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Final

Corrective Measures Study Work Plan
SWMUs 53 and 54

Naval Station Roosevelt Roads

RCRA/HSWA Permit No. PR2170027203

Ceiba, Puerto Rico

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Prepared by

CH2M HILL

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

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LIST OF ACRONYMS AND ABBREVIATIONS

AUF	Area Use Factor
BAF	Bioaccumulation Factor
Baker	Baker Environmental, Inc.
BB&L	Blasland, Bouck, and Lee
BCF	Bioconcentration Factor
bgs	below ground surface
BW	Body Weight
CAOs	Corrective Action Objectives
CERCLA	Comprehensive Environmental Recovery, Compensation, and Liabilities Act
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
CNO	Chief of Naval Operations
COC	Constituent of Concern
COPC	Chemical of Potential Concern
CTO	Contract Task Order
DDT	dichlorodiphenyltrichloroethane
D.I.	deionized water
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
FC_{xi}	Maximum Concentration of Chemical x in Food Item i
FIR	Food Ingestion Rate
GPS	Global Positioning System
HQ	Hazard Quotient
HSWA	Hazardous and Solid Waste Amendments
IRIS	Integrated Risk Information System
K_{ow}	Octanol-Water Partition Coefficient
LANTDIV	United States Navy, Atlantic Division
LD_{50}	Median Lethal Dose
LOAEL	Lowest Observed Adverse Effect Level
MATC	Maximum Acceptable Toxicant Concentration
MCLs	Maximum Contaminant Levels
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NEX	Navy Exchange
NOAEL	No Observed Adverse Effect Level
NSRR	Naval Station Roosevelt Roads
PAH	Polynuclear Aromatic Hydrocarbons
PAH_cs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

PDF_i	Proportion of Diet Composed Food Item i
PREQB	Puerto Rico Environmental Quality Board
QA/QC	Quality Assurance/Quality Control
R	rejected
RA	Risk Assessment
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SAP	Sampling and Analysis Plan
SC_x	Concentration of Chemical x in Soil/Sediment
SDWA	Safe Drinking Water Act
SMDP	Scientific/Management Decision Point
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TSCA	Toxic Substance Control Act
UST	Underground Storage Tank
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WCx	Concentration of Chemical x in Water
WIR	Water Ingestion Rate

1.0 INTRODUCTION

This work plan presents the technical approach for conducting a Corrective Measures Study (CMS) for Solid Waste Management Units (SWMUs) 53 and 54, located at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico. This CMS work plan has been prepared under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-95-D-6007, Contract Task Order (CTO) 099. This work plan was developed in accordance with NSRR Final RCRA/HSWA Permit No. PR2170027203 dated October 29, 1994 (USEPA, 1994). Specifically Module III Appendix B Scope of Work for a Corrective Measures Study at U.S. Naval Station Roosevelt Roads.

1.1 Site Background

The following subsections present a brief description and background on each of the two SWMUs that are dealt with in this CMS work plan.

1.1.1 SWMU 53 – Building 64 (Malaria Control Building)

SWMU 53 is located at NSRR as shown on Figure 1-1. The Malaria Control Building (Building 64) was built in 1942 and condemned in 1980. The building is presently unoccupied and lies on approximately 1/8 acre. The building structure itself is 21 feet by 18 feet in dimension, and occupies about 10 percent of the total SWMU 53 acreage. This SWMU is located on a gentle slope (approximately 5-7% grade) from northeast (upgradient) to the southwest (downgradient) approximately 200 feet away from Forrestal Drive. The building was utilized to store pesticides, such as malathion, aldrin, and dichlorodiphenyltrichloroethane (DDT). It is not known if stocks of pesticides were maintained in the building for the entire duration. Although no direct evidence exists, it is assumed that mixing and other preparation for pesticide use was also performed at the building. No wastes are known to have been disposed of at the unit and there are no known releases related to this unit. No other use of the site was identified. The information gathered from the visual site inspection by Baker Environmental, Inc. (Baker) and environmental staff at NSRR revealed that there are no known wastes dumped at this facility, nor is there any evidence of source contamination (Baker, 2000a). Baker observed signs of possible past leakage of chemicals on the storage shelves inside the building, and identified migration pathways along the floor leading to the outside. With this information, along with the activities known to have taken place at this SWMU, a site characterization was performed to determine whether a release of

hazardous waste including hazardous constituents has occurred, is likely to have occurred, or is likely to occur.

The site characterization investigation, as well as the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) conducted at the site indicated that the surface soil at this site has been impacted by past site operations. These impacts are discussed further in Section 1.2. This CMS work plan is designed to fill identified data gaps and to provide a guide for selecting corrective measures to mitigate human health and ecological risks associated with contamination related to site operations.

1.1.2 SWMU 54 – Building 1914 (Former Navy Exchange [NEX] Repair/Maintenance Shop)

SWMU 54 is located at NSRR as shown on Figure 1-1. The Former NEX Repair/Maintenance Shop (Building 1914) built in 1979, is currently unoccupied and lies on approximately 1 acre of land in the Bundy Area of NSRR. The building structure and pavement covers approximately 40 percent of the total SWMU 54 acreage. This SWMU contains a slight slope to the west and a small hill to the east approximately 100 feet in elevation. A small hill lies in the southern part of this SWMU, which is approximately 50 feet in elevation. The building structure itself consists of a small concrete block building with a center office area and open bays on either side. The building was used to perform maintenance on vehicles including oil changes, lubrications, etc. No wastes are known to have been disposed of at the unit and there are no known releases related to the unit. Site 510 is an underground storage tank (UST) site located south of Building 1914. A 4,000 gallon UST associated with Building 510 was located south of Building 1914. The UST was constructed of steel and used to store fuel for fueling operations conducted in the area. The date of installation and the type of fuel stored is unknown, but is assumed to be gasoline. In December 1992, the tank was removed from Site 510 (Blasland, Bouck, and Lee [BB&L], 1995).

The information gathered from the visual site inspection performed by CH2M Hill and environmental staff at NSRR revealed that there were several areas of oil stained soil around NEX Building 1914 (CH2M Hill, 2000). For that reason, it was recommended that a sampling program be performed to characterize the areas around several structures in the SWMU 54 area. CH2M Hill also observed two open excavation locations south of the building containing algae stained water. With this information, along with the activities (oil changes, lubrications, etc.) known to have taken place at this SWMU, a site characterization was performed to determine

whether a release of hazardous waste including hazardous constituents has occurred, is likely to have occurred, or is likely to occur.

The RFI conducted at this site indicated that various environmental media were impacted by past operations in the area. These impacts are discussed further in Section 1.2. This CMS work plan is designed to provide a guide for selecting corrective measures to mitigate human health and ecological risks associated with contamination related to site operations.

1.2 Investigative History & Basis for the Work Plan

Building 64 (Malaria Control Building) and Building 1914 (Former NEX Repair/Maintenance Shop) were first listed as SWMUs in the May 31, 2000 RCRA Quarterly Progress Report (Baker, 2000b). Attachments two and three of the aforementioned report contained the Phase I Environmental Assessment Report for SWMUs 53 and 54, respectively. A Draft Sampling and Analysis Plan (SAP) was submitted for SWMUs 53 and 54 on August 4, 2000 (Baker, 2000c), and was approved by the United States Environmental Protection Agency (USEPA) on October 10, 2000. The field investigation was conducted in December 2000 in accordance with the EPA approved sampling and analysis plan. The Draft Sampling and Analysis Report for SWMUs 53 and 54 was submitted on April 11, 2001. The EPA commented on this report on July 5, 2001, requesting that a RFI work plan be submitted to further delineate contamination found at SWMUs 53 and 54, as well as the submission of a Final Sampling and Analysis Report. The Final Sampling and Analysis Report was submitted on August 27, 2001. The Final RFI Work Plan for SWMUs 53 and 54 was submitted on December 6, 2001 (Baker, 2001a), and was approved by the EPA on January 3, 2002. The field investigation was conducted in February and March 2002 in accordance with the EPA approved RFI work plan. The Draft RFI Report for SWMUs 53 and 54 (Baker, 2002) was submitted on July 17, 2002 and subsequently approved by the EPA on September 19, 2002 pending the performance of a CMS.

The EPA requested that the Navy submit a Draft CMS Work Plan within 60 days of receipt of their letter for SWMUs 53 and 54. The CMS Work Plan for SWMU 53 is to incorporate the delineation of the chlordane and heptachlor epoxide contamination in the surface soil, as well as to present a proposal for the removal of chlordane, heptachlor epoxide, arsenic, lead, and 4,4-DDT contaminated soil throughout the site. The development of this work plan has made it apparent that additional sampling will be required to address potential ecological concerns at the

site through development of the CMS. These issues with respect to the environment are outlined in the following sections of this work plan.

The CMS Work Plan for SWMU 54 is to evaluate trichloroethene (TCE), benzene, ethylbenzene, chloroform, and benzo(a)pyrene as a potential chemical of concern (COC) for groundwater. Although the Draft RFI Report for SWMUs 53 and 54 recommended no further action for surface and subsurface soils at SWMU 54 (Baker, 2002), 1,2-Dibromo-3-chloropropane will be evaluated as a potential COC in the subsurface soil as part of the CMS because of a detection above the USEPA Region III Residential Risk Based Concentration (RBC) during the RFI. This work plan is to present proposals for evaluating remedial alternatives for the above mentioned COCs at SWMU 54.

1.2.1 Findings of the Investigations

The following subsections present a summary of the findings for the sampling and analysis investigation and the RFI investigation performed at SWMUs 53 and 54 mentioned above. A complete detailed evaluation of the findings from the previous investigations at SWMUs 53 and 54 can be found in the EPA approved Final Sampling and Analysis Report (Baker, 2001b) and the EPA approved Draft RCRA Facility Investigation Report (Baker, 2002).

1.2.1.1 SWMU 53

Based on results of the 2000 SAP and 2002 RFI field investigations, arsenic, lead, and 4,4-DDT, the three primary COCs identified from the Sampling and Analysis Report (Baker, 2001b), were successfully delineated at SWMU 53 during the 2002 field investigation (See Figures 1-2, 1-3, and 1-4). Of these three constituents, only the metals, lead and arsenic had previously exceeded the EPA Region III Industrial RBC in the surface soil duringthe 2000 investigation. The results from the 2002 investigation provided delineation of arsenic and lead, but no other exceedance of the Industrial RBC for arsenic and lead was observed.

During the 2002 RFI, arsenic, chlordane, and heptachlor epoxide were found to exceed the EPA Region III Residential RBCs in surface soil. Chlordane and heptachlor epoxide were found to exceed the residential RBCs in sample 53SB14, located on the outer edge of the investigated area during the 2002 RFI.Therefore these two constituents were not delineated during the 2002 RFI, however, further delineation of these constituents will be addressed in Section 3.0 of this document. .

As mentioned previously, the soil data from SWMU 53 was evaluated by Baker for environmental concerns during the development of this CMS work plan. This evaluation determined that in addition to the constituents to be delineated during the CMS investigation (i.e, chlordane and heptachlor epoxide), copper, lead, and zinc are also to be added to that list based on their previous detections as presented on Figure 3-2

1.2.1.2 SWMU 54

Based on results of the 2000 SAP and 2002 RFI field investigations, TCE, benzene, chloroform, benzo(a)pyrene, and ethylbenzene were all identified as potential COCs in groundwater. Figures 1-5 through 1-7 graphically present 2002 RFI investigation detections of TCE, benzene, and ethylbenzene, repectively, from within the confines of SWMU 54. In addition to the above mentioned constituents, chloroform exceeded the EPA Region III Tap Water RBC in three of the nine groundwater samples collected during the 2000 investigations, as well as nine of the 30 groundwater samples collected during the 2002 investigation. Benzo(a)pyrene exceeded both the Federal MCL and EPA Region III Tap Water RBC in three of the nine groundwater samples collected during the 2000 investigation, while it was not detected during the 2002 investigation. The results from the 2002 investigation provided delineation of the groundwater COCs.

One volatile organic compound (VOC) was identified as potential COC in soil. 1,2-Dibromo-3-chloropropane was detected above the EPA Region III Residential RBC in one of the five subsurface soil samples collected during the 2002 investigation. This is likely indicative of a benzene, toluene, ethylbenzene, and xylene (BTEX) plume located in the vicinity of sample 54TW15A. The 1,2-Dibromo-3-chloropropane was not detected during the 2000 investigation. The results of the 2002 investigation provided delineation of the subsurface soil potential COC.

1.3 Organization of the CMS Work Plan

This CMS Work Plan is organized into seven sections. Section 1.0, the Introduction, is designed to introduce the reader to the basis for the work plan and a summary of the site status. Section 2.0 provides the objectives and the corrective measure standards being utilized for this project. The CMS Investigation to be performed at SWMU 53 is discussed in Section 3.0, with the corresponding CMS Investigation reporting discussed in Section 4.0. The ecological risk assessment to be performed is described in Section 5.0. Section 6.0 establishes the corrective action objectives with the identification of COCs discussed in Section 7.0. The tasks to be

accomplished as part of the Corrective Measure Study are described in Section 8.0. The project schedule is provided in Section 9.0. Section 10.0 provides the project organization. Section 11.0 provides the references cited in this report.

2.0 CMS OBJECTIVES AND CORRECTIVE MEASURE STANDARDS

This section discusses the objectives of this CMS and the standards to assess the performance of the selected corrective measure.

2.1 Objectives

The objectives of this CMS work plan are as follows:

- To identify those tasks required for the further delineation of two pesticides (chlordane and heptachlor epoxide) within the surface soil at SWMU 53.

- To identify those tasks required for the further delineation of three metals (lead, copper, and zinc) within the surface soil at SWMU 53.

- To identify those tasks required to evaluate lead, zinc, copper, arsenic, chlordane, 4,4-DDT, and heptachlor epoxide as a potential COC for surface and subsurface soils at SWMU 53.

- To identify those tasks required to evaluate trichloroethene (TCE), benzene, ethylbenzene, chloroform and benzo(a)pyrene as a potential COC for groundwater at SWMU 54.

- To identify those tasks required to evaluate 1,2-Dibromo-3-chloropropane as a potential COC for subsurface soils at SWMU 54.

- To identify those tasks required for assisting in screening applicable remedial technologies for SWMUs 53 and 54.

This work plan documents the scope and objectives of a highly focused or streamlined CMS for SWMU 53 and a full CMS for SWMU 54, as well as the activities required to implement the program. The work plan serves as a tool for assigning responsibilities and establishing the project schedule and costs.

A highly focused or streamlined CMS is appropriate for SWMU 53 since this site has "straightforward remedial solutions" where standard engineering solutions can be applied that have proven effective in similar situations (USEPA 1994). This site has only one impacted media: soil. Because SWMU 53 is located on the island of Puerto Rico, there are limited technologies that are time and cost effective in treating the impacted media. Therefore, the screening of clean-up technologies, normally conducted in a CMS, will not occur. The anticipated remedial action for SWMU 53 is excavation and disposal off-site.

2.2 Corrective Measures Standards

Corrective measure standards that may be applicable to SWMUs 53 and 54 will be developed as part of the CMS "Task I" reporting effort. Once the possible corrective measures are selected for applicability to these two sites, the appropriate standards will be developed.

The corrective measure standards to be considered will include the applicable Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) and Toxic Substance Control Act (TSCA) regulations and the Puerto Rico Environmental Quality Board (PREQB) standards. The Code of Federal Regulations (CFR) (40 CFR 264.100) will also be reviewed for applicability to the sites. In addition, ecological risks will be considered in the development of corrective measures standards by incorporating standards that are determined to be protective of ecological receptors by the risk assessment process described in Section 5.0.

All of this information to be considered for the corrective measure standards is taken into account when the corrective action objectives for human health and the environment are developed as discussed in Section 6.0.

The corrective measures standards correlate with the development of the corrective action objectives. These standards are utilized in part for the selection of contaminants of potential concern as described in Sections 5.0 and 6.0.

3.0 CMS INVESTIGATION (SWMU 53)

This section of the work plan describes the technical elements of the field investigation for SWMU 53. The USEPA has approved a RFI Work Plan for the initial work at Roosevelt Roads under the Corrective Action Program (Baker, 1995). The RFI Work Plan addressed all the necessary technical elements including provisions of the following separate plans:

- Project Management Plan
- Data Collection Quality Assurance Plan
- Data Management Plan, and
- Health and Safety Plan

Together, these plans provided all the details regarding field investigation techniques, laboratory analyses, data validation and data evaluation needed to fulfill the requirements of the CMS program. Since the above-mentioned document is in place and approved, it will form the basis of this plan. All the investigation tasks described in subsequent sections of this plan will be performed in accordance with the techniques and methodologies provided in the original USEPA approved work plan. Therefore, only the work elements themselves are discussed in the sections that follow.

The objectives of this CMS Investigation are as follows:

- To delineate the chlordane and heptachlor epoxide concentrations at SWMU 53 detected during the RFI investigation in February 2002 (Baker, 2002), as well as to delineate previous detections of lead, copper, and zinc.

3.1 Surface Soil Sample Locations

An additional eleven surface soil samples, including one duplicate sample, will be collected north of Building 64 to address the detections of chlordane and heptachlor epoxide found in surface soil sample 53SB14 during the RFI investigation (Baker, 2002). These samples will be analyzed for pesticides only, specifically chlordane, heptachlor, and heptachlor epoxide. This additional sampling will assist in delineating the extent of contamination of the previously listed constituents within the surface soil north of Building 64. The additional samples to be obtained

and analyzed for pesticides during the CMS investigation are 53SS07 through 53SS16, as depicted on Figure 3-1. Two of the ten additional surface soil samples collected (53SS07 and 53SS13) will also be analyzed for lead, zinc, and copper. This analysis will help to effectively evaluate ecological concerns for these constituents during the CMS.

An additional 15 surface soil samples, including two duplicate samples, will be collected from around, as well as down-gradient of Building 64 to evaluate ecological concerns dealing with lead, zinc, and copper during the CMS. Two sample locations (53SS07 and 53SS13) will be utilized for metals evaluation along with the pesticide analysis as mentioned above. This additional sampling will assist in delineating the extent of contamination of the above-mentioned metals within the surface soil at SWMU 53. The additional samples to be obtained and analyzed for metals during the CMS investigation are 53SS07, 53SS13, 53SS17 through 53SS29, as depicted on Figure 3-2.

All surface soil sampling locations will be flagged in the field and will be surveyed for horizontal location utilizing a portable global positioning system (GPS) unit.

3.2 Laboratory Analyses

Eleven of the 26 surface soil samples collected from SWMU 53 will be submitted to a mainland laboratory for analysis of Appendix IX pesticide constituents (chlordane, heptachlor, and heptachlor epoxide) as presented in Table 3-1. The remaining 15 surface soil samples, along with 53SS07 and 53SS13 will be analyzed for lead, copper, and zinc.

Baker is requesting that the mainland laboratory extract all 26 surface soil samples at the same time due to holding time requirements. However, of the samples requiring pesticide analysis, the laboratory will be instructed to only analyze surface soil samples (53SS07 and 53SS08) to determine whether the above-mentioned contamination is found at these locations. If these locations do not have any chlordane, heptachlor, and heptachlor epoxide, then the analysis of the remaining eight surface soil samples for pesticide analysis is not required. However, if these samples contain detections of the above-mentioned pesticides above either the EPA Region III Residential RBCs and/or Ecological Screening values (See Figure 3-3), then the next five surface soil samples (53SS09, 53SS10, 53SS11, 53SS12, and 53SS13) will be analyzed for the specified constituents. This analysis process will continue unless these constituents are not detected.

Figure 3-3 presents a laboratory analysis decision tree to further explain the decision process for the analysis of the surface soil samples analyzed for pesticides at the mainland laboratory.

Baker is requesting that the mainland laboratory analyze all surface soil samples including 53SS07 and 53SS13 requiring metals analysis, to determine whether the above-mentioned metals are found at these locations.

The same firm will be retained for this investigation that performed the laboratory analysis for the previous RFI investigation. This will ensure a consistency of techniques for analysis of the samples. Specific analytical methods are presented on Table 3-2.

3.3 Data Validation

All mainland laboratory data generated by the investigation will be subjected to independent, third party, validation. The USEPA Region II Data Validation Standard Operating Procedures will be followed. The same firm will be retained for this investigation that performed data validation for the previous RFI report. This will ensure a consistency of techniques and that an equivalent review of the data is performed.

3.4 Field QA/QC

The collection of Quality Assurance/Quality Control (QA/QC) samples will be obtained during these investigations. These will include the collection of equipment rinsate samples, field blanks, field duplicates, and matrix spike/matrix spike duplicate (MS/MSD).

Equipment rinsate blanks will be collected daily during the sampling event. Initially, samples from every other day should be analyzed. If analytes pertinent to the project are detected in any equipment rinsate blank, the remaining rinsate blanks will be analyzed. The results from the blanks will be used to verify that the disposable stainless steel spoons that will be used were contaminate free to begin with. This comparison is made during data validation, and the equipment rinsate blank is analyzed for the same parameters as the related samples. One equipment rinsate will be collected per day of field sampling.

One field blank sample will be collected which will consist of lab grade deionized water (D.I.) used in the collection of the equipment rinsate sample.

Surface soil sample field duplicates will be homogenized and split and collected at a frequency of ten percent.

Analysis of duplicate and blanks associated with surface soil sampling will include Appendix IX pesticide constituents (chlordane, heptachlor, heptachlor epoxide, lead, copper, and zinc).

MS/MSD samples are collected to evaluate the matrix effect of the sample upon the analytical methodology. An MS and MSD must be performed for each group of samples of a similar matrix (e.g., surface soil). MS/MSD samples will be collected at a frequency of five percent per media.

4.0 CMS INVESTIGATION REPORT (SWMU 53)

A report will be prepared on the methodologies and findings of the surface soil sampling at SWMU 53. A draft report will be submitted to the USEPA 42 days upon receipt of the validated analytical data. The main elements of the document will consist of the following:

- Introduction
- Investigation Methodologies
- Nature and Extent of Contamination
- Conclusions and Recommendations

4.1 Introduction

The introduction will consist of a discussion of the historical background of the investigations conducted at SWMU 53 and incorporate this CMS investigation in that context. The introduction will also provide a regulatory framework for Roosevelt Roads and SWMU 53, as well as a discussion of current conditions.

4.2 Investigation Methodologies

The investigation methodologies section will detail the investigation. The section will discuss sample locations, sample collection and handling procedures, QA/QC procedures, and analytical methods used. This section will also discuss problems encountered and problem resolution.

4.3 Nature and Extent of Contamination

The nature and extent of contamination section will present analytical results and interpretation of the data. Data will be presented on tables and figures with textual explanation. Results of QA/QC procedures will also be presented.

4.4 Conclusions and Recommendations

Information from the nature and extent of contamination will be synthesized into conclusions regarding site conditions. Recommendations will be made from these conclusions, which will then be incorporated into the SWMU 53 CMS as appropriate.

5.0 ECOLOGICAL RISK ASSESSMENT

This section presents the technical approach (described in general terms) for conducting an ecological risk assessment (ERA) at SWMUs 53 (Building 64 - Malaria Control Building) and 54 (Building 1914 - Former NEX Repair\Maintenance Shop), located at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico.

The ERA process at SWMUs 53 and 54 will be conducted in accordance with the Chief of Naval Operations (CNO) document entitled Navy Policy for Conducting Ecological Risk Assessments (CNO 1999). The Navy ERA process (see Figure 5-1) consists of eight steps organized into three tiers and represents a clarification and interpretation of the eight-step ERA process outlined in the USEPA ERA guidance for the Superfund program (USEPA 1997a). Tier 1 of the Navy ERA process represents the screening-level ERA:

- Screening-level problem formulation and ecological effects evaluation (Step 1).

- Screening-level exposure estimate and risk calculation (Step 2).

Under Navy policy, if the results of Step 1 and Step 2 (Tier 1 screening-level ERA) indicate that, based on a set of conservative exposure assumptions, there are chemicals present in environmental media that may present a risk to receptor species/communities, the ERA process proceeds to the baseline ERA. According to Superfund guidance (USEPA 1997a), Step 3 represents the problem formulation phase of the baseline ERA. Under Navy policy, the baseline ERA is defined as Tier 2, and the first activity under Tier 2 is Step 3a. Step 3a precedes the baseline risk assessment problem formulation (Step 3b). In Step 3a, the conservative exposure assumptions applied in Tier 1 are refined and risk estimates are recalculated using the same conceptual site model. The evaluation of risks in Step 3a may also include consideration of background data, chemical bioavailability, and the frequency of detection. If the re-evaluation of the conservative exposure assumptions does not support an acceptable risk determination, the site continues in the baseline ERA process (Step 3b baseline risk assessment problem formulation). The focus of this section will be on Steps 1 and 2 (screening-level ERA) and Step 3a (refinement of the screening-level ERA exposure assumptions), although later steps of the ERA process are also briefly discussed (should the results of Step 3a warrant continuing the ERA process at a particular site).

Due to the potential complexity of ERAs, they are often conducted using a tiered approach and are punctuated with Scientific/Management Decision Points (SMDPs). SMDPs represent points in the ERA process where agreements on conclusions, actions, or methodologies are needed so that the ERA process can continue (or terminate) in a technically defensible manner. These decision points generally occur following the completion of a step in the ERA process. The results of the ERA process at the decision point are used to determine how the ERA process should proceed, for example, to the next step in the process or directly to a later step. The process continues until a final decision has been reached for a site (e.g., remedial action if risks are identified or no further action if risks are acceptable). The process can also be iterative if data needs are identified at any step; the needed data are collected and the process starts again at the point appropriate to the type of data collected.

5.1 Screening-Level Problem Formulation

The screening-level problem formulation is the first phase of the ERA process and establishes the goals, scope, and focus of the screening-level ERA. Major components of the screening-level problem formulation include:

- **Environmental Setting** – A general description of the site history and site features, with emphasis on the habitats and ecological receptors known or likely to be present on or near the site. This description is typically based on existing information and mapping.

- **Existing Analytical Data** – A summary of existing analytical chemistry data for ecologically relevant media at the site.

- **Contaminant Fate and Transport Mechanisms** – A characterization of known or potential contaminant sources and the likely transport mechanisms (if any) to ecological habitats based on the fate properties of the source-related chemicals. The mechanisms of toxicity for these chemicals are also considered.

- **Exposure Routes and Pathways** – An evaluation of potential exposure routes and a determination of the existence of any potentially complete exposure pathways.

- **Conceptual Model** – The screening-level problem formulation culminates in the

development of a preliminary conceptual model, which describes how chemicals associated with the site may come into contact with ecological receptors.

- **Endpoint Selection** – Assessment and measurement endpoints to be evaluated in the screening-level ERA are selected for potentially complete exposure pathways identified in the conceptual model.

These major components of the screening-level problem formulation are described in more detail in the following sections. This phase of the ERA process is intended to answer two main questions: (1) do complete exposure pathways exist at the site? and (2) are sufficient data available to conduct the screening level ERA?

5.1.1 Environmental Setting

As described above, the description of the environmental setting focuses on the SWMU history (how the SWMU was used in the past and how it is currently being used), physical site features, habitats and biota, and the existing analytical chemistry data for ecologically relevant media. The environmental setting will be described both for NSRR as a whole and for the specific SWMUs under consideration.

5.1.1.1 Site Description and Physical Features

Information on the site history provides an indication of the types of chemicals expected on the site and the media in which they are likely to be present. The physical features of the site, which include geological (e.g., soils), hydrogeological (e.g., surface water and groundwater flow patterns), and climatologic (e.g., precipitation) parameters, are important in determining how chemicals from source areas could be transported to ecological habitats. Sources of this information may include site-specific documents, facility personnel, available mapping, soil survey documents, weather records, and site visits.

5.1.1.2 Habitat Types and Ecological Receptors

Descriptions of the habitat types and ecological receptors known or likely to be present on the site are an important part of describing the environmental setting. This can encompass aquatic habitats (e.g., creeks and ponds) and receptors (e.g., fish), wetland habitats (e.g., marshes) and

receptors (e.g., amphibians), and/or terrestrial habitats (e.g., forests) and receptors (e.g., wildlife and vegetation). Sources of this information may include facility-specific documents (e.g., natural resource management plans), available mapping, the literature, and site visits.

5.1.2 Existing Analytical Data

The existing analytical data for ecologically relevant media will be compiled and evaluated. The evaluation will consider such factors as sample size, sample location, analytical parameters, and reporting limits to determine if the available data are adequate to conduct the screening-level ERA.

5.1.3 Contaminant Fate and Transport Mechanisms

In the absence of measured values of chemicals within biotic media, the transport and partitioning of constituents into particular environmental compartments, and their ultimate fate in those compartments, can be predicted from key physical-chemical characteristics. The physical-chemical characteristics that are most relevant for exposure modeling in this assessment include water solubility, adsorption to solids, octanol-water partitioning, and degradability. These characteristics are defined below.

The water solubility of a compound influences it's partitioning to aqueous media. Highly water-soluble constituents, such as most volatile organic compounds (VOCs), have a tendency to remain dissolved in the water column rather than partitioning to sediment (Howard 1991). Compounds with high water solubility also generally exhibit a lower tendency to bioconcentrate in aquatic organisms and a greater likelihood of biodegradation, at least over the short term (Howard 1991).

Adsorption is a measure of a compound's affinity for binding to solids, such as soil or sediment particles. Adsorption is expressed in terms of partitioning, either adsorption coefficient (K_d); (a unitless expression of the equilibrium concentration in the solid phase versus the water phase) or as organic carbon partition coefficient (K_{oc}) (K_d normalized to the organic carbon content of the solid phase; again unitless) (Howard 1991). For a given organic chemical, the higher the K_{oc} or K_d, the greater the tendency for that chemical to adhere strongly to soil or sediment particles. K_{oc} values can be measured directly or can be estimated from either water solubility or the octanol-

water partition coefficient using one of several available regression equations (Howard 1991).

Octanol-water partitioning indicates whether a compound is hydrophilic or hydrophobic. The Octanol-water partition coefficient (K_{ow}) expresses the relative partitioning of a compound between octanol (lipids) and water. A high affinity for lipids equates to a high K_{ow} and vice versa. As discussed above, K_{ow} has been shown to correlate well with Bioconcentration Factors (BCFs) in aquatic organisms, adsorption to soil or sediment particles, and the potential to bioaccumulate in the food chain (Howard 1991). Typically expressed as log K_{ow}, a value of three (3.0) or less generally indicates that the chemical will not bioconcentrate to a significant degree (Maki and Duthie 1978). A log K_{ow} of three equates to an aquatic species BCF of about 100, using the following equation from Lyman et al. (1990):

$$\log BCF = (0.76)(\log K_{ow}) - 0.23 \qquad \text{(Equation 5-1)}$$

Degradability is an important factor in determining whether there will be significant loss of mass or change in the form of a chemical over time in the environment. The half-life of a compound is typically used to describe losses from either degradation (biological or abiotic) or from transfer from one compartment to another (e.g., volatilization from soil to air). The half-life is the time required for one-half of the mass of a compound to undergo the loss or degradation process.

5.1.4 Exposure Routes and Pathways

An exposure pathway links a source of contamination with one or more receptors through exposure to one or more ecologically relevant media. Exposure, and thus potential risk, can only occur if complete exposure pathways exist.

An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical present in an environmental medium. The most common exposure routes are dermal contact, direct uptake, ingestion, and inhalation. Terrestrial vegetation may be exposed to chemicals present in surface soils through their root surfaces during water and nutrient uptake. Unrooted, floating aquatic plants, rooted submerged aquatic plants, and algae may be exposed to chemicals directly from the water of (for rooted plants) from sediments. Terrestrial and aquatic invertebrates may be exposed to chemicals in surface soil, sediment, or surface water through dermal adsorption and ingestion. Much of the toxicological data available for terrestrial and

aquatic invertebrates are based on *in situ* studies that represent both pathways. Therefore, both pathways are typically considered together. Invertebrates also present a link between soil/sediment chemicals and invertebrate consumers through food web transfer. As such, they are typically included as prey items for upper trophic level dietary exposures.

Birds and mammals may be exposed to chemicals through: (1) the inhalation of gaseous chemicals or chemicals adhered to particulate matter; (2) the incidental ingestion of contaminated abiotic media (e.g., soil or sediment) during feeding or cleaning activities; (3) the ingestion of contaminated water; (4) the ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs; and/or (5) dermal contact with contaminated abiotic media. Their relative importance depends in part on the chemical being evaluated. For chemicals having the potential to bioaccumulate (e.g., polychlorinated biphenyls [PCBs]), the greatest exposure to wildlife is likely to be from the ingestion of prey. For chemicals having a limited potential to bioaccumulate (i.e., aluminum), the exposure of wildlife to chemicals is likely to be greatest through the direct ingestion of abiotic media, such as soil or sediment.

5.1.5 Conceptual Model

The conceptual model is designed to diagrammatically relate potentially exposed receptor populations with potential contaminant source areas based on the physical nature of the SWMU and potential exposure pathways. Important components of the preliminary conceptual model are the identification of potential sources of contaminants, transport pathways, exposure media, potential exposure routes, and potential receptor groups. Actual or potential exposures of ecological receptors associated with a SWMU will be determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has four components: (1) a source of chemicals that can be released to the environment; (2) a release and transport mechanism to move the chemicals from the source to an exposure point; (3) an exposure point where ecological receptors could contact the affected media; and (4) an exposure route whereby chemicals can be taken up by ecological receptors.

The main objective of the conceptual model in Step 1 of the ERA process is to identify any complete exposure pathways present at a site. The site-specific ERAs will provide conceptual models that relate directly to the SWMUs under consideration.

5.1.6 Endpoints and Risk Hypotheses

The screening-level problem formulation includes the selection of ecological endpoints. Endpoints in the screening level ERA define ecological attributes that are to be protected (assessment endpoints) and a measurable characteristic of those attributes (measurement endpoints) that can be used to gauge the degree of impact that has or may occur (USEPA 1992; 1997, and 1998). Assessment endpoints most often relate to attributes of biological populations or communities, and are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by chemicals attributable to the site (USEPA 1997b). Assessment endpoints contain an entity (e.g., red-tailed hawk) and an attribute of that entity (e.g., survival rate). Individual assessment endpoints usually encompass a group of species or populations (the receptor) with some common characteristic, such as specific exposure route or contaminant sensitivity, with the receptor then used to represent the assessment endpoint in the risk evaluation.

The considerations for selecting assessment and measurement endpoints are summarized in USEPA (1992 and 1997) and discussed in detail in Suter (1989, 1990, and 1993). Assessment and measurement endpoints may involve ecological components from any level of biological organization, from individual organisms to the ecosystem (USEPA 1992). Effects on individuals are important for some receptors, such as rare and endangered species, but population- and community-level effects are typically more relevant to ecosystems. Population- and community-level effects are usually difficult to evaluate directly without long-term and extensive study. However, measurement endpoint evaluations at the individual level, such as an evaluation of the effects of chemical exposure on reproduction, can be used to predict effects on an assessment endpoint at the population- or community-level. In addition, use of criteria values designed to protect the vast majority (e.g., 95 percent) of the components of a community (e.g., Ambient Water Quality Criteria for the Protection of Aquatic Life) can be useful in evaluating potential community- and/or population-level effects.

The most appropriate generic assessment endpoint for ERAs will be the maintenance of receptor populations. Therefore, the specific objective of the ERA will be to determine if exposure to site-related chemicals present in surface water, groundwater (if appropriate), sediment, and/or surface soil are likely to result in declines in ecological receptor populations. Declines in populations could result in a shift in community structure and possible elimination of resident species.

Measurement endpoints are used in ERAs because it is often difficult or impossible to directly assess whether the environmental value that is to be protected (the assessment endpoint) is being impacted. For example, an assessment endpoint may involve a decline in a particular population or a shift in the structure of a community. While these things might be quantifiable, the necessary studies would generally be time-consuming and difficult to interpret. However, measurement endpoints indicative of observed adverse effects on individuals are relatively easy to measure in toxicity studies and can be related to the assessment endpoint. For example, contaminant concentrations that lead to decreased reproductive success or increased mortality of individuals in toxicity tests could, if found in the environment, result in shifts in population structure, potentially altering the community composition associated with a site.

Risk hypotheses are testable hypotheses about the relationship among the assessment endpoints and their predicted responses when exposed to chemicals. Although USEPA (1997a) prescribes that risk hypotheses be developed in Step 3 (baseline risk assessment problem formulation), it is generally useful to develop preliminary risk hypotheses as part of the screening-level problem formulation.

5.1.6.1 Selection of Receptors

Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, receptor species (e.g., red-tailed hawk) or species groups (e.g., terrestrial invertebrates) are often selected as surrogates to evaluate potential risks to larger components of the ecological community (guilds; e.g., insectivorous birds) represented in the assessment endpoints (e.g., survival and reproduction of insectivorous birds). Selection criteria typically include those species that:

- Are known to occur, or are likely to occur, at the site.
- Have a particular ecological, economic, or aesthetic value.
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present at the site for which complete exposure pathways are likely to exist.

- Can, because of toxicological sensitivity or potential exposure magnitude, be expected to represent potentially sensitive populations at the site.

- Have sufficient ecotoxicological information available on which to base an evaluation.

Upper trophic level receptor species will be chosen for dietary exposure modeling based on the criteria listed above, the general guidelines presented in USEPA (1991), the environmental setting, (e.g., habitats), and the assessment endpoints selected at each SWMU.

Lower trophic level receptor species (e.g., terrestrial and aquatic invertebrates and plants) are generally evaluated in screening-level ERAs based on those taxonomic groupings for which screening values have been developed. These groupings and screening values are used in most ecological risk assessments. As such, specific species of lower trophic level biota will not be chosen as receptor species because of the limited information available for specific species and because these biota are dealt with on a community level via a comparison to media-specific screening values.

5.1.7 Screening-Level Problem Formulation Decision Point

As discussed in Section 5.1, the screening-level problem formulation is intended to answer two main questions: (1) do complete exposure pathways exist at the SWMU? and (2) are sufficient data available to conduct the screening level ERA? Complete exposure pathways from a source area are likely to exist if all of the following are present:

- Habitat that supports ecological receptor populations (note that ecological habitat may be absent due to chemical contamination or habitat alteration).

- Contaminant transport pathways to ecologically relevant media. Although a site may contain no or marginal ecological habitat, it will be assessed if site-related chemicals have the potential to migrate to areas containing more extensive or more viable habitat. A site of this nature may contribute to overall contamination in the watershed in which it exists.

- Complete exposure routes.

If no complete exposure pathways exist at a site, the ERA process will terminate at the screening-level problem formulation with a conclusion of negligible risk. If one or more complete exposure pathways are known or likely to exist, the ERA process will continue to the screening-level ecological effects evaluation, screening-level exposure estimation, and screening-level risk calculation but will only evaluates those pathways that have been determined to be complete.

5.2 Screening-Level Ecological Effects Evaluation

The purpose of the screening-level ecological effects evaluation is the establishment of chemical exposure levels (screening values) that represent conservative thresholds for adverse ecological effects. One set of screening values is typically developed for each of the selected assessment endpoints. The completed screening-level ERA will contain tables listing the screening values selected, by medium, for SWMUs 53 and 54.

Two types of screening values (media-specific screening values and ingestion-based screening values) will be developed. Media-specific screening values will be developed for ecologically relevant media at each SWMU (e.g., surface soil). Ingestion-based screening values for dietary exposures will be derived for each receptor species and chemical evaluated for food web exposures. Toxicological information from the literature for wildlife species most closely related to the receptor species will be used if available. This information will be supplemented by laboratory studies of non-wildlife species (e.g., laboratory mice) when necessary.

Chronic No Observed Adverse Effect Levels (NOAELs) based on growth or reproduction will be preferentially used as ingestion-based screening values for upper trophic level receptors. NOAELs represent the highest dose of a chemical at which an effect being measured in a toxicity test does not occur. If several chronic toxicity studies are available from the literature for a given chemical, the most appropriate study will be selected for each receptor species based on study design, study methodology, study duration, study endpoint and test species. When chronic NOAEL values are unavailable, estimates will be derived or extrapolated from chronic Lowest Observed Adverse Effect Levels (LOAELs) or acute values (LD_{50}). LOAELs represent the lowest dose of a chemical at which an effect being measured in a toxicity test occurs, while an LD_{50} represents the dose of a chemical at which half of the organisms being tested die. An uncertainty factor of 10 will be used to convert a reported LOAEL to a NOAEL, while an

uncertainty factor of 100 will be used to convert the acute LD_{50} to a chronic NOAEL (i.e., the LD_{50} will be multiplied by 0.01 to obtain the chronic NOAEL).

Not all chemicals analyzed in ecologically relevant media will be evaluated for food web exposures. The organic chemicals evaluated for food web exposures will be limited to those chemicals with the potential to bioaccumulate to a significant extent. Bioaccumulative organic chemicals are defined in this work plan as those with a maximum reported log octanol-water partition coefficient (log K_{ow}) greater than or equal to 3.0. Rational for using a log K_{ow} of 3.0 to identify an organic chemical with the potential to bioaccumulate will be included in the completed screening-level ERAs. For conservatism, all inorganic chemicals will be evaluated for food web exposures. The exception is cyanide, which will be excluded from the evaluation of food web exposures because it is readily metabolized and does not bioaccumulate (Eisler 1991).

5.3 Screening-Level Exposure Estimation

This portion of the screening-level ERA involves the identification of the data to be used to represent concentrations of chemicals to which ecological receptors may be exposed to in various media and the derivation of exposure point concentrations (EPCs) from those data (typically the maximum detected concentration). Exposure assumptions, exposure models, and model input parameters are also presented and discussed.

5.3.1 Selection Criteria for Analytical Data

Available analytical data for ecologically relevant media will be selected for use in the screening level ERA based on a set of selection criteria that will include:

- Data must be validated by a qualified data validator using acceptable data validation methods. Rejected (R) values will not be used in the ERA. Unqualified data and data qualified as J will be treated as detected. Data qualified as U or UJ will be treated as non-detected.

- Maximum reporting limits will be conservatively used to estimate exposure for non-detected chemicals.

- In some instances, duplicate samples have been collected in the field. The maximum concentration of each chemical in the original or duplicate sample will be used as a conservative estimate of chemical concentrations at a particular sampling point.

- For surface soil, analytical data for samples collected from the surface to a maximum depth of one foot below ground surface (bgs) will be used since this depth range is the most active biological zone (Suter II 1995).

- For groundwater, total (unfiltered) metal concentrations will be used for comparison to surface water screening values.

Background chemical concentrations may be gathered from facility-wide, site-specific, or region-wide data and presented in the screening level ERA for comparative purposes. These data will not be quantitatively considered until Step 3a (if the ERA progresses to this step).

5.3.2 Exposure Point Concentrations – Abiotic Media

Maximum detected concentrations in abiotic media (e.g., surface soil) will be used to conservatively estimate potential chemical exposures for the ecological receptors selected to represent the assessment endpoints. For conservatism, the maximum detection limit for chemicals that were analyzed for but not detected will also be compared to medium-specific screening values and (where applicable) used for food web exposure modeling. This will be done to ensure that detection limits were similar to, or less than, chemical concentrations at which potential adverse effects to ecological receptors may occur. For samples with duplicate analyses, the higher of the two concentrations will be used in the screening (when both values were detects or both values were non-detects). In cases where one result is a detection and the other a non-detect, the detected value will be used in the assessment.

5.3.3 Exposure Point Concentrations – Prey items

Exposures for upper trophic level receptor species via the food web will be determined by estimating the chemical-specific concentrations in each dietary component using uptake and food web models. Ingestion of abiotic media, if appropriate, will also be included when calculating the total level of exposure. As indicated previously, maximum measured concentrations in abiotic media will be used in all calculations to provide a conservative assessment.

Estimates for food web exposures will be based on bioaccumulation factors developed from the literature. The uptake of chemicals from the abiotic media into these food items will be based on conservative (e.g., maximum or 90th percentile) BCFs or bioaccumulation factors (BAFs). Default factors of 1.0 (dry weight to dry weight) will be used only where data are unavailable for a chemical in the literature. The completed screening-level ERAs for each SWMU will contain tables listing the BAFs/BCFs selected for each prey item. The methodology and models used to derive these estimates will also be included within the completed screening-level ERAs.

5.3.3.1 Dietary Intakes

Dietary intakes for each upper trophic level receptor species selected to represent the assessment endpoints will be calculated using the following formula (modified from USEPA [1993]):

$$DI_x = \frac{[[\sum_i [(FIR)(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)] + [(WIR)(WC_x)]][AUF]}{BW}$$

where:

DI_x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR	=	Food ingestion rate (kg/day, dry weight)
FC_{xi}	=	Concentration of chemical x in food item i (mg/kg, dry weight)
PDF_i	=	Proportion of diet composed of food item i (dry weight basis)
SC_x	=	Concentration of chemical x in soil/sediment (mg/kg, dry weight)
PDS	=	Proportion of diet composed of soil/sediment (dry weight basis)
WIR	=	Water ingestion rate (L/day)
WC_x	=	Concentration of chemical x in water (mg/L)
BW	=	Body weight (kg, wet weight)
AUF	=	Area Use Factor (unitless)

As discussed in USEPA (1997a), exposure parameter values used in this food web model will be selected to provide for a conservative evaluation in the screening-level ERA. Examples of these conservative assumptions include:

- All of the dietary items consumed by the receptor are obtained from the site (i.e., an Area Use Factor [AUF} of 1 will be assumed) at the point of maximum concentrations.

- Chemicals are assumed to be 100 percent bioavailable.

- Maximum ingestion rates will be used (calculated maximum ingestion rates are based on the maximum body weight).

- Minimum body weights will be used.

5.4 Screening-Level Risk Calculation

The screening-level risk calculation is the final step in a screening-level ERA. In this step, the maximum exposure concentrations (abiotic media) or exposure doses (upper trophic level receptor species) are compared with the corresponding screening values to derive screening risk estimates. The outcome of this step is a list of preliminary Ecological Chemicals of Potential Concern (COPCs) for each medium-pathway-receptor combination evaluated or a conclusion of negligible risk.

5.4.1 Selection of Preliminary Ecological Chemicals of Potential Concern

Preliminary ecological COPCs will be selected using the hazard quotient (HQ) method. HQs are calculated by dividing the maximum chemical concentration in the medium being evaluated by the corresponding medium-specific screening value or, in the case of upper trophic level receptors, by dividing the exposure dose by the corresponding ingestion-based screening value. Chemicals with HQs greater than or equal to 1.0 will be considered preliminary ecological COPCs in the screening level ERA.

The following conservative methodology will be used to identify preliminary ecological COPCs for abiotic media:

- The maximum detected concentration in each ecologically relevant media will be used to calculate media-specific HQs. For a given medium, chemicals with HQs greater than or equal to 1.0 based on maximum detected concentrations will be identified as preliminary ecological COPCs for that medium.

- For chemicals not detected in any samples of a particular medium, the maximum reporting limit will be used to calculate media-specific HQs. For a given medium, non-detected chemicals with HQs greater than or equal to 1.0 based on maximum reporting limits will b e identified as preliminary ecological COPCs for that medium.

- Chemicals (detected and non-detected) without screening values for a given medium will be identified as preliminary ecological COPCs for that medium.

To select preliminary ecological COPCs by evaluating food web exposures, maximum chemical concentrations in ecologically relevant abiotic media will be used to estimate dietary doses for each receptor. All inorganics (excluding cyanide) and all organic chemicals with a log K_{ow} greater than or equal to 3.0 will be evaluated for food web exposures. HQs will be calculated with NOAELs, LOAELs, and Maximum Acceptable Toxicant Concentrations (MATCs) (the geometric mean of the NOAEL and LOAEL). Calculations with NOAELs provide the most conservative risk estimate, while calculations with LOAELs provide the least conservative risk estimate. Calculations with MATCs provide realistic risk estimates since the MATC represents an estimation of the threshold concentration (i.e., the concentration above which a toxic effect on the test endpoint is produced). For the screening-level ERA, chemicals (detected and non-detected) with NOAEL-based HQs greater than or equal to 1.0 will be identified as preliminary ecological COPCs. Identical to the media-specific screening, chemicals without ingestion-based screening values will also be retained as ecological COPCs for upper trophic level receptors.

HQs exceeding one indicate the potential for risk since the chemical concentration or dose (exposure) exceeds the screening value (effect). However, screening values and exposure estimates are derived using intentionally conservative assumptions such that HQs greater than or equal to one do not necessarily indicate that risks are present or impacts are occurring. Rather, it identifies chemical-pathway-receptor combinations requiring further evaluation. Following the same reasoning, HQs that are less than one indicate that risks are very unlikely, enabling a conclusion of no unacceptable risk to be reached with high confidence.

5.5 Uncertainties

Once the screening-level ERA is complete, the results will be evaluated to identify the type and magnitude of uncertainty associated with the risk conclusions. Reliance on results from a risk

assessment can be misleading without a consideration of uncertainties, limitations, and assumptions inherent in the process. Uncertainties are present in all risk assessments because of the limitations of the available data and the need to make certain assumptions and extrapolations based on incomplete information.

5.6 Screening-Level ERA Decision Point

The results of the ERA will be used to evaluate the status of each SWMU in terms of potential ecological risk. Possible decision points following completion of the screening-level ERA are:

- **No further action is warranted**. This decision is appropriate if the screening-level ERA indicates that sufficient data are available on which to base a conclusion of no unacceptable risk (HQ values for each media-pathway-receptor combination is less than one).

- **Further evaluation is warranted**. This decision is appropriate if the screening-level ERA indicates that there is the potential for unacceptable risk for one or more media-pathway-receptor combinations. In this instance, the ERA process will proceed to Step 3a wherein the risk estimates are refined based on more realistic and site-specific assumptions and data.

- **Further data are required**. This decision is appropriate if the screening-level ERA indicates that there are insufficient data on which to base a risk estimate. This decision may also be appropriate if the potential for unacceptable risks is identified following the screening-level ERA and additional data are needed to refine these estimates in Step 3a.

- **Take remedial action**. This decision may be appropriate for sites in which the potential for unacceptable risks was identified following the screening-level ERA but these potential risks could be best addressed through remedial action (e.g., presumptive remedy, soil removal) rather than additional study.

5.7 Baseline Ecological Risk Assessment

If the results of the screening ERA suggest that further ecological risk evaluation or data collection is warranted for a particular site, the ERA process will proceed to the baseline ERA which is a more detailed phase of the ERA process (Steps 3 through 7).

This section documents the technical approach to the baseline ERA (Steps 3 through 7 of the ERA process). The first step of the baseline ERA (Step 3) is the baseline problem formulation. The baseline problem formulation refines the risk estimates from the screening ERA using more realistic exposure assumptions (Step 3a), and if unacceptable risks are still possible, refines the conceptual model and endpoints (Step 3b) in order to determine the direction of subsequent steps of the ERA process.

5.7.1 General Methodology for the Baseline ERA

The basic purpose of the baseline ERA is to refine the risk estimates from the screening ERA. Potential risk estimates will be refined using a focused conceptual model based on more realistic and site-specific exposure assumptions, additional site-specific data, and/or detailed literature review. The focused conceptual model would include refined assessment endpoints, measurement endpoints, and risk questions or hypotheses. Following the completion of Step 3, a decision point will be reached with two potential outcomes. If the refined risk estimates are acceptable for each assessment endpoint, the investigation can proceed to risk characterization (Step 7) to document this conclusion. If the uncertainties associated with the refined risk estimates are unacceptable and/or the risk estimates indicate potential risks, site-specific studies might be required and the ERA process will continue (Steps 4 through 6).

Step 7 consists of the documentation and synthesis of the information and data identified in Steps 1 through 3 (no additional study) or 1 through 6 (additional study). In this step, risk is evaluated and characterized using both quantitative and qualitative methods. Conclusions are made on whether or not there is a reasonable potential for unacceptable ecological risk at the site, and if there is a potential for ecological risk, the magnitude of that risk. The results of the completed baseline risk assessment (Step 7) are used to make any necessary risk management decisions (Step 8).

5.7.1.1 Step 3a

The first activity (Step 3a) of the baseline ERA is to refine the conservative exposure assumptions employed in the screening ERA and recalculate the risk estimates. This reevaluation may include considerations of background, sample detection frequency, bioavailability, and realistic exposure scenarios (CNO, 1999). Realistic exposure scenarios might include the use of average rather than maximum: (1) exposure point concentrations, (2) species ingestion rates, and (3) exposure frequency or duration. A review of the literature will be used to refine the conservative exposure assumptions (such as species body weight) used in the screening ERA. In the screening ERA, minimum species body weights are used and these are often not region-specific. Average species body weights for the state, region, and/or subspecies will be used, if available.

Step 3a will also include a re-screening against medium-specific screening values. As appropriate to a baseline analysis, alternate screening values may be developed, where appropriate, to account for bioavailability issues (such as the use of dissolved metals, rather than total metals, in surface water). These alternative screening values will be obtained from the scientific literature, available federal and state regulatory guidance, and other appropriate sources. These screening values will be adjusted, where appropriate, based on modifying factors such as hardness or total organic carbon. The rationale for these alternate screening values will be provided.

Following the completion of Steps 3a and (if warranted) 3b, a decision point will be reached with two potential outcomes. If Steps 3a and 3b indicate that there are no unacceptable risks, the ERA process would skip directly to Step 7 to document this conclusion. If unacceptable risks are still possible following Step 3, or if the level of uncertainty in the risk estimates is unacceptable, additional studies (Steps 4 through 6) could be undertaken to further refine the risk estimates. Completion of Step 7 ends the baseline (Tier 2) assessment.

5.7.2 Results of the Baseline ERA Process

Possible decision points based on the results of the baseline ERA are evaluated in Step 8 of the process and involve risk management decisions. Possible decisions include:

- **No further action is warranted.** This decision is appropriate if the baseline ERA indicates that there is no reasonable potential for unacceptable ecological risk within acceptable uncertainty.

- **Evaluate the need for remedial action.** This decision is appropriate if the baseline ERA indicates that there is a reasonable likelihood for unacceptable ecological risks within acceptable uncertainty. Whether or not remedial actions are taken will depend upon a number of risk management factors such as the results of any human health risk assessments and the potential impact of the remedial action itself on the habitats and biota present on the site. This analysis would occur as part of Step 8 (Tier 3).

5.8 Ecological Corrective Action Objectives

Corrective Action Objectives (CAOs) will be established for chemicals retained as ecological COPCs in Step 3a of the Navy ERA process. CAOs for abiotic media (e.g., surface soil) will be developed by multiplying media-specific screening values by 0.99:

$$CAO_x = (SV_x)(0.99)$$

where CAO_x is the Corrective Action Objective for chemical x and SV_x is the media-specific screening value for chemical x.. CAOs for food web exposures will be developed by modifying the dietary intake equation presented in Section 5.3.3.1. Using surface soil as an example, the CAOs for food web exposures will be calculated as follows:

$$CAO_x = \frac{(0.99)(SV_{xj})(BW_j)}{[[\sum_i (FIR_j)(BAF_{ix} or BCF_{ix})(PDF_{ij})] + [(FIR_j)(PDS_j)]][AUF]}$$

CAO_x	=	Corrective Action Objective for chemical x (mg/kg, dry weight)
SV_{ij}	=	Ingestion-based screening value for chemical i applied to receptor j (mg chemical/kg body weight/day)
BWj	=	Body weight for receptor j (kg, wet weight)
FIR	=	Food ingestion rate for receptor j (kg/day, dry-weight)

BAF_{ix}	=	Surface soil-Biota BAF for chemical x and food item i dry weight basis)
BCF_{ix}	=	Surface soil-Biota BCF for chemical x and food item i (dry weight basis)
PDF_{ij}	=	Proportion of diet composed of food item i for receptor j (dry weight basis)
PDS_j	=	Proportion of diet composed of surface soil for receptor j (dry weight basis)
AUF_j	=	Area Use Factor for receptor j (unitless)

If a chemical is retained as an ecological COPC for abiotic media and food web exposures (e.g., retained as a surface soil COPC and an upper trophic level terrestrial receptor COPC in Step 3a of the ERA process), the minimum CAO will be selected as the final CAO.

6.0 ESTABLISHMENT OF CORRECTIVE ACTION OBJECTIVES

6.1 Introduction

The results from the Sampling and Analysis Report for SWMUs 53 and 54 (Baker, 2001) as well as from the Draft RCRA Facility Investigation Report for SWMUs 53 and 54 (Baker, 2002) indicated that several constituents exceeded listed criteria and therefore are considered chemicals of potential concern. The chemicals of potential concern (COPCs) for SWMUs 53 include chlordane, heptachlor epoxide, 4,4-DDT, arsenic, and lead for surface and subsurface soil. The COPCs for SWMU 54 include TCE, benzene, ethylbenzene, chloroform, and benzo(a)pyrene for groundwater, and 1,2-dibromo-3-chloropropane for subsurface soil. This section of the document will discuss the steps required to establish the site-specific objectives and clean up goals used to identify corrective measures.

The first step in evaluating corrective measures will be to develop CAOs, which consist of medium- and chemical-specific goals for protecting human health and the environment. The CAOs will be used to focus the development of corrective measure alternatives on technologies that may achieve appropriate target levels, thereby limiting the number of alternatives analyzed.

CAOs can be specific and numerical (i.e., quantitative) or general and descriptive (i.e., qualitative). They are achieved by reducing exposure (e.g., installing a soil cover or limiting access) or by reducing contaminant levels (e.g., active remediation; USEPA, 1988). CAOs will be used to evaluate which samples/areas within a site may require corrective measures, and which corrective measures alternative best protects human health and the environment.

6.2 Land Use and Potentially Exposed Receptors

To focus on developing practicable and cost-effective corrective measures alternatives for both SWMUs, and to streamline the environmental cleanup process for SWMU 53, EPA guidance ("Land Use in the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Remedy Selection Process," (USEPA, 1995a)) and U.S. Department of Defense (Longuemare, 1997) direct that CAOs should reflect the reasonably anticipated land use.

SWMU 53 (Malaria Control Building) and SWMU 54 (Former NEX Repair/Maintenance Shop) are industrial areas of NSRR. Future property use of these sites is expected to remain industrial for the duration of Naval operations of NSRR. As a result, potential human exposure is limited to industrial or commercial property use, now and in the foreseeable future.

Therefore, based on EPA and Department of Defense guidance that CAOs should reflect actual anticipated land use, the assumed land use will be continued military use, with industrial workers (i.e., civilians and or military personnel stationed at NSRR) the most likely receptors. Construction workers may be exposed to soil from the surface to a depth of ten feet below ground surface. It is unlikely that either of these two sites would ever be developed into a residential area given the topography of the area. If land use changes in the future, the SWMUs will be reevaluated.

6.3 Selection of Contaminants of Potential Concern

The CAO development process in the CMS for SWMUs 53 and 54 will identify the potential for human health risk to onsite workers and future residents exposed to soil at SWMU 53, and soil and groundwater at SWMU 54, which are affected by site-related activities. The previously mentioned potential COPCs from the SAP (Baker, 2001) and the RFI (Baker, 2002) will be incorporated into the CMS.

COPCs are those contaminants retained for further evaluation at this stage of the CMS process. They are contaminants that are detected in at least one sample in a given media at concentrations that are greater than screening criteria. The screening criteria are USEPA Region III RBCs, the Federal MCLs, and the USEPA Region III Tap Water RBCs. RBCs are derived by USEPA Region III using default exposure parameter values and the most recent toxicological criteria available. The RBCs used for this report are those issued in April 2002 (USEPA, 2002a) and are based on conservative residential exposure for soil and residential tap water exposure for groundwater. (The target risk used to calculate the RBCs is $1x10^{-6}$, while the target hazard quotient (HQ) is 0.1 to account for cumulative effects.) .

Tables will be provided which summarize the data for the media identified at SWMU 53 (surface soil, zero to one foot depth; subsurface soil, zero to ten foot depth) as well as at SWMU 54 (subsurface soil, zero to eleven foot depth; and groundwater), and the COPC selection process.

6.4 Exposure Assessment and Methodology for Development of CAOs

6.4.1 Qualitative CAOs

6.4.1.1 Groundwater

There is no direct current exposure to contaminated groundwater at SWMU 54 nor is future exposure likely based on the future land use scenarios discussed in Section 6.1.2. (Indirect exposure via inhalation of volatiles emitted from the contaminated groundwater through the overlying soils is possible, as discussed in detail below.) Groundwater is not currently used for potable purposes because drinking water is supplied via pipeline from El Yunque (rain forest), which supplies all of NSRR's present and projected needs.

Under nonresidential land use – particularly the continued military future land use scenario, in which the U.S. Navy determines the specific use of the property – it is reasonable to assume that no groundwater well will be installed within the limited volume of contaminated groundwater and be used for domestic purposes. Section 6.4.2 describes the methodology and exposure pathways for developing quantitative CAOs. The qualitative CAOs for contaminated groundwater are:

- To prevent further degradation of Puerto Rico's waters (Anti-degradation Policy, Regulation No. 4282, Puerto Rico Water Quality Standards Regulation, effective August 19, 1990.)

- To further restrict and prevent possible exposure to contaminated groundwater (e.g., by institutional controls).

- To protect public health and the environment in accordance with regulatory requirements (i.e., the general objective of all corrective measures).

6.4.1.2 Soil

Under the continued military land use scenario, contact with contaminants will occur from both surface and subsurface soil at SWMUs 53 and 54. Section 6.4.2 describes the methodology and

exposure pathways for developing quantitative CAOs based on these potential exposures. The qualitative CAOs for soil are:

- To prevent further degradation of Puerto Rico's waters (Anti-degradation Policy, Regulation No. 4282, Puerto Rico Water Quality Standards Regulation, effective August 19, 1990.)

- To protect human health and the environment in accordance with regulatory requirements (i.e., the general objective of all corrective measures).

6.4.2 Quantitative CAOs

Quantitative CAOs are acceptable residual contaminant concentrations. The following components will be used to determine CAOs for soil and groundwater:

- Intake by assumed exposure pathways.

- Chemical-specific toxicity data in the form of health effects criteria (see Section 6.5).

- Assumed target cancer risk level and noncancer hazard quotient.

The target risk level and HQ are general health effects levels deemed acceptable for exposure to individual carcinogenic and noncarcinogenic contaminants, respectively. The general equation for chemical intake that will be used in the human health RA is:

$$Intake(mg/kg\text{-}day) = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT} \qquad \text{(Eq 6-1)}$$

where:

C	=	chemical concentration
IR	=	intake rate
EF	=	exposure frequency
ED	=	exposure duration

CF	=	conversion factor (to attain proper units)
BW	=	body weight
AT	=	averaging time for cancer or noncancer effects.

This equation is algebraically combined with the general expressions for cancer risk and noncancer health effects, respectively:

$$Risk = Intake\ H\ SF \qquad \text{(Eq 6-2)}$$

$$HQ = Intake/RfD \qquad \text{(Eq 6-3)}$$

where:

Risk	=	target risk level ($1H10^{-6}$, or one in 1 million excess cancer cases due to exposure to a chemical, given the assumed exposure pathway).
SF	=	slope factor, or health effects criterion for cancer effects.
HQ	=	target HQ (1.0, implying that intake should not exceed the RfD).
RfD	=	reference dose, or health effects criterion for noncancer effects.

Assumed values for risk and HQ and chemical-specific SFs or RfDs are used to solve for the concentration term, or the pathway-specific CAO.

For the continued military land use scenario at these sites, the industrial worker and construction worker will be used to characterize potential future exposure to contaminated soil and groundwater. Industrial worker exposure is limited to surface soil (defined as zero to two feet) at SWMUs 53 and 54, while construction workers may also be exposed to subsurface soil (zero to ten feet) at SWMUs 53 and 54.

The exposure pathways evaluated for developing quantitative CAOs for soil in the CMS are likely to be inadvertent ingestion, inhalation of contaminants in particulates; inhalation of volatiles emitted from soil, and dermal absorption of contaminants following direct contact.

Industrial workers will only likely to be exposed to contaminants in groundwater via inhalation of volatiles emitted through the soil into buildings. The methodology outlined in EPA's November 29,

2002 Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) (USEPA, 2002c) will be used to determine whether the subsurface vapor intrusion pathway is complete and, if so, whether vapors are present at levels that may pose unacceptable exposure risk. This guidance includes a three-tiered approach for screening the exposure pathway. The three tiers involve increasing levels of complexity and specificity, and generic screening levels allow for a simple quantitative screen of contaminant concentrations.

The Johnson and Ettinger (1991) model, included as part of the guidance, may beused to quantify this exposure if the screening procedure outlined in the Subsurface Vapor Intrusion Guidance (USEPA, 2002c) suggests it is necessary. EPA placed this model into a spreadsheet format and produced a User's Guide for use at contaminated sites (USEPA, 2000). The new version of the Johnson and Ettinger model states that exposure by indoor inhalation of contaminants is much greater than outdoor exposure due to greater dilution in outside air and enhanced volatilization indoors due to chimney and pressure effects. For these reasons, and because the model assumes full time exposure indoors (i.e., leaving no time for additional outdoor exposure), outdoor inhalation exposure to groundwater is not quantitatively evaluated.

6.5 Toxicity Evaluation

For the development of quantitative CAOs based on exposure to chemicals, the following health effects criteria will be of principal importance:

- RfDs for oral exposure – estimates of acceptable daily intake for chronic and subchronic exposure that will not produce deleterious noncancer effects. EPA defines subchronic exposure as periods of less than 7 years (USEPA, 1989a). Therefore, subchronic RfDs apply to construction workers, while chronic RfDs apply to industrial workers.

- Reference concentrations (RfCs) for inhalation exposure – estimates of acceptable concentrations for chronic and subchronic exposure that will not produce deleterious noncancer effects. These values are converted to inhalation RfDs by multiplying the RfC by the reference IR value of 20 m^3/day and dividing by the reference BW of 70 kilograms. RfCs are used in the Johnson and Ettinger (1991) model, while other

inhalation pathways use the inhalation RfD. Subchronic inhalation RfDs and RfCs apply to the construction worker only, as discussed for RfDs for oral exposure.

- SFs for oral exposure – plausible upper-bound estimates of the probability of an individual developing cancer as a result of lifetime exposure to a potential carcinogen (USEPA, 1989a).

- SFs for the inhalation route – plausible upper-bound estimates of the probability of an individual developing cancer as a result of lifetime exposure to a potential carcinogen (USEPA, 1989a). Inhalation SFs are calculated from inhalation unit risk values in a similar manner as described above for inhalation RfDs. Unit risk values are used in the Johnson and Ettinger (1991) model, while all other inhalation pathways use the inhalation SF.

The primary source of chemical-specific health effects criteria which will be used during the CMS will be EPA's Integrated Risk Information System (IRIS) database (USEPA, 2002b). IRIS is a computer-housed catalog of EPA health effects criteria and information. Data in IRIS are reviewed and updated monthly. If health effects criteria are not available in IRIS, EPA recommends use of the Office of Research and Development's Health Effects Assessment Summary Tables (HEAST; USEPA, 1997b) as a secondary data source. The Superfund Technical Support Center (STSC) is used for additional health effects criteria not provided in IRIS or HEAST. STSC develops provisional RfDs and SFs on a site-specific basis for those contaminants with adequate toxicological data, but for which no approved values exist in IRIS or HEAST.

Health effects criteria are available only for the oral and inhalation routes, and most of these criteria are based on the administered rather than the absorbed dose (i.e., the amount of chemical at a human exchange boundary, such as skin, that is available for absorption – but not the amount actually absorbed into the blood).

Adjustment will be made using oral absorption efficiency data (i.e., data on gastrointestinal absorption) from the species on which the oral health effects criteria are based. The administered dose oral health effects criterion will be multiplied (for RfDs) or divided (for SFs) by the gastrointestinal absorption factor to derive the absorbed dose criterion. New EPA guidance on

the dermal exposure pathway (USEPA, 2001) recommends adjusting health effects criteria only if gastrointestinal absorption is less than 50 percent.

6.6 Background Concentrations as CAOs

Background concentrations of inorganics may be used as quantitative CAOs when they exceed risk-based CAOs. The National Contingency Plan (NCP) preamble (55 *Federal Register*, 8717) states that preliminary remediation goals (PRGs; i.e., the CERCLA equivalent to quantitative CAOs) may be revised based on consideration of "technical factors," which may include background levels of contaminants. Therefore, if a calculated CAO is less than background inorganic constituents, the background concentration is used as the CAO.

7.0 IDENTIFICATION OF COCs

Contaminants of concern (COCs) are those contaminants detected at a site at concentrations that exceed human health based CAOs or that pose an unacceptable ecological risk. Once COCs are identified they are evaluated as potential candidates for clean-up throughout the remainder of the CMS process. This evaluation includes examination of the spatial and concentration distributions of COCs within the media in which they occur.

8.0 POTENTIAL CORRECTIVE MEASURES (SWMUs 53 and 54)

This section of the CMS work plan describes the stepwise approach to be taken in performing the CMS for SWMUs 53 (Malaria Control Building) and 54 (Former NEX Repair/Maintenance Shop). The CMS consists of four tasks, which are described in the sections that follow.

8.1 Task I - Identification and Development of the Corrective Measure Alternative or Alternatives

This task will identify, screen, and develop the alternative or alternatives for removal, containment, treatment and/or other disposition of the contamination based on the objectives established for the corrective measure. The analysis will be based on the results of the all previous investigations at SWMUs 53 and 54 as well as the CMS investigation described in Sections 3.0 and 4.0 of this document.

8.1.1 Description of the Current Situation

The current situation and the known nature and extent of contamination at SWMUs 53 and 54 will be described in this section. A statement of the purpose for the response, based on the results of the RFI investigations will be provided, as will the actual or potential exposure pathways that will be addressed by the corrective measures.

8.1.2 Establishment of Corrective Action Objectives

Site specific objectives for the corrective action will be established in conjunction with the USEPA. These objectives will be based on public health and environmental criteria, information obtained from site investigations, USEPA guidance, and any applicable federal or Commonwealth of Puerto Rico statutes. The corrective action objectives will be consistent with 40 CFR 264.100 as applicable.

8.1.3 Screening of Corrective Measure Technologies

The preliminary corrective measure technologies screened in the Pre-Investigative Measures Screening Report (Baker, 1994), and any additional technologies, which are applicable at the

facility, will be reviewed based on all the available data and information at SWMU 54. This screening process focuses on eliminating those technologies that have severe limitations for a given set of waste and site-specific conditions or due to inherent technology limitations. The screening of the technologies will look in detail at the site and waste characteristics as well as the technology limitations.

A screening of corrective measures technologies will not be conducted for SWMU 53 since a highly focused or streamlined CMS is appropriate for the site as discussed previously in Section 2.1 of this document. It is assumed that the remedial solution will consist of excavation of the contaminated soil with off-site disposal. Site reconstruction will be completed with clean soil. This solution is preferred because of the permanence in reduction of the volume and toxicity of the contaminated soil which will be protective of human health and the environment.

8.1.4 Identification of the Corrective Measure Alternative or Alternatives

The corrective measure alternative or alternatives will be developed based on the corrective action objectives and analysis of the corrective measure technologies. Those alternatives that appear most suitable for the site based on sound engineering will be retained. Technologies can be combined to form the overall corrective action alternative or alternatives. The reasons for excluding any technology shall be documented.

8.2 Task II - Evaluation of the Corrective Measure Alternative or Alternatives

Each corrective measure technology and its components that passed through the initial screening in Task I will be described and evaluated. This evaluation will be based on technical, environmental, human health, and institutional concerns. Cost estimates for each corrective measure will also be developed.

8.2.1 Technical/Environmental/Human Health/Institutional

A description of each corrective measure alternative which includes but is not limited to preliminary process flow sheets, preliminary sizing and type of construction for buildings and structures, and rough quantities of utilities required will be provided. Each alternative will be evaluated in the following four areas:

8.2.1.1 Technical

Each corrective measure alternative will be evaluated based on performance, reliability, implementability, and safety.

8.2.1.2 Environmental

An environmental assessment will be performed for each alternative, which will focus on the facility conditions and pathways of contamination actually addressed by each alternative. The environmental assessment for each alternative will include, at a minimum, an evaluation of: the short and long term beneficial and adverse effects of the response alternative; any adverse effects on environmentally sensitive areas; and an analysis of measures to mitigate adverse effects.

8.2.1.3 Human Health

Each alternative will be assessed in terms of the extent to which it mitigates short- and long-term potential exposure to any residual contamination and protects human health both during and after implementation of the corrective measure. The assessment will describe the levels and characterizations of contaminants on-site, potential exposure routes, and potentially affected populations. Each alternative will be evaluated to determine the level of exposure to contaminants and the reduction over time. For management of mitigation measures, the relative reduction of impact will be determined by comparing residual levels of each alternative with existing criteria, standards, or guidelines acceptable to the USEPA.

8.2.1.4 Institutional

The relevant institutional needs for each alternative will be assessed. Specifically the effects of Federal, State, and local environmental and public health standards, regulations, guidance, advisories, ordinances, or community relations on the design, operation, and timing of each alternative will be examined.

8.2.2 Cost Estimate

A cost estimate of each corrective measure alternative will be developed. The cost estimate will include capital, operation, and maintenance costs.

8.3 Task III - Justification and Recommendation of the Corrective Measure or Measures

The corrective measure alternative will be recommended and justified using technical, human health, and environmental criteria. Tradeoffs among health risks, environmental effects, and other pertinent factors will be highlighted. The USEPA will select the corrective measure alternative or alternatives to be implemented based on the results of Task II and III. At a minimum the criteria in the sections that follow will be used to justify the final corrective measure or measures.

8.3.1 Technical

8.3.1.1 Performance

Corrective measure or measures that are most effective at performing their intended functions and maintaining the performance over extended periods of time will be given preference.

8.3.1.2 Reliability

Corrective measure or measures that do not require frequent or complex operation and maintenance activities and that have proven effective under waste and facility conditions similar to those anticipated will be given preference.

8.3.1.3 Implementability

Corrective measure or measures that can be constructed and operated to reduce levels of contamination to attain or exceed applicable standards in the shortest period of time will be preferred.

8.3.1.4 Safety

Corrective measure or measures that pose the least threat to the safety of nearby residents and environments as well as workers during implementation will be preferred.

8.3.2 Human Health

The corrective measure or measures will comply with existing USEPA criteria, standards, or guidelines for the protection of human health. Corrective measures that provide the minimum level of exposure to contaminants and the maximum reduction in exposure with time are preferred.

8.3.3 Environmental

The corrective measure or measures posing the least adverse impact (or greatest improvement) over the shortest period of time on the environment will be favored.

8.4 Task IV - Reports

8.4.1 Progress

The USEPA will be provided with signed progress reports as required by Condition B.8. (a) of Module III of the Permit.

8.4.2 Corrective Measures Study Final Report

A CMS Final Report will be prepared and submitted for approval within forty-five (45) days after completion of the CMS. The CMS Final Report to be developed will include all the information gathered under the approved CMS Work Plan. At a minimum the report will include:

- A description of the facility;
  - Site topographic map & preliminary layouts.

- A summary of the corrective measure or measures;
  - Description of the corrective measure or measures and rationale for selection;
  - Performance expectations;
  - Preliminary design criteria and rationale;
  - General operation and maintenance requirements; and
  - Long-term monitoring requirements.

- A summary of the previous investigations and impact on the selected corrective measure or measures,;
  - Field studies (groundwater and soil); and
  - Laboratory studies (bench scale, pick scale).

- Design and Implementation Precautions;
  - Special technical problems;
  - Additional engineering data required;
  - Permits and regulatory requirements;
  - Access, easements, right-of-way;
  - Health and safety requirements; and
  - Community relations activities.

- Cost Estimates and Schedules;
  - Capital cost estimate;
  - Operation and maintenance cost estimate; and
  - Project schedule (design, construction, operation).

9.0 SCHEDULE

The schedule for implementation of this work plan commenced upon receipt of an USEPA notification letter dated September 19, 2002 and received September 30, 2002 (Figure 9-1). Initiation of the CMS and CMS Investigation will be based on USEPA approval of the Final CMS Work Plan. The schedule of events included in this Work Plan is presented on Figure 9-1. It should be noted that this schedule is dependent upon USEPA review time. Many other factors can also extend the schedule such as, resampling if further re-characterization is required, weather delays in the field, consensus cannot be reached on how the USEPA's comments are incorporated.

10.0 PROJECT ORGANIZATION

An organizational chart presenting the proposed staffing for this project is provided on Figure 10-1. This section also outlines the responsibilities and reporting requirements of field personnel and staff.

10.1 Project Team Responsibilities

Mr. Mark Kimes, P.E of Baker Environmental, Inc. who is the Activity Manager for all work in Puerto Rico, will manage the Baker Project Team. His responsibilities will be to direct the technical performance of the project staff, costs and schedule, ensuring that QA/QC procedures are followed during the course of the project. He will maintain communication with the LANTDIV Navy Technical Representative (NTR), Mr. Kevin Cloe, P.E.

The field portion of this project will consist of one field team managed by the Environmental Scientist, Mr. Jon C. Edel, Jr. Mr. Edel's responsibilities include directing the Baker field team and subcontractors. Mr. Edel will also direct the reporting effort of the field investigation. Mr. Edel will direct and ensure that all necessary staff is utilized to assist in developing the CMS Investigation report for SWMU 53.

Mr. Mark E. Kimes, P.E. will manage the engineering portion of this project. Mr. Kimes will direct and ensure that all necessary staff is utilized in developing the Corrective Measure Study for SWMUs 53 and 54.

10.2 Field Reporting Requirements

The Environmental Scientist will maintain a daily summary of each day's field activities. The following information will be included in this summary:

- Baker and subcontractor personnel on site
- Major activities of the day
- Samples collected
- Problems encountered
- Other pertinent site information

The Environmental Scientist will receive direction from the Project Manager regarding any changes in scope of the investigation.

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TABLES

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Analytical Parameters		
Sample Media	**Sample Designation**	**Sample Depth (ft bgs)**	**App IX Pest[1]**	**App IX Metals[2]**	**Comments**
Surface Soil	53SS07	0.00 - 1.00	X	X	
	53SS08	0.00 - 1.00	X		
	53SS09	0.00 - 1.00	X		
	53SS09D	0.00 - 1.00	X		Duplicate
	53SS09MS/MSD	0.00 - 1.00	X		Matrix Spike/Matrix Spike Duplicate
	53SS10	0.00 - 1.00	X		
	53SS11	0.00 - 1.00	X		
	53SS12	0.00 - 1.00	X		
	53SS13	0.00 - 1.00	X	X	
	53SS14	0.00 - 1.00	X		
	53SS15	0.00 - 1.00	X		
	53SS16	0.00 - 1.00	X		
	53SS17	0.00 - 1.00		X	
	53SS17D	0.00 - 1.00		X	Duplicate
	53SS18	0.00 - 1.00		X	
	53SS19	0.00 - 1.00		X	
	53SS20	0.00 - 1.00		X	
	53SS21	0.00 - 1.00		X	
	53SS22	0.00 - 1.00		X	
	53SS23	0.00 - 1.00		X	
	53SS24	0.00 - 1.00		X	
	53SS25	0.00 - 1.00		X	
	53SS26	0.00 - 1.00		X	
	53SS27	0.00 - 1.00		X	
	53SS27D	0.00 - 1.00		X	Duplicate
	53SS27MS/MSD	0.00 - 1.00		X	Matrix Spike/Matrix Spike Duplicate
	53SS28	0.00 - 1.00		X	
	53SS29	0.00 - 1.00		X	

Notes:

ft bgs - feet below ground surface.

[1] - Appendix IX Pesticides (Chlordane, Heptachlor, and Heptachlor Epoxide) only.

[2] - Appendix IX Metals (Lead, Copper, and Zinc) only.

TABLE 3-2

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

Pesticides	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
Chlordane	0.5	17	8081
Heptachlor	0.05	1.7	8081
Heptachlor epoxide	0.05	1.7	8081

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

µg/kg - micrograms per kilogram.
µg/L - micrograms per liter.

TABLE 3-2

LABORATORY ANALYTICAL METHODS
TWFF - ADDITIONAL DATA COLLECTION INVESTIGATION
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Quantitation Limits*			
Inorganics	**Water (mg/L)**	**Low Soil (mg/kg)**	**Method Number**	**Method Description**
Copper	20	2.0	6010	Inductively Coupled Plasma
Lead	5.0	0.5	6010	Inductively Coupled Plasma
Zinc	20	2.0	6010	Inductively Coupled Plasma

Note:

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

µg/kg - micrograms per kilogram.
µg/L - micrograms per liter.

FIGURES

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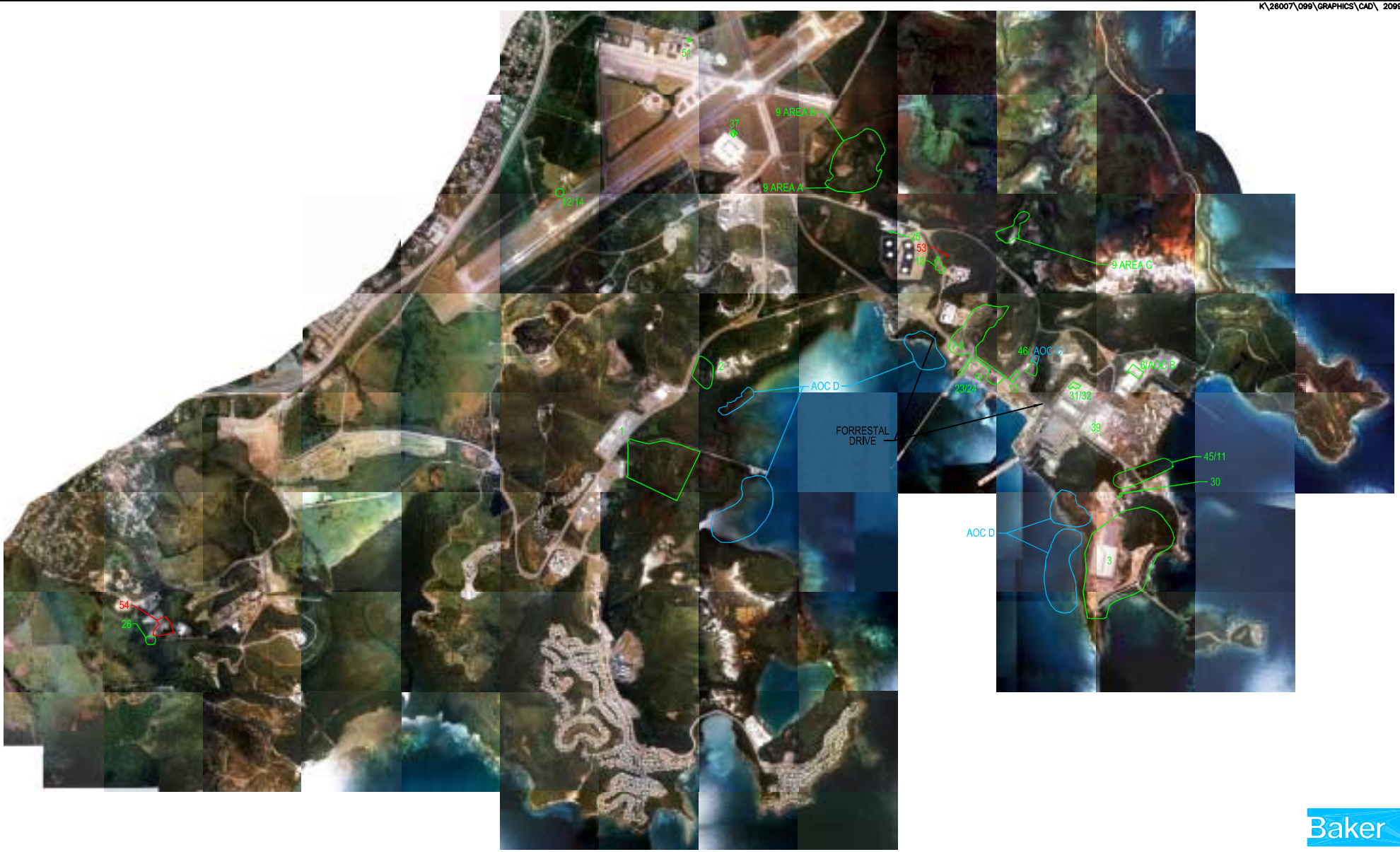


Baker

LEGEND

1 – SWMUs

53 – AREA OF WHICH THIS WORK PLAN PERTAINS TO

AOC D – AOCs

SOURCE: GEO-MARINE, INC., SEPTEMBER 6, 2000.

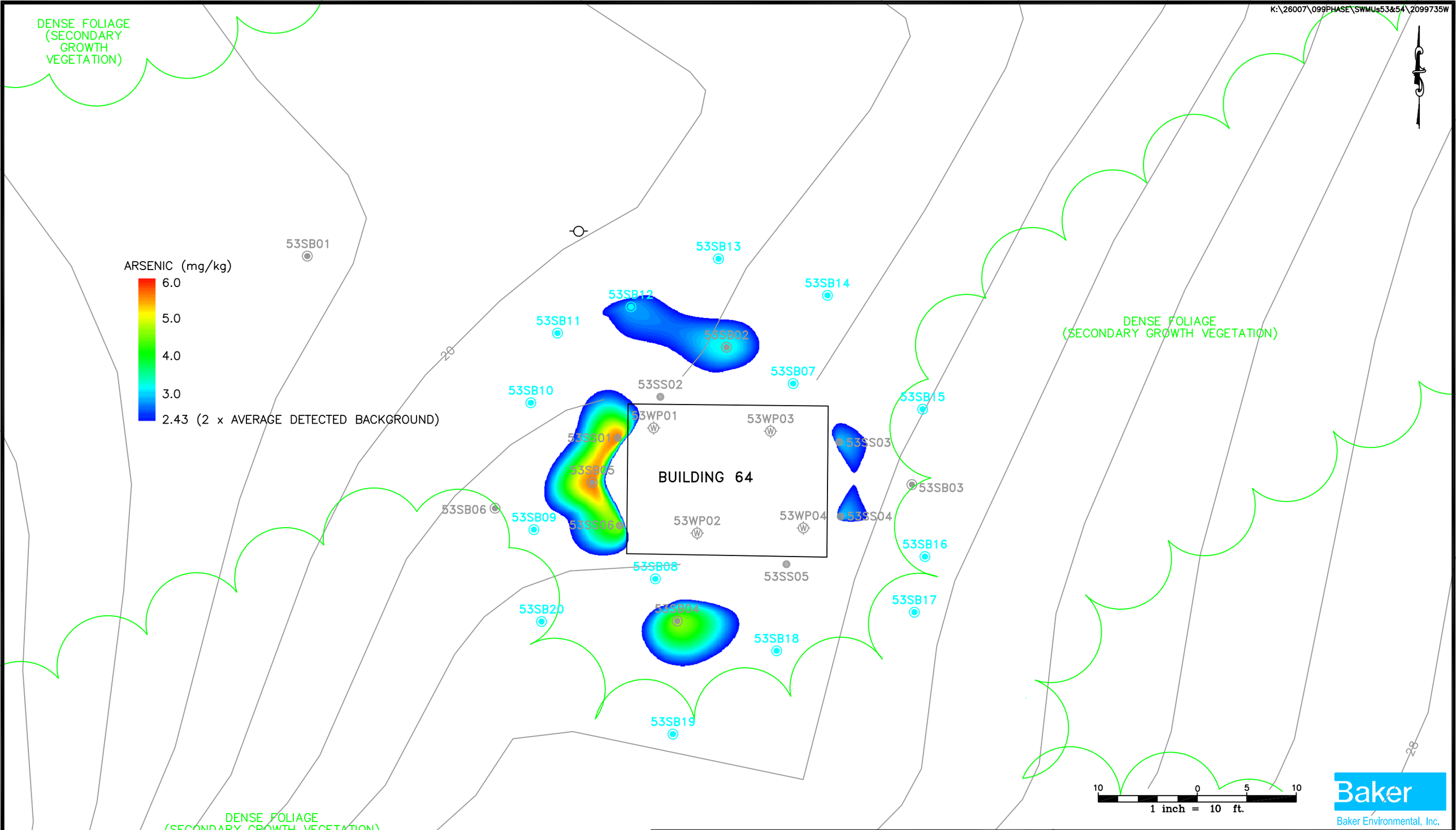
2500 0 1250 2500

1 inch = 2500 ft.

FIGURE 1-1
SWMU/AOC LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

K:\26007\099PHASE\SWMUs53&54\2099735W



Baker
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NOTE: CONCENTRATIONS OBTAINED FROM DUPLICATE SAMPLES AT THE SAME LOCATION WERE AVERAGED.

LEGEND

- WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (RFI, 2002)
- OVERHEAD ELECTRIC UTILITY POLE
- BUILDING
- GROUND SURFACE CONTOUR LINE
- TREE LINE

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 1–2
ARSENIC IN SURFACE SOILS
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
RCRA FACILITY INVESTIGATION
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

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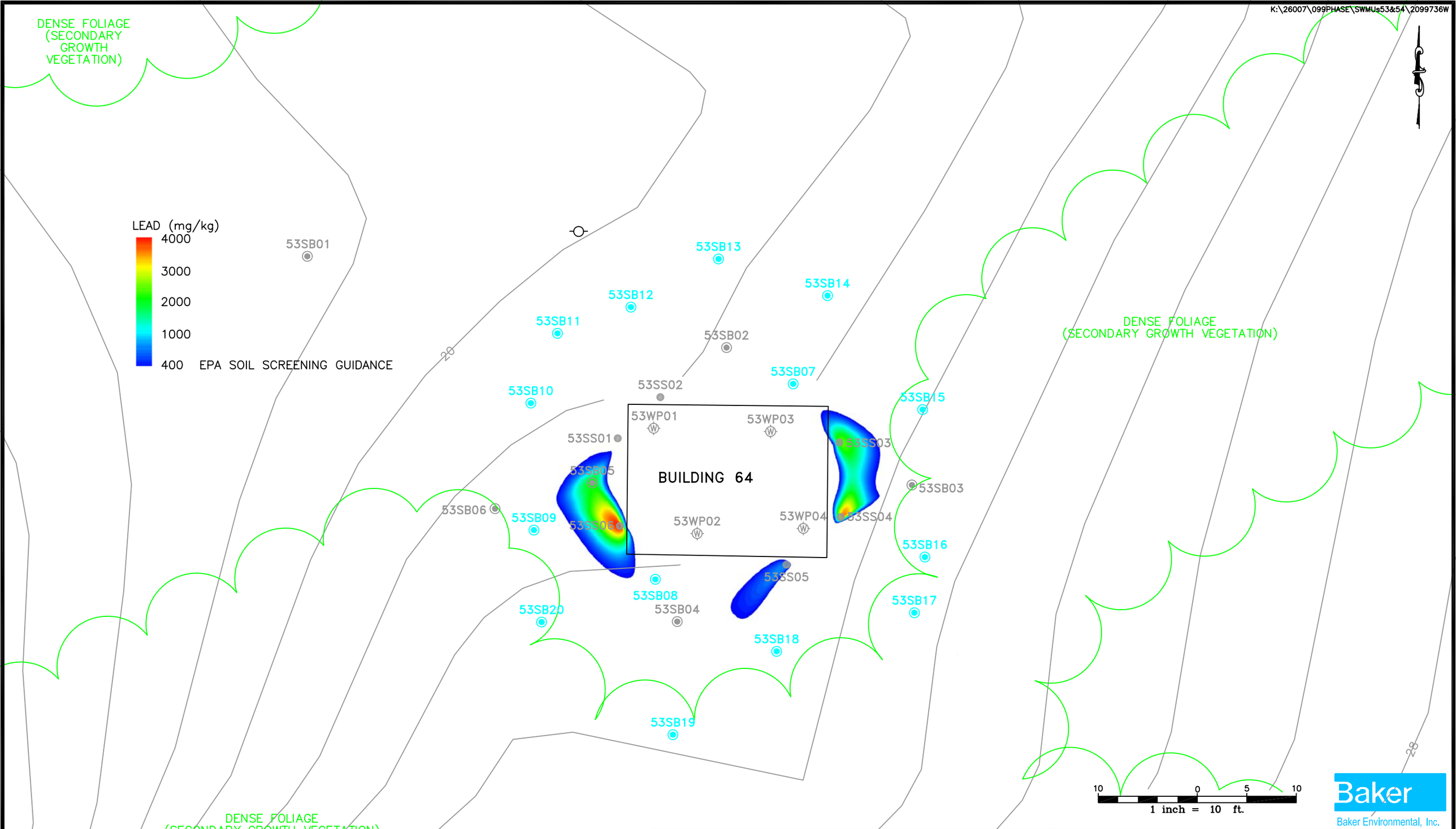

Baker
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NOTE: CONCENTRATIONS OBTAINED FROM DUPLICATE SAMPLES AT THE SAME LOCATION WERE AVERAGED.

LEGEND

- WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (RFI, 2002)
- OVERHEAD ELECTRIC UTILITY POLE
- BUILDING
- GROUND SURFACE CONTOUR LINE
- TREE LINE

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 1-3
LEAD IN SURFACE SOIL
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
RCRA FACILITY INVESTIGATION
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

K:\26007\099PHASE\SWMUs53&54\2099737W

DENSE FOLIAGE (SECONDARY GROWTH VEGETATION)

DDT (ug/kg)
5500
5000
4000
3000
2000
1000
500

53SB01
53SB13
53SB14
53SB12
53SB11
53SB02
53SB07
53SB10
53SS02
53SB15
53WP01
53WP03
53SS01
53SS03
53SB05
BUILDING 64
53SB03
53SB06
53SB09
53SS06
53WP02
53WP04
53SS04
53SB16
53SB08
53SS05
53SB17
53SB20
53SB04
53SB18
53SB19

DENSE FOLIAGE (SECONDARY GROWTH VEGETATION)

DENSE FOLIAGE (SECONDARY GROWTH VEGETATION)

10 0 5 10
1 inch = 10 ft.

Baker
Baker Environmental, Inc.

NOTE: CONCENTRATIONS OBTAINED FROM DUPLICATE SAMPLES AT THE SAME LOCATION WERE AVERAGED.

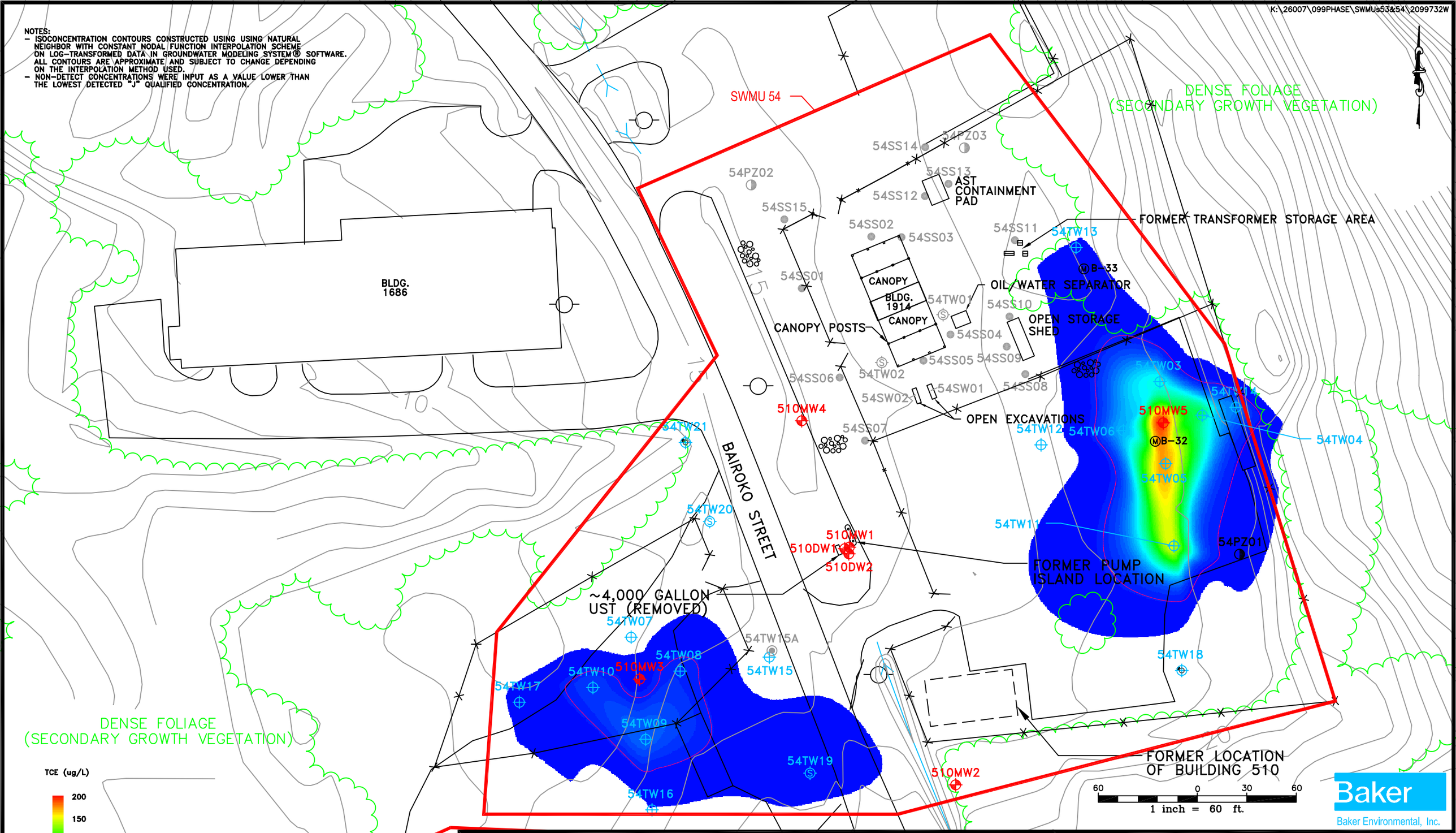
LEGEND
- WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (RFI, 2002)
- OVERHEAD ELECTRIC UTILITY POLE
- BUILDING
- GROUND SURFACE CONTOUR LINE
- TREE LINE
- RESIDENTAL RBC FOR 4,4'-DDT OF 1900 ug/kg

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 1-4
DDT IN SURFACE SOIL
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
RCRA FACILITY INVESTIGATION
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

K:\26007\099PHASE\SWMUs53&54\2099732W

NOTES:
- ISOCONCENTRATION CONTOURS CONSTRUCTED USING USING NATURAL NEIGHBOR WITH CONSTANT NODAL FUNCTION INTERPOLATION SCHEME ON LOG-TRANSFORMED DATA IN GROUNDWATER MODELING SYSTEM® SOFTWARE. ALL CONTOURS ARE APPROXIMATE AND SUBJECT TO CHANGE DEPENDING ON THE INTERPOLATION METHOD USED.
- NON-DETECT CONCENTRATIONS WERE INPUT AS A VALUE LOWER THAN THE LOWEST DETECTED "J" QUALIFIED CONCENTRATION.



SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2002)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE
- FEDERAL MCL FOR TCE = 5 ug/L

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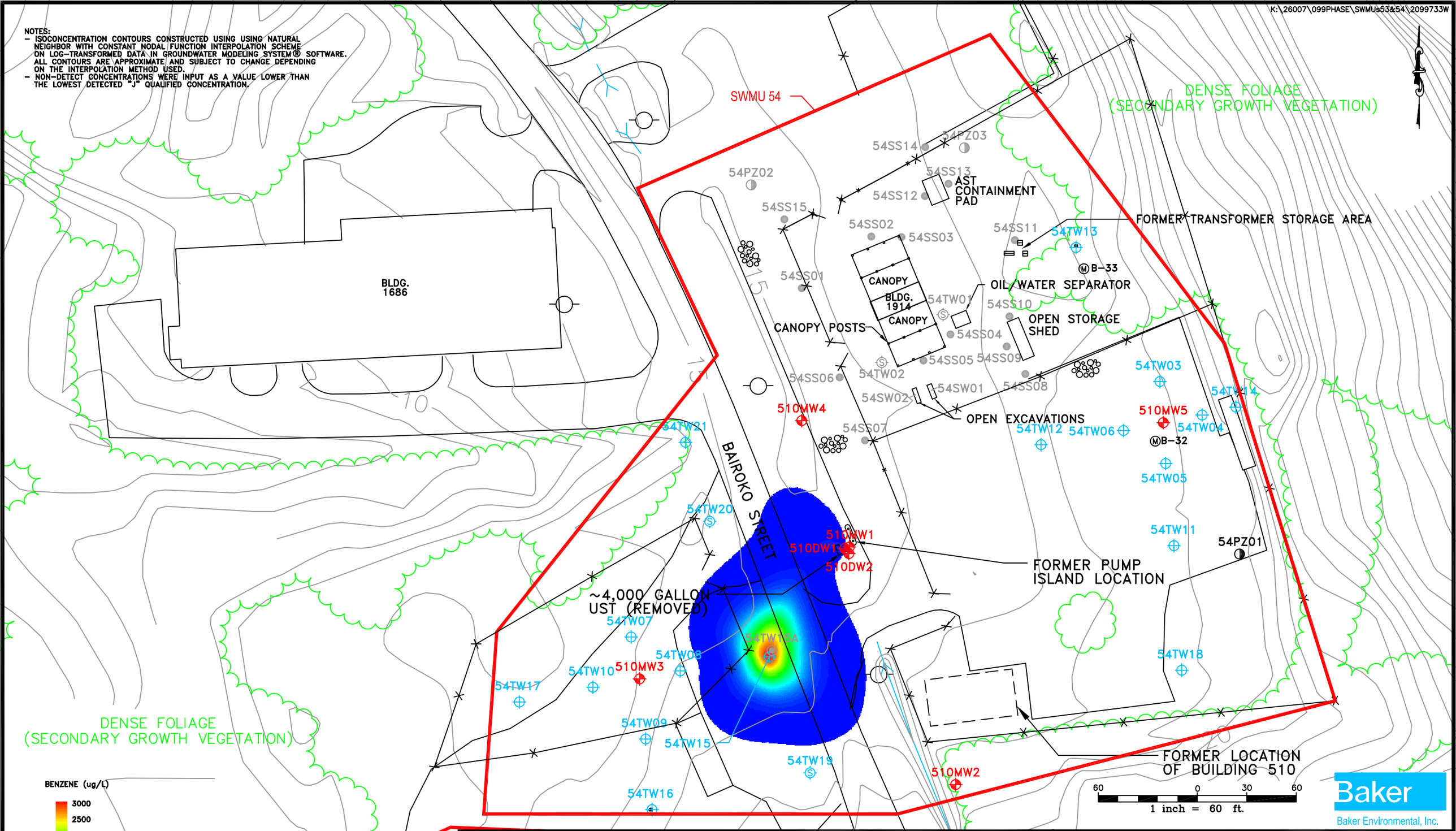
FIGURE 1-5
TCE IN GROUNDWATER
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
RCRA FACILITY INVESTIGATION
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

K:\26007\099PHASE\SWMUs53&54\2099733W

NOTES:
- ISOCONCENTRATION CONTOURS CONSTRUCTED USING USING NATURAL NEIGHBOR WITH CONSTANT NODAL FUNCTION INTERPOLATION SCHEME ON LOG-TRANSFORMED DATA IN GROUNDWATER MODELING SYSTEM® SOFTWARE. ALL CONTOURS ARE APPROXIMATE AND SUBJECT TO CHANGE DEPENDING ON THE INTERPOLATION METHOD USED.
- NON-DETECT CONCENTRATIONS WERE INPUT AS A VALUE LOWER THAN THE LOWEST DETECTED "J" QUALIFIED CONCENTRATION.



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LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2002)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE

SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

FIGURE 1-6
BENZENE IN GROUNDWATER
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
RCRA FACILITY INVESTIGATION
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

K:\26007\099PHASE\SWMUs53&54\2099734W

NOTES:
- ISOCONCENTRATION CONTOURS CONSTRUCTED USING USING NATURAL NEIGHBOR WITH CONSTANT NODAL FUNCTION INTERPOLATION SCHEME ON LOG-TRANSFORMED DATA IN GROUNDWATER MODELING SYSTEM® SOFTWARE. ALL CONTOURS ARE APPROXIMATE AND SUBJECT TO CHANGE DEPENDING ON THE INTERPOLATION METHOD USED.
- NON-DETECT CONCENTRATIONS WERE INPUT AS A VALUE LOWER THAN THE LOWEST DETECTED "J" QUALIFIED CONCENTRATION.

SWMU 54

DENSE FOLIAGE (SECONDARY GROWTH VEGETATION)

BLDG. 1686

54SS14 54PZ03 54PZ02 54SS13 54SS12 AST CONTAINMENT PAD 54SS15 54SS02 54SS03 54SS11 54TW13 FORMER TRANSFORMER STORAGE AREA B-33 54SS01 CANOPY BLDG. 1914 CANOPY 54TW01 OIL/WATER SEPARATOR 54SS10 OPEN STORAGE SHED CANOPY POSTS 54SS04 54SS05 54SS09 54SS06 54TW02 54SS08 54TW03 54SW01 54SW02 510MW4 OPEN EXCAVATIONS 510MW5 54TW14 54TW21 54SS07 54TW12 54TW06 54TW04 B-32 54TW05 BAIROKO STREET 54TW20 510MW1 510DW1 510DW2 54TW11 54PZ01 FORMER PUMP ISLAND LOCATION ~4,000 GALLON UST (REMOVED) 54TW07 54TW15A 54TW08 54TW18 54TW10 510MW3 54TW17 54TW15 54TW09 54TW19 510MW2 FORMER LOCATION OF BUILDING 510 54TW16

DENSE FOLIAGE (SECONDARY GROWTH VEGETATION)

ETHYLBENZENE (ug/L)
2500
2000
1500
1000
500
5

SWMU 26

60 0 30 60
1 inch = 60 ft.

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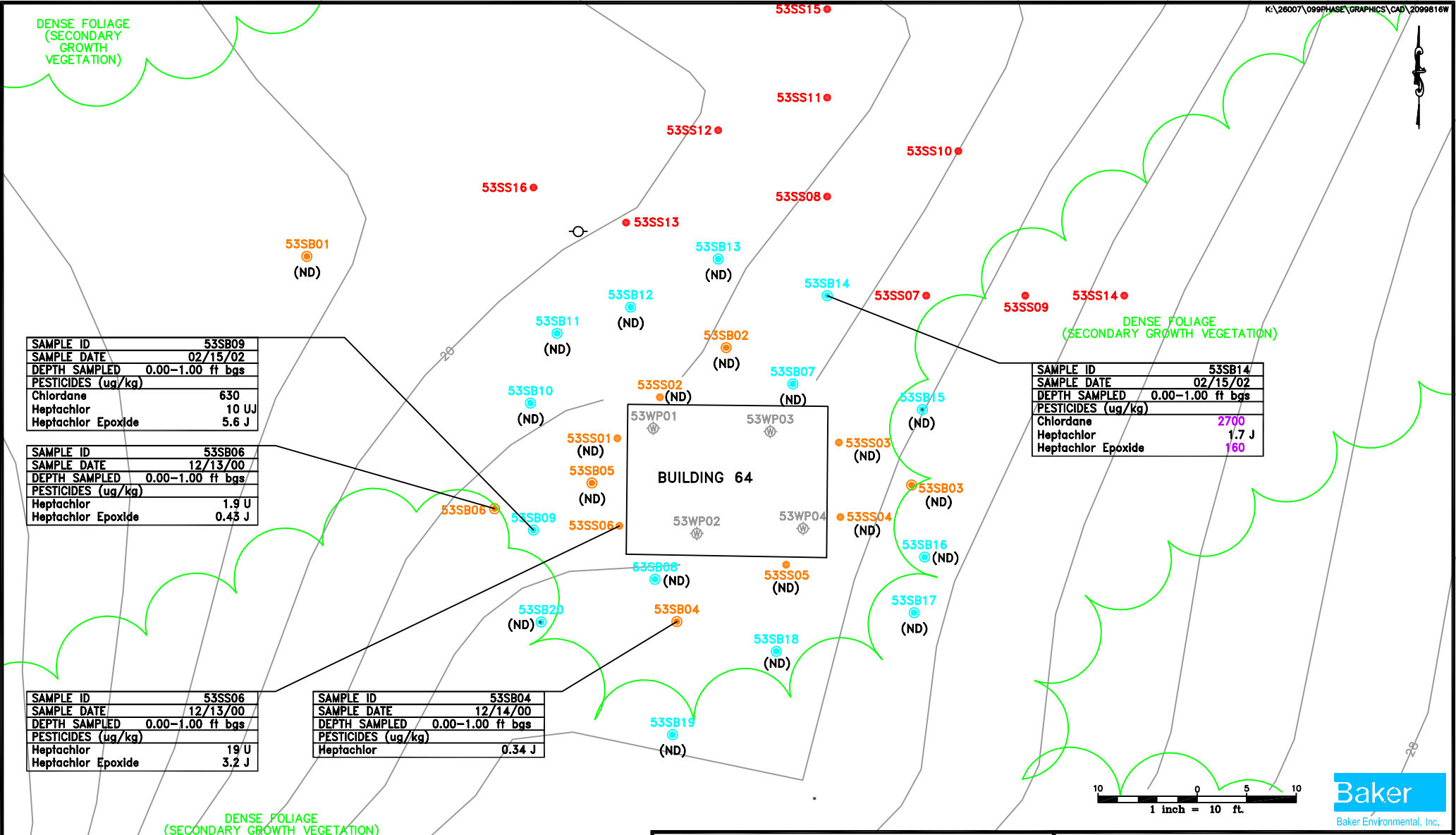
SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2002)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE

FIGURE 1-7
ETHYLBENZENE IN GROUNDWATER
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
RCRA FACILITY INVESTIGATION
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



SAMPLE ID	53SB09
SAMPLE DATE	02/15/02
DEPTH SAMPLED	0.00–1.00 ft bgs
PESTICIDES (ug/kg)	
Chlordane	630
Heptachlor	10 UJ
Heptachlor Epoxide	5.6 J

SAMPLE ID	53SB06
SAMPLE DATE	12/13/00
DEPTH SAMPLED	0.00–1.00 ft bgs
PESTICIDES (ug/kg)	
Heptachlor	1.9 U
Heptachlor Epoxide	0.43 J

SAMPLE ID	53SB14
SAMPLE DATE	02/15/02
DEPTH SAMPLED	0.00–1.00 ft bgs
PESTICIDES (ug/kg)	
Chlordane	2700
Heptachlor	1.7 J
Heptachlor Epoxide	160

SAMPLE ID	53SS06
SAMPLE DATE	12/13/00
DEPTH SAMPLED	0.00–1.00 ft bgs
PESTICIDES (ug/kg)	
Heptachlor	19 U
Heptachlor Epoxide	3.2 J

SAMPLE ID	53SB04
SAMPLE DATE	12/14/00
DEPTH SAMPLED	0.00–1.00 ft bgs
PESTICIDES (ug/kg)	
Heptachlor	0.34 J

NOTES:
(ND) NOT DETECTED FOR CHLORDANE, HEPTACHLOR, AND HEPTACHLOR EPOXIDE.
EXCEEDS EPA REGION III RESIDENTIAL RBC.

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

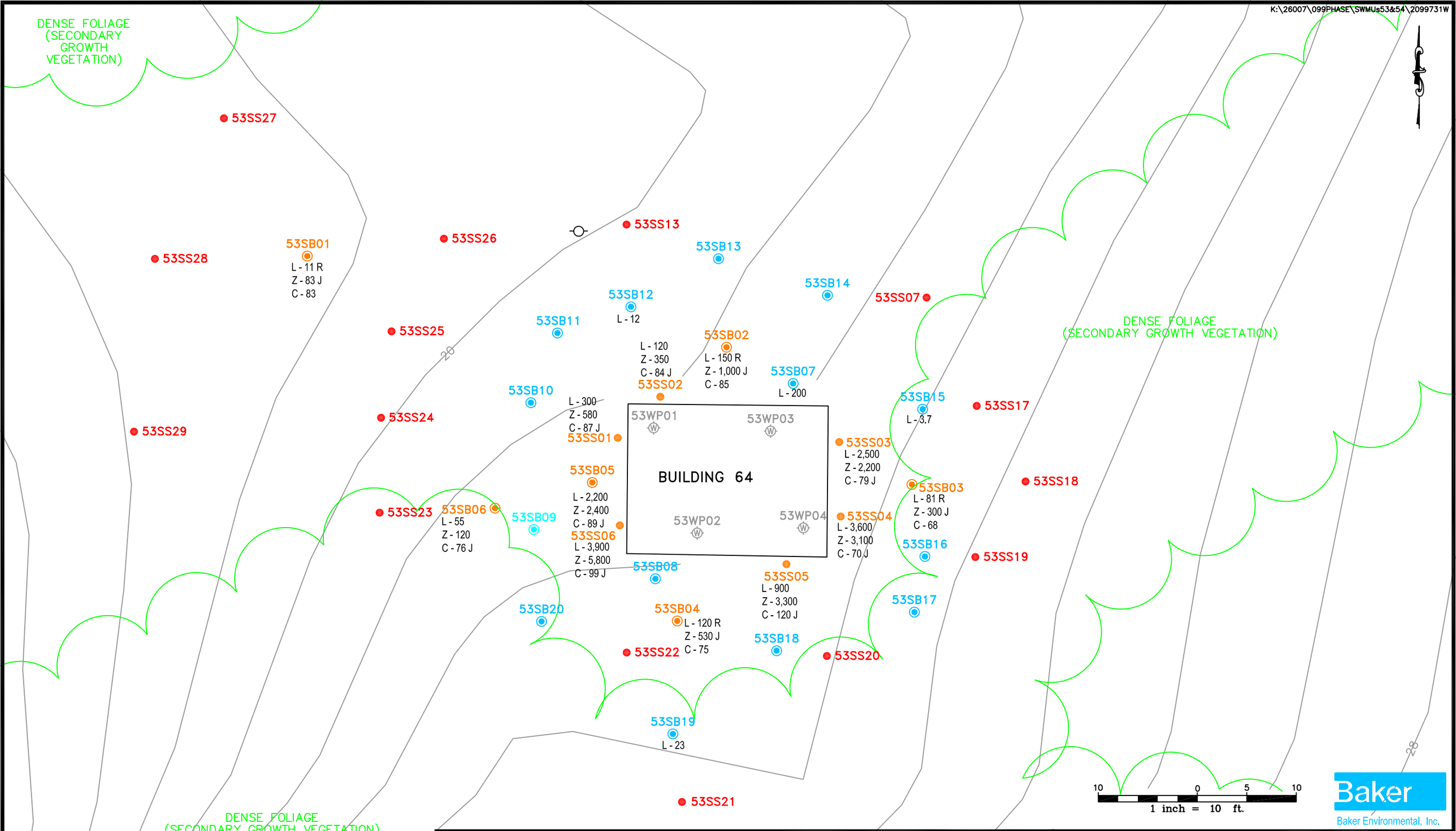
LEGEND
- WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- PROPOSED SURFACE SOIL SAMPLE LOCATION
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (RFI, 2002)
- OVERHEAD ELECTRIC UTILITY POLE
- BUILDING
- GROUND SURFACE CONTOUR LINE
- TREE LINE

FIGURE 3–1

SURFACE SOIL SAMPLING LOCATIONS – SWMU 53
PREVIOUS PESTICIDE INVESTIGATION RESULTS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

K:\26007\099PHASE\SWMUs53&54\2099731W



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LEGEND

- (W) – WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- – PROPOSED SURFACE SOIL SAMPLE LOCATION
- – SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- – SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- – SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (RFI, 2002)
- – OVERHEAD ELECTRIC UTILITY POLE
- – BUILDING
- – GROUND SURFACE CONTOUR LINE
- – TREE LINE

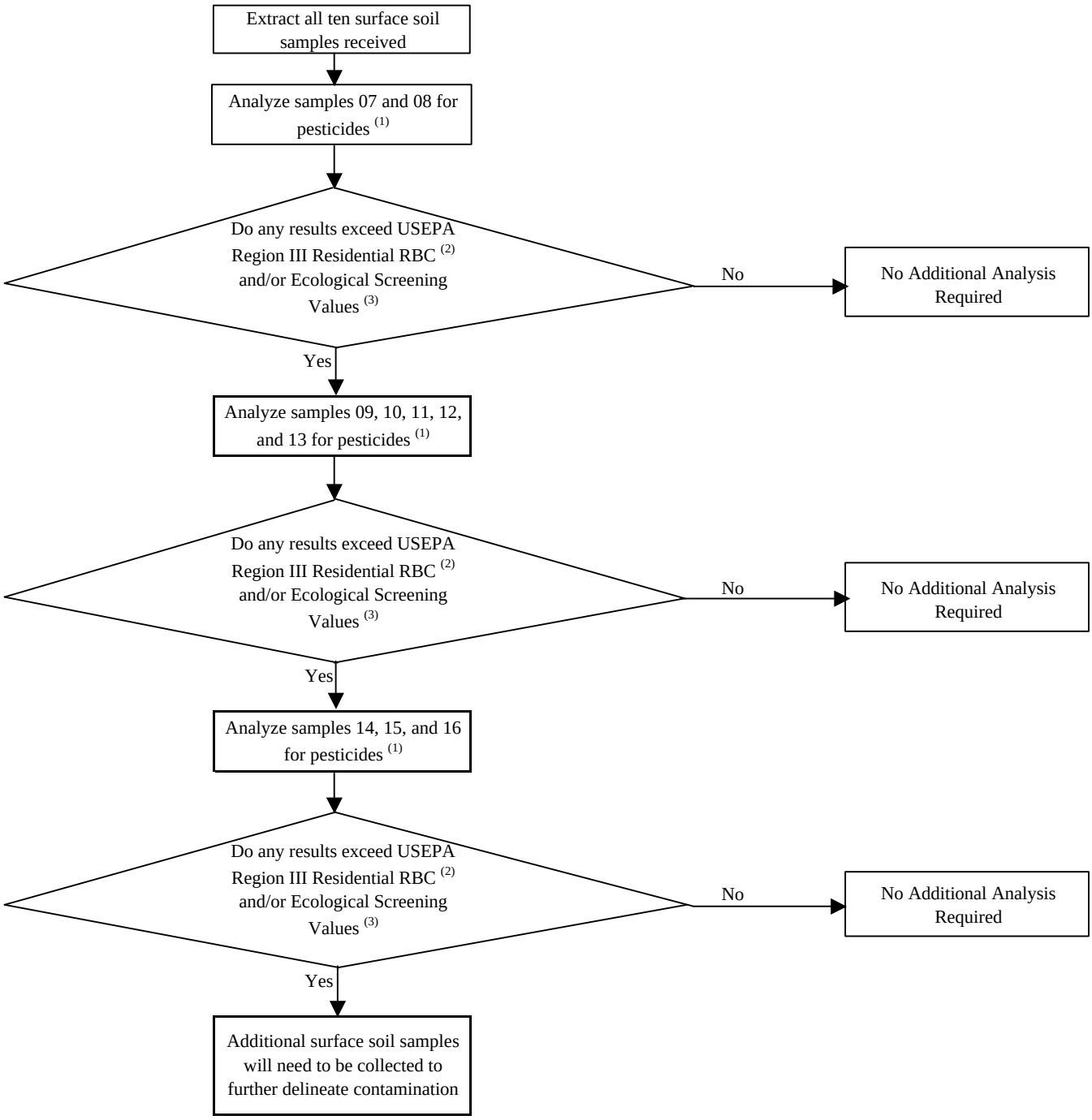
L – LEAD
C – COPPER
Z – ZINC

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 3–2
ADDITIONAL SURFACE SOIL SAMPLES FOR LEAD, ZINC, AND COPPER
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

FIGURE 3-3

LABORATORY ANALYSIS DECISION TREE FOR PESTICIDES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO



Notes:

(1) - Only chlordane, heptachlor, and heptachlor epoxide will be reported.

(2) - USEPA Region III Residential RBCs: (Chlordane - 1.825 ppm, Heptachlor - 0.142 ppm, Heptachlor Epoxide - 0.0702 ppm).

(3) - Ecological Screening Values (Buchman 1994): (Chlordane - 0.1 ppm, Heptachlor Epoxide - 0.1 ppm). EPA Region 5 Ecological Data Quality Levels (www.epa.gov/RCRIS-Region-5/ca/edql.htm): (Heptachlor - 0.006 ppm).

- All sample locations will have the prefix 53SS.

NA - Not Available.

Figure 5-1: Navy Ecological Risk Assessment Tiered Approach

RPM Input and Risk Management Consideration[3]

Step 8: Risk Management

Tier 1. Screening Risk Assessment (SRA): Identify pathways and compare exposure point concentrations to bench marks.

Step 1: Site visit; Pathway Identification/Problem Formulation; Toxicity Evaluation

Step 2: Exposure Estimate; Risk Calculation (SMDP) [1]

Proceed to Exit Criteria for SRA

Exit Criteria for the Screening Risk Assessment: Decision for exiting or continuing the ecological risk assessment.

1) Site passes screening risk assessment: A determination is made that the site poses acceptable risk and shall be closed out for ecological concerns.

2) Site fails screening risk assessment: The site must have both complete pathway and unacceptable risk. As a result the site will either have an interim cleanup or moves to the second tier.

Tier 2. Baseline Ecological Risk Assessment (BERA): Detailed assessment of exposure and hazard to "assessment endpoints" (ecological qualities to be protected). Develop site specific values that are protective of the environment.

Step 3a: Refinement of Conservative Exposure Assumptions[2] (SRA)---- **Proceed to Exit Criteria for Step 3a**

Step 3b: Problem Formulation - Toxicity Evaluation; Assessment Endpoints; Conceptual Model; Risk Hypothesis (SMDP)

Step 4: Study Design/DQO - Lines of Evidence; Measurement Endpoints; Work Plan and Sampling & Analysis Plan (SMDP)

Step 5: Verification of Field Sampling Design (SMDP)

Step 6: Site Investigation and Data Analysis [SMDP]

Step 7: Risk Characterization

Proceed to Exit Criteria for BERA

Exit Criteria Step 3a Refinement

1) If re-evaluation of the conservative exposure assumptions (SRA) support an acceptable risk determination then the site exits the ecological risk assessment process.

2) If re-evaluation of the conservative exposure assumptions (SRA) do not support an acceptable risk determination then the site continues in the Baseline Ecological Risk Assessment process. **Proceed to Step 3b**.

Exit Criteria Baseline Risk Assessment

1) If the site poses acceptable risk then no further evaluation and no remediation from an ecological perspective is warranted.

2) If the site poses unacceptable ecological risk and additional evaluation in the form of remedy development and evaluation is appropriate, proceed to third tier.

Tier 3. Evaluation of Remedial Alternative (RAGs C)

a. Develop site specific risk based cleanup values.

b. Qualitatively evaluate risk posed to the environment by implementation of each alternative (short term) impacts and estimate risk reduction provided by each (long-term) impacts; provide quantitative evaluation where appropriate. Weigh alternative using the remaining CERCLA 9 Evaluation Criteria. Plan for monitoring and site closeout.

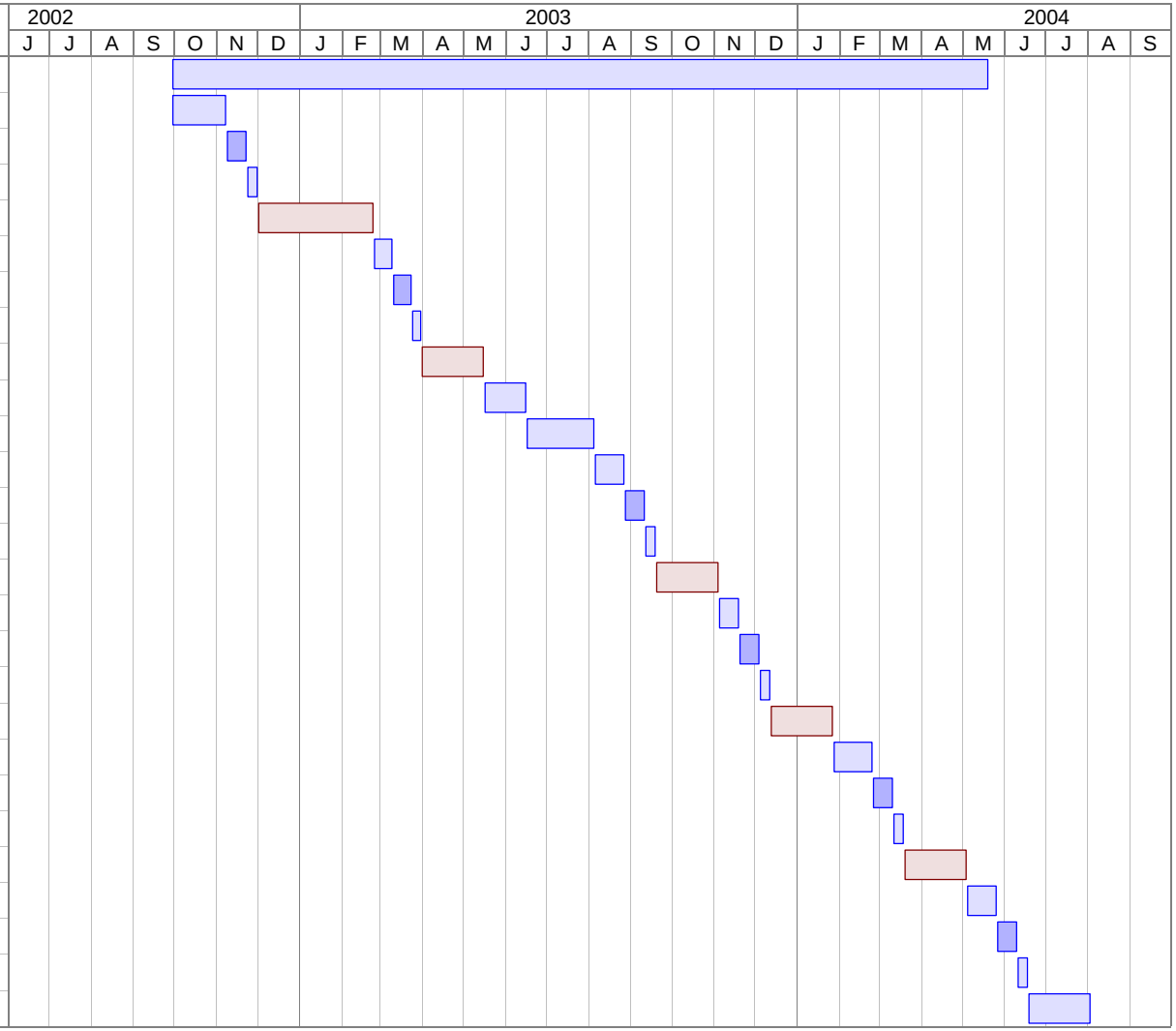
Notes: 1) See EPA's 8 Steps ERA Process for requirements for each Scientific Management Decision Point (SMDP).

2) Refinement includes but is not limited to background, bioavailability, detection frequency. Etc.

3) Risk Management is incorporated throughout the tiered approach.

Figure 6-1
Corrective Measures Study - Proposed Schedule
SWMUs 53 and 54
Naval Station Roosevelt Roads, Ceiba, Puerto Rico

ID	Task Name	Duration	Start	Finish
1	**SWMU 53 and 54 CMS**	598 edays	9/30/02	5/20/04
2	Draft CMS Work Plan	39 edays	9/30/02	11/8/02
3	Navy Review	14 edays	11/9/02	11/23/02
4	Adress Navy Comments	7 edays	11/24/02	12/1/02
5	EPA Review	84 edays	12/2/02	2/24/03
6	Final CMS Work Plan	13 edays	2/25/03	3/10/03
7	Navy Review	13 edays	3/11/03	3/24/03
8	Address Navy Comments	6 edays	3/25/03	3/31/03
9	EPA Review/Approval	45 edays	4/1/03	5/16/03
10	Initiate Field Work	30 edays	5/17/03	6/16/03
11	Fieldwork/Lab/Validation	49 edays	6/17/03	8/5/03
12	Draft CMS Investigation Report	21 edays	8/6/03	8/27/03
13	Navy Review	14 edays	8/28/03	9/11/03
14	Address Navy Comments	7 edays	9/12/03	9/19/03
15	EPA Review	45 edays	9/20/03	11/4/03
16	Final CMS Investigation Report	14 edays	11/5/03	11/19/03
17	Navy Review	14 edays	11/20/03	12/4/03
18	Address Navy Comments	7 edays	12/5/03	12/12/03
19	EPA Review/Approval	45 edays	12/13/03	1/27/04
20	Draft CMS Final Report	28 edays	1/28/04	2/25/04
21	Navy Review	14 edays	2/26/04	3/11/04
22	Address Navy Comments	7 edays	3/12/04	3/19/04
23	EPA Review	45 edays	3/20/04	5/4/04
24	Final CMS Final Report	21 edays	5/5/04	5/26/04
25	Navy Review	14 edays	5/27/04	6/10/04
26	Address Navy Comments	7 edays	6/11/04	6/18/04
27	EPA Review/Approval	45 edays	6/19/04	8/3/04



Project: CTO-0099
Date: 3/11/03

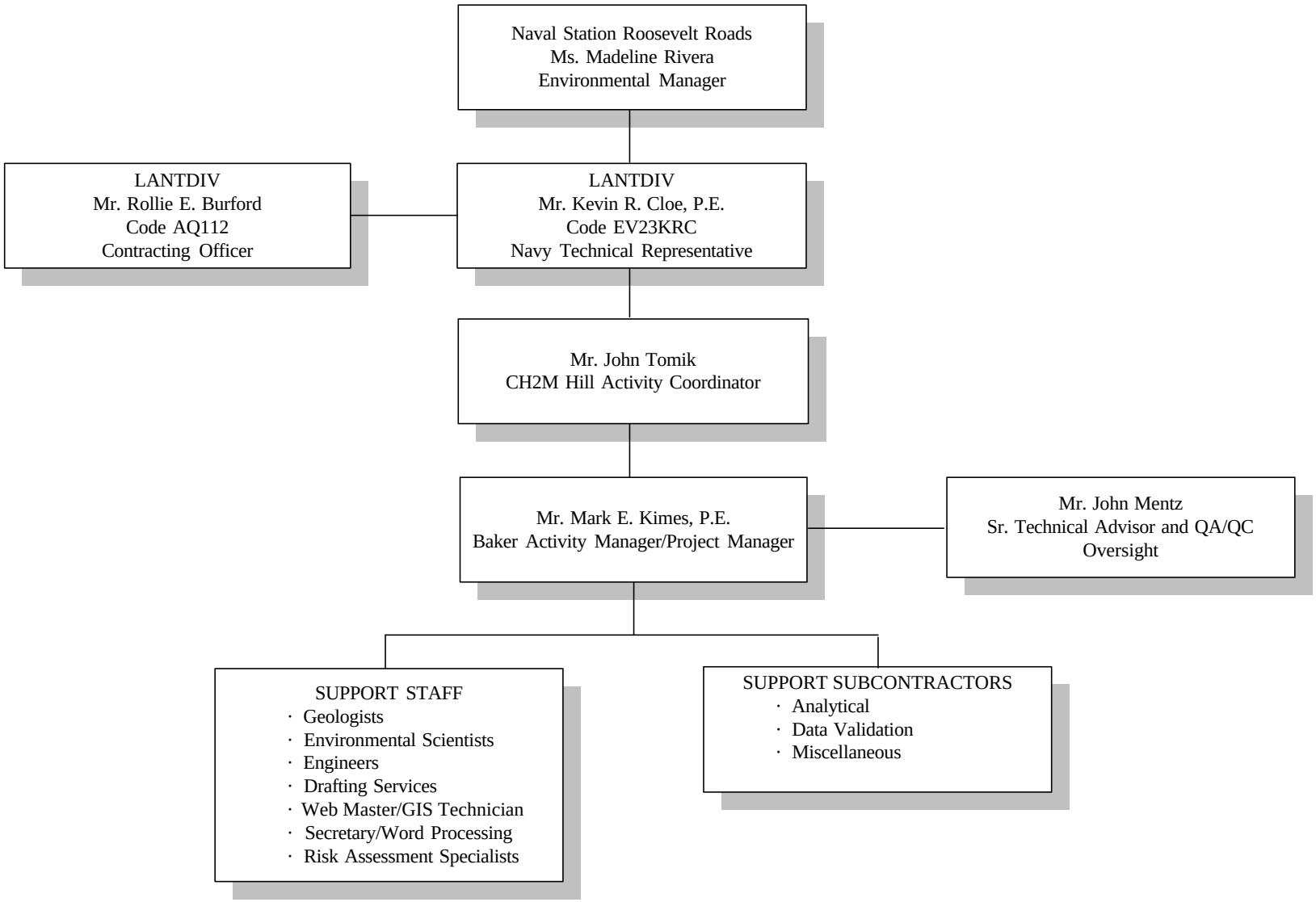



FIGURE 10-1
PROJECT ORGANIZATION
SWMUS 53 and 54 - CORRECTIVE MEASURE STUDY
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO