the site is not developed for residential use, the Navy will place a land use restriction on the site which will limit its use to industrial purposes only. Should, at any time in the future, the base decide to construct an industrial use operation at the SWMU, the environmental site conditions will be reviewed with respect to the potential need for full or partial site cleanup and for potential risk to construction workers (even though the present risk scenario shows no unacceptable risk). In the event of this happening, EPA will receive advance notification.

7.3.2 SWMU 2

The conclusions, recommendations and rationale for SWMU 2 are identical to those for SWMU 1 which makes sense given their similarity of use and areal juxtaposition.

7.3.3 SWMU 45

SWMU 45 includes the three areas previously described (Building 38 UST area, tunnel soils and Puerca Bay sediments). An ICM was performed in the Building 38 UST area which addressed the problems there. A Corrective Measures Study (CMS) is recommended for the remaining two areas within SWMU 45.

Cooling Water Tunnel Soils

The source for any continuing release at this area was removed when the tunnel was cleaned out and backfilled with concrete. Only a very limited extent of soil contamination appears to exist immediately adjacent to the tunnel and related groundwater is apparently unaffected. A CMS will be prepared which will address the minimal risks posed by the residual hydrocarbons in the subsurface soil.

Puerca Bay Sediments

The source for continuing releases to the sediments was removed when the tunnel was cleaned out and backfilled with concrete.

The first step in the CMS for this area will be to analyze ecological risk associated with the sediment contamination. Depending on the results of this, remedial alternatives may need to be reviewed.

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