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Final

Corrective Measures Study Final Report

SWMU 53

Naval Station Roosevelt Roads
RCRA/HSWA Permit No. PR2170027203
Ceiba, Puerto Rico

Prepared For

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

Contract No. N62470-95-D-6007
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November 24, 2003

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FINAL

CORRECTIVE MEASURES STUDY FINAL REPORT

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CONTRACT TASK ORDER 0099

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DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
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LIST OF ACRONYMS AND ABBREVIATIONS

ABS	absorption factors
AF	adherence factors
AOC	Area of Concern
AT	averaging time
AUF	area use factor
BAF	bioaccumulation factor
Baker	Baker Environmental, Inc.
BCF	bioconcentration factor
bgs	below ground surface
BTAG	Biological technical Assistance Group
B_v	soil-plant bioconcentration factor
BW	body weight
BW_j	body weight applied to receptor j
C	chemical concentration
CAOs	Corrective Action Objectives
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
CFR	Code of Federal Regulations
CMI	Corrective Measures Implementation
CMS	Corrective Measure Study
CNO	Chief of Naval Operations
COCs	Contaminants of Concern
COPC	Chemical of Potential Concern
C_{SAT}	Soil Saturated Concentration
CS_x	mean concentration of chemical x in surface soil
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DI_x	dietary intake for chemical x
DoN	Department of the Navy's
DRMO	Defense Reutilization and Marketing Office
ED	exposure duration
EF	exposure frequency
ERA	ecological risk assessment
FIR	food ingestion rate
FC_{xi}	maximum concentration of chemical x in food item I
ft	feet
HEAST	Health Effects Assessment Summary Tables
HQ	hazard quotient
HQ_x	refined hazard quotient for chemical x
IEUBK	integrated exposure uptake/biokinetic model
IR	Installation Restoration
IRIS	Integrated Risk Information System
J	estimated concentration (data qualifier)
kg/day	kilogram per day

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

K_d	adsorption coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol-water partition coefficient
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
LD_{50}	median lethal dose
LOAEL	Lowest Observed adverse effect Concentration
m^3/day	cubic meters per day
MATC	Maximum Acceptable Toxicant Concentration
mg/kg	milligrams per kilogram
mg/kg-BW/day	milligram per kilogram- Body weight per day
MHSPE	Ministry of Housing, Spatial Planning and Environment
MSDS	material safety data sheet
NAWQC	National Ambient Water Quality Criteria
NCP	National Contingency Plan
NFPA	National Fire Protection Act
NOAEL	No Observed Adverse Effect Level
$NOAEL_x$	No Observed Adverse Effect Level for chemical x
$NOAEL_{ij}$	No Observed Adverse Effect Level for chemical I applied to receptor j
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NSRR	Naval Station Roosevelt Roads
PCB	Polychlorinated biphenyl
PDF_i	proportion of diet composed of food item i
PDS	proportion of diet composed of surface soil
ppm	parts per million
ppt	parts per thousand
R	rejected (data qualifier)
RBCs	Risk Based Concentrations
RCRA	Resource Conservation and Recovery Act
RfCs	Reference Concentrations
RfDs	Reference Doses
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SA	Surface area
SAP	Sampling and Analysis Plan
SC_x	maximum concentration of chemical x in surface soil
SF	slope factor
$SSSV_x$	surface soil screening value for chemical x
STSC	Superfund Technical Support Center
SWMU	Solid Waste Management Unit
T	exposure time
U	not detected (data qualifier÷
]g/kg	micrograms per kilogram

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

USACE	United States Army Corps of Engineers
UJ	not detected, estimated value (data qualifier)
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USTs	underground storage tanks
VF	volatization factor
VOC	volatile organic compound

1.0 INTRODUCTION

This document presents the Corrective Measure Study (CMS) Final Report for Solid Waste Management Unit (SWMU) 53 at the Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico. The report has been prepared under the Corrective Action provisions of the Station's Resource Conservation and Recovery Act (RCRA) permit (RCRA/HSWA Permit No. PR2170027203). This report has been prepared by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV).

1.1 Regulatory Framework

In 1943, NSRR was commissioned as a Naval Operations Base. NSRR continued in this status until 1957 when it was redesignated a naval station with the mission of providing full support for Atlantic Fleet weapons training and development activities. Until 1993 all environmental operations, with the exception of underground storage tanks (USTs), were conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations as part of the Department of the Navy's (DoN) Installation Restoration (IR) Program. On October 20, 1994, a Final RCRA Part B permit was issued by the United States Environmental Protection Agency (USEPA) Region II to the Defense Reutilization and Marketing Office (DRMO), NSRR. This corrective action provisions of the permit required RCRA Facility Investigation (RFI) activities at 25 SWMUs and 3 Areas of Concern (AOCs). Two additional SWMUs were identified during May of 2000 bringing the total to 27 SWMUs and 3 AOCs.

RCRA regulations provide a procedure to investigate and remediate areas that may have been affected by a release of hazardous wastes. The first steps for investigating a site are the RCRA Facility Assessment (RFA) and the RFI. These assessments and investigations are studies on a property to determine if there has been a release of hazardous waste and to quantify any releases that have occurred. If these studies determine that a release has occurred, a CMS is performed to identify the most appropriate corrective measure for a given site.

A RFA was performed in 1988 and updated in 1993 by A.T. Kearney, Inc. for the USEPA to identify SWMUs and AOCs, and to assess the potential for the release of hazardous constituents from any areas or units. The RFA identified 52 SWMUs and 4 AOCs, and recommended additional investigation at 25 of the SWMUs and three of the AOCs.

Building 64 (Malaria Control Building) at SWMU 53 was first listed as a SWMU in the May 31, 2000 RCRA Quarterly Progress Report (Baker, 2000a). Attachment 2 of the aforementioned report contained the Phase I Environmental Assessment Report for SWMUs 53. A Draft Sampling and Analysis Plan (SAP) was submitted for SWMUs 53 and 54 on August 4, 2000 (Baker, 2000b), and was approved by the USEPA on October 10, 2000. The associated 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 (Baker, 2001a). The Final RFI Work Plan for SWMUs 53 and 54 was submitted on December 6, 2001 (Baker, 2001b), 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 was submitted on July 17, 2002 (Baker, 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 was 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. A Draft CMS Work Plan was submitted on November 27, 2002. The EPA commented on this report on February 19, 2003, requesting that a revised CMS work plan be submitted. On March 7, 2003, a Final CMS Work Plan was submitted for SWMUs 53 and 54 (Baker, 2003a). The CMS investigation at SWMU 53 was conducted on March 23, 2003, after the Navy received verbal acceptance on the proposed sampling methods presented in the Final CMS Work Plan mentioned above. The EPA provided written approval on the CMS work plan on June 3, 2003. This investigation report focuses on the objectives outlined in the CMS work plan. It is attached as Appendix A to this CMS Final Report.

1.2 Intent of the Focused CMS

The purpose of a CMS is typically:

- to identify and evaluate remedial alternatives that may be used to address a release at a facility;
- to justify the recommended corrective action based upon technical, human health, and environmental considerations;
- to determine clean up levels;
- to provide a system for reporting compliance requirements and use this system to document remediation activities; and
- to provide information pertinent to the remedial design.

A highly focused or streamlined CMS is appropriate for facilities that have "straightforward remedial solutions" where standard engineering solutions can be applied that have proven effective in similar situations (USEPA 1994). The area that is the focus of this report has only one impacted media: soil (surface and subsurface soil). Because the SWMU is located on the island of Puerto Rico, there are limited technologies that are time and cost effective in treating the impacted media. Also, the extent of contamination at this site has been fully characterized, and was found to be limited. Therefore, the screening of clean-up technologies, normally conducted in a CMS, will not occur. The remedy selected and documented in this CMS will provide the quickest remediation of the SWMU.

1.3 Goals of the Corrective Measure Process

The goal of this CMS is to identify the appropriate technical approach needed to address contamination in the surface and subsurface soil at SWMU 53. The contaminant levels in the soil will be reduced to levels at or below the clean up goals established in this CMS. This CMS establishes the framework for the remediation of SWMU 53 by providing remediation goals, a

selected remediation method, and other information that is pertinent for the preparation of the remedial design and ultimately SWMU clean up.

1.4 Organization of the Report

This report is divided into eight sections. Section 1.0 of this document includes this introduction, as well as the regulatory framework, intent of the focused CMS, and the goals of the corrective measure process. The description of current conditions, including general site description, previous RCRA activities at SWMU 53, and summary of site conditions are included in Section 2.0. Section 3.0 presents the screening-level ecological risk assessment and step 3a of the baseline ecological risk assessment. The ecological corrective action objectives (CAOs) are given in Section 4.0. The establishment of the human health CAOs is presented in Section 5.0. Section 6.0 presents the recommendations and justifications of the focused remedy for SWMU 53, while Section 7.0 presents the technical approach to the corrective measure implementation. The references for this CMS Final Report are provided in Section 8.0.

2.0 DESCRIPTION OF CURRENT CONDITIONS

This section of the report provides an update to the information describing the current situation at SWMU 53, as well as the known nature and extent of contamination as documented by the Sampling and Analysis Report (Baker, 2001a), the RFI Report (Baker, 2002), and the Corrective Measures Study Investigation Report (Baker, 2003b). An update of the previous RCRA activities at SWMU 53 including previous response activities, are also provided. Figure 2-1 presents the regional location map showing NSRR in conjunction to the rest of Puerto Rico. Figure 2-2 presents a site location map of SWMU 53 in relation to the base.

2.1 General Site Description SWMU 53 – Building 64 (Malaria Control Building)

SWMU 53 is located at NSRR as shown on Figure 2-2. 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 southeast (up gradient) to the northwest (down gradient), approximately 200 feet away from Forrestal Drive. Figure 2-3 presents a site plan for SWMU 53. The building was utilized to store pesticides, such as 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 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, 2000c). 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.

2.2 Previous RCRA Activities at SWMU 53

Numerous environmental investigations have been conducted at NSRR; however, this section deals only with those associated with SMWU 53. Table 2-1 presents a summary of all investigations conducted at SWMU 53 as described in the following subsections.

2.2.1 Phase I Environmental Assessment

A Phase I Environmental Assessment Report was prepared by Baker for SWMU 53 and presented in the May 31, 2000 RCRA Quarterly Progress Report, as mentioned in Section 1.1. This report consisted of a description and characterization of the site, as well as a site history and a description of surrounding land uses. This report also documented any sensitive receptors if present within the site area, and described any releases of hazardous materials if applicable.

2.2.2 Sampling and Analysis Investigation

A Draft Sampling and Analysis Plan was submitted for SWMUs 53 and 54 on August 4, 2000 (Baker, 2000b), and was approved by the USEPA on October 10, 2000. The work proposed in this plan consisted of the collection of 15 surface soil samples, including three duplicate samples,

and seven subsurface soil samples in the SWMU 53 vicinity, as well as four wipe samples within Building 64. The soil borings were advanced to depths ranging from two feet to ten feet below ground surface (bgs). The soil samples were analyzed for pesticides/PCBs and Appendix IX Metals, while the wipe sample were analyzed for pesticides/PCBs only. The purpose of this investigation was to determine whether a release of hazardous waste including hazardous constituents has occurred, is likely to have occurred, or is likely to occur. The associated 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. It was concluded in the report that it was likely that there was a release of contaminants to the surface soils in the vicinity of the Malaria Control Building. Results indicated the presence of pesticides, arsenic, and lead in the surface and subsurface soils at SWMU 53. Wipe samples also indicated the presence of pesticides on the concrete pad within Building 64. A RFI was proposed at SWMU 53 to delineate the 4,4-DDT, lead, and arsenic contamination in the surface and subsurface soils. 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 (Baker, 2001a).

2.2.3 RCRA Facility Investigation

A Final RFI Work Plan for SWMUs 53 and 54 was submitted on December 6, 2001 (Baker, 2001b), and was approved by the EPA on January 3, 2002. The work proposed in the RFI work plan consisted of the collection of 16 surface soil samples, inluding two duplicate samples, as well as 16 subsurface soil samples, including two duplicate samples, in the SWMU 53 vicinity. The soil borings were advanced to depths ranging from two to four feet bgs. The soil samples were all screened in the field for DDT and lead, with a select number of samples sent to the mainland laboratory for analysis of DDT and lead for confirmation purposes. All soil samples collected were sent to the mainland laboratory for arsenic analysis. The objective of this investigation was to assess the environmental impact of past operations at this site. 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 was submitted on July 17, 2002 (Baker, 2002) and subsequently approved by the EPA on September 19, 2002 pending the performance of a CMS. It was concluded in the RFI report that three of the primary chemicals of potential concern (COPCs) identified in the Sampling and Analysis Report had been delineated. However, additional constituents were detected in samples collected on the outer edge of the investigative area during the 2002 RFI, and therefore, have not been delineated. It was proposed that an additional field investigation be conducted to delineate chlordane and heptachlor epoxide within the surface soil. Once this field investigation would be completed, a CMS would be conducted to develop remedial alternatives for the pesticides and metals that are present in the soils at SWMU 53.

2.2.4 Corrective Measures Study Investigation

A Final CMS Work Plan for SWMU 53 was submitted on March 7, 2003 (Baker, 2003a). This work plan incorporated the delineation of the chlordane, heptachlor epoxide, heptachlor, lead, copper, and zinc contamination in the surface soil. This work plan also presented those tasks required to evaluate lead, zinc, copper, arsenic, chlordane, 4,4'-DDT, and heptachlor epoxide as COPCs for soils at SWMU 53. The work proposed in the CMS work plan consisted of 26

surface soil samples, including three duplicate samples, in the SWMU 53 vicinity. Six surface soil samples, including one duplicate sample, were analyzed for chlordane, heptachlor, and heptachlor epoxide, while 15 surface soil samples, including two duplicate samples, were analyzed for lead, copper, and zinc. Four surface soil samples (53SS12, 53SS14, 53SS15, and 53DD16) were collected but not analyzed in the laboratory because delineation of the target constituents had already been achieved. Therefore, the analysis of these samples was not necessary. The CMS investigation at SWMU 53 was conducted on March 23, 2003, after the Navy received verbal acceptance on the proposed sampling methods presented in the Final CMS Work Plan mentioned above.

The Draft CMS Report for SWMU 53 is submitted as Appendix A to this report. It was concluded in the CMS Investigation Report that the concentrations of chlordane, heptachlor, and heptachlor epoxide were delineated during the CMS investigation. Although the lead, copper, and zinc results were all below the listed USEPA Industrial and Residential RBCs, their concentrations exceeded the NSRR Ecological Surface Soil Plant and/or Invertebrate values. There appears to be a potential risk to site plants and invertebrates as a result of the levels of the abovementioned three metals. It was proposed that a CMS report be completed to develop remedial alternatives for the abovementioned pesticides and metals that are present in the surface and subsurface soil at SWMU 53.

2.3 Summary of Site Conditions

The following subsections describe the current conditions at SWMU 53. Figures 2-4 through Figure 2-7 present the current extent of contamination in both the surface soil and subsurface soil media, as well as wipe sample results from the concrete pad of Building 64. In addition, Appendix B contains the composite summary of analytical data for SWMU 53 from the three aforementioned investigations.

2.3.1 Surface Soil Results

Surface soil was characterized in each of the three field investigations mentioned above in Section 2.2. The organic detections that have been documented within the surface soil at this site include 4,4'-dichlorodiphenyldichloroethane (DDD), 4,4'-dichlorodiphenyldichloroethylene (DDE), 4,4'-DDT, aldrin, chlordane, heptachlor epoxide, heptachlor, and kepone. Several inorganic constituents have been evaluated and found to have positive detections. Only arsenic, lead, copper, and zinc were determined to be of concern at this site (Baker 2003a, 2002). During the preparation of the CMS Report (this report), it was determined that chromium may pose an ecological risk at SWMU 53. Therefore, this constituent was added to the list of COPCs (see Section 3.0). The results of these constituents from each investigation are presented in the following subsections. Figures 2-4 and 2-5 present the positive detections of all organic constituents and the positive detections of the inorganic COPCs during all the investigations.

2.3.1.1 Sampling and Analysis Investigation

SWMU 53 surface soil sample results were compared with several criteria. Organic compounds detected in surface soil samples were compared with their respective risk-based concentrations (RBCs) for both industrial and residential conditions as determined by EPA Region III (EPA, 2000). Inorganic compounds were compared against the RBCs and the base background analytical data. The background screening criteria was determined by taking twice the average of each constituent detected in the four base background surface soil samples and eight base

background subsurface soil samples. In the case of a non-detect, one-half the detection limit was used to calculate the average. This background value was determined in accordance with EPA guidance (EPA, 1999). This background value was determined in accordance with a phone conversation with Ms. Gina Ferreira (EPA, 1999).

A total of 15 surface soil samples, including three duplicate samples, were collected during this investigation as presented in the Final Sampling and Analysis Report (Baker, 2001a). 4-4'-DDD, 4-4'-DDE, 4,4'-DDT, Heptachlor, and Heptachlor epoxide all contained positive detections within the samples collected. 4,4'-DDT was the only pesticide detected which exceeded any of the listed screening criteria for surface soil. It should be noted that this sample was located off of the down-gradient side of Building 64. No other pesticides were detected above the screening criteria. (See Figure 2-4.)

A total of 15 different metals were detected in the surface soil samples collected during this investigation. Of the fifteen different metals detected, the five that are a concern at this site are arsenic, copper, lead, zinc, and chromium. Arsenic, chromium, and zinc were the only three listed which exceeded the residential RBCs. Four out of the twelve arsenic detections were also in excess of the industrial RBCs. Lead was detected above the USEPA soil screening value of 400 milligrams per kilogram (mg/kg) in five of the eight samples collected, while there were no detections of copper above any of the listed criteria. (See Figure 2-5).

2.3.1.2 RFI Investigation

SWMU 53 surface soil sample results presented in the following sections were compared with the same criteria as the surface soil results in Section 2.3.1.1.

A total of four surface soil samples were analyzed for pesticides by the mainland laboratory during this investigation as presented in Draft RCRA Facility Investigation Report (Baker, 2002). 4-4'-DDE, 4,4'-DDT, aldrin, chlordane, kepone, heptachlor, and heptachlor epoxide were positively detected within the samples collected. Chlordane, heptachlor epoxide, and kepone were the only constituents of those mentioned above to exceed the residential RBCs. Execeedances of these three constituents occurred in sample 53SB14-00, while exceedances of chlordane and kepone occurred in sample 53SB09-00, located north and west of Building 64, repectively. Figure 2-4 presents the concentrations detected within the surface soil at SWMU 53. The kepone exceedances mentioned above were not presented in the write up found in the Final RFI Report submitted September 30, 2002. Due to the RBCs for both industrial and residential receptors for kepone not being established until October 2002. Therefore, kepone did not exceed any RBC values at that time. During the development of the Draft CMS Investigation Report dated July 23, 2003, and concurrently, the Draft CMS Final Report, the RBC values for kepone were utilized [360 and 80 micrograms per kilogram (µg/kg), respectively]. Thus the reasoning for Figure 2-4 presenting the results for kepone at sample location 53SB09 and 53SB14 as exceedances.

Arsenic and lead were the only two metals analyzed in the subsurface soil during this investigation. Arsenic was the only constituent of the two that exceeded the residential RBC. It should be noted that the arsenic results did not exceed the two times the average detected background criteria.

Based on the results of the 2000 field investigation mentioned in Section 2.3.1.1, samples collected for the 2002 RFI investigation were analyzed in the field for DDT and lead for delineation purposes. If positive detections of lead above 400 parts per million (ppm) or DDT above 1 ppm

were detected then additional samples were obtained another 10 feet away from the previous location. This methodology continued until the site was characterized for lead and DDT in soil. A total of 15 samples (including 1 duplicate) were analyzed in the field using the Envirogard® DDT in Soil Test Kit and Lead Check test kits. There were no detections above 0.2 ppm for DDT using the Envirogard® DDT in Soil Test Kit for either the surface or subsurface soil. One Lead Check test kit surface soil sample (53SB07-00) contained a detection of lead above 400 ppm. However, a sample ten feet northeast of 53SB07-00 (53SB14-00) did not contain a detection above 400 ppm. The Lead Check test kits did not detect lead above 400 ppm for subsurface soil. A minimum of four surface soil samples and four subsurface soil samples screened in the field were submitted to the mainland laboratory for confirmatory analysis of 4,4'-DDT and lead. One hundred percent correlation was achieved with the test kits and the laboratory confirmatory analysis for 4,4'-DDT, while eighty-eight percent correlation was achieved for lead. Therefore, 4,4'-DDT and lead were both delineated at this site during the RFI investigation.

2.3.1.3 CMS Investigation

The SWMU 53 area surface soil sample results presented in the following sections were compared with several criteria. Organic compounds detected in surface soil samples were compared with their respective RBCs for both industrial and residential conditions as determined by EPA Region III (EPA, 2003). The organic results were also compared to their respective NSRR Ecological Surface Soil Screening Values. The ecological screening criteria was used to help determine potential risk to ecological receptors at the site for use in Section 3.0 of this report. The inorganic compounds detected in the surface soil samples were compared with their respective RBCs, as well as their corresponding NSRR Ecological Surface Soil Plant and Invertebrate values. This ecological screening criteria was also used to help determine potential risk from metals to ecological receptors at the site.

A total of six surface soil samples, including one duplicate sample, were analyzed for heptachlor, heptachlor epoxide, and chlordane during this investigation as presented in Draft CMS Investigation Report (Baker, 2003b). Heptachlor epoxide and chlordane were the only two constituents positively detected within the samples collected. Chlordane was the only constituent of the two mentioned above, to exceed screening criteria (NSRR Ecological Surface Soil Screening Values). The exceedance of screening criteria occurred in only one sample (53SS07), located northeast of Building 64.

It should be noted that lab analyses were not reported or validated for any other constituents than heptachlor, heptachlor epoxide, and chlordane. Since kepone and 4,4'-DDE were also listed as detected in the Sampling and Analysis Investigation, and may be a COPC for ecological risk, unvalidated results of these two analytes were able to be obtained from the laboratory. These results will be used for delineation purposes only and not for any risk assessment calculations.

Copper, lead, and zinc were the only metals analyzed in the surface soil during this investigation. All three metals were positively detected in the samples that were collected. Copper and zinc exceeded both the NSRR Ecological Surface Soil Plant and Invertebrate values, while lead only exceeded the NSRR Ecological Surface Soil Plant values.

2.3.2 Subsurface Soil Results

Subsurface soil was characterized in the Sampling and Analysis Investigation and the RFI Investigation only. The COPCs that have been documented within the subsurface soil at this site

based on their detections, include 4,4'-DDT, heptachlor, chlorobenzilate, arsenic, lead, copper, and zinc. The results of these constituents from each investigation are presented in the following subsections. Figures 2-6 and 2-7 present the positive detections of all organics and any inorganic constituents of potential concern during all investigations.

2.3.2.1 Sampling and Analysis Investigation

SWMU 53 subsurface soil sample results presented in this section were compared with the same criteria as the surface soil results in Section 2.3.1.1.

A total of seven subsurface soil samples were collected during this investigation at SWMU 53, as presented in the Final Sampling and Analysis Report (Baker, 2001a). Only one pesticide: 4,4'-DDT was detected in only two of the seven samples collected. The two positive detections of 4,4'-DDT were below the screening criteria. It should be noted that these detections were from the soil borings located off of the down gradient side of Building 64. (See Figure 2-6.)

Twelve different metals were detected in the subsurface soil samples during this investigation. Of the twelve different metals detected, the four that are of a concern at this site as mentioned above, are arsenic, copper, lead, chromium, and zinc. Arsenic and chromium were the only metals of the five that exceeded any of the listed criteria. It should be noted that these results were below its corresponding two times the average detected background criteria. The detections of copper, lead, and zinc did not exceed the industrial nor residential RBCs.

2.3.2.2 RFI Investigation

SWMU 53 subsurface soil sample results presented in the following sections were compared with the same criteria as the surface soil in Section 2.3.1.1.

A total of four subsurface soil samples were analyzed for pesticides by the mainland laboratory during this investigation as presented in Draft RCRA Facility Investigation Report (Baker, 2002). Heptachlor and chlorobenzilate were the only constituents positively detected within the subsurface soil. However, the detections of both were below all screening criteria. Figure 2-6 presents the concentrations within the subsurface soil at SWMU 53.

Arsenic and lead were the only two metals analyzed in the subsurface soil during this investigation. Arsenic was the only constituent of the two which exceeded the residential RBC. It should be noted that the arsenic results did not exceed the two times the average detected background criteria. Figure 2-7 presents the concentrations of arsenic and lead, as well as copper and zinc, within the subsurface soil at SWMU 53.

2.3.3 Wipe Sample Results

A total of four wipe samples from the concrete pad within Building 64 were characterized during the Sampling and Analysis Investigation only. The four wipe samples were analyzed for pesticides/polychlorinated biphenyls (PCBs). 4,4'-DDD, 4-4'-DDE, and 4,4'DDT were detected in all four wipe samples collected. Figure 2-8 depicts the results of the wipe sample analyses as well as their locations.

TABLES

TABLE 2-1

SUMMARY OF PREVIOUS INVESTIGATIONS
SWMU 53, BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Investigation	Date Conducted	Scope	Results
Phase I Environmental Assessment	2000	To perform a records search, site description and characterization, site history and description of surrounding land uses, an inventory of sensitive receptors at the site, and description of know or suspected releases.	Building structure was in poor condition, and was condemned in 1980. Staining was only evident on the wooden shelves inside the building. Pesticide odor noticed inside the building and adjacent to the northern side of the building. Exterior of the building was heavily vegetated with a clearing in the vegetation running adjacent to the overhead electrical line that intersects the site.
Sampling and Analysis Plan	2000	To provide work plans for proposed Sampling and Analysis Investigation.	
Final Sampling and Analysis Report	2001	15 surface soil samples, including three duplicate samples, 7 subsurface soil samples, and four wipe samples were collected.	Results indicated the presence of pesticides, arsenic, and lead in the surface and subsurface soils at SWMU 53. Wipe samples also indicated the presence of pesticides on the concrete pad within Building 64.
Final RCRA Facility Investigation Work Plan	2001	To provide work plans for proposed RFI.	
Draft RCRA Facility Investigation Report for SWMUs 53 and 54	2002	16 surface soil samples, including two duplicate samples, and 16 subsurface soil samples, including two duplicate samples were collected.	Results indicated delineation of COCs presented in the Sampling and Analysis Report. Additional constituents were detected along the outer ring of sampling, and therefore, were not delineated.
Final CMS Work Plan for SWMUs 53 and 54	2003	To address USEPA comments on the Draft RFI report, as well as to provide work plans for a proposed CMS investigation.	
Draft CMS Investigation Report for SWMU 53	2003	To provide delineation of COCs collected during the previous two field investigations, as well as lead copper, and zinc within the surface soil. 22 surface soil samples, including three duplicate samples were collected.	All three pesticide COCs (heptachlor, heptachlor epoxide, and chlordane) were delineated within the surface soil. All three metals have been delineated when compared to their respective RBC values, but not when compared to NSRR surface soil screening values. Potential risk appears to be present for site plants and invertebrates in surface soil at this site.

FIGURES

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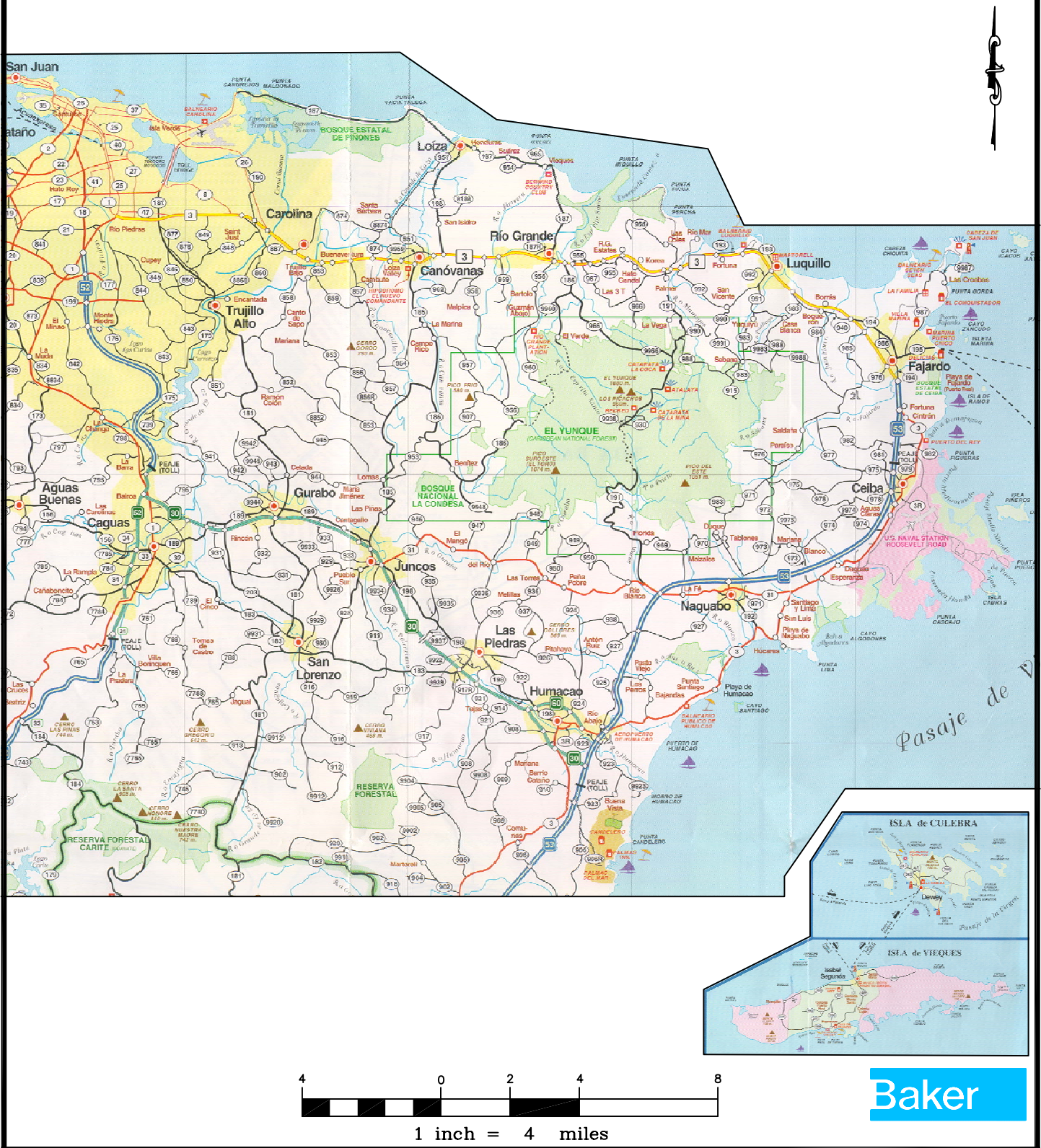

4 0 2 4 8

1 inch = 4 miles

Baker

FIGURE 2-1
REGIONAL LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SOURCE: METRODATA, INC., 1999.

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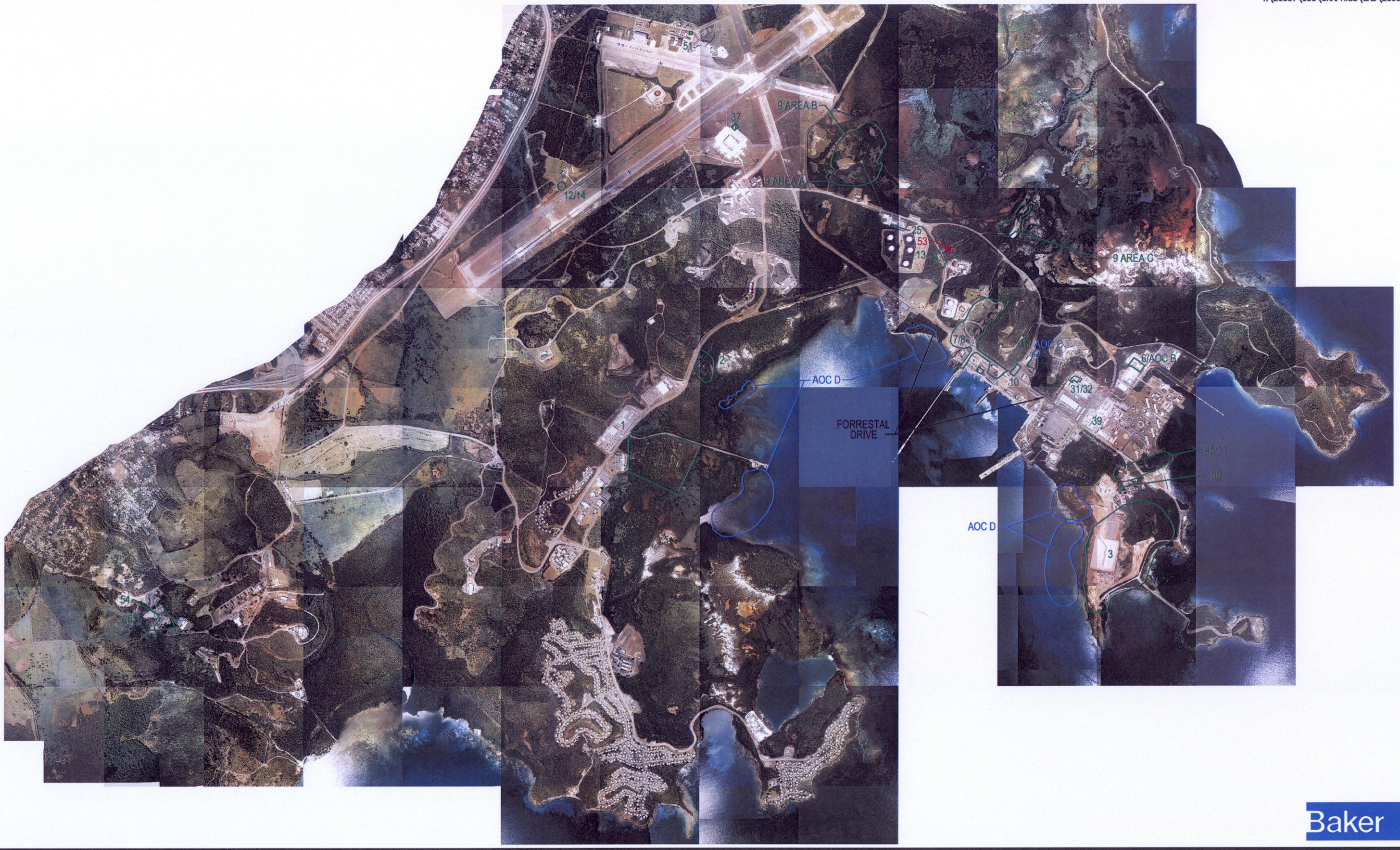


Baker

LEGEND

1 – SWMUs

53 – AREA OF WHICH THIS REPORT PERTAINS TO

AOC D – AOCs

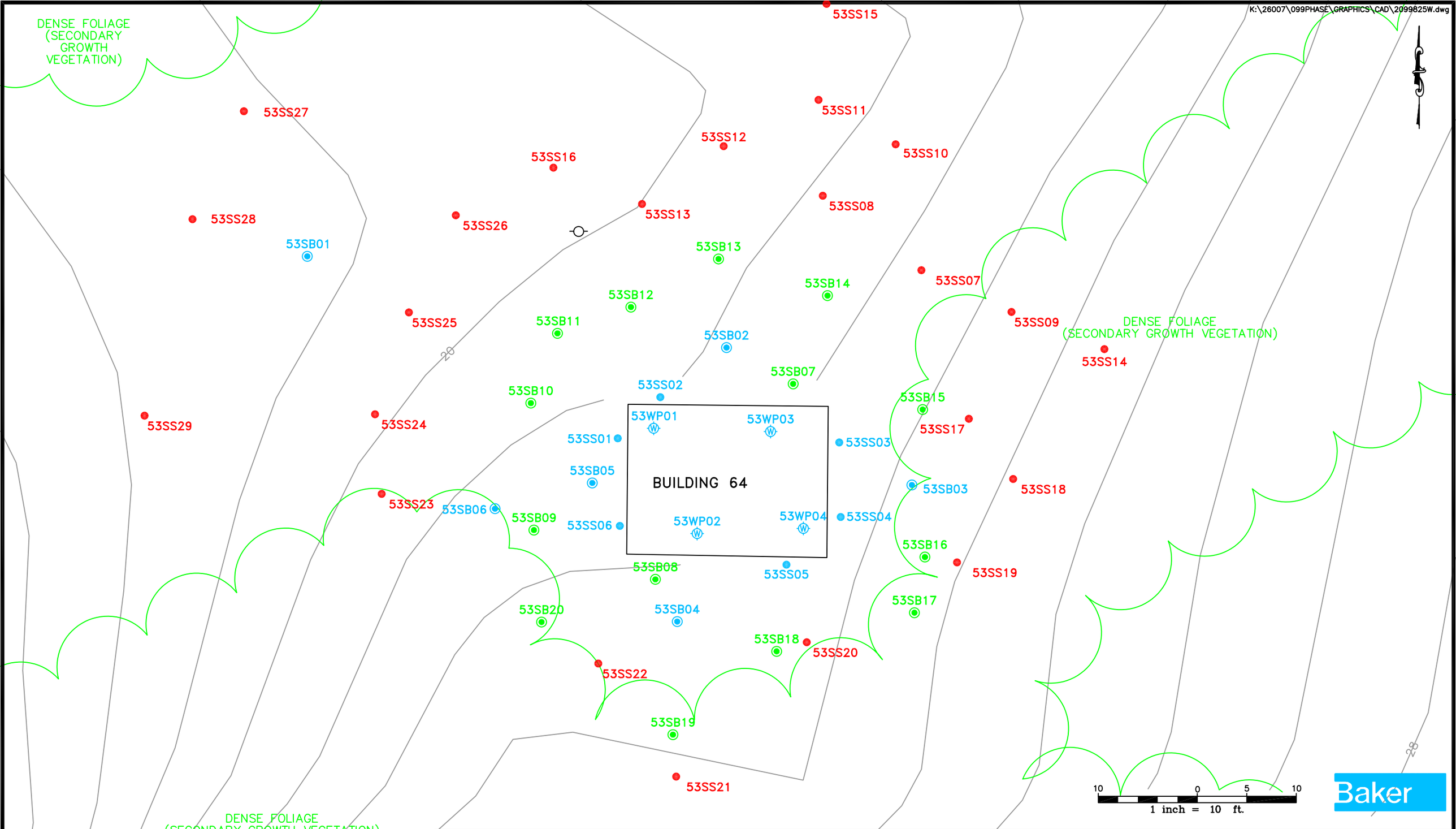
SOURCE: GEO–MARINE, INC., SEPTEMBER 6, 2000.

2500 0 1250 2500

1 inch = 2500 ft.

FIGURE 2–2
SWMU/AOC LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- ADDITIONAL SURFACE SOIL SAMPLE LOCATION (CMS INVESTIGATION, 2003)
- 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 2-3
SITE PLAN AND SAMPLING LOCATIONS
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

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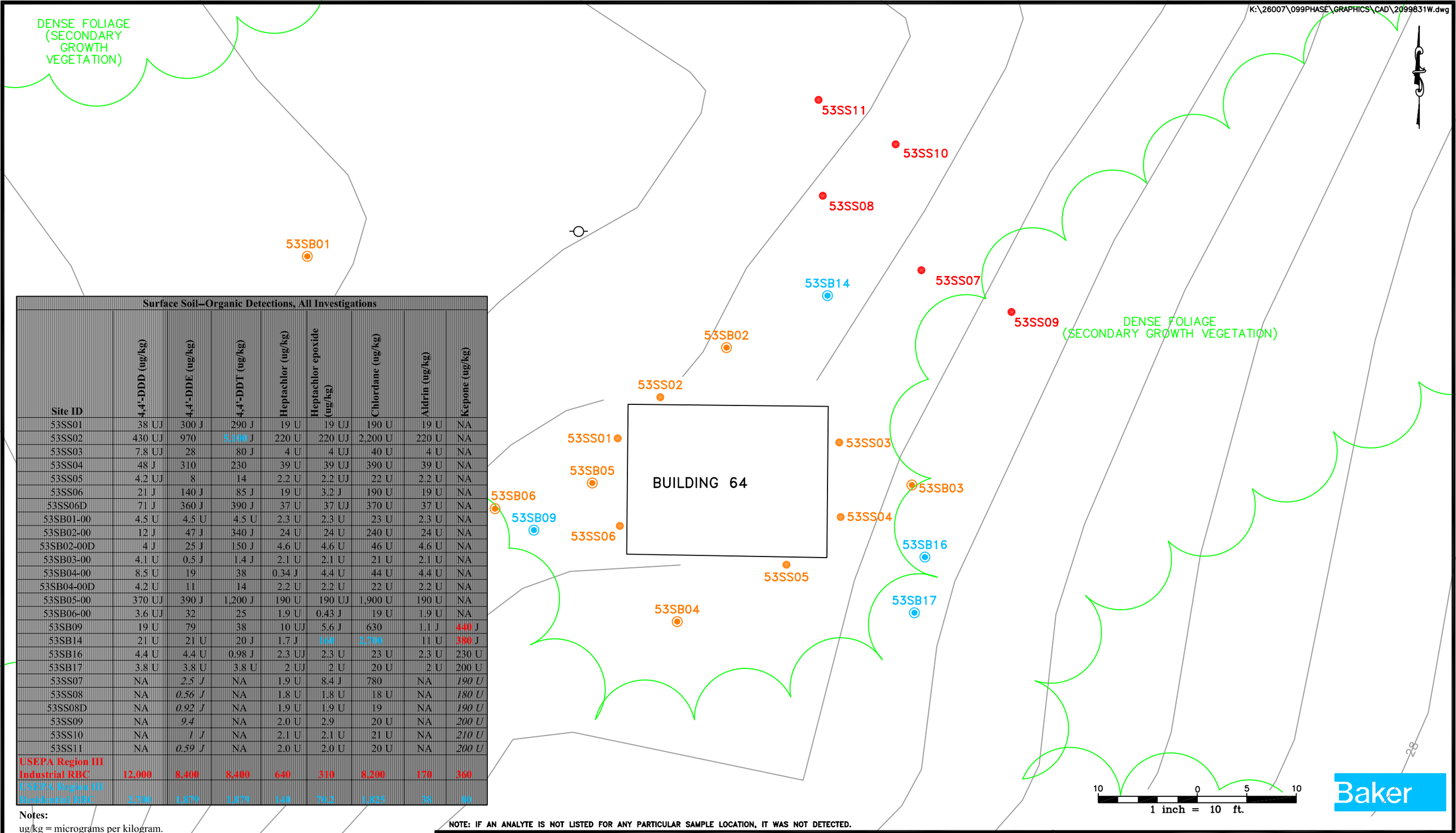

Surface Soil–Organic Detections, All Investigations

Site ID	4,4'-DDD (ug/kg)	4,4'-DDE (ug/kg)	4,4'-DDT (ug/kg)	Heptachlor (ug/kg)	Heptachlor epoxide (ug/kg)	Chlordane (ug/kg)	Aldrin (ug/kg)	Kepone (ug/kg)
53SS01	38 UJ	300 J	290 J	19 U	19 UJ	190 U	19 U	NA
53SS02	430 UJ	970	5,100 J	220 U	220 UJ	2,200 U	220 U	NA
53SS03	7.8 UJ	28	80 J	4 U	4 UJ	40 U	4 U	NA
53SS04	48 J	310	230	39 U	39 UJ	390 U	39 U	NA
53SS05	4.2 UJ	8	14	2.2 U	2.2 UJ	22 U	2.2 U	NA
53SS06	21 J	140 J	85 J	19 U	3.2 J	190 U	19 U	NA
53SS06D	71 J	360 J	390 J	37 U	37 UJ	370 U	37 U	NA
53SB01-00	4.5 U	4.5 U	4.5 U	2.3 U	2.3 U	23 U	2.3 U	NA
53SB02-00	12 J	47 J	340 J	24 U	24 U	240 U	24 U	NA
53SB02-00D	4 J	25 J	150 J	4.6 U	4.6 U	46 U	4.6 U	NA
53SB03-00	4.1 U	0.5 J	1.4 J	2.1 U	2.1 U	21 U	2.1 U	NA
53SB04-00	8.5 U	19	38	0.34 J	4.4 U	44 U	4.4 U	NA
53SB04-00D	4.2 U	11	14	2.2 U	2.2 U	22 U	2.2 U	NA
53SB05-00	370 UJ	390 J	1,200 J	190 U	190 UJ	1,900 U	190 U	NA
53SB06-00	3.6 UJ	32	25	1.9 U	0.43 J	19 U	1.9 U	NA
53SB09	19 U	79	38	10 UJ	5.6 J	630	1.1 J	440 J
53SB14	21 U	21 U	20 J	1.7 J	160	2,700	11 U	380 J
53SB16	4.4 U	4.4 U	0.98 J	2.3 UJ	2.3 U	23 U	2.3 U	230 U
53SB17	3.8 U	3.8 U	3.8 U	2 UJ	2 U	20 U	2 U	200 U
53SS07	NA	*2.5 J*	NA	1.9 U	8.4 J	780	NA	*190 U*
53SS08	NA	*0.56 J*	NA	1.8 U	1.8 U	18 U	NA	*180 U*
53SS08D	NA	*0.92 J*	NA	1.9 U	1.9 U	19	NA	*190 U*
53SS09	NA	*9.4*	NA	2.0 U	2.9	20 U	NA	*200 U*
53SS10	NA	*1 J*	NA	2.1 U	2.1 U	21 U	NA	*210 U*
53SS11	NA	*0.59 J*	NA	2.0 U	2.0 U	20 U	NA	*200 U*
USEPA Region III Industrial RBC	**12,000**	**8,400**	**8,400**	**640**	**310**	**8,200**	**170**	**360**
USEPA Region III Residential RBC	2,700	1,875	1,875	140	70.2	1,825	58	80

Notes:
ug/kg = micrograms per kilogram.
U = Not Deteced.
J = Estimated Value.
UJ = Report Quantitation Limit Qualified As Estimated
NA - Not Analyzed.
D - "D" at the end of the sample ID designates a duplicate sample.
Italics - Data not validated

NOTE: IF AN ANALYTE IS NOT LISTED FOR ANY PARTICULAR SAMPLE LOCATION, IT WAS NOT DETECTED.

LEGEND
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- ADDITIONAL SURFACE SOIL SAMPLE LOCATION (CMS INVESTIGATION, 2003)
- 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 2–4
ORGANIC SURFACE SOIL CONTAMINATION
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

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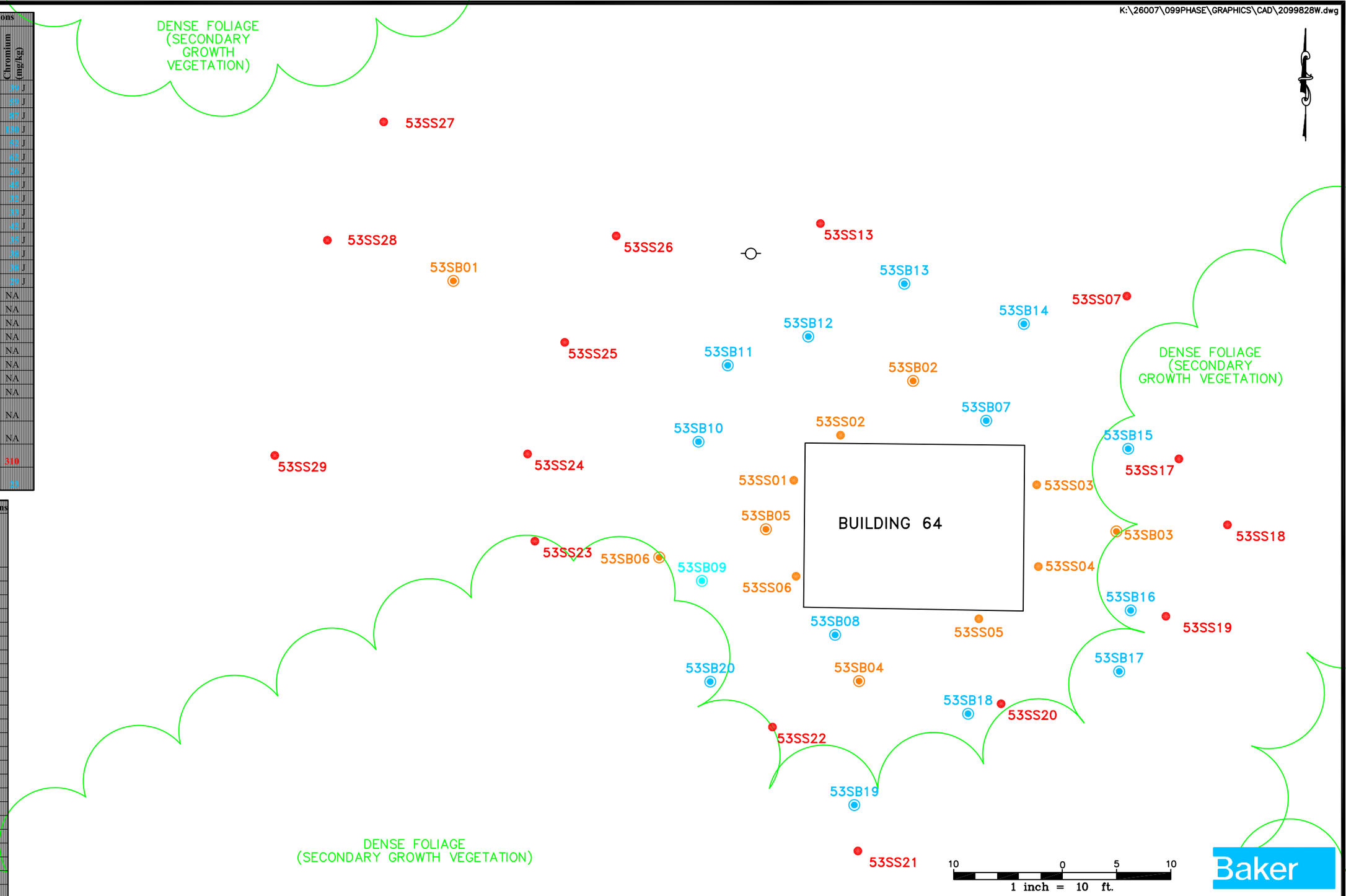
Surface Soil--Inorganic COPC Detections, All Investigations

Site ID	Arsenic (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	Chromium (mg/kg)
53SS01	5.6	87 J	300	580	96 J
53SS02	1.8	84 J	120	350	50 J
53SS03	3.1	79 J	2,500	2,200	57 J
53SS04	3.1	70 J	3,600	3,100	120 J
53SS05	1.9	120 J	900	3,100	52 J
53SS06	4.7	99 J	3,900	6,000	42 J
53SS06D	2.2	110 J	470	1,600	50 J
53SB01-00	2.3 J	83	11 R	83 J	45 J
53SB02-00	3.4 J	85	150 R	1,000 J	72 J
53SB02-00D	2.7	69	220 R	530 J	53 J
53SB03-00	0.86 J	68	81 R	300 J	42 J
53SB04-00	2.9	75	120 R	530 J	55 J
53SB04-00D	4.7	86	210 R	750 J	96 J
53SB05-00	5.6	89 J	2,200	2,600	59 J
53SB06-00	1.8	76 J	55	120	50 J
53SB07	1.1	NA	200	NA	NA
53SB08	0.85 J	NA	NA	NA	NA
53SB09	0.7	NA	NA	NA	NA
53SB10	0.97 J	NA	NA	NA	NA
53SB11	2.6 U	NA	NA	NA	NA
53SB12	3	NA	12	NA	NA
53SB13	0.86 J	NA	NA	NA	NA
53SB14	0.5 J	NA	NA	NA	NA
53SB15	0.79 J	NA	3.7	NA	NA
53SB15D	0.82 J	NA	NA	NA	NA
USEPA Region III Industrial RBC	1.9	4,100	400 (1)	31,000	310
USEPA Region III Residential RBC	0.43	310	400 (1)	2,300	23

Surface Soil--Inorganic COPC Detections, All Investigations

Site ID	Arsenic (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
53SB16	0.58 J	NA	NA	NA
53SB17	1.1 U	NA	NA	NA
53SB18	0.8	NA	NA	NA
53SB18	0.6	NA	NA	NA
53SB19	0.63 J	NA	23	NA
53SB20	0.58 J	NA	NA	NA
53SS07	NA	79	46	100
53SS13	NA	82	8.4	99
53SS17	NA	68	34	100
53SS17D	NA	71	25	85
53SS18	NA	61	53	130
53SS19	NA	98	24	100
53SS20	NA	74	70	240
53SS21	NA	63	54	200
53SS22	NA	91	190	670
53SS23	NA	86	2.7	63
53SS24	NA	72	100	220
53SS25	NA	64	7.1	65
53SS26	NA	100	19	160
53SS27	NA	82	12	85
53SS27D	NA	82	12	93
53SS28	NA	62	7.1	58
53SS29	NA	39	2.6	48
USEPA Region III Industrial RBC	1.9	4,100	400 (1)	31,000
USEPA Region III Residential RBC	0.43	310	400 (1)	2,300

Notes:
mg/kg - milligrams per kilogram.
NA - Not Analyzed.
(1) - 1996 Soil Screening Guidance.
R - Result is rejected and unusable.
J - Results are qualified as estimated.
U - Not Detected
D - "D" at the end of the sample ID designates a duplicate sample.



NOTE: IF AN ANALYTE IS NOT LISTED FOR ANY PARTICULAR SAMPLE LOCATION, IT WAS NOT DETECTED.

LEGEND

- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- ADDITIONAL SURFACE SOIL SAMPLE LOCATION (CMS INVESTIGATION, 2003)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (RFI, 2002)
- OVERHEAD ELECTRIC UTILITY POLE
- BUILDING
- TREE LINE

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 2-5
INORGANIC SURFACE SOIL CONTAMINATION
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

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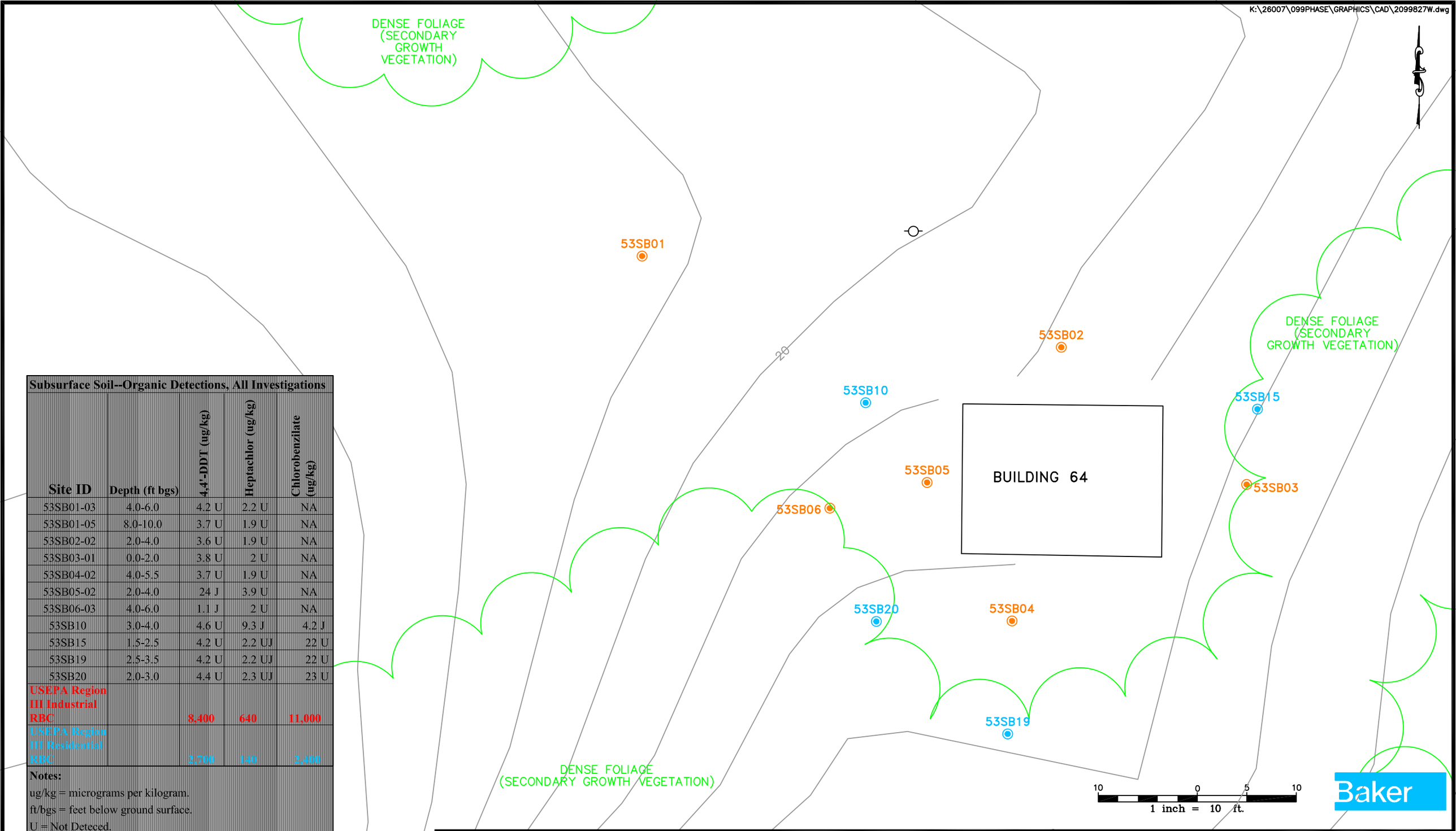

Subsurface Soil--Organic Detections, All Investigations

Site ID	Depth (ft bgs)	4,4'-DDT (ug/kg)	Heptachlor (ug/kg)	Chlorobenzilate (ug/kg)
53SB01-03	4.0-6.0	4.2 U	2.2 U	NA
53SB01-05	8.0-10.0	3.7 U	1.9 U	NA
53SB02-02	2.0-4.0	3.6 U	1.9 U	NA
53SB03-01	0.0-2.0	3.8 U	2 U	NA
53SB04-02	4.0-5.5	3.7 U	1.9 U	NA
53SB05-02	2.0-4.0	24 J	3.9 U	NA
53SB06-03	4.0-6.0	1.1 J	2 U	NA
53SB10	3.0-4.0	4.6 U	9.3 J	4.2 J
53SB15	1.5-2.5	4.2 U	2.2 UJ	22 U
53SB19	2.5-3.5	4.2 U	2.2 UJ	22 U
53SB20	2.0-3.0	4.4 U	2.3 UJ	23 U
USEPA Region III Industrial RBC		8,400	640	11,000
USEPA Region III Residential RBC		2,700	140	2,400

Notes:
ug/kg = micrograms per kilogram.
ft/bgs = feet below ground surface.
U = Not Deteced.
J = Estimated Value.
UJ = report quantitation limit is qualified as estimated.

LEGEND
- 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

NOTE: IF AN ANALYTE IS NOT LISTED FOR ANY PARTICULAR SAMPLE LOCATION, IT WAS NOT DETECTED.

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 2-6
ORGANIC SUBSURFACE SOIL CONTAMINATION
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

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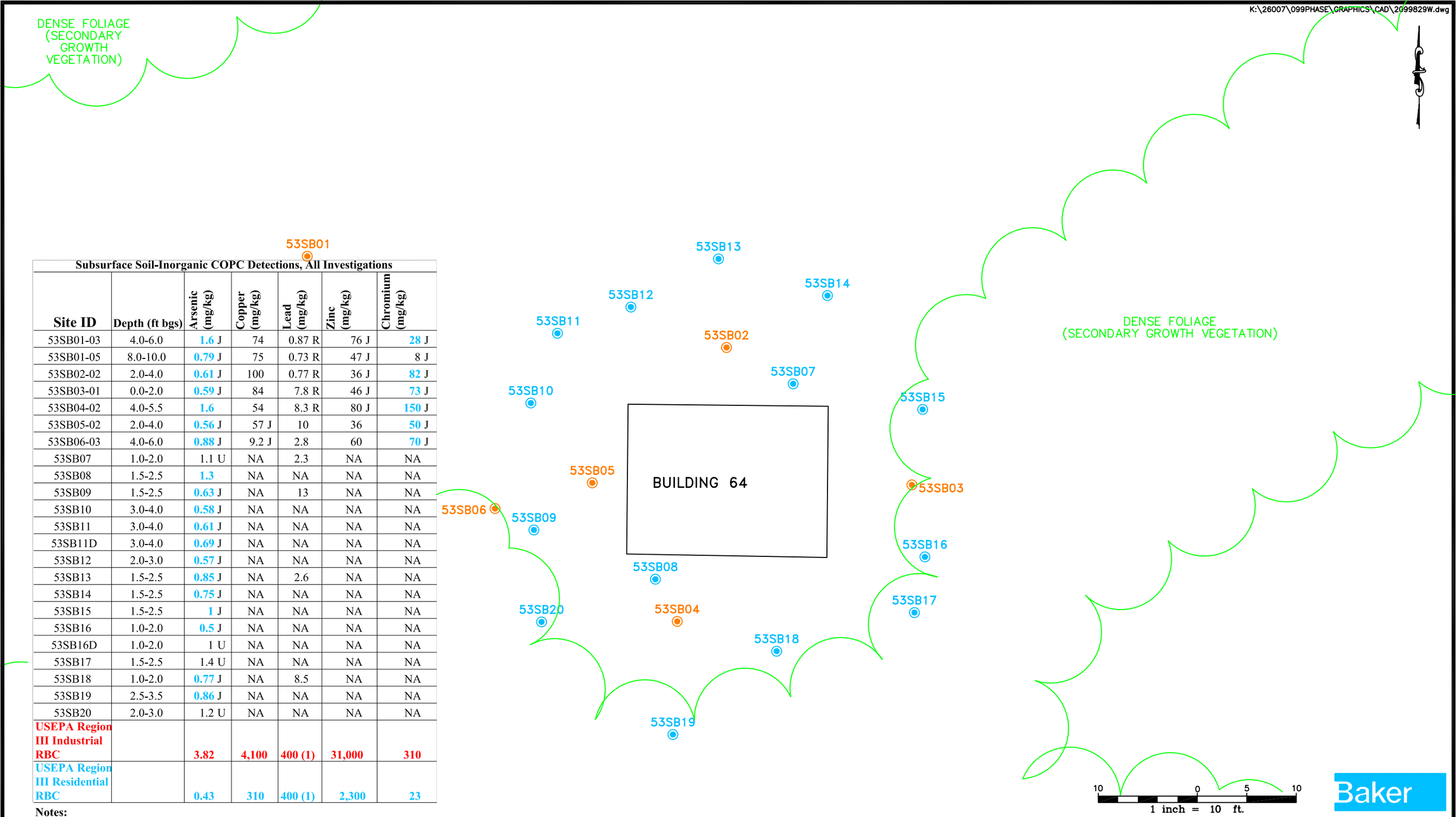

Subsurface Soil-Inorganic COPC Detections, All Investigations

Site ID	Depth (ft bgs)	Arsenic (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	Chromium (mg/kg)
53SB01-03	4.0-6.0	1.6 J	74	0.87 R	76 J	28 J
53SB01-05	8.0-10.0	0.79 J	75	0.73 R	47 J	8 J
53SB02-02	2.0-4.0	0.61 J	100	0.77 R	36 J	82 J
53SB03-01	0.0-2.0	0.59 J	84	7.8 R	46 J	73 J
53SB04-02	4.0-5.5	1.6	54	8.3 R	80 J	150 J
53SB05-02	2.0-4.0	0.56 J	57 J	10	36	50 J
53SB06-03	4.0-6.0	0.88 J	9.2 J	2.8	60	70 J
53SB07	1.0-2.0	1.1 U	NA	2.3	NA	NA
53SB08	1.5-2.5	1.3	NA	NA	NA	NA
53SB09	1.5-2.5	0.63 J	NA	13	NA	NA
53SB10	3.0-4.0	0.58 J	NA	NA	NA	NA
53SB11	3.0-4.0	0.61 J	NA	NA	NA	NA
53SB11D	3.0-4.0	0.69 J	NA	NA	NA	NA
53SB12	2.0-3.0	0.57 J	NA	NA	NA	NA
53SB13	1.5-2.5	0.85 J	NA	2.6	NA	NA
53SB14	1.5-2.5	0.75 J	NA	NA	NA	NA
53SB15	1.5-2.5	1 J	NA	NA	NA	NA
53SB16	1.0-2.0	0.5 J	NA	NA	NA	NA
53SB16D	1.0-2.0	1 U	NA	NA	NA	NA
53SB17	1.5-2.5	1.4 U	NA	NA	NA	NA
53SB18	1.0-2.0	0.77 J	NA	8.5	NA	NA
53SB19	2.5-3.5	0.86 J	NA	NA	NA	NA
53SB20	2.0-3.0	1.2 U	NA	NA	NA	NA
USEPA Region III Industrial RBC		3.82	4,100	400 (1)	31,000	310
USEPA Region III Residential RBC		0.43	310	400 (1)	2,300	23

Notes:

mg/kg - milligrams per kilogram.
ft bgs - Feet Below Ground Surface
NA - Not Analyzed.
(1)- 1996 Soil Screening Guidance.
R - Result is rejected and unusable.
J - Results are qualified as estimated.
U- Non Detected
D - "D" at the end of the sample ID designates a duplicate sample.

DENSE FOLIAGE
(SECONDARY GROWTH VEGETATION)

LEGEND

- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- ADDITIONAL SURFACE SOIL SAMPLE LOCATION (CMS INVESTIGATION, 2003)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (RFI, 2002)
- OVERHEAD ELECTRIC UTILITY POLE
- BUILDING
- TREE LINE

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

Baker

FIGURE 2-7
INORGANIC SUBSURFACE SOIL CONTAMINATION
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

K:\26007\099PHASE\GRAPHICS\CAD\2099826W.dwg

DENSE FOLIAGE (SECONDARY GROWTH VEGETATION)

DENSE FOLIAGE (SECONDARY GROWTH VEGETATION)

DENSE FOLIAGE (SECONDARY GROWTH VEGETATION)

Wipe Sample Results

Site ID	4,4'-DDE (ug/100 cm^2)	4,4'-DDD(ug/100 cm^2)	4,4'-DDT (ug/100 cm^2)
53WP01	5.5 J	0.4 UJ	17 D
53WP02	1.1	0.1 UJ	1.4
53WP03	1.6	0.12 J	1.1
53WP04	0.47	0.2 UJ	3.7

Notes:

ug/100 cm^2 = micrograms per 100 centimeters squared

J = Estimated value.

UJ = Reported quantitation limit is qualified as estimated.

D = Result value is based on dilution analysis.

53WP01 (W)

53WP03 (W)

BUILDING 64

53WP02 (W)

53WP04 (W)

28

10 0 5 10

1 inch = 10 ft.

Baker

LEGEND

(W) – WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2003)

– BUILDING

– GROUND SURFACE CONTOUR LINE

– TREE LINE

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 2–8

WIPE SAMPLE RESULTS
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

3.0 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT AND STEP 3A OF THE BASELINE ECOLOGICAL RISK ASSESSMENT

This section presents a screening-level ecological risk assessment (ERA) and Step 3a of the baseline ERA for SWMU 53, located at NSRR, Ceiba, Puerto Rico. The ERA was 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 3-1) consists of eight steps organized into three tiers and represents a clarification and interpretation of the eight-step ERA process outlined in the United States Environmental Protection Agency ERA guidance for the Superfund program (USEPA 1997). 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 Steps 1 and 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 1997), 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. 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 ERA problem formulation).

3.1 Environmental Setting

The sections that follow provide a brief description of the site. The habitats occurring within and contiguous to SWMU 53 are also described, as well as the biota that may be present. The description of habitats and biota relies primarily on literature-based information for Puerto Rico and NSRR. This information is supplemented by site-specific information when available.

3.1.1 Site History

NSRR occupies over 8,600 acres on the East Coast of Puerto Rico, along Vieques Passage (see Figure 2-1), with Vieques Island lying approximately ten miles to the east. NSRR was commissioned in 1943 as a Naval Operations Base and re-designated a Naval Station in 1957. The primary mission of NSRR is provision of full support for Atlantic Fleet weapons training and development activities.

SWMU 53 (The Malaria Control Building [Building 64]) was built in 1942 and condemned in 1980. The building was used for the storage of pesticides, such as aldrin and DDT. No other use of the building and surrounding land has been identified. Although no direct evidence exists, it is assumed that mixing and other preparation for pesticide use was also performed in the building. 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 ten percent of the total SWMU 53

acreage. The SWMU is located on a gentle slope (approximately 5-7 percent grade) from the northeast (upgradient) to the southwest (downgradient), approximately 200 feet from Forrestal Drive (see Figures 2-2 and 2-3).

3.1.2 Terrestrial and Marine Habitats

The upland habitat bounded by NSRR is classified as subtropical dry forest (Ewel and Witmore 1973). Similar to other forested areas of Puerto Rico, this region was previously clear-cut in the early part of the century, primarily for pastureland (Geo-Marine, Inc. 1998). After acquisition by the Navy, a secondary growth of thick scrub, dominated by leadtree (*Leucaena spp*.), box briar (*Randia aculeate*), sweet acacia (*Acacia famesiana*), and Australian corkwood (*Sesbania grandiflora*) grew in the previously grazed sections (Geo-Marine, Inc. 1998). Secondary growth communities (upland coastal forest communities and coastal scrub forest communities) exist today throughout the station's undeveloped upland. The vegetative community within and contiguous to SWMU 53 is classified as an upland coastal forest community (see Figure 3-2).

The marine environment surrounding NSRR includes mudflats, mangroves (black mangrove and red mangrove communities), and seagrass beds (turtle grass and manatee grass). The total area of mudflats, mangroves, and sea grass beds in the offshore environment is approximately 161 acres, 2,700 acres, and 1,900 acres, respectively (Geo-Marine, Inc. 1998). Coral reefs are also located in the offshore marine environment. Seagrass beds represent grazing areas for the green sea turtle (*Chelonia mydas*) and the West Indian manatee (*Trichechas manatus*). The green sea turtle is a federally threatened species, while the West Indian manatee is a federally endangered species. Both species have been reported from the marine environment surrounding NSRR.

The nearest surface water body downgradient from SWMU 53 is the Ensenada Honda (approximately 2000 feet to the south). A map showing the spatial relationship of SWMU 53 to the Ensenada Honda is provided as Figure 3-3. Included on this map are wetland units identified by the Cowardian Wetland Classification System (Cowardian et al. 1979 [see Figure 3-4]). The wetlands depicted on Figure 3-3 were delineated by Geo-Marine, Inc. in December 1999 from 1993 color infrared and 1998 true color aerial photography. Twenty percent of the wetlands delineated by aerial photography were field checked to verify the accuracy of the delineations. Field verification was based on the 1987 Corps of Engineers wetland delineation manual (United States Army Corps of Engineers [USACE] 1987). As evidenced by Figure 3-3, there are no freshwater or estuarine wetland units within or contiguous to SWMU 53.

3.1.3 Biota

A total of 22 terrestrial mammal species are known historically from Puerto Rico; however, all mammals except bats (13 species) have been extirpated (United States Geological Society [USGS] 1999). None of the bats found on Puerto Rico are exclusive to the island. The West Indian manatee is known to occur in the marine environment surrounding NSRR. As depicted on Figure 3-2, sea grass beds are located throughout much of the shallow water habitat within the Ensenada Honda and the marine environment surrounding NSRR. Their locations represent potential feeding habitat for the West Indian manatee.

Several mammals have been introduced into Puerto Rico, including the black rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*), and mongoose (*Herpestes javanicus*). These nonindigenous mammals have been implicated in the decline of native bird and reptile populations (USGS 1999 and United States Fish and Wildlife Service [USFWS] 1996).

A total of 239 bird species are native to Puerto Rico (Raffaele 1989). This total includes breeding permanent residents and non-breeding migrants. In addition, many nonindigenous bird species have been introduced to Puerto Rico, including the shiny cowbird (*Molothrus bonariensis*) and several parrot species, such as the budgerigar (*Melopsittacus undulates*), orange-fronted parrot (*Aratinga canicularis*), and monk parrot (*Myiopsitta monaqchus*). Of the 239 species native to Puerto Rico, 12 are endemic to the island (Raffaele 1989).

Numerous native and migratory bird species have been reported at NSRR (Geo-Marine, Inc. 1998). A list of bird species reported at NSRR or having the potential to occur is provided in Table 3-1. The list, compiled from literature-based information pre-dating 1990, includes the great blue heron (*Ardea herodias*), snowy egret (*Egretta thula*), little blue heron (*Florida caerulea*), black-crowned night heron (*Nycticorax nycticorax*), belted kingfisher (*Ceryle alcyon*), spotted sandpiper (*Actitis macularia*), greater yellowlegs (*Tringa melanoleauca*), black-bellied plover (*Squatarola squatarola*), clapper rail (*Rallus longirostris*), Royal tern (*Thalasseus maximus*), sandwich tern (*Thalasseus sandvicensis*), least tern (*Stema albifrons*), yellow warbler (*Dendroica petechia*), palm warbler (*Dendroica palmarum*), prairie warbler (*Dendroica discolar*), magnolia warbler (*Dendrocia magnolia*), mourning dove (*Zenaida macroura*), red-legged thrush (*Mimocichla plumbea*), common nighthawk (*Chordeiles minor*), and red-tailed hawk (*Buteo jamaicensis*).

Endemic species reported from NSRR include the Puerto Rican lizard cuckoo (*Saurothera vieilloti*), Puerto Rican flycatcher (*Myiarchus antillarum*), Puerto Rican woodpecker (*Malanerpes portoricensis*), Puerto Rican emerald (*Chlorostilbon maugaeus*), and yellow-shouldered blackbird (*Agelaius xanthomus*).

The yellow-shouldered blackbird is a federally endangered species. One of the principal reasons for the status of this species is attributed to parasitism by the nonindigenous shiny cowbird, which lays its eggs in blackbird nests and sometimes punctures the host's eggs (USFWS 1983). Other factors contributing to the status of this species include nest predation by the introduced black rat, Norway rat, and mongoose, as well as habitat modification and destruction (USFWS 1996). The entire land area of NSRR was declared critical habitat for the yellow-shouldered blackbird in 1976; however, a 1980 agreement with the USFWS exempted certain areas from this categorization (Geo-Marine, Inc. 1998). A study conducted by the Naval Facilities Engineering Command (1996) reported that the mangrove forests surrounding NSRR should be considered the most important nesting habitats for the yellow-shouldered blackbird. As evidenced by Figure 3-2, SWMU 53 is not located within the critical habitat designation (i.e., mangroves) for the yellow-shouldered blackbird. It is noted that the last reported nesting pair of yellow-shouldered blackbirds at NSRR was in 1986 (USFWS 1996). Other federally listed bird species that have been reported at NSRR or have the potential to occur are the brown pelican (*Pelecanus occidentalis occidentalis*), roseate tern (*Sterna dougallii dougallii*), and the piping plover (*Charadrius melodus*) (Geo-Marine, Inc. 1998). Given their habitat preferences (aquatic) and prey preferences (aquatic invertebrates or fish), these species are not expected to occur at SWMU 53.

A total of 23 amphibians and 47 reptiles are known from Puerto Rico and the adjacent waters (USGS 1999). Fifteen of the amphibians and 29 of the reptiles are endemic, while four amphibian species and three reptilian species have been introduced (USGS 1999). Puerto Rico's native amphibian species include 16 species of tiny frogs commonly called coquis. On the coastal lowlands, almost all coqui species are arboreal. Only the Puerto Rican ridge-headed toad (*Peltophryene lemur*) and the golden coqui (*Eleutherodactylus jasperi*) have been listed as threatened under provisions of the Endangered Species Act of 1973. Distribution of the golden coqui is restricted to areas of dense bromeliad growth. All specimens to date have been collected

from a small semicircular area of a 6-mile radius south of Cayeye (approximately 30 miles southwest of NSRR), generally at elevations above 700 meters (USFWS 1984). The Puerto Rican ridge-headed toad occurs at low elevations (below 200 meters) where there is exposed limestone or porous, well drained soil offering an abundance of fissures and cavities (USFWS 1987). A single large population is known to exist from the southwest coast in Guanica Commonwealth Forest, and a small population is believed to survive on the north coast near Quebradillas, Arecibo, Barceloneta, Viga Baja, and Bayamon (USFWS 1987). It has also been collected on the southeastern coastal plain near Coamo (USFWS 1987). Given the habitat preferences and locations of known occurrences, these two species are not expected to occur at NSRR. Puerto Rico's native reptilian species include 31 lizards, 8 snakes, 1 freshwater turtle, and 5 sea turtles (USGS 1999). Of the five sea turtles, only the green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), and loggerhead sea turtle (*Dermochelys coriacea*) nest within Puerto Rico. The green sea turtle, hawksbill sea turtle, and the loggerhead sea turtle, as well as the leatherback sea turtle (*Caretta caretta*) and the Puerto Rican boa (*Epicrates inornatus*) have been listed under the provisions of the Endangered Species Act of 1973 (USGS 1999).

A diverse fish and invertebrate community can be found in the marine environment surrounding NSRR. This can be attributed to the varied habitats that include marine and estuarine open water habitat, mud flats, sea grass beds, and mangrove forests. The fish community is represented by stingrays, herrings, groupers, needlefishes, mullets, barracudas, jacks, snappers, grunts, snooks, lizardfishes, parrotfishes, gobies, filefishes, wrasses, damselfishes, and butterflyfishes (Geo-Marine, Inc. 1998). The benthic invertebrate community includes sponges, corals, anemones, sea cucumbers, sea stars, urchins, and crabs. A list of known species residing within the Ensenada Honda, the nearest downgradient surface water body to SWMU 53, is not available.

3.2 Sources of Available Analytical Data

Sampling activities at SWMU 53 have been conducted under three separate field investigations:

> A sampling program conducted in December 2000 in accordance with the Draft Sampling and Analysis Plan for SWMUs 53/54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 2000).
>
> A sampling program conducted in February 2002 in accordance with the Final RCRA Facility Investigation Work Plan for SWMUs 53 and 54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 2001a).
>
> A sampling program conducted in March 2003 in accordance with the Final Corrective Measures Study Work Plan for SWMUs 53 and 54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 2003).

Environmental media collected during these field investigations included surface soil and/or subsurface soil (i.e., soil collected at depths greater than one foot bgs). Analytical data from the December 2000 sampling event were presented and discussed in the Final Sampling and Analysis Report for SWMUs 53 and 54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 2002a), while analytical results from the RFI field investigation were presented and discussed in the Draft RCRA Facility Investigation Report for SWMUs 53 and 54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 2002b). Analytical results from the CMS field investigation are

presented and discussed in Appendix A. A summary of the analytical results from the field investigations was also presented and discussed in Section 2.0 of this Task I CMS report.

A listing of the surface and subsurface soil samples collected during the SWMU 53 field investigations is provided in Table 3-2. Included in the table are collection dates, sample depths, and analytical parameters (by chemical group). Sample locations are depicted on Figure 2-3. The specific analytical data used in the screening-level ERA, as well as the criteria for their selection are presented and discussed in Section 3.5.1.

3.3 Screening-Level Problem Formulation

Problem formulation establishes the goals, scope, and focus of the ERA. The products of the screening-level problem formulation are (1) the preliminary conceptual model and (2) the assessment and measurement endpoints. The purpose of the preliminary conceptual model is to describe how ecological receptors may be exposed to chemicals originating from the site. The preliminary conceptual model is developed using information regarding major habitats and ecological receptors, media of concern, and potential contaminant sources in conjunction with an understanding of potential transport pathways, exposure pathways, and exposure routes. The fate, transport, and toxicological properties of the chemicals present at the site are also considered during this process. Assessment and measurement endpoints define the ecological attributes to be protected. They are selected to evaluate those receptors for which complete and potentially significant exposure pathways are likely to exist.

3.3.1 Preliminary Conceptual Model

Exposure, and thus potential for risk, can only occur if each of the following conditions are present (USEPA, 1998):

A source of contamination must be present.

Release and transport mechanisms must be available to move the contaminants from the source to an exposure point.

An exposure point must exist where ecological receptors could contact affected media.

An exposure route must exist whereby the contaminant can be taken up by ecological receptors.

Figure 3-5 presents a preliminary conceptual model for SWMU 53. The conceptual model outlines potential sources of contaminants, transport pathways, exposure media, potential exposure routes, and receptor groups at SWMU 53. Specific components of the preliminary conceptual model (i.e., source areas, transport pathways, and exposure pathways and routes) are discussed in the sections that follow.

3.3.1.1 Source Areas

The Malaria Control Building (Building 64) represents a historical source area for the release of chemicals (i.e., pesticides) to abiotic media (i.e., surface soil). Contaminated surface and subsurface soil also represent current potential source areas for the release of chemicals to groundwater and/or downgradient surface soil.

3.3.1.2 Transport Pathways

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media. As depicted on Figure 3-5, the primary mechanisms for contaminant transport from current potential source areas at SWMU 53 are believed to include the following:

Overland transport of chemicals with surface soil via surface runoff to downgradient surface soil.
Uptake by biota from surface soil and trophic transfer to upper trophic level receptors.

Leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport to Ensenada Honda surface water and sediment with groundwater is also a potential transport pathway. However, this pathway is considered is not considered significant for the following reasons:

The physical and chemical properties of the organochlorine pesticides detected in SWMU 53 surface soil (see Section 3.3.3) suggest that these chemicals have a tendency to adhere strongly to soil particles. This line of reasoning is supported by subsurface soil analytical data for SWMU 53. Only a single pesticide (4,4'-DDT) was detected in subsurface soil (24 J micrograms per kilogram [µg/kg] in 53SB05-02 [4.0-5.5 feet [ft] bgs] and 1.1 J µg/kg in 53SB06-03 [4.0-6.0 ft bgs]). Given maximum detected surface soil concentrations of 5,100 J µg/kg for 4,4'DDT, 970 µg/kg for 4,4'-DDE, and 2,700 µg/kg for chlordane, the subsurface soil analytical data indicate that organochlorine pesticides are not migrating in a vertical direction with infiltrating precipitation to a significant extent.

The subsurface soil data also indicate that inorganics are not migrating in a vertical direction with infiltrating precipitation to a significant extent. For example, maximum detected lead and zinc concentrations in surface soil were 3,900 mg/kg and 5,800 mg/kg, respectively. However, maximum detected lead and zinc concentrations in subsurface soil were only 10 mg/kg and 80 J mg/kg, respectively.

Bedrock underlies the entire site at depths ranging from 4.5 to 10 feet bgs. Because groundwater underlying the site is located within the bedrock, groundwater is not in contact with subsurface soils at the site.

Given the distance of the nearest downgradient surface water body to SWMU 53 (Ensenada Honda is located approximately 2000 feet south of SWMU 53), chemicals in groundwater would be expected to undergo significant attenuation prior to reaching the Ensenada Honda.

Although leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport to Ensenada Honda surface water and sediment with groundwater is considered an insignificant transport pathway, the lack of groundwater is a source of uncertainty in this screening-level ERA.

There are no storm drains or drainage ditches within or immediately contiguous to SWMU 53 that could serve as transport pathways for the migration of chemicals with storm water to downgradient surface water and sediment within the Ensenada Honda. A drainage ditch is

located adjacent to Forrestal Road, approximately 200 feet downgradient from Building 64 (see Figure 3-6). This ditch is located within the drainage area for a National Pollutant Discharge Elimination System (NPDES) permitted storm water outfall (Outfall 002), which discharges to a mangrove forest bordering the Ensenada Honda. Given the 5-7 percent grade from the northeast to southwest direction at SWMU 53, storm water runoff from the SWMU has the potential to enter the drainage ditch. However, given the dense coverage of secondary growth vegetation at SWMU 53, migration of chemicals with surface soil via surface water runoff to this drainage ditch is not likely. This line of reasoning is supported by analytical data from the RFI field investigation (see Baker 2000b) and CMS field investigation (see Appendix A). These investigations have demonstrated that the spatial extent of surface soil contamination at SWMU 53 is limited to the immediate vicinity of Building 64 and does not extend to the drainage ditch adjacent to Forrestal Drive. For the reasons discussed above, overland transport of chemicals with surface soil via surface runoff to downgradient surface water and sediment is not considered a significant pathway at SWMU 53. While there is no evidence that chemicals are currently migrating to the drainage ditch, future transport with surface soil via surface runoff remains a possibility. Corrective measures will be implemented at SWMU 53 to address potential risks to terrestrial receptors detected by this ERA, thus minimizing the possibility of future transport.

3.3.1.3 Exposure Pathways and Routes

An exposure pathway links a source of contamination with one or more receptors via exposure to one or more media. Requirements for a complete exposure pathway were presented in Section 3.3.1. As depicted on Figure 3-5, potentially complete and significant exposure pathways exist at SWMU 53.

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 plants may be exposed to chemicals present in surface soil 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 or (for rooted plants) from sediments. Terrestrial and aquatic invertebrates may be exposed to chemicals in soil, sediment, or surface water through dermal adsorption and ingestion. Much of the toxicological data available for terrestrial invertebrates are based upon *in situ* studies that represent both pathways. Therefore, both pathways were considered together in this screening-level ERA. Terrestrial invertebrates also present a link between surface soil and terrestrial invertebrate consumers through food web transfer. As such, they were 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. These exposure routes, where applicable, are depicted on Figure 3-5. Their relative importance depends in part on the chemical being evaluated. For chemicals having the potential to bioaccumulate (e.g., PCBs and organochlorine pesticides), the greatest exposure to wildlife is likely to be from the ingestion of prey. For chemicals having a limited potential to bioaccumulate (e.g., aluminum), the exposure of wildlife to chemicals is likely to be greatest through the direct ingestion of abiotic media, such as surface soil.

Direct ingestion of drinking water is only considered if the salinity of a drinking water source is less than 15 parts per thousand (ppt), the approximate toxic threshold for wildlife receptors (Humphreys 1988). As evidenced by Figure 3-3, there are no fresh surface water bodies within or contiguous to SWMU 53 that can serve as a drinking water source. Thus, ingestion of surface water is not a potential complete exposure pathway and was not considered in risk calculations for upper trophic level receptors.

Certain potential exposure pathways and/or routes identified on or excluded from Figure 3-5 were not evaluated in the screening-level ERA. Though potentially complete, these pathways were considered insignificant relative to other pathways due to low potential for exposure and low levels of relevant contaminants. For example, dermal exposures were not identified as significant relative to ingestion exposures for upper trophic level receptors and were not evaluated in the screening-level ERA. This approach is supported by evidence outlined in Suter II et al. (2000) and the USEPA (2000), including the general fate properties of the compounds detected in surface soil, (e.g., low affinity for dermal uptake), the low potential exposure frequency and duration, and the protection offered by feathers, fur, and scales to avian, mammalian, and reptilian receptors. In addition, literature reviews indicate that dermal exposures to wildlife from classes of chemicals known or suspected to be of concern via dermal adsorption (e.g., volatile organic compounds [VOCs] and petroleum compounds) are often overestimated in laboratory studies (where feathers/fur are removed) and do not represent realistic exposure scenarios (USEPA 2000). Furthermore, though burrowing reptiles (which would be expected to experience the most significant exposure) potentially inhabit SWMU 53, chemicals known or suspected to be of concern via dermal adsorption are not associated with historical activities at the site. Moreover, in developing surface soil screening levels for twenty-four important compounds identified from National Priorities List (NPL) sites and Biological Technical Assistant Group (BTAG) recommendations, USEPA calculated that the contribution of dermal exposures to the total dose received by terrestrial receptors to be 0.5% or less and therefore omitted the dermal pathway from in their exposure estimates (USEPA, 2000). Direct contact exposures were considered for lower trophic level receptors (i.e., terrestrial invertebrates).

Inhalation of gaseous chemicals and chemicals adhered to particulate matter (e.g., soil) were also excluded from evaluation in this screening-level ERA as the inhalation pathway is considered insignificant relative to ingestion pathways. As described above for dermal exposures, this approach is consistent with Suter II et al. (2000) and USEPA (1997 and 2000), which recognize the relatively small contribution the inhalation pathway contributes to exposure estimates. For example, USEPA (2000) estimates the expected contribution of exposure to dust particles and VOCs via inhalation to be 0.01% and 0.5% or less, respectively relative to ingestion. Site conditions further reduces the importance of this exposure route relative to ingestion. The vegetative groundcover at SWMU 53 minimizes the suspension of dust and thus, the potential for exposure via inhalation of chemicals adhered to soil particles. Furthermore, inhalation of gaseous chemicals that have volatilized from surface soil is unlikely given the types of chemicals associated with SWMU 53 (pesticides and metals) and their general fate properties.

Potentially complete and significant exposure pathways for terrestrial mammals (i.e., incidental ingestion of surface soil and ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs) were not selected for evaluation. The exclusion of mammals is appropriate because the potentially exposed mammalian receptors are limited to nonindigenous, nuisance species (see Section 3.1.3). However, because they represent a potential link between surface soil chemicals and terrestrial carnivores, they were included as food items in this screening-level ERA.

Though potentially complete exposure pathways have been identified for terrestrial reptiles and amphibians (i.e., coquis) at SWMU 53 (see Figure 3-5), there is a paucity of data concerning the toxicological effects of chemicals for reptiles and amphibians, rendering a quantitative evaluation problematic (USEPA 2000). However, it can be qualitatively stated that reptiles and amphibians are not at risk if no risks are identified to other upper trophic level receptors utilizing the site that occupy a similar trophic level. Therefore, an examination of exposures and risks to ecological receptors occupying similar trophic levels was performed. Although this represents an uncertainty in the assessment, it is assumed that terrestrial reptiles and amphibians are not likely to be more sensitive to chemical exposures than the other receptor groups that are included in the screening-level ERA.

3.3.2 Endpoints and Risk Hypotheses

The conclusion of the screening-level problem formulation includes the selection of ecological endpoints, which are based on the preliminary conceptual model. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the ERA process as are risk hypotheses or risk questions (USEPA 1997 and 1998). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic that is related to the component or value chosen as the assessment endpoint. The considerations for selecting assessment and measurement endpoints are summarized in USEPA (1992 and 1997) and discussed in detail in Suter II (1989, 1990, and 1993). Risk hypotheses are testable hypotheses about the relationship among the assessment endpoints and their predicted responses when exposed to contaminants.

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. 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 1997). Assessment endpoints contain an entity (e.g., muskrat population) 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.

Assessment and measurement endpoints may involve ecological components from any level of biological organization, from individual organisms to the ecosystem itself (USEPA 1992). Effects on individuals are important for some receptors, such as rare and endangered species; however, 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., National Ambient Water Quality Criteria [NAWQC] for the Protection of Aquatic Life) can be useful in evaluating potential community- and/or population-level effects.

Table 3-3 summarizes the assessment endpoints, risk hypotheses, and measurement endpoints selected for the screening-level ERA. The assessment endpoints selected were based on the survival, growth, and reproduction of terrestrial receptor groups (terrestrial invertebrates and plants) and upper trophic level birds (herbivores, omnivores, and carnivores). The population traits of interest for each of the assessment endpoints represent components of a healthy population.

Failure or impairment of survival, growth, or reproduction will adversely affect the ability of the population to be healthy and viable and fill its appropriate role in an ecosystem.

3.3.2.1 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, specific receptor species (e.g., red-tailed hawk) or species groups (e.g., soil invertebrates) are often selected as surrogates to evaluate potential risks to larger components of the ecological community (e.g., avian carnivores) used to represent the assessment endpoints (e.g., survival, growth, and reproduction of avian carnivores). 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; and

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

Lower trophic level receptor species were evaluated based on those taxonomic groupings (i.e., terrestrial plants and invertebrates) for which screening values have been developed. These groupings and screening values are used in most ERAs. As such, specific receptor species of lower trophic level terrestrial biota were not chosen because of the limited species-specific information available. These receptors were instead dealt with on a community level via a comparison to surface soil screening values.

The upper trophic level receptor species listed below were chosen for dietary exposure modeling based on the criteria listed above, the general guidelines presented in USEPA (1991), and the assessment endpoints (see Table 3-3).

Mourning dove (*Zenaida macroura*) (avian herbivore)

American robin (*Turdus migratorius*) (avian omnivore)

Red-tailed hawk (*Buteo jamaicensis*) (avian carnivore)

With the exception of the American robin, the upper trophic level receptors listed above are known to occur at NSRR (Raffaele 1989). The American robin was selected as a surrogate species to represent birds reported from NSRR with similar feeding habits and dietary preferences (e.g., red-legged thrush). As discussed previously in Section 3.3.1.3, a terrestrial mammal was not selected as an ecological receptor for the following reasons:

With the exception of bats, all native terrestrial mammals have been extirpated from Puerto Rico. Life history information for Puerto Rico's native bat species is severely limited or lacking altogether.

The terrestrial mammals represented by potentially complete exposure pathways are limited to nonindigenous, nuisance species (i.e., Norway rat, black rat, and mongoose) that have been implicated in the decline of native reptilian and bird populations.

While exposure pathways to terrestrial reptiles and amphibians are likely to be complete, a specific reptilian and amphibian species was not selected as a receptor species in this screening level ERA since the life history and toxicological database concerning the effects of chemicals on reptiles and amphibians is severely limited. It is assumed that terrestrial reptiles and amphibians potentially present at the site are not exposed to significantly higher concentrations of chemicals and are not more sensitive to chemicals than the other receptor species evaluated in the risk assessment. This assumption is a source of uncertainty in the screening-level ERA.

3.3.3 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 adsorption to solids, octanol-water partitioning, and organic carbon partitioning. These characteristics are defined below.

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, with either the 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 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 3.0 or less generally indicates that the chemical will not bioconcentrate to a significant degree (Maki and Duthie 198). Log K_{ow} values and K_{oc} values for organic chemicals analyzed in environmental media collected from SWMU 53 are presented in Table 3-4. The Log K_{ow} and K_{oc} values presented in Table 3-4 indicate that the organic chemicals associated with SWMU 53 will not undergo significant transport from potential source area.

3.4 Screening-Level Effects Evaluation

The purpose of the screening level 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 selected assessment endpoint. For this evaluation, two types of screening values were developed (media-specific screening values and ingestion-based screening values). Media-specific screening values were developed for surface soil, while ingestion-based screening values were developed for avian food web (dietary) exposures.

3.4.1 Surface Soil Screening Values

The literature-based toxicological benchmarks listed below, expressed as dry weight concentrations, were selected for use as surface soil screening values.

Toxicological thresholds for earthworms (Efroymson et al. 1997a)
Toxicological thresholds for plants (Efroymson et al. 1997b)

For a given chemical, when more than one screening value was available from the sources listed above, the lowest value was conservatively selected as the surface soil screening value for use in the screening-level ERA. As evidenced by Table 3-5, the toxicological thresholds available from Efroymson et al. 1997a and 1997b for chemicals analyzed in surface soil samples collected from SWMU 53 are limited to inorganics. Plant and invertebrate-based toxicological thresholds for organochlorine pesticides were not available from other literature sources (e.g., USEPA 1999 and 2000). For these chemicals, Dutch Ministry of Housing, Spatial Planning and Environment soil standards (MHSPE 1994) were used as surface soil screening values. MHSPE soil standards were derived assuming a minimum default soil organic carbon content of 2.0 percent (MHSPE 1994). For those pesticides lacking a soil standard, background-based values from Friday (1998) were used as surface soil screening values. Because background-based values do not represent effect concentrations, their use as surface soil screening values represents a source of uncertainty in the screening-level ERA.

3.4.2 Ingestion-Based Screening Values

Ingestion-based screening values for dietary exposures were 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 was used if available. This information was 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 were 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 were available from the literature, the most appropriate study was selected for each receptor species based on study design, study methodology, study duration, study endpoint and test species. When chronic NOAEL values were unavailable, estimates were derived or extrapolated from chronic Lowest Observed Adverse Effect Levels (LOAELs) or median lethal dose 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 was used to convert a reported chronic LOAEL to a chronic NOAEL,

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

Ingestion-based screening values for the bird species selected as ecological receptors (American robin, mourning dove, and red-tailed hawk), expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day), are summarized in Table 3-6. Sample et al. (1996) consider a scaling factor of 1.0 most appropriate for interspecies extrapolation between birds. Therefore, the NOAEL and LOAEL values summarized in Table 3-6 were not adjusted to reflect differences in body weight between avian test species and receptor species.

3.5 Screening-Level Exposure Estimation

This section presents the analytical data, exposure assumptions, and the exposure models and input parameters that were used to estimate the potential exposure of ecological receptors to chemicals in surface soil.

3.5.1 Selection Criteria for Analytical Data

The available analytical data (described in Section 3.3 and summarized in Table 3-2 were reviewed against a set of selection criteria to identify specific data that would be used to estimate potential ecological receptor exposures. The analytical data selected for use in this screening-level ERA are included as Appendix C. The criteria used to select these analytical data are listed below.

> Data must have been validated by a qualified data validator using acceptable data validation methodology. Rejected (R) values were not used in the screening-level ERA. Unqualified data and data qualified as J and NJ were treated as detected, while data qualified as U or UJ were treated as non-detected.
>
> Analytical data for soil samples collected from the surface to a maximum depth of one foot bgs were used since this depth range is the most active biological zone (most soil heterotrophic activity occurs within the surface soil and soil invertebrates occur on the surface or within the oxidized root zone [Suter II 1995]).
>
> Maximum detection limits were conservatively used to estimate exposure for non-detected chemicals.
>
> In some instances, duplicate samples were collected in the field. The maximum concentration of each chemical (or the maximum non-detected value) in the original or duplicate sample was used as a conservative estimate of contaminant concentration at a particular sampling point. Results from duplicate samples were not evaluated individually.

In addition to the SWMU-specific analytical data discussed above, available background surface soil data from NSRR were used in this screening-level ERA. The background database includes four basewide background surface soil samples and five SWMU 9 background surface soil samples. The background data were used in Step 3a of the baseline ERA to determine the significance of ecological COPCs in surface soil. A discussion of these data are presented in Section 3.7.

3.5.2 Exposure Estimation

Maximum detected concentrations in surface soil were used to conservatively estimate potential chemical exposures for the ecological receptors selected to represent the assessment endpoints. For conservatism, maximum detection limits for chemicals that were analyzed for but not detected were also compared to surface soil screening values and used for food web exposure modeling. This was done to ensure that reporting 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 was used in the screening (when both values were detects or both values were non-detects). In cases where one result was a detection and the other a non-detect, the detected value was used in the assessment.

3.5.2.1 Terrestrial Receptor Groups

Maximum measured chemical concentrations in surface soil were compared to the surface soil screening values presented in Section 3.4.1 to conservatively evaluate the potential for adverse ecological effects to the terrestrial groups selected as assessment endpoints (terrestrial plants and invertebrates). Exposure point concentrations for terrestrial plants and invertebrates were maximum measured surface soil concentrations.

3.5.2.2 Upper Trophic Level Receptors

Exposures for upper trophic level receptor species via the food web were determined by estimating chemical-specific concentrations in each dietary component using uptake and food web models. Incidental ingestion of surface soil was also included when calculating the total level of exposure. As indicated previously, maximum measured surface soil concentrations were used in all calculations to provide a conservative assessment.

Tissue concentrations were modeled for terrestrial plants (food item for American robin and mourning dove), soil invertebrates (food item for American robin), and small mammals (food item for red-tailed hawk). Specific small mammals species were not selected as dietary items for the red-tailed hawk. Instead, a specific trophic level (omnivore) was used to represent the small mammals present on Puerto Rico that represent potential food items for the red-tailed hawk (Norway rat and black rat). Small mammal herbivores and insectivores were excluded as food items for the red-tailed hawk because they are not part of the Puerto Rican mammalian fauna (see Section 3.1.3).

3.5.2.2.1 Exposure Point Concentrations

The uptake of chemicals from the abiotic media into terrestrial food items is based (where available) on conservative (e.g., maximum or 90th percentile) bioconcentration factors (BCFs) or bioaccumulation factors (BAFs) from the literature. A BCF indicates the degree to which a chemical may accumulate in organisms coincident with the concentration of the chemical in the surrounding media. They are calculated by dividing the concentration of a chemical in the tissue of organisms by the concentration in the surrounding media. BAF values consider both direct exposures to the surrounding media, as well as uptake from dietary exposures. As such, BAFs were given preference over BCFs when estimating prey item tissue concentrations. Default factors of 1.0 were used only when data are unavailable for chemicals in the literature. The methodology and models used to derive these estimates are described below.

Terrestrial Plants. Tissue concentrations in the aboveground vegetative portion of terrestrial plants were estimated by multiplying the maximum measured surface soil concentration for each chemical by chemical-specific soil-to-plant BCFs obtained from the literature. The BCF values used were based on root uptake from soil and on the ratio between dry-weight soil and dry-weight plant tissue. Literature values based on the ratio between dry-weight soil and wet-weight plant tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for terrestrial plants (15 percent [0.15]; Sample et al. 1997).

BCFs for terrestrial plants are those reported in Baes et al. (1984) or Bechtel Jacobs (1998). For organic chemicals without literature based BCFs, soil-to-plant BCFs were estimated using the algorithm provided in Travis and Arms (1988):

$$Log\ B_v = 1.588 - (0.578)\ (Log\ K_{ow}) \qquad \text{(Equation 3-1)}$$

where:

$Log\ B_v$ = Log soil-to-plant BCF (unitless; dry weight basis)
$Log\ K_{ow}$ = Log octanol-water partitioning coefficient (unitless)

The Log K_{ow} values used in the calculations were obtained primarily from USEPA 1995 and 1996a and are listed in Table 3-4. The soil-to-plant BCFs used in the screening-level ERA are summarized in Table 3-7.

Earthworms. Tissue concentrations in soil invertebrates (earthworms) were estimated by multiplying the maximum measured surface soil concentration for each chemical by chemical-specific BCFs or BAFs obtained from the literature. BCFs are calculated by dividing the concentration of a chemical in the tissues of an organism by the concentration of that same chemical in the surrounding environmental medium (in this case, surface soil) without accounting for uptake via the diet. BAFs consider both direct exposure to soil and exposure via the diet. Since earthworms consume soil, BAFs are more appropriate values and were used in the food web models when available. BAFs based on depurated analyses (soil was purged from the gut of the earthworm prior to analysis) were given preference over undepurated analyses when selecting BAF values since direct ingestion of surface soil is accounted for separately in the food web model.

The BCF/BAF values used in this screening-level ERA (see Table 3-7) are based on the ratio between dry-weight soil and dry-weight earthworm tissue. Literature values based on the ratio between dry-weight soil and wet-weight earthworm tissue were converted to a dry-weight basis by dividing the wet-weight BCF/BAF by the estimated solids content for earthworms (16 percent [0.16]; USEPA 1993b). For inorganic chemicals without available measured BCFs/BAFs, an earthworm BAF of 1.0 was assumed.

Small Mammals. Whole-body tissue concentrations in small mammals (omnivores) were estimated using one of two methodologies. For chemicals with literature-based soil-to-small mammal BAFs, the small mammal tissue concentration was obtained by multiplying the maximum measured surface soil concentration for each chemical by a chemical-specific soil-to-small mammal BAF. The BAF values used are based on the ratio between dry-weight soil and whole-body dry-weight tissue. Literature values based on the ratio between dry-weight soil and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for small mammals (32 percent [0.32]; USEPA 1993b). The soil-to-small

mammal BAFs used in the screening-level ERA (see Table 3-8) are those in Sample et al. (1998b) for omnivores (or for general small mammals if omnivore values were unavailable).

For those chemicals without soil-to-small mammal BAF values, an alternate approach was used to estimate whole-body tissue concentrations. Because most chemical exposure for small mammal species is via the diet, it was assumed that the concentration of each chemical in a small mammal's tissues is equal to the chemical concentration in its diet, that is, a diet to whole-body BAF (wet-weight basis) of one was assumed. Resulting tissue concentrations (wet-weight) were converted to dry weight using an estimated solids content of 32 percent (see above).

The use of a diet to whole-body BAF of one is likely to result in a conservative estimate of chemical concentrations for chemicals that are not known to biomagnify in terrestrial food chains (e.g., aluminum). For chemicals that are known to biomagnify (e.g., PCBs), a diet to whole-body BAF value of one will likely result in a realistic estimate of tissue concentrations based on reported literature values. For example, a maximum BAF (wet weight) value of 1.0 was reported by Simmons and McKee (1992) for PCBs based on laboratory studies with white-footed mice. Menzie et al. (1992) reported BAF values (wet-weight) for DDT of 0.3 for voles and 0.2 for short-tailed shrews. Reported BAF (wet-weight) values for dioxin are only slightly above one (1.4) for the deer mouse (USEPA 1990).

3.5.2.2.2 Dietary Intakes

Dietary intakes for each upper trophic level receptor species were calculated using the following formula (Equation 3-2) modified from USEPA (1993b).

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

where:

DI_x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR	=	Food ingestion rate (kilograms per day [kg/day], dry-weight)
FC_{xi}	=	Maximum concentration of chemical x in food item i (mg/kg, dry weight)
PDF_i	=	Proportion of diet composed of food item i (mg/kg, dry weight)
SC_x	=	Maximum concentration of chemical x in surface soil (mg/kg, dry weight)
PDS	=	Proportion of diet composed of surface soil (dry weight basis)
BW	=	Body weight (kg, wet weight)
AUF	=	Area Use Factor (unitless)

Conservative receptor-specific exposure parameters (maximum food ingestion rates and minimum body weights) for the American robin, mourning dove, and red-tailed hawk are provided in Table 3-9. The food items selected for each receptor species and the percent contribution to their total diet is provided in Table 3-10. As discussed previously in Section 3.3.1.3, receptor exposures via surface water ingestion were not included in the estimation of dietary intakes. As such, drinking water ingestion rates for the receptor species are not included in Table 3-10.

Although not evaluated for food web exposures, Table 3-9 contains exposure parameters and Table 3-10 contains a dietary composition for a small mammal omnivore. As discussed in Section 3.5.2.2, the diet of the red-tailed hawk (excluding surface soil) is assumed to be small mammal omnivores. This assumption is based on likely small mammal prey species present in Puerto Rico

(rats). Identification of exposure parameters and food items was necessary when estimating small mammal whole body tissue concentrations for those chemicals that lack a literature-based soil-to-small mammal BAF (an exposure dose was necessary to estimate tissue concentrations). An assumed diet of 49 percent terrestrial vegetation, 49 percent terrestrial invertebrates, and 2 percent soil was selected as the diet for a small mammal omnivore.

For the screening-level ERA, an AUF of 1.0 was assumed (i.e., each receptor is assumed to spend 100 percent of its time on the site). As such, receptor-specific home ranges were not considered in the estimation of dietary intakes.

3.6 Screening-Level Risk Calculation

The screening-level risk calculation is the final step in a screening-level ERA. In this step, maximum chemical concentrations in abiotic media or maximum exposure doses for 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 ecological COPCs for each media-pathway-receptor combination evaluated or a conclusion of negligible risk

3.6.1 Selection of Ecological Chemicals of Potential Concern

Ecological COPCs were selected using the hazard quotient (HQ) method. For a given chemical, an HQ was calculated by dividing the maximum chemical concentration in the medium being evaluated by the corresponding media-specific screening value or, in the case of upper trophic level receptors, by dividing the maximum exposure dose by the corresponding ingestion-based screening value.

The following conservative methodology was used to identify ecological COPCs for surface soil:

> The maximum detected concentration in surface soil was 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 were identified as ecological COPCs.
>
> For non-detected chemicals, the maximum reporting limit was used to calculate surface soil HQ values. Non-detected chemicals with HQs greater than or equal to 1.0 based on maximum reporting limits were identified as ecological COPCs.
>
> Detected and non-detected chemicals without surface soil screening values were identified as ecological COPCs.

To select preliminary ecological COPCs by evaluating food web exposures, maximum chemical concentrations in surface soil were used to estimate dietary doses for each receptor. HQs were calculated with NOAELs, LOAELs, and Maximum Acceptable Toxicant Concentrations (MATCs). The MATC is derived by taking 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 were identified as ecological COPCs. Identical to the surface soil screening, detected and

non-detected chemicals without ingestion-based screening values were identified as ecological COPCs for terrestrial receptor exposures.

HQs greater than or equal to 1.0 indicate the potential for risk since the chemical concentration or dose (exposure) exceeds the screening value (effect). However, screening values and exposure doses are derived using intentionally conservative assumptions (maximum media concentrations, maximum ingestion rates, and minimum body weights) such that HQs greater than or equal to 1.0 do not necessarily indicate that risks are present or impacts are occurring. Rather, they identify chemical-pathway-receptor combinations requiring further evaluation. Following the same reasoning, HQs less than one indicate that risks are very unlikely, enabling a conclusion of no unacceptable risk to be reached with high confidence.

It is noted that the screening-level ERA considers independent effects of chemicals. However, the potential does exist for multiple chemicals in environmental media to interact. Much uncertainty is involved with the interpretation of chemical interactions due to the complexity of potential effects (e.g., synergistic, antagonistic, or additive), and due to varying toxicities of compounds in different species. For these reasons, cumulative effects were not addressed in this screening-level ERA. Chemical interactions can be addressed by site-specific studies conducted in Step 6 of the Navy ERA process (i.e., site investigation and data analysis [see Figure 3-1]).

3.6.1.1 Screening-Level Risk Calculation for Surface Soil

Table 3-11 presents the results of the screening-level risk calculation for surface soil. Pesticide and inorganic detections above surface soil screening values is shown on Figures 3-7 and 3-8, respectively.

Eight pesticides were detected in surface soils collected from SWMU 53 (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, chlordane, heptachlor, heptachlor epoxide, and kepone). Of these eight pesticides, 4,4'-DDE, 4,4-'DDT, chlordane, heptachlor epoxide, and kepone were identified as ecological COPCs because maximum detected concentrations exceeded surface soil screening values. Thirteen non-detected pesticides were also identified as ecological COPCs for surface soil because maximum reporting limits exceeded screening values.

Fifteen metals were detected in surface soil samples collected from SWMU 53. Maximum detected concentrations for antimony, barium, chromium, cobalt, copper, lead, selenium, vanadium, and zinc exceeded surface soil screening values. These nine metals were identified as ecological COPCs for surface soil. Although not detected, thallium was also identified as an ecological COPC because the maximum reporting limit for this metal exceeded the surface soil screening value.

As evidenced by Figures 3-7 and 3-8, maximum detected concentrations for the ecological COPCs identified in the preceding paragraphs were primary located immediately adjacent to Building 64.

3.6.1.5 Screening-Level Risk Calculation for Terrestrial Food Web Exposures

Results of the risk calculations for terrestrial food web exposures are provided in Table 3-12. Based on the comparison of maximum exposure doses to NOAEL-based screening values, two detected pesticides (4,4'-DDE and 4,4'-DDT) had HQ values greater than or equal to 1.0 for one or more of the terrestrial avian receptors. These two pesticides were identified as ecological COPCs for terrestrial food web exposures. Although not detected, dieldrin, endrin, endrin

aldehyde, and toxaphene were identified as an ecological COPC for terrestrial food web exposures because maximum exposure doses (based on reporting limits) for the American robin exceeded NOAEL-based screening values. Two non-detected pesticides (chlorobenzilate and isodrin) and one detected pesticide (kepone) were also identified as ecological COPCs due to the lack of ingestion-based screening values.

Eight detected metals (barium, cadmium, chromium, cobalt, lead, mercury, selenium, and zinc) had HQ values greater than or equal to 1.0 for one or more of the terrestrial avian receptors. The highest HQ values were calculated for the American robin (HQ = 415 for lead and 374 for zinc). These eight metals were identified as ecological COPCs for terrestrial food web exposures. Beryllium was also identified as an ecological COPC for terrestrial food web exposures due to the lack of an ingestion-based screening value.

3.6.2 Uncertainties Associated With the Screening-Level Risk Characterization

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties because of the limitations of the available data and the need to make certain assumptions and extrapolations based on incomplete information. The major uncertainties associated with the screening-level ERA and their effect on risk conclusions are presented and discussed below.

Analytical Data. Groundwater was not collected during sampling activities at SWMU 53. Although leaching of chemicals from surface and subsurface chemicals by infiltrating precipitation and transport to surface water and sediment with groundwater is considered an insignificant transport pathway for the reasons presented in Section 3.3.1.2, the absence of groundwater is a source of uncertainty.

Reporting Limits. Reporting limits for many chemicals exceeded surface soil screening values.

Identification of Ecological COPCs. Chemicals without available screening values were identified as preliminary ecological COPCs even if they were not detected. This likely overstates the number of actual COPCs.

A second source of uncertainty related to the selection of preliminary ecological COPCs applies to the use of NOAEL-based screening values in risk calculations for upper trophic level receptors. The use of NOAEL-based screening values is extremely conservative since they give no indication as to how much higher a concentration must be before adverse effects are observed.

Exposure Point Concentrations. The maximum measured concentration provides a conservative estimate for immobile biota or those with a limited home range. The most realistic exposure estimates for mobile species with relatively large home ranges and for species populations (even those that are immobile or have limited home ranges) are those based on the mean chemical concentrations in each medium to which these receptors are exposed. This is reflected in the wildlife dietary exposure models contained in the Wildlife Exposure Factors Handbook (USEPA 1993b), which specify the use of average media concentrations. Given the mobility of the upper trophic level receptor species used in the screening-level ERA, the use of maximum chemical concentrations (rather than mean concentrations) to estimate the exposure via food webs is very conservative. The use of

mean concentrations to estimate exposure in Step 3a of the baseline ERA is more likely to provide a more accurate estimate of potential risks at SWMU 53.

Surface Soil Screening Values. Toxicological thresholds were not available from the literature for many of the organochlorine pesticides. The surface soil screening values used in the comparison to surface soil analytical data for these pesticides were background-based concentrations. Because the background-based screening values do not represent effect concentrations, their use in the screening-level ERA likely resulted in an overstatement of the actual number of ecological COPCs.

A second source of uncertainty related to surface soil screening values applies to metals. When a toxicological threshold was available for both plants and invertebrates, the minimum value was selected as the screening value. For several metals, only a plant or earthworm toxicological threshold was available from the Efroymson et al. 1997a and 1997b. It was assumed in this ERA that the screening value selected for these metals are protective of both receptor communities.

Ingestion-Based Screening Values. Data on the toxicity of many chemicals to the receptor species were sparse or lacking, requiring the extrapolation of data from other wildlife species or from laboratory studies with non-wildlife species. This is a typical limitation for ecological risk assessments because so few wildlife species have been tested directly for most chemicals. The uncertainties associated with toxicity extrapolation were minimized through the selection of the most appropriate test species for which suitable toxicity data were available. The factors that were considered in selecting a test species to represent a receptor species included taxonomic relatedness, trophic level, foraging method, and similarity of diet.

A second source of uncertainty related to the derivation of ingestion screening values applies to metals. Most of the toxicological studies on which the ingestion-based screening values for metals were based used forms of the metal (such as salts) that have high water solubility and high bioavailability to receptors. Since the analytical samples on which site-specific exposure estimates were based measured total metal concentrations, regardless of form, and these highly bioavailable forms are expected to compose only a fraction of the total metal concentration, this is likely to result in an overestimation of potential risks for these chemicals.

A third source of uncertainty related to the derivation of ingestion screening values concerns the use of uncertainty factors. For example, in some cases NOAELs were extrapolated to LOAELs using an uncertainty factor of ten. This approach is likely to be conservative since Dourson and Stara (1983) determined that 96 percent of the chemicals included in a data review had LOAEL/NOAEL ratios of five or less. The use of an uncertainty factor of 10, although potentially conservative, also serves to counter some of the uncertainty associated with interspecies extrapolations, for which a specific uncertainty factor was not used.

A fourth source of uncertainty related to the derivation of ingestion-based screening values applies to mercury and selenium. The ingestion-based screening values used for these two metals were based on organometallic (methylated) forms. For example, the NOAEL-based mercury screening value used for birds (0.0064 mg/kg-BW/day) is based on a laboratory study that used methyl mercury dicyandiamide as the test material. Screening values for inorganic forms of mercury are substantially higher (0.45 mg/kg-

BW/day for mercuric chloride [see Table 3-6]). Given that inorganic forms likely contribute significantly to the total mercury and selenium, use of NOAEL-based screening values based on organometallic forms tends to make the screening values for these metals extremely conservative and likely overestimates potential risk.

Ecological Receptors. Although exposure pathways to terrestrial reptiles and amphibians are likely to be complete, reptilian and amphibian species were not selected as ecological receptors because the life history and toxicological database concerning the effects on reptiles and amphibians is severely limited. It was assumed that any terrestrial reptiles and amphibians present at SWMU 53 are not exposed to significantly higher concentrations of chemicals and are not more sensitive to chemicals than the other receptor species evaluated in the risk assessment.

Exposure Routes. Although inhalation and/or dermal adsorption represent potential exposure routes for upper trophic level receptors, they were not evaluated in the ERA because they were considered insignificant relative to ingestion exposures (see Section 3.3.1.3). While this is a reasonable assumption for the terrestrial birds selected as ecological receptors, the exclusion of inhalation and dermal adsorption represents a source of uncertainty.

Food Web Exposure Modeling. Chemical concentrations in terrestrial and aquatic food items (plants, earthworms, and small mammal omnivores) were modeled from measured media concentrations and were not directly measured. The use of generic, literature-derived exposure models and bioaccumulation factors introduces some uncertainty into the resulting estimates. The values selected and the methodology employed was intended to provide a reasonable estimate of potential food web exposure concentrations.

A second source of uncertainty related to the food web models is the use of default assumptions for exposure parameters such as BCFs and BAFs. Although BCFs or BAFs for many bioaccumulative chemicals were readily available from the literature and were used in the ERA, the use of a default factor of 1.0 to estimate the concentration of some chemicals in receptor prey items is a source of uncertainty. However, for most chemicals, the assumption that the chemical body burden in the prey item is at the same concentration as in soil is conservative, particularly when many of the chemicals are known not to accumulate to any significant degree.

A third source of uncertainty related to the food web models is the use of unrealistically conservative exposure parameters. The use of maximum ingestion rates and minimum body weights result in a conservative estimate of exposure. In addition, AUFs were assumed to equal one. This is a conservative assumption since a significant percentage of each upper trophic level receptor species time could be spent foraging off-site in areas not impacted by site-related chemicals or areas where chemical concentrations are expected to be significantly lower.

Chemical Mixtures. Information on the ecotoxicological effects of chemical interactions is generally lacking, which required (as is standard for ecological risk assessments) that the chemicals be evaluated on a compound-by-compound basis during the comparison to screening values. This could result in an underestimation of risk (if there are additive or synergistic effects among chemicals) or an overestimation of risks (if there are antagonistic effects among chemicals).

3.6.3 Screening-Level Risk Assessment Conclusions

The screening-level ERA for SWMU 53 indicated that, based on a set of conservative exposure assumptions, there are multiple chemicals that may present risks to one or more of the receptor/receptor group evaluated in the screening-level ERA (see Table 3-13). Therefore, additional evaluation is recommended for SWMU 53 (i.e., Step 3a of the baseline ERA). This evaluation is presented in the sections that follow.

3.7 Step 3a of the Baseline Risk Assessment (Refinement of Conservative Exposure Assumptions)

The results of the screening-level risk calculation indicated that, based on a set of conservative exposure assumptions, there are one or more chemicals that may present a risk to ecological receptor groups/species. As such, the ERA process at SWMU 53 proceeded to the baseline risk assessment.

According to Superfund guidance (USEPA 1997), Step 3 initiates the problem formulation phase of the baseline ERA. Under Navy guidance (CNO 1999), the baseline ERA is defined as Tier 2, and the first activity under Tier 2 is Step 3a (see Figure 3-1). In Step 3a, the conservative assumptions employed in Tier 1 are refined and risk estimates are recalculated using the same conceptual model. Step 3a may also include consideration of background data, the frequency at which chemicals were detected, and chemical bioavailability.

The specific assumptions, parameters, and methods that were modified for the recalculation of media-specific and food web HQ values are identified below, along with justification for each modification. These refinements and methods were used to weigh the evidence of potential risk for each ecological COPC identified for surface soil and/or food web exposures to determine if the development of Corrective Action Objectives (CAOs) is necessary for the protection of the environment.

> Maximum chemical concentrations were replaced by average (arithmetic mean) chemical concentrations. For individual receptor species, average chemical concentrations provide a better estimate of the likely level of chemical exposure because each receptor would be expected to forage in several different areas of the site, and, in many cases, off-site. Average concentrations are also appropriate for evaluating impacts *to populations* of lower trophic level receptors (i.e., terrestrial invertebrates, terrestrial plants, aquatic plants, benthic invertebrates, and fish). Because some of these receptors are relatively immobile, *individuals* are likely to be impacted by locations of maximum concentrations. However, evaluation of the average exposure case is more indicative of the level of impact that might be expected at the *population* level.
>
> Literature-based BCFs and BAFs based on, or modeled from, central tendency estimates (e.g., mean, median, midpoint) were used in place of maximum or high-end (e.g., 90th percentile) estimates for many chemicals. An assumed BCF/BAF of 1.0 was still used for those chemicals lacking a literature-based BAF/BCF. A summary of the surface soil-to-terrestrial plant BCFs and surface soil-to-terrestrial invertebrate BAFs used in Step 3a of the baseline ERA are summarized in Table 3-14, while surface soil-to-small mammal BAFs are summarized in Table 3-15.

Central tendency estimates (e.g., mean, median, midpoint) for body weight and food ingestion rate (see Table 3-16) were used to develop exposure estimates for upper trophic level receptors rather than the minimum body weights and maximum food ingestion rates used in the screening-level ERA. The use of central tendency estimates is more relevant because they represent the characteristics of a greater proportion of the individuals in the population. As evidenced by Table 3-16, the evaluation of food web exposures still assumed an AUF of 1.0.

In addition to the NOAELs-based risk estimates used in the screening-level ERA, consideration was also given to food web exposure risk estimates based on LOAELs and MATCs.

Consideration was given to available background surface soil concentrations. The specific background data used in Step 3a of the baseline ERA were base background data and SWMU 9 background data (see Table 3-17). Base background and SWMU 9 background sampling locations are depicted on Figures 3-9 and 3-10, respectively. An evaluation of the comparability of base and SWMU 9 background data was previously presented in the Draft CMS report for SWMU 9 (Baker 2001b).

Chemicals that were not identified as ecological COPCs for surface soil because maximum detected concentrations (or maximum reporting limits in the case of non-detected chemicals) were less than surface soil screening values were not evaluated in the Step 3a surface soil exposure estimate and risk calculation since a conclusion of no unacceptable risk can be made with high confidence. Detected and non-detected chemicals with maximum dietary intakes less than ingestion-based screening values, as well as non-detected chemicals lacking ingestion-based screening values (chlorobenzilate and isodrin) were also excluded from evaluation in the refined risk calculations for terrestrial food web exposures. Although eliminated from further evaluation, non-detected chemicals lacking ingestion-based screening values remain ecological COPCs but are not considered potential risk drivers since it is as likely that the concentrations of these chemicals are near zero and not present at ecologically significant concentrations.

3.7.1 Refined Screening-Level Risk Calculation

The refined media-specific screening evaluation for surface soil and upper trophic level receptor HQ values based on mean exposure doses are presented and discussed in the sections that follow. As discussed in Section 3.7, only those detected and non-detected chemicals with maximum concentrations or maximum exposure doses greater than screening values, as well as detected chemicals lacking screening values were addressed by the refined screening level risk calculation.

3.7.1.1 Refined Risk Calculation and Risk Evaluation for Surface Soil

Five pesticides were identified as ecological COPCs in Step 2 of the screening-level ERA because maximum detected concentrations exceeded surface soil screening values (4,4'-DDE, 4,4'-DDT, chlordane, heptachlor epoxide, and kepone). Ten metals were also identified as ecological COPCs in Step 2. Antimony, barium, chromium, cobalt, copper, lead, selenium, vanadium, and zinc were identified as ecological COPCs because maximum detected concentrations exceeded surface soil screening values, while thallium was identified as an ecological COPC because the maximum reporting limit for this metal exceeded the surface soil screening value.

Table 3-18 presents the results of the refined screening-level risk calculation for surface soil. The mean concentration of 4,4'-DDE (HQ = 0.40) and heptachlor epoxide (HQ = 0.21) were less than surface soil screening values. For both pesticides, detections above surface soil screening values were spatially limited to a single sample (4,4'-DDE was detected in 53SS02 and heptachlor epoxide was detected in 53SB14 at concentrations greater than screening values [see Figure 3-7]). Based on mean concentrations less than screening values (i.e., HQs less than 1.0) and their low spatial coverage at concentrations greater than screening values, 4,4'-DDE and heptachlor epoxide are not considered potential risk drivers for terrestrial invertebrates and plants at SWMU 53 and further evaluation is not recommended.

The mean concentrations of 4,4'-DDT (HQ = 1.21), chlordane (HQ = 3.29), and kepone (HQ = 2.59) exceeded their surface soil screening values. 4,4'DDT detections above the surface soil screening value were spatially limited to 53SS02 (5,100 J µg/kg) and 53SB05 (1,200 J µg/kg), while chlordane detections above the surface soil screening value were spatially limited to 53SB09 (630 µg/kg), 53SB14 (2,700 µg/kg), and 53SS07 (780 µg/kg). Although mean HQ values are only slightly elevated above 1.0 and detections above screenings values are spatially limited to two of sixteen samples for 4,4'-DDT and three of twenty-one samples for chlordane, both pesticides are considered potential risk drivers for terrestrial invertebrates and plants at SWMU 53. As such, development of CAOs is recommended. This recommendation is based on the presence of hot spots that contain concentrations up to an order of magnitude greater than screening values. Based on a mean HQ greater than 1.0 and a high frequency of detection at concentrations greater than the surface soil screening value (detected in 2 of 4 samples at a concentration greater than the screening value), kepone is also considered a potential risk driver for terrestrial invertebrates and plants. Development of a CAO for this pesticide is recommended as well.

Mean concentrations for the non-detected pesticides methoxychlor (HQ = 1.79) and toxaphene (17.85) are greater than surface soil screening values. However, since it is as likely that the concentration of these non-detected pesticides are near zero and not present at ecologically important concentrations, they are not considered potential risk drivers for terrestrial invertebrates and plants at SWMU 53 and additional evaluation is not recommended.

Thallium was identified as an ecological COPC in Step 2 of the screening-level ERA because the maximum reporting limit for this non-detected metal exceeded the screening value. As evidenced by Table 3-18, the mean non-detected concentration for thallium is less than the surface soil screening value (HQ = 0.58). Given a mean HQ less than 1.0 and the likelihood that the concentration of this metal is near zero and not present at ecologically important concentrations, thallium is not considered a potential risk driver for terrestrial invertebrates and plants at SWMU 53 and additional evaluation is not recommended.

Mean concentrations for antimony (HQ = 0.44), barium (HQ = 0.49), and selenium (HQ = 0.71) are less than screening values. For each metal, the spatial coverage of detected concentrations above the screening value is limited to two samples (see Figure 3-8). Furthermore, as evidenced by the maximum HQ values presented in Table 3-11, detections in these samples were only slightly elevated above screening values (Maximum HQ for antimony, barium, and selenium were 1.22, 1.34, and 1.30, respectively). Based on mean HQ values less than 1.0 and the low spatial coverage and magnitude of detections above screening values, antimony, barium, and selenium are not considered potential risk drivers for terrestrial invertebrates and plants at SWMU 53. As such, additional evaluation is not recommended.

Mean concentrations for chromium (HQ = 136), cobalt (HQ = 1.66), copper (HQ = 1.60), lead (HQ = 10.70), vanadium (HQ = 76.25), and zinc (16.54) are greater than screening values. To

determine the significance of chromium, cobalt, copper, lead, vanadium, and zinc, mean concentrations were compared to alternative screening values from the literature and available background data from NSRR. This analysis is presented in the paragraphs that follow.

As evidenced by Table 3-5, the surface soil screening value used for chromium and copper in this ERA are toxicological thresholds for earthworms, while the surface soil screening values used for cobalt, lead, vanadium, and zinc are toxicological thresholds for plants. The mean chromium concentration in SWMU 53 surface soil (54.5 mg/kg) exceeds a plant-based toxicological threshold of 1.0 mg/kg reported by Efroymson et al. (1997a), while the mean copper concentration in SWMU 53 surface soil (80 mg/kg) is less than a plant-based toxicological threshold (100 mg/kg) reported by this same source. The mean lead and zinc concentrations in SWMU 53 surface soil (535 mg/kg and 827 mg/kg, respectively) exceed earthworm-based toxicological thresholds (500 mg/kg for lead and 200 mg/kg for zinc) reported in Efroymson et al. (1997b). Cobalt and vanadium do not have literature-based toxicological thresholds specific to earthworms. As such, a comparison to alternative screening values could not be performed. The comparison of mean concentrations to alternative screening values indicate that both plant and invertebrate communities at SWMU 53 are potentially impacted by chromium, lead, and zinc, while only invertebrate communities are potentially impacted by copper.

To evaluate the potential significance of risks presented by these metals relative to background concentrations, the site surface soil data for these metals were compared to base background and SWMU 9 background surface soil concentrations. As evidenced by Table 3-19, the maximum and mean background concentrations for copper and vanadium are greater than maximum and mean site concentrations. Maximum and mean vanadium concentrations in SWMU 53 surface soil are also less than the maximum and mean SWMU 9 background surface soil concentrations presented in Table 3-17. Although maximum and mean copper concentrations in SWMU 53 surface soil (120 mg/kg and 80 mg/kg) are slightly elevated above maximum and mean SWMU 9 background concentrations (100 mg/kg and 75.6 mg/kg, respectively), they are comparable. These data indicate that copper and vanadium are not presenting a risk to terrestrial invertebrates and plants at the site above base background and/or SWMU 9 levels. As such, copper and vanadium are not considered potential risk drivers for terrestrial invertebrates and plants at SWMU 53 and additional evaluation is not recommended.

Maximum and mean chromium, lead, and zinc concentrations in SWMU 53 surface soil exceed maximum and mean base background surface soil concentrations (see Table 3-19), as well as the maximum and mean SWMU 9 background surface soil concentrations presented in Table 3-17. Based on mean HQ values greater than 1.0, maximum and mean concentrations greater than base background and SWMU 9 background concentrations, the spatial coverage and magnitude of detections above plant and earthworm-based screening values, chromium, lead, and zinc are considered potential risk drivers for terrestrial invertebrates and plants at SWMU 53 and the development of CAOs for these three metals is recommended.

Maximum and mean cobalt concentrations in SWMU 53 surface soil (57 mg/kg and 33.3 mg/kg) exceeded maximum and mean base background concentrations (30.2 mg/kg and 22.0 mg/kg, respectively. However, maximum and mean site concentrations for cobalt do not exceed maximum and mean SWMU 9 background concentrations (64 mg/kg and 33.4 mg/kg). Based on the comparison of SWMU 53 cobalt data to SWMU 9 background concentrations, as well as the evenness of cobalt detections in SWMU 53 surface soil (which does not suggest a release has occurred), this metal is not considered a potential risk driver for terrestrial invertebrates at SWMU 53 and additional evaluation is not recommended.

In summary, the following chemicals were identified as potential risk drivers for lower trophic level terrestrial receptor groups (terrestrial invertebrates and plants) and development of CAOs is recommended: 4,4'-DDT, chlordane, kepone, chromium, lead, and zinc. Although 4,4'-DDE, heptachlor epoxide, antimony, barium, cobalt, copper, selenium, and vanadium were detected in surface soil and identified as ecological COPCs in Step 2 of the ERA, they are not recommended for further evaluation based on the discussion presented in the preceding paragraphs. Further evaluation was also not recommended for the non-detected chemicals identified as ecological COPCs in Step 2 of the ERA (i.e., methoxychlor, toxaphene, and thallium).

3.7.1.2 Refined Risk Calculation and Risk Evaluation for Terrestrial Food Web Exposures

Two detected pesticides (4,4'-DDE and 4,4'-DDT) and eight detected metals (barium, cadmium, chromium, cobalt, lead, mercury, selenium, and zinc) were identified as ecological COPCs in Step 2 of the screening-level ERA because maximum exposure doses for one or more of the terrestrial receptors exceeded NOAEL-based screening values (see Table 3-12). The detected metal beryllium was identified as an ecological COPC for terrestrial food web exposures due to the lack of a screening value, while the non-detected pesticides dieldrin, endrin, endrin aldehyde, toxaphene were identified as an ecological COPC because maximum exposure doses for the American robin exceeded the NOAEL-based screening value.

HQ values based mean exposure doses are presented in Table 3-20. American robin, mourning dove, and red-tailed hawk mean exposure doses for 4,4'DDT, dieldrin, endrin, endrin aldehyde, barium, cadmium, mercury, and selenium are less than NOAEL-, MATC-, and LOAEL-based screening values. Based on mean exposure doses less than ingestion-based screening values, dieldrin, endrin, endrin aldehyde, barium, cadmium, mercury, and selenium are not considered potential risk drivers for terrestrial food web exposures at SWMU 53 and additional evaluation is not recommended. Although American robin, mourning dove, and red-tailed hawk mean exposure doses for 4,4'-DDT are less than NOAEL-based screening values, this pesticide is considered a potential risk driver at SWMU 53 for terrestrial food web exposures. This determination is based on the presence of elevated concentrations in surface soil samples 53SS02 (5,100 J µg/kg) and 53SB05 (1,200 µg/kg), the high frequency of detection (detected in 14 of 16 surface soil samples), and the ability of this pesticide to bioaccumulate and biomagnify through terrestrial food webs. Based on the identification of 4,4'-DDT as a potential risk driver, development of a CAO for this pesticide is recommended for terrestrial food web exposures.

An ingestion-based screening value was not available for beryllium from the literature. To evaluate the potential significance of risks presented by beryllium to upper trophic level receptors surface soil data for this metal was compared to base and SWMU 9 background concentrations. Maximum and mean surface soil concentrations at SWMU 53 (0.38 mg/kg and 0.24 mg/kg) are comparable to maximum and mean base background concentrations (0.36 mg/kg and 0.23 mg/kg, respectively) and SWMU 9 background concentrations (0.36 mg/kg and 0.23 mg/kg, respectively). Therefore, it is not likely that this metal is presenting a risk At SWMU 53 above background risk. For this reason, beryllium is not considered a potential risk driver for terrestrial food web exposures and additional evaluation is not recommended.

American robin mean exposure doses for 4,4'-DDE (HQ = 1.49), chromium (HQ = 1.03), lead (HQ = 8.80), and zinc (HQ = 6.57) exceed NOAEL-based screening values for this receptor. American robin mean exposure doses for lead and zinc also exceed MATC-based screening values (HQ = 2.78 for lead and 2.19 for zinc). Mourning dove mean exposure doses for lead (HQ = 4.87) and zinc (HQ = 2.66) exceed NOAEL-based screening values for this receptor.

The use of NOAEL-based screening values is extremely conservative since they give no indication as to how much higher a concentration must be before adverse effects are observed. Given that LOAEL and MATC-based HQ values for chromium are less than 1.0 for the American robin (see Table 3-20) and the conservatism associated with the use of NOAELs, this metal is not likely to present unacceptable risks to avian omnivore populations. For this reason, chromium is not considered a potential risk driver for terrestrial food web exposures and additional evaluation for this metal is not recommended.

This line of reasoning can also be applied to 4,4'-DDE; however, given this pesticides potential to bioaccumulate in tissue and biomagnify through terrestrial food webs, as well as the high frequency of detection in SWMU 53 surface soils (detected in 12 of 16 samples), 4,4'DDE is considered a potential risk driver at SWMU 53 for terrestrial food web exposures. Lead and zinc are also considered potential risk drivers for terrestrial food web exposures. This determination is based on mean exposure doses greater than NOAEL- and MATC-based screening values for the American robin and NOAEL-based screening values for the mourning dove, their high frequency of detection in SWMU 53 surface soil (100 percent), and the presence of elevated concentrations well above base and SWMU 9 background concentrations (see Section 3.7.1.1). As such, the development of CAOs for 4,4'-DDE, lead, and zinc is recommended.

Kepone was detected in 2 of 4 samples collected at SWMU 53; however, an evaluation of potential risks from mean dietary exposures could not be performed due to the lack of a literature-based screening value. As such, this pesticide is considered a potential risk driver for terrestrial food web exposures at SWMU 53. The lack of an ingestion-based screening value prohibits the ability to develop a CAO for this pesticide. It is assumed that the avian receptors evaluated in this ERA are not more sensitive to kepone than other pesticides. As such, the CAO developed for 4,4'-DDE terrestrial food web exposures (see Section 4.0) will also be applied to kepone.

In summary, the following chemicals were identified as potential risk drivers for terrestrial food web exposures: 4,4'-DDT, 4,4'-DDE, kepone, lead, and zinc. Although barium, beryllium, cadmium, chromium, mercury, and selenium were detected in surface soil and identified as ecological COPCs in Step 2 of the ERA, they are not recommended for further evaluation based on the discussion presented in the preceding paragraphs. Further evaluation was also not recommended for the non-detected chemicals identified as ecological COPCs in Step 2 of the ERA (i.e., dieldrin, endrin, endrin aldehyde, and toxaphene).

3.7.2 Uncertainties Associated With the Refined Screening-Level Risk Characterization

Many of the uncertainties identified in Section 3.6.2 also apply to the refined screening-level risk characterization. Those uncertainties associated with the refined risk calculation are listed below.

> Identification of Potential Risk Drivers. Non-detected chemicals with mean exposure doses greater than ingestion-based screening values due to elevated reporting limits (methoxychlor and toxaphene) were not identified as potential risk drivers for terrestrial food web exposures.
>
> A second source of uncertainty related to the identification of potential risk drivers in the refined risk calculation applies to non-detected chemicals lacking ingestion-based screening values (i.e., chlorobenzilate and isodrin). Non-detected chemicals lacking lacking ingestion-based screening values were not evaluated in the refined risk calculation, nor were they considered potential risk drivers.

A third source of uncertainty related to the identification of potential risk drivers in the refined screening-level risk characterization applies to the use of NOAEL-based screening values in risk calculations for upper trophic level receptors. The use of NOAEL-based screening values is extremely conservative since they give no indication as to how much higher a concentration must be before adverse effects are observed. This uncertainty was reduced in the refined risk calculation by considering HQ values derived using MATC- and LOAEL-based screening values

Surface Soil Screening Values. Toxicological thresholds were not available from the literature for many of the organochlorine pesticides. The surface soil screening values used in the comparison to surface soil analytical data for these pesticides were background-based concentrations. Because the background-based screening values do not represent effect concentrations, their use in the refined risk calculation may have resulted in an overstatement of potential risk drivers.

A second source of uncertainty related to surface soil screening values applies to metals. When a toxicological threshold was available for both plants and invertebrates, the minimum value was selected as the screening value. For several metals, only a plant or earthworm toxicological threshold was available from the literature. It was assumed in this ERA that the screening value selected for these metals are protective of both receptor communities.

Ingestion-Based Screening Values. Data on the toxicity of many chemicals to the receptor species were sparse or lacking, requiring the extrapolation of data from other wildlife species or from laboratory studies with non-wildlife species. This is a typical limitation for ecological risk assessments because so few wildlife species have been tested directly for most chemicals. The uncertainties associated with toxicity extrapolation were minimized through the selection of the most appropriate test species for which suitable toxicity data were available. The factors that were considered in selecting a test species to represent a receptor species included taxonomic relatedness, trophic level, foraging method, and similarity of diet.

A second source of uncertainty related to the derivation of ingestion screening values applies to metals. Most of the toxicological studies on which the ingestion screening values for metals were based used forms of the metal (such as salts) that have high water solubility and high bioavailability to receptors. Since the analytical samples on which site-specific exposure estimates were based measured total metal concentrations, regardless of form, and these highly bioavailable forms are expected to compose only a fraction of the total metal concentration, this is likely to result in an overestimation of potential risks for these chemicals.

A third source of uncertainty related to the derivation of ingestion screening values concerns the use of uncertainty factors. For example, in some cases NOAELs were extrapolated to LOAELs using an uncertainty factor of ten. This approach is likely to be conservative since Dourson and Stara (1983) determined that 96 percent of the chemicals included in a data review had LOAEL/NOAEL ratios of five or less. The use of an uncertainty factor of 10, although potentially conservative, also serves to counter some of the uncertainty associated with interspecies extrapolations, for which a specific uncertainty factor was not used.

A fourth source of uncertainty related to the derivation of ingestion-based screening values applies to mercury and selenium. The ingestion-based screening values used for these two metals were based on organometallic (methylated) forms. For example, the NOAEL-based mercury screening value used for birds (0.0064 mg/kg-BW/day) is based on a laboratory study that used methyl mercury dicyandiamide as the test material. Screening values for inorganic forms of mercury are substantially higher (0.45 mg/kg-BW/day for mercuric chloride [see Table 3-12]). Given that inorganic forms likely contribute significantly to the total mercury and selenium, use of NOAEL-based screening values based on organometallic forms tends to make the screening values for these metals extremely conservative and likely overestimates potential risk.

Ecological Receptors. Although exposure pathways to terrestrial reptiles and amphibians are likely to be complete, reptilian and amphibian species were not selected as ecological receptors because the life history and toxicological database concerning the effects on terrestrial reptiles and amphibians is severely limited. It was assumed that any reptiles and amphibians present at SWMU 53 are not exposed to significantly higher concentrations of chemicals and are not more sensitive to chemicals than the other receptor species evaluated in the risk assessment.

Exposure Routes. Although inhalation and/or dermal adsorption represent potential exposure routes for upper trophic level receptors, they were not evaluated in the ERA because they were considered insignificant relative to ingestion exposures (see Section 3.3.1.3). While this is a reasonable assumption for the terrestrial birds selected as ecological receptors, the exclusion of inhalation and dermal adsorption represents a source of uncertainty.

Food Web Exposure Modeling. Chemical concentrations in terrestrial and aquatic food items (plants, earthworms, small mammal omnivores, aquatic invertebrates, and fish) were modeled from measured media concentrations and were not directly measured. The use of generic, literature-derived exposure models and bioaccumulation factors introduces some uncertainty into the resulting estimates. The values selected and methodology employed were intended to provide a reasonable estimate of potential food web exposure concentrations.

A second source of uncertainty related to the food web models is the use of default assumptions for exposure parameters such as BCFs and BAFs. Although BCFs or BAFs for many bioaccumulative chemicals were readily available from the literature and were used in the ERA, the use of a default factor of 1.0 to estimate the concentration of some chemicals in receptor prey items is a source of uncertainty. However, for most chemicals, the assumption that the chemical body burden in the prey item is at the same concentration as in soil is conservative, particularly when many of the chemicals are known not to accumulate to any significant degree.

Chemical Mixtures. Information on the ecotoxicological effects of chemical interactions is generally lacking, which required (as is standard for ecological risk assessments) that the chemicals be evaluated on a compound-by-compound basis during the comparison to screening value. This could result in an underestimation of risk (if there are additive or synergistic effects among chemicals) or an overestimation of risks (if there are antagonistic effects among chemicals).

3.8 Conclusions and Recommendations

A summary of potential risk drivers identified in surface soil at SWMU 53 is presented in Table 3-21. Based on the evaluation of chemical concentrations in surface soil, 4,4'-DDT, chlordane, kepone, chromium, lead, and zinc have the potential to impact terrestrial invertebrate and plant communities at SWMU 53. In addition, 4,4'-DDT, 4,4'-DDE, kepone, lead, and zinc have the potential to impact avian omnivores and/or herbivores at the site. The development of CAOs for these potential risk drivers is presented in Section 4.0.

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TABLES

TABLE 3-1

LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS
SWMU 53 – BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Common Name [1]		
Pied-billed grebe	Red-billed tropicbird	Brown pelican [2]
Brown booby	Magnificent frigatebird	Great blue heron
Louisiana heron	Snowy egret	Great egret
Striated heron	Little blue heron	Cattle egret
Least bittern	Yellow-crowned night heron	Black-crowned night heron
White-cheeked pintail	Blue-winged teal	American widgeon
Red-tailed hawk	Osprey	Merlin
Clapper rail	American coot	Caribbean coot
Common gallinule	Piping plover [3]	Semipalmated plover
Black-bellied plover	Wilson's plover	Killdeer
Ruddy turnstone	Black-necked stilt	Whimbrel
Spotted sandpiper	Semipalmated sandpiper	Short-billed dowitcher
Greater yellowlegs	Lesser yellowlegs	Willet
Stilt sandpiper	Pectoral sandpiper	Laughing gull
Royal tern	Sandwich tern	Bridled tern
Least tern	Brown noddy	White-winged dove
Zenaida dove	White-crowned pigeon	Mourning dove
Red-necked pigeon	Common ground dove	Bridled quail dove
Ruddy quail dove	Caribbean parakeet	Smooth-billed ani
Yellow-billed cuckoo	Mangrove cockoo	Short-eared owl
Chuck-will's-widow	Common nighthawk	Antillean crested hummingbird
Green-throated carib	Antillean mango	Belted kingfisher

TABLE 3-1 (continued)

LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS
SWMU 53 – BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Common Name [1]		
Gray kingbird	Loggerhead kingbird	Stolid flycatcher
Caribbean elaenia	Purple martin	Cave swallow
Barn swallow	Northern mockingbird	Pearly-eyed thrasher
Red-legged thrush	Black-whiskered vireo	American redstart
Parula warbler	Prairie warbler	Yellow warbler
Magnolia warbler	Cape May warbler	Black-throated blue warbler
Adelaide's warbler	Palm warbler	Black and white warbler
Ovenbird	Northern water thrush	Bananaquit
Striped-headed tanager	Shiny cowbird	Black-cowled oriole
Greater Antillean grackle	Yellow-shouldered blackbird [2]	Hooded mannikin
Yellow-faced grassquit	Black-faced grassquit	Least sandpiper
Western sandpiper	Puerto Rican woodpecker	Rock dove
Puerto Rican emerald	Puerto Rican flycatcher	Pin-tailed whydah
Spice finch	Ruddy duck	Peregrine falcon
Marbled godwit	Puerto Rican lizard cuckoo	Prothonotary warbler
Green-winged teal	Orange-cheeked waxbill	Roseate tern [3][4]
Least grebe	West Indian whistling duck	Puerto Rican screech owl
Puerto Rican tody		

Notes:

[1] List of birds taken from Geo-Marine, Inc. (1998).
[2] Federally-designated endangered species.
[3] Federally-designated threatened species.
[4] Species has the potential to occur at Naval Station Roosevelt Roads.

TABLE 3-2

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

				Analysis Requested Solid Samples							
Investigation	**Sample ID**	**Date Collected**	**Sample Depth (ft bgs)**	**Pesticides (1)**	**Pesticides**	**APP IX Metals**	**Arsenic**	**Lead**	**Copper**	**Zinc**	**Comments**
Sampling and Analysis Investigation	**Surface Soil:**										
	53SS01	12/13/2000	0.0-1.0		X	X					
	53SS02	12/13/2000	0.0-1.0		X	X					
	53SS03	12/13/2000	0.0-1.0		X	X					
	53SS04	12/13/2000	0.0-1.0		X	X					
	53SS05	12/13/2000	0.0-1.0		X	X					
	53SS06	12/13/2000	0.0-1.0		X	X					
	53SS06D	12/13/2000	0.0-1.0		X	X					Duplicate
	53SB01-00	12/14/2000	0.0-1.0		X	X					
	53SB02-00	12/14/2000	0.0-1.0		X	X					
	53SB02-00D	12/14/2000	0.0-1.0		X	X					Duplicate
	53SB03-00	12/14/2000	0.0-1.0		X	X					
	53SB04-00	12/14/2000	0.0-1.0		X	X					
	53SS04-00D	12/14/2000	0.0-1.0		X	X					Duplicate
	53SB05-00	12/13/2000	0.0-1.0		X	X					
	53SB06-00	12/13/2000	0.0-1.0		X	X					
	Subsurface Soil:										
	53SB01-03	12/14/2000	4.0-6.0		X	X					
	53SB01-05	12/14/2000	8.0-10.0		X	X					
	53SB02-02	12/14/2000	2.0-4.0		X	X					
	53SB03-01	12/14/2000	0.0-2.0		X	X					
	53SB04-02	12/14/2000	4.0-5.5		X	X					
	53SB05-02	12/13/2000	2.0-4.0		X	X					
	53SB06-03	12/13/2000	4.0-6.0		X	X					

TABLE 3-2 (continued)

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

				Analysis Requested Solid Samples							
Investigation	**Sample ID**	**Date Collected**	**Sample Depth (ft bgs)**	**Pesticides (1)**	**Pesticides**	**APP IX Metals**	**Arsenic**	**Lead**	**Copper**	**Zinc**	**Comments**
RCRA Facility Investigation	**Surface Soil:**										
	53SB07-00	2/15/2002	0.0-1.0				X	X			
	53SB08-00	2/15/2002	0.0-1.0				X				
	53SB09-00	2/15/2002	0.0-1.0		X		X				
	53SB10-00	2/15/2002	0.0-1.0				X				
	53SB11-00	2/15/2002	0.0-1.0				X				
	53SB12-00	2/15/2002	0.0-1.0				X	X			
	53SB13-00	2/15/2002	0.0-1.0				X				
	53SB14-00	2/15/2002	0.0-1.0		X		X				
	53SB15-00	2/15/2002	0.0-1.0				X	X			
	53SB15-00D	2/15/2002	0.0-1.0				X				Duplicate
	53SB16-00	2/15/2002	0.0-1.0		X		X				
	53SB17-00	2/15/2002	0.0-1.0		X		X				
	53SB18-00	2/15/2002	0.0-1.0				X				
	53SB18-00D	2/15/2002	0.0-1.0				X				Duplicate
	53SB19-00	2/15/2002	0.0-1.0				X	X			
	53SB20-00	2/15/2002	0.0-1.0				X				
	Subsurface Soil:										
	53SB07-01	2/15/2002	1.0-2.0				X	X			
	53SB08-01	2/15/2002	1.5-2.5				X				
	53SB09-01	2/15/2002	1.5-2.5				X	X			
	53SB10-01	2/15/2002	3.0-4.0		X		X				
	53SB11-01	2/15/2002	3.0-4.0				X				
	53SB11-01D	2/15/2002	3.0-4.0				X				Duplicate
	53SB12-01	2/15/2002	2.0-3.0				X				
	53SB13-01	2/15/2002	1.5-2.5				X	X			
	53SB14-01	2/15/2002	1.5-2.5				X				

TABLE 3-2 (continued)

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

				Analysis Requested Solid Samples							
Investigation	**Sample ID**	**Date Collected**	**Sample Depth (ft bgs)**	**Pesticides (1)**	**Pesticides**	**APP IX Metals**	**Arsenic**	**Lead**	**Copper**	**Zinc**	**Comments**
RCRA Facility Investigation (Cont.)	**Subsurface Soil (cont.):**										
	53SB15-01	2/15/2002	1.5-2.5		X		X				
	53SB16-01	2/15/2002	1.0-2.0				X				
	53SB16-01D	2/15/2002	1.0-2.0				X				Duplicate
	53SB17-01	2/15/2002	1.5-2.5				X				
	53SB18-01	2/15/2002	1.0-2.0				X	X			
	53SB19-01	2/15/2002	2.5-3.5		X		X				
	53SB20-01	2/15/2002	2.0-3.0		X		X				
CMS Investigation	**Surface Soil:**										
	53SS07	3/23/2003	0.0 - 1.0	X				X	X	X	
	53SS08	3/23/2003	0.0 - 1.0	X							
	53SS08D	3/23/2003	0.0 - 1.0	X							Duplicate
	53SS09	3/23/2003	0.0 - 1.0	X							
	53SS10	3/23/2003	0.0 - 1.0	X							
	53SS11	3/23/2003	0.0 - 1.0	X							
	53SS12	3/23/2003	0.0 - 1.0	X(2)							
	53SS13	3/23/2003	0.0 - 1.0					X	X	X	
	53SS14	3/23/2003	0.0 - 1.0	X(2)							
	53SS15	3/23/2003	0.0 - 1.0	X(2)							
	53SS16	3/23/2003	0.0 - 1.0	X(2)							
	53SS17	3/23/2003	0.0 - 1.0					X	X	X	
	53SS17D	3/23/2003	0.0 - 1.0					X	X	X	Duplicate
	53SS18	3/23/2003	0.0 - 1.0					X	X	X	
	53SS19	3/23/2003	0.0 - 1.0					X	X	X	
	53SS20	3/23/2003	0.0 - 1.0					X	X	X	
	53SS21	3/23/2003	0.0 - 1.0					X	X	X	

TABLE 3-2 (continued)

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

				Analysis Requested Solid Samples							
Investigation	**Sample ID**	**Date Collected**	**Sample Depth (ft bgs)**	**Pesticides [1]**	**Pesticides**	**APP IX Metals**	**Arsenic**	**Lead**	**Copper**	**Zinc**	**Comments**
CMS Investigation (Cont.)	**Surface Soil (cont.):**										
	53SS22	3/23/2003	0.0 - 1.0					X	X	X	
	53SS23	3/23/2003	0.0 - 1.0					X	X	X	
	53SS24	3/23/2003	0.0 - 1.0					X	X	X	
	53SS25	3/23/2003	0.0 - 1.0					X	X	X	
	53SS26	3/23/2003	0.0 - 1.0					X	X	X	
	53SS27	3/23/2003	0.0 - 1.0					X	X	X	
	53SS27D	3/23/2003	0.0 - 1.0					X	X	X	Duplicate
	53SS28	3/23/2003	0.0 - 1.0					X	X	X	
	53SS29	3/23/2003	0.0 - 1.0					X	X	X	

Notes:

ft bgs = feet below ground surface.

[1] Chlordane, heptachlor, and heptachlor Epoxide only.

[2] Sample was extracted at the laboratory but not analyzed due to the delineation of pesticides in samples 53SS09 through 53SS11.

TABLE 3-3

PRELIMINARY ASSESSMENT ENDPOINTS, RISK HYPOTHESES, AND MEASUREMENT ENDPOINTS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint [1]
Terrestrial Habitats: Survival, growth, and reproduction of terrestrial invertebrate communities	Are site-related chemical concentrations in surface soil sufficient to adversely affect soil invertebrate communities based on conservative screening values?	Comparison of maximum chemical concentrations in surface soil with surface soil screening values.
Survival, growth, and reproduction of terrestrial plant communities	Are site-related chemical concentrations in surface soil sufficient to adversely affect soil plant communities based on conservative screening values?	Comparison of maximum chemical concentrations in surface soil with surface soil screening values.
Survival, growth, and reproduction of terrestrial avian herbivores.	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume terrestrial plants from the site?	Comparison of literature-derived chronic NOAEL values for survival, growth, or reproductive effects with modeled dietary exposures based on maximum surface soil concentrations.
Survival, growth, and reproduction of terrestrial avian omnivores	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume terrestrial plants and invertebrates from the site?	Comparison of literature-derived chronic NOAEL values for survival, growth, or reproductive effects with modeled dietary exposures based on maximum surface soil concentrations.
Survival, growth, and reproduction of terrestrial avian carnivores	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume small mammals from the site?	Comparison of literature-derived chronic NOAEL values for survival, growth, or reproductive effects with modeled dietary exposures based on maximum surface soil concentrations.
Survival, growth, and reproduction of terrestrial reptiles	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to terrestrial reptiles?	Qualitative examination of exposures and risks to ecological receptors occupying similar trophic levels.

Notes:

[1] Mean surface soil concentrations were used in Step 3a of the baseline ecological risk assessment.

TABLE 3-4

LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow} (1)	Reference	K_{oc} (2) (L/Kg)	Bioaccumulative Chemical (3)
Organochlorine Pesticides:					
4,4'-DDD	4.73 to 6.66	6.10	USEPA 1995	992,156	Yes
4,4'-DDE	5.63 to 6.96	6.76	USEPA 1995	4,419,366	Yes
4,4'-DDT	3.98 to 7.01	6.53	USEPA 1995	2,625,851	Yes
Aldrin	6.11 to 7.50	6.50	USEPA 1995	2,453,466	Yes
Chlordane	5.80 to 6.41	6.32	USEPA 1995	1,632,450	Yes
Chlorobenzilate	3.86 to 4.38	4.38	USEPA 1995	20,222	Yes
Dieldrin	3.63 to 6.20	5.40	USEPA 1995	203,460	Yes
Endosulfan I	Not reported	4.10	USEPA 1996a	10,730	Yes
Endosulfan II	Not reported	4.10	USEPA 1996a	10,730	Yes
Endosulfan sulfate	Not reported	3.66	USEPA 1996a	3,963	Yes
Endrin	2.92 to 5.20	5.06	USEPA 1995	94,245	Yes
Endrin aldehyde	---	4.00	USEPA 1995	8,556	Yes
Heptachlor	4.93 to 6.26	6.26	USEPA 1995	1,425,148	Yes
Heptachlor epoxide	3.50 to 5.40	5.00	USEPA 1995	82,277	Yes
Isodrin	Not reported	6.50	SRC 1998	2,453,466	Yes
Kepone	4.45 to 5.30	5.30	USEPA 1995	162,248	Yes
Methoxychlor	3.31 to 5.60	5.08	USEPA 1995	98,610	Yes
Toxaphene	3.23 to 5.56	5.50	USEPA 1995	255,141	Yes
alpha-BHC	3.75 to 3.81	3.80	USEPA 1995	5,441	Yes
beta-BHC	3.75 to 3.84	3.81	USEPA 1995	5,566	Yes
delta-BHC	Not reported	4.14	USEPA 1996	11,746	Yes
gamma-BHC	3.00 to 4.95	3.73	USEPA 1995	4,644	Yes

Notes:

K_{ow} = Octanol-Water Partition Coefficient.
K_{oc} = Organic Carbon Partition Coefficient.

(1) Log K_{ow} values are measured values unless otherwise noted.

(2) K_{oc} values were estimated from the following equation: Log K_{oc} = 0.00028 + (0.983)(Log K_{ow}) (EPA 1993a and 1996b).

(3) An organic chemical is considered a bioaccumulative chemical if its Log K_{ow} value is greater than or equal to 3.0. When a range of Log K_{ow} values is reported, the upper value within the range was conservatively used to identify bioaccumulative chemicals.

(4) The Log`K_{ow} value shown is an estimated value.

TABLE 3-5

SURFACE SOIL SCREENING VALUES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Organochlorine Pesticides (ug/kg):			
4,4'-DDD	400 (1)	MHSPE 1994	Screening value for total DDD, DDE, and DDT
4,4'-DDE	400 (1)	MHSPE 1994	Screening value for total DDD, DDE, and DDT
4,4'-DDT	400 (1)	MHSPE 1994	Screening value for total DDD, DDE, and DDT
Aldrin	400 (1)	MHSPE 1994	Screening value for total aldrin, endrin and dieldrin
alpha-Chlordane	100	Friday 1998	Background-based screening value
gamma-Chlordane	100	Friday 1998	Background-based screening value
Dieldrin	400 (1)	MHSPE 1994	Screening value for total aldrin, endrin and dieldrin
Endosulfan I	100	Friday 1998	Background-based screening value
Endosulfan II	100	Friday 1998	Background-based screening value
Endosulfan sulfate	100	Friday 1998	Background-based screening value
Endrin	400 (1)	MHSPE 1994	Screening value for total aldrin, endrin and dieldrin
Endrin aldehyde	100	Friday 1998	Background-based screening value
Heptachlor	100	Friday 1998	Background-based screening value
Heptachlor epoxide	100	Friday 1998	Background-based screening value
Kepone	100	Friday 1998	Background-based screening value
Isodrin	100	Friday 1998	Background-based screening value
Methoxychlor	100	Friday 1998	Background-based screening value
Toxaphene	100	Friday 1998	Background-based screening value
alpha-BHC	200 (1)	MHSPE 1994	Screening value for total BHC compounds
beta-BHC	200 (1)	MHSPE 1994	Screening value for total BHC compounds
delta-BHC	200 (1)	MHSPE 1994	Screening value for total BHC compounds
gamma-BHC (Lindane)	200 (1)	MHSPE 1994	Screening value for total BHC compounds
Inorganics (mg/kg):			
Antimony	5	Efroymson et al. 1997b	Toxicological threshold for plants
Arsenic	10	Efroymson et al. 1997b	Toxicological threshold for plants
Barium	500	Efroymson et al. 1997b	Toxicological threshold for plants
Beryllium	10	Efroymson et al. 1997b	Toxicological threshold for plants
Cadmium	4	Efroymson et al. 1997b	Toxicological threshold for plants
Chromium (total)	0.4	Efroymson et al. 1997a	Toxicological threshold for earthworms

TABLE 3-5 (continued)

SURFACE SOIL SCREENING VALUES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Inorganics (mg/kg) (cont.):			
Cobalt	20	Efroymson et al. 1997b	Toxicological threshold for plants
Copper	50	Efroymson et al. 1997a	Toxicological threshold for earthworms
Lead	50	Efroymson et al. 1997b	Toxicological threshold for plants
Mercury	0.10	Efroymson et al. 1997a	Toxicological threshold for earthworms
Nickel	30	Efroymson et al. 1997b	Toxicological threshold for plants
Selenium	1	Efroymson et al. 1997b	Toxicological threshold for plants
Silver	2	Efroymson et al. 1997b	Toxicological threshold for plants
Thallium	1	Efroymson et al. 1997b	Toxicological threshold for plants
Tin	50	Efroymson et al. 1997b	Toxicological threshold for plants
Vanadium	2	Efroymson et al. 1997b	Toxicological threshold for plants
Zinc	50	Efroymson et al. 1997b	Toxicological threshold for plants

Notes:

MHSPE = Ministry of Housing, Spatial Planning and Environment.

(1) The screening value shown is an average of the target and intervention soil standards. The value is based on a default organic carbon content (f_{oc}) 2.0 percent, which represents a minimum value (adjustment range is 2 to 30 percent).

TABLE 3-6

INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Ecological Receptors
Organochlorine Pesticides:										
4,4'-DDD	Mallard duck	1.134	Chronic	Oral	Reproduction	Not Applicable	5.2	0.52	Stickel 1973	---
	American kestrel	0.115	2 years	Oral	Reproduction	Not Applicable	0.5	0.05	McLane and Hall 1972	American robin, mourning dove, and red-tailed hawk
4,4'-DDE	Brown pelican	3.5	Chronic	Oral	Reproduction	Not Applicable	1.31	0.131	Beyer et al. 1996	---
	American kestrel	0.115	2 years	Oral	Reproduction	Not Applicable	0.5	0.05	McLane and Hall 1972	American robin, mourning dove, and red-tailed hawk
4,4'-DDT	Mallard duck	1.134	Chronic	Oral	Reproduction	Not Applicable	1.04	0.104	Davidson and Sell 1974	---
	American kestrel	0.115	2 years	Oral	Reproduction	Not Applicable	0.5	0.05	McLane and Hall 1972	American robin, mourning dove, and red-tailed hawk
Aldrin	Mallard duck	1.134	Chronic	Oral	Mortality	Not Applicable	5	0.5	Tucker and Crabtree 1970	American robin, mourning dove, and red-tailed hawk
Chlordane	Red-winged blackbird	0.064	84 Days	Oral in diet	Mortality	Not Applicable	10.7	2.14	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Chlorobenzilate	---	---	---	---	---	---	NA	NA	---	---
Dieldrin	Barn owl	0.466	2 years	Oral in diet	Reproduction	Not Applicable	0.77	0.077	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Endosulfan 1	Grey partridge	0.4	4 weeks	Oral in diet	Reproduction	Not Applicable	100	10	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Endosulfan 11	Grey partridge	0.4	4 weeks	Oral in diet	Reproduction	Not Applicable	100	10	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Endosulfan sulfate	Grey partridge	0.4	4 weeks	Oral in diet	Reproduction	Not Applicable	100	10	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Endrin	Mallard duck	1.15	>200 days	Oral in diet	Reproduction	Not Applicable	3	0.3	Sample et al. 1996	---
	Screech owl	0.181	>83 days	Oral in diet	Reproduction	Not Applicable	0.1	0.01	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Endrin aldehyde	Mallard duck	1.15	>200 days	Oral in diet	Reproduction	Not Applicable	3	0.3	Sample et al. 1996	---
	Screech owl	0.181	>83 days	Oral in diet	Reproduction	Not Applicable	0.1	0.01	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Heptachlor	Quail	0.191	5 days	Oral in diet	Mortality	Not Applicable	4.05	0.405	Hill et al. 1975	American robin, mourning dove, and red-tailed hawk
Heptachlor epoxide	Quail	0.191	5 days	Oral in diet	Mortality	Not Applicable	4.05	0.405	Hill et al. 1975	American robin, mourning dove, and red-tailed hawk
Kepone	---	---	---	---	---	---	NA	NA	---	---
Isodrin	---	---	---	---	---	---	NA	NA	---	---
Methoxychlor	Quail	0.191	5 days	Oral in diet	Mortality	Not Applicable	4,050	405	Hill and Camardese 1986	American robin, mourning dove, and red-tailed hawk
Toxaphene	Mallard duck	1.043	5 days	Oral in diet	Mortality	Not Applicable	3.07	0.307	Hill and Camardese 1986	American robin, mourning dove, and red-tailed hawk
alpha-BHC	Japanese quail	0.15	90 days	Oral in diet	Reproduction	Not Applicable	2.25	0.56	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
beta-BHC	Japanese quail	0.15	90 days	Oral in diet	Reproduction	Not Applicable	2.25	0.56	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
delta-BHC	Japanese quail	0.15	90 days	Oral in diet	Reproduction	Not Applicable	2.25	0.56	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
gamma-BHC (lindane)	Mallard duck	1	8 weeks	Oral (intubation)	Reproduction	Not Applicable	20	2	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Inorganics:										
Antimony	Northern bobwhite	0.19	6 weeks	Oral	?	?	47,400	4,740	Opresko et al. 1993	American robin, mourning dove, and red-tailed hawk
Arsenic	Brown-headed cowbird	0.049	7 months	Oral in diet	Mortality	Copper acetoarsenite	7.38	2.46	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
	Mallard duck	1.0	128 days	Oral in diet	Mortality	Sodium arsenite	12.84	5.14	Sample et al. 1996	---
Barium	One-day old chicks	0.121	4 weeks	Oral in diet	Mortality	Barium hydroxide	41.7	20.8	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Beryllium	---	---	---	---	---	---	NA	NA	---	---
Cadmium	Mallard duck	1.153	90 days	Oral in diet	Reproduction	Cadmium chloride	20	1.45	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Chromium	American black duck	1.25	10 months	Oral in diet	Reproduction	Cr^{+3} as $CrK(SO_4)_2$	5	1	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Cobalt	Chicken	1.8	14 Days	Oral in diet	Growth	?	14.7	1.47	Diaz et al. 1994	American robin, mourning dove, and red-tailed hawk
Copper	One-day old chicks	0.534	10 weeks	Oral in diet	Growth/mortality	Copper oxide	61.7	47	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Lead	Japanese quail	0.15	12 weeks	Oral in diet	Reproduction	Lead acetate	11.3	1.13	Sample et al. 1996	American robin and mourning dove
	American kestrel	0.13	7 months	Oral in diet	Reproduction	Metallic lead	38.5	3.85	Sample et al. 1996	Red-tailed hawk
Mercury	Japanese quail	0.15	1 year	Oral in diet	Reproduction	Mercuric chloride	0.9	0.45	Sample et al. 1996	---
	Coturnix quail	?	5 days	Oral	Mortality	Mercuric chloride	32.5	3.25	USEPA 1999	---
	Mallard duck	1	3 generations	Oral in diet	Reproduction	Methyl mercury dicyandiamide	0.064	0.0064	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Nickel	Mallard duckling	0.782	90 days	Oral in diet	Growth/mortality	Nickel sulfate	107	77.4	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
	Coturnix quail	?	5 days	Oral	Mortality	?	650	65	USEPA 1999	---

TABLE 3-6 (continued)

INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Ecological Receptors
Inorganics (cont.):										
Selenium	Mallard duck	1	100 days	Oral in diet	Reproduction	Selanomethionine	0.8	0.4	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted
	Mallard duck	1	78 days	Oral in diet	Reproduction	Sodium Selenite	1	0.5	Sample et al. 1996	---
	Screech owl	0.2	13.7 weeks	Oral in diet	Reproduction	Selanomethionine	1.5	0.44	Sample et al. 1996	---
	Black-crowned night heron	0.883	94 days	Oral in diet	Reproduction	Selanomethionine	11.8	1.8	Sample et al. 1996	---
Silver	Mallard duck	?	14 days	Oral	?	?	1,780	178	EPA 1999	American robin, mourning dove, and red-tailed hawk
Thallium	European starling	?	acute	Oral	?	?	3.5	0.35	EPA 1999	American robin, mourning dove, and red-tailed hawk
Tin	Japanese quail	0.15	6 weeks	Oral in diet	Reproduction	bis(Tributyltin)-oxide	16.9	6.8	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Vanadium	Mallard duck	1.17	12 weeks	Oral in diet	Growth/mortality	Vanadyl sulfate	114	11.4	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk
Zinc	White leghorn hen	1.935	44 weeks	Oral in diet	Reproduction	Zinc sulfate	131	14.5	Sample et al. 1996	American robin, mourning dove, and red-tailed hawk

Notes:

NA = Not Available
NOAEL = No Observed Adverse Effect Level
LOAEL = Lowest Observed Adverse Effect Level

TABLE 3-7

CONSERVATIVE SOIL BIOCONCENTRATION FACTORS USED FOR TERRESTRIAL PLANTS AND BIOACCUMULATION FACTORS USED FOR TERRESTRIAL INVERTEBRATES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Organochlorine Pesticides:				
4,4'-DDD	0.0115	Travis and Arms 1988	2	Menzie et al. 1992
4,4'-DDE	0.0048	Travis and Arms 1988	10.6	Menzie et al. 1992
4,4'-DDT	0.0065	Travis and Arms 1988	0.7	Menzie et al. 1992
Aldrin	0.0068	Travis and Arms 1988	1	Assumed
Chlordane	0.0086	Travis and Arms 1988	3	Menzie et al. 1992
Chlorobenzilate	0.1139	Travis and Arms 1988	1	Assumed
Dieldrin	0.0293	Travis and Arms 1988	8	Beyer and Gish 1980
Endosulfan I	0.1653	Travis and Arms 1988	1	Assumed
Endosulfan II	0.1653	Travis and Arms 1988	1	Assumed
Endosulfan sulfate	0.2968	Travis and Arms 1988	1	Assumed
Endrin	0.0461	Travis and Arms 1988	1	Assumed
Endrin aldehyde	0.1888	Travis and Arms 1988	1	Assumed
Heptachlor	0.0093	Travis and Arms 1988	10	Roberts and Dorough 1985
Heptachlor epoxide	0.0499	Travis and Arms 1988	10	Roberts and Dorough 1985
Isodrin	0.0068	Travis and Arms 1988	1	Assumed
Kepone	0.0335	Travis and Arms 1988	1	Assumed
Methoxychlor	0.0448	Travis and Arms 1988	1	Assumed
Toxaphene	0.0256	Travis and Arms 1988	1	Assumed
alpha-BHC	0.2464	Travis and Arms 1988	1	Assumed
beta-BHC	0.2431	Travis and Arms 1988	1	Assumed
delta-BHC	0.1567	Travis and Arms 1988	1	Assumed
gamma-BHC	0.2704	Travis and Arms 1988	1	Assumed
Inorganics:				
Antimony	0.2	Baes et al. 1984	1	Assumed
Arsenic	1.103	Bechtel Jacobs 1998a	0.523	Sample et al. 1998a
Barium	0.15	Baes et al. 1984	0.36	Beyer and Stafford 1993
Beryllium	0.01	Baes et al. 1984	1	Assumed
Cadmium	3.25	Bechtel Jacobs 1998a	40.69	Sample et al. 1998a
Chromium (total)	0.0075	Baes et al. 1984	3.162	Sample et al. 1998a

TABLE 3-7 (continued)

CONSERVATIVE SOIL BIOCONCENTRATION FACTORS USED FOR TERRESTRIAL PLANTS AND BIOACCUMULATION FACTORS USED FOR TERRESTRIAL INVERTEBRATES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Inorganics (cont.):				
Cobalt	0.02	Baes et al. 1984	1	Assumed
Copper	0.625	Bechtel Jacobs 1998a	1.531	Sample et al. 1998a
Lead	0.468	Bechtel Jacobs 1998a	1.522	Sample et al. 1998a
Mercury	5	Bechtel Jacobs 1998a	20.63	Sample et al. 1998a
Nickel	1.411	Bechtel Jacobs 1998a	4.73	Sample et al. 1998a
Selenium	3.012	Bechtel Jacobs 1998a	1.34	Sample et al. 1998a
Silver	0.4	Baes et al. 1984	1	Assumed
Thallium	0.004	Baes et al. 1984	1	Assumed
Tin	0.03	Baes et al. 1984	1	Assumed
Vanadium	0.0055	Baes et al. 1984	0.088	Sample et al. 1998a
Zinc	1.82	Bechtel Jacobs 1998a	12.89	Sample et al. 1998a

Notes:

BCF = Bioconcentration Factor
BAF = Bioaccumulation Factor

TABLE 3-8

CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Omnivore BAF (dry weight)	
	Value	Reference
Organochlorine Pesticides:		
4,4'-DDD	---	see text
4,4'-DDE	---	see text
4,4'-DDT	---	see text
Aldrin	---	see text
Chlordane	---	see text
Chlorobenzilate	---	see text
Dieldrin	---	see text
Endosulfan I	---	see text
Endosulfan II	---	see text
Endosulfan sulfate	---	see text
Endrin	---	see text
Endrin aldehyde	---	see text
Heptachlor	---	see text
Heptachlor epoxide	---	see text
Isodrin	---	see text
Kepone	---	see text
Methoxychlor	---	see text
Toxaphene	---	see text
alpha-BHC	---	see text
beta-BHC	---	see text
delta-BHC	---	see text
gamma-BHC (lindane)	---	see text
Inorganics:		
Antimony	---	see text
Arsenic	0.014	Sample et al. 1998b
Barium	0.069	Sample et al. 1998b
Beryllium	---	see text
Cadmium	0.462	Sample et al. 1998b
Chromium (total)	0.349	Sample et al. 1998b
Cobalt	0.025	Sample et al. 1998b
Copper	0.554	Sample et al. 1998b
Lead	0.286	Sample et al. 1998b
Mercury	0.13	Sample et al. 1998b
Nickel	0.589	Sample et al. 1998b
Selenium	1.263	Sample et al. 1998b
Silver	---	see text
Thallium	0.1227	Sample et al. 1998b
Tin	---	see text
Vanadium	---	see text
Zinc	2.7822	Sample et al. 1998b

Notes:

BAF = Bioaccumulation Factor

TABLE 3-9

CONSERVATIVE EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Receptor	Habitat	Minimum Body Weight (kg)		Maximum Food Ingestion Rate (kg/day - dry)		Area Use Factor (unitless)
		Value	Reference	Value	Reference	
Birds:						
American robin	Terrestrial	0.0635	USEPA 1993b	0.00567 (1)	Levey and Karasov 1989	1.0
Mourning dove	Terrestrial	0.105	Tomlinson et al. 1994	0.01787	Allometric equation from Nagy 1987 for all birds	1.0
Red-tailed hawk	Terrestrial	0.957	USEPA 1993b	0.03952	Sample and Suter II 1994	1.0
Mammals (Prey Items):						
Small mammal omnivores	Terrestrial	0.175 (2)	Jackson 1992	0.0176	Allometric equation from Nagy 1987 for rodents	1.0

Notes

USEPA = United States Environmental Protection Agency

(1) Food ingestion rate weighted by dietary component (plants and invertebrates) based on an invertebrate ingestion rate of 0.31 g/g-day and a plant ingestion rate of 0.59 g/g-day plants.

(2) The minimum body weight shown represents an average of the Norway rat minimum body weight (0.2 kg) and the black rat minumum body weight (0.15 kg).

TABLE 3-10

DIETARY COMPOSITIONS FOR UPPER TROPHIC LEVEL RECEPTORS
SWMU 53 - BUILDIING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Ecological Receptor	Dietary Composition (percent)							Soil/ Sediment Ingestion (percent)	
	Terr. Plants	Soil Invert.	Small Mammals	Frogs	Aquatic Plants	Aquatic Invert.	Reference	Value	Reference
Birds:									
American robin	12	78.9 (1)	0	0	0	0	Martin et al. 1951	9.1	Sample and Suter II 1994
Mourning dove	95	0	0	0	0	0	Tomlinson et al. 1994	5	Assumed
Red-tailed hawk	0	0	97.5 (2)	0	0	0	USEPA 1993b; Sample and Suter II 1994	2.5	Assumed
Mammals (Prey Items):									
Small mammal omnivore (3)	49	49	0	0	0	0	Assumed	2	Assumed

Notes:

USEPA = United States Environmental Protection Agency

(1) Dietary compositions were available for spring, summer, winter, and fall. For conservatism, the percentage of soil invertebrates shown represents the highest percentage of terrestrial insects reported for a given season (spring).

(2) Potential small mammal prey items include the black rat and Norway rat.

(3) Puerto Rican small mammal populations are limited to omnivores (e.g., black rat, Norway rat, and mongoose).

TABLE 3-11

FREQUENCY AND RANGE OF SURFACE SOIL ANALYTICAL DATA (MAXIMUM CONCNETRATIONS) COMPARED TO SURFACE SOIL SCREENING VALUES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Contaminant Frequency/Range					Surface Soil Screening Value (SSSV)		Max. HQ (2)	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Step 2 Screen (1)					
Organochlorine Pesticides (ug/kg):										
4,4'-DDD	3/16	12J - 71J	3.6UJ - 430UJ	36.90	71	400	MHSPE 1994	0.18	No	HQ<1.0
4,4'-DDE	12/16	0.5J - 970	3.8U - 21U	160.02	970	400	MHSPE 1994	2.43	Yes	HQ>1.0
4,4'-DDT	14/16	0.98J - 5100J	3.8U - 4.5U	485.72	5,100	400	MHSPE 1994	12.75	Yes	HQ>1.0
Aldrin	1/16	1.1J - 1.1J	1.9U - 220U	17.61	1.1	400	MHSPE 1994	<0.01	No	HQ<1.0
Chlordane	4/21	19 - 2700	19U - 2200U	329.07	2,700	100	Friday 1998	27.00	Yes	HQ>1.0
Chlorobenzilate	0/4	NA	20U - 110UJ	31.63	110	100	Friday 1998	1.10	Yes	HQ>1.0
Dieldrin	0/16	NA	3.6U - 430UJ	34.78	430	400	MHSPE 1994	1.08	Yes	HQ>1.0
Endosulfan I	0/16	NA	1.9U - 220U	17.85	220	100	Friday 1998	2.20	Yes	HQ>1.0
Endosulfan II	0/16	NA	3.6U - 430UJ	34.78	430	100	Friday 1998	4.30	Yes	HQ>1.0
Endosulfan sulfate	0/16	NA	3.6UJ - 430U	34.78	430	100	Friday 1998	4.30	Yes	HQ>1.0
Endrin	0/16	NA	3.6UJ - 430UJ	34.78	430	400	MHSPE 1994	1.08	Yes	HQ>1.0
Endrin aldehyde	0/16	NA	3.6U - 430U	34.47	430	100	Friday 1998	4.30	Yes	HQ>1.0
Heptachlor	2/21	0.34J - 1.7J	1.9U - 220U	13.57	1.7	100	Friday 1998	0.02	No	HQ<1.0
Heptachlor epoxide	6/21	0.43J - 160	1.9U - 220UJ	20.91	160	100	Friday 1998	1.60	Yes	HQ>1.0
Isodrin	0/4	NA	3.8U - 21U	6.03	21	100	Friday 1998	0.21	No	HQ<1.0
Kepone	2/4	380J - 440J	200U - 230U	258.75	440	100	Friday 1998	4.40	Yes	HQ>1.0
Methoxychlor	0/16	NA	19U - 2200U	178.50	2,200	100	Friday 1998	22.00	Yes	HQ>1.0
Toxaphene	0/16	NA	190U - 22000U	1785.00	22,000	100	Friday 1998	220.00	Yes	HQ>1.0
alpha-BHC	0/16	NA	1.9U - 220U	17.85	220	200	MHSPE 1994	1.10	Yes	HQ>1.0
beta-BHC	0/16	NA	1.9U - 220U	17.85	220	200	MHSPE 1994	1.10	Yes	HQ>1.0
delta-BHC	0/16	NA	1.9U - 220U	17.85	220	200	MHSPE 1994	1.10	Yes	HQ>1.0
gamma-BHC(Lindane)	0/16	NA	1.9U - 220U	17.85	220	200	MHSPE 1994	1.10	Yes	HQ>1.0
Inorganics (mg/kg):										
Antimony	9/12	0.53J - 6.1J	2UJ - 2.5UJ	2.21	6.1	5	Efroymson et al. 1997b	1.22	Yes	HQ>1.0
Arsenic	24/26	0.65J - 5.6	1.1U - 2.6U	2.03	5.6	10	Efroymson et al. 1997b	0.56	No	HQ<1.0
Barium	12/12	68J - 670J	NA	245.67	670	500	Efroymson et al. 1997b	1.34	Yes	HQ>1.0
Beryllium	12/12	0.16J - 0.38J	NA	0.24	0.38	10	Efroymson et al. 1997b	0.04	No	HQ<1.0
Cadmium	12/12	0.47J - 3.6	NA	1.55	3.6	4	Efroymson et al. 1997b	0.90	No	HQ<1.0
Chromium	12/12	29J - 130J	NA	54.50	130	0.4	Efroymson et al. 1997a	325.00	Yes	HQ>1.0
Cobalt	12/12	20 - 57	NA	33.25	57	20	Efroymson et al. 1997b	2.85	Yes	HQ>1.0
Copper	27/27	39 - 120J	NA	80.04	120	50	Efroymson et al. 1997a	2.40	Yes	HQ>1.0
Lead	27/27	2.6 - 3900	NA	534.95	3,900	50	Efroymson et al.1997b	78.00	Yes	HQ>1.0
Mercury	12/12	0.011J - 0.069J	NA	0.04	0.069	0.1	Efroymson et al. 1997a	0.69	No	HQ<1.0
Nickel	12/12	17 - 25	NA	20.75	25	30	Efroymson et al. 1997b	0.83	No	HQ<1.0
Selenium	7/12	0.58J - 1.3	1U - 1.4U	0.71	1.3	1	Efroymson et al. 1997b	1.30	Yes	HQ>1.0
Silver	0/12	NA	1U - 1.4U	0.58	1.4	2	Efroymson et al. 1997b	0.70	No	HQ<1.0
Thallium	0/12	NA	1U - 1.4U	0.58	1.4	1	Efroymson et al. 1997b	1.40	Yes	HQ>1.0
Tin	7/12	6.4 - 35	5U - 6.2U	9.55	35	50	Efroymson et al. 1997b	0.70	No	HQ<1.0

TABLE 3-11 (continued)
FREQUENCY AND RANGE OF SURFACE SOIL ANALYTICAL DATA (MAXIMUM CONCNETRATIONS COMPARED TO SURFACE SOIL SCREENING VALUES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Contaminant Frequency/Range					Surface Soil Screening Value (SSSV) [2]		Max. HQ [3]	CCOPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Step 2 Screen [1]					
Inorganics (mg/kg) (cont.):										
Vanadium	12/12	110 - 180	NA	152.50	180	2	Efroymson et al. 1997b	90	Yes	HQ>1.0
Zinc	27/27	48 - 5800	NA	827.00	5,800	50	Efroymson et al. 1997b	116	Yes	HQ>1.0

Notes:

COPC = Chemical of Potetnial Concern
SSSV = Surface Soil Screening Value
HQ = Hazard Quotient
NA = Not Applicable

J = value is estimated
U = Not detected
UJ = Not detected, value is estimated

[1] Maximum detected concentration (or maximum reporting limit for non-detected chemicals).
[2] For a given chemical, the Hazard Quotient (HQ) is the maximum detected concentration (or maximum reporting limit for non-detected chemicals) divided by the surface soil screening value.

TABLE 3-12

SUMMARY OF HAZARD QUOTIENTS FOR TERRESTRIAL FOOD WEB EXPOSURE
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	American robin			Mourning dove			Red-tailed hawk		
Chemical	**NOAEL**	**LOAEL**	**MATC**	**NOAEL**	**LOAEL**	**MATC**	**NOAEL**	**LOAEL**	**MATC**
Organochlorine Pesticides:									
4,4'-DDD	0.21	0.02	0.07	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
4,4'-DDE	14.65	1.46	4.63	0.07	<0.01	0.02	1.30	0.13	0.41
4,4'-DDT	5.87	0.59	1.86	0.47	0.05	0.15	0.58	0.06	0.18
Aldrin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chlordane	0.28	0.06	0.12	0.01	<0.01	<0.01	0.03	<0.01	<0.01
Chlorobenzilate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	3.19	0.32	1.01	0.07	<0.01	0.02	0.29	0.03	0.09
Endosulfan I	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan II	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan Sulfate	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endrin	3.40	0.34	1.08	0.02	<0.01	<0.01	0.33	0.03	0.11
Endrin Aldehyde	3.47	0.35	1.10	0.06	<0.01	0.02	0.37	0.04	0.12
Heptachlor	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heptachlor Epoxide	0.28	0.03	0.09	<0.01	<0.01	<0.01	0.03	<0.01	<0.01
Isodrin	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kepone	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methoxychlor	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Toxaphene	5.65	0.57	1.79	0.91	0.09	0.29	0.55	0.05	0.17
alpha-BHC	0.03	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
beta-BHC	0.03	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
delta-BHC	0.03	<0.01	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Gamma-BHC (Lindane)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Inorganics:									
Antimony	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	0.13	0.04	0.07	0.43	0.14	0.25	<0.01	<0.01	<0.01
Barium	1.13	0.56	0.80	1.06	0.53	0.75	0.12	0.06	0.09
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7.22	0.52	1.95	1.33	0.10	0.36	0.05	<0.01	0.01
Chromium	30.03	6.01	13.43	1.26	0.25	0.57	1.96	0.39	0.88
Cobalt	3.06	0.31	0.97	0.46	0.05	0.14	0.08	<0.01	0.03
Copper	0.31	0.24	0.27	0.28	0.21	0.24	0.06	0.05	0.05
Lead	415.48	41.55	131.39	290.47	29.05	91.86	12.71	1.27	4.02
Mercury	16.34	1.63	5.17	8.81	0.88	2.78	0.07	<0.01	0.02
Nickel	0.12	0.08	0.10	0.08	0.06	0.06	<0.01	<0.01	<0.01
Selenium	0.44	0.22	0.31	1.61	0.81	1.14	0.17	0.08	0.12
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thallium	0.31	0.03	0.10	0.04	<0.01	0.01	0.02	<0.01	<0.01
Tin	0.41	0.16	0.26	0.07	0.03	0.04	0.04	0.02	0.03
Vanadium	0.23	0.02	0.07	0.15	0.01	0.05	0.03	<0.01	<0.01
Zinc	374.35	41.44	124.54	121.09	13.40	40.29	45.22	5.01	15.04

TABLE 3-13

SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Hazard Quotient	
	Surface Soil Screening Evaluation	Food Web Evaluation [1]
Organochlorine Pesticides:		
4,4'-DDD		
4,4'-DDE	2.43	14.65 - American robin
4,4'-DDT	12.75	5.87 - American robin
Aldrin		
Chlordane	27.00	
Chlorobenzilate	1.10	No screening value
Dieldrin	1.08	3.19 - American robin
Endosulfan I	2.20	
Endosulfan II	4.30	
Endosulfan sulfate	4.30	
Endrin	1.08	3.40 - American robin
Endrin aldehyde	4.30	3.47 - American robin
Heptachlor		
Heptachlor epoxide	1.60	
Isodrin		No screening value
Kepone	4.40	No screening value
Methoxychlor	22.00	
Toxaphene	220.00	5.65 - American robin
alpha-BHC	1.10	
beta-BHC	1.10	
delta-BHC	1.10	
gamma-BHC	1.10	
Inorganics:		
Antimony	1.22	
Arsenic		
Barium	1.34	1.13 - American robin
Beryllium		No screening value
Cadmium		7.22 - American robin
Chromium (total)	325.00	30.03 - American robin
Cobalt	2.85	3.06 - American robin
Copper	2.40	
Lead	78.00	414.48 - American robin
Mercury		16.34 - American robin
Nickel		
Selenium	1.30	1.61 - Mourning dove
Silver		
Thallium	1.40	
Tin		
Vanadium	90.00	
Zinc	116.00	374.35 - American robin

Shaded cell indicates that the chemical was detected.
Numbers within cells are HQ values

Notes:

[1] For a given chemical, only the maximum HQ value is shown.

TABLE 3-14

LESS CONSERVATIVE SOIL BIOCONCENTRATION FACTORS USED FOR TERRESTRIAL PLANTS AND BIOACCUMULATION FACTORS USED FOR TERRESTRIAL INVERTEBRATES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Organochlorine Pesticides:				
4,4'-DDE	0.0048	Travis and Arms 1988	10.6	Menzie et al. 1992
4,4'-DDT	0.0065	Travis and Arms 1988	0.7	Menzie et al. 1992
Dieldrin	0.0293	Travis and Arms 1988	8	Beyer and Gish 1980
Endrin	0.0461	Travis and Arms 1988	1	Assumed
Endrin aldehyde	0.1888	Travis and Arms 1988	1	Assumed
Kepone	0.0335	Travis and Arms 1988	1	Assumed
Toxaphene	0.0256	Travis and Arms 1988	1	Assumed
Inorganics (mg/kg):				
Barium	0.15	Baes et al. 1984	0.36	Beyer and Stafford 1993
Beryllium	0.01	Baes et al. 1984	1	Assumed
Cadmium	3.25	Bechtel Jacobs 1998a	7.66	Sample et al. 1998a
Chromium (total)	0.0075	Baes et al. 1984	0.32	Sample et al. 1998a
Cobalt	0.02	Baes et al. 1984	0.38	Helmke et al. 1979
Lead	0.468	Bechtel Jacobs 1998a	0.307	Sample et al. 1998a
Mercury	5	Bechtel Jacobs 1998a	1.186	Sample et al. 1998a
Selenium	3.012	Bechtel Jacobs 1998a	0.982	Sample et al. 1998a
Zinc	1.82	Bechtel Jacobs 1998a	2.482	Sample et al. 1998a

Notes:

BCF = Bioconcentration Factor
BAF = Bioaccumulation Factor

TABLE 3-15

LESS CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Omnivore BAF (dry weight)	
	Value	Reference
Organochlorine Pesticides:		
4,4'-DDE	---	see text
4,4'-DDT	---	see text
Dieldrin	---	see text
Endrin	---	see text
Endrin aldehyde	---	see text
Kepone	---	see text
Toxaphene	---	see text
Inorganics:		
Barium	0.0451	Sample et al. 1998b
Beryllium	---	see text
Cadmium	0.144	Sample et al. 1998b
Chromium (total)	0.092	Sample et al. 1998b
Cobalt	0.0168	Sample et al. 1998b
Lead	0.0548	Sample et al. 1998b
Mercury	0.0731	Sample et al. 1998b
Selenium	0.2579	Sample et al. 1998b
Zinc	0.5092	Sample et al. 1998b

Notes:

BAF = Bioaccumulation Factor

TABLE 3-16

LESS CONSERVATIVE EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Receptor	Habitat	Mean Body Weight (kg)		Mean Food Ingestion Rate (kg/day - dry)		Area Use Factor (unitless)
		Value	Reference	Value	Reference	
Birds:						
American robin	Terrestrial	0.0773	USEPA 1993b	0.00426 (1)	Levey and Karasov 1989	1.0
Mourning dove	Terrestrial	0.1265	Tomlinson et al. 1994	0.0152	Allometric equation from Nagy 1987 for all birds	1.0
Red-tailed hawk	Terrestrial	1.126	Sample and Sutter II 1994	0.0360	Sample and Suter II 1994	1.0
Mammals (Prey Items):						
Small mammal omnivores	Terrestrial	0.275 (2)	Jackson 1992	0.0148	Allometric equation from Nagy 1987 for rodents	1.0

Notes

USEPA = United States Environmental Protection Agency

(1) Food ingestion rate weighted by dietary component (plants and invertebrates) based on an invertebrate ingestion rate of 0.31 g/g-day and a plant ingestion rate of 0.59 g/g-day plants.

(2) The minimum body weight shown represents an average of the Norway rat minimum body weight (0.2 kg) and the black rat minumum body weight (0.15 kg).

TABLE 3-17

FREQUENCY AND RANGE OF BASE BACKGROUND AND SWMU 9 BACKGROUND ANALYTICAL DATA FOR SURFACE SOIL
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	SWMU 9 Background						Base Background (NSRR)					
Chemical	**No. of Positive Detects/No. of Samples**	**Range of Non-Detects**	**Range of Positive Detections**	**Maximum Detected Conc.**	**Arithmatic Mean (half Non-detects)**	**Standard Deviation**	**No. of Positive Detects/No. of Samples**	**Range of Non-Detects**	**Range of Positive Detections**	**Maximum Detected Conc.**	**Arithmatic Mean (half Non-detects)**	**Standard Deviation**
Inorganics (mg/kg):												
Antimony	0/0	(1)	(1)	(1)	(1)	(1)	0/4	2.2 UJ-2.4 UJ	NA	NA	1.15	0.04
Arsenic	5/5	NA	0.21 J-2.5 J	2.5 J	1.86	0.94	4/4	NA	0.35 J-1.8	1.8	1.21	0.63
Barium	5/5	NA	53 -110	110	76.40	23.48	4/4	NA	35.6-169	169	90.60	57.47
Beryllium	5/5	NA	0.15 J-0.36 J	0.36 J	0.24	0.10	3/4	0.1 U-0.1 U	0.21 -0.36	0.36	0.23	0.13
Cadmium	2/5	0.059 U-0.062 U	0.18 J-0.92 J	0.92 J	0.24	0.39	0/4	0.26 U-0.28 U	NA	NA	0.14	0.00
Chromium	5/5	NA	9.6 -34	34	19.52	10.74	4/4	NA	11 J-44.1 J	44.1 J	29.65	13.81
Cobalt	5/5	NA	16 -64	64	33.40	18.23	4/4	NA	9.5 -30.2	30.2	21.98	9.11
Copper	5/5	NA	66 J-100 J	100 J	75.60	14.50	4/4	NA	57-250	250	117.10	90.48
Lead	0/5	NA	3.5 J-21 J	21 J	10.54	7.71	4/4	NA	2.4 -11.9	11.9	7.63	4.10
Mercury	5/5	NA	0.03 J-0.12 J	0.12 J	0.06	0.04	3/4	0.04 U-0.04 U	0.06-0.07	0.07	0.06	0.02
Nickel	5/5	NA	4.6 J-17	17	9.74	5.80	4/4	NA	5.8 -10.9	10.9	8.28	2.11
Selenium	0/5	0.41 UJ-2.1 UJ	NA	NA	0.54	0.31	3/4	0.13 UJ-0.13 UJ	0.56 J-1.2 J	1.2 J	0.73	0.53
Silver	0/5	0.067 U-0.15 U	NA	NA	0.04	0.02	0/4	0.35 U-0.39 U	NA	NA	0.19	0.01
Sulfide	2/5	29 U-31 U	39 -44	44	25.60	14.63	0/4	26.7 U-29.2 U	NA	NA	14.24	0.60
Thallium	0/5	0.21 UJ-0.36 UJ	NA	NA	0.12	0.03	1/4	0.08 U-0.09 UJ	0.1 J-0.1 J	0.1 J	0.06	0.03
Tin	5/5	NA	1.4 J-2.3 J	2.3 J	2.02	0.37	2/4	1.2 U-1.3 U	1.4 -2.2	2.2	1.21	0.75
Vanadium	5/5	NA	120 -270	270	196.00	56.83	4/4	NA	123 -227	227	177.25	43.24
Zinc	5/5	NA	36 J-67 J	67 J	52.60	11.97	4/4	NA	34.2 J-106 J	106 J	62.58	31.90
Cyanide	0/5	1.1 U-1.2 U	NA	NA	0.59	0.02	0/4	0.46 U-0.57 U	NA	NA	0.26	0.03

Notes :

NA= Not Analyzed
U = Not Detected
UJ = Not detected, estimated value
J = Estimated Value

(1) Sample results were rejected during data validation.

TABLE 3-18

FREQUENCY AND RANGE OF SURFACE SOIL ANALYTICAL DATA (MEAN CONCENTRATIONS) COMPARED TO SURFACE SOIL SCREENING VALUES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEFELT ROADS, CEIBA, PUERTO RICO

Chemical	Contaminant Frequency/Range					Surface Soil Screening Value (SSSV)		Mean HQ [2]	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value Used in Step 3a Screen [1]				
Pesticides (ug/kg):									
4,4'-DDE	12/16	0.5J - 970	3.8U - 21U	160.02	160.02	400	USEPA 2002	0.40	HQ<1.0
4,4'-DDT	14/16	0.98J - 5100J	3.8U - 4.5U	485.72	485.72	400	USEPA 2002	1.21	HQ>1
Chlordane	4/21	19 - 2700	19U - 2200U	329.07	329.07	100	USEPA 2002	3.29	HQ>1
Chlorobenzilate	0/4	NA	20U - 110UJ	31.63	31.63	100	USEPA 2002	0.32	HQ<1.0
Dieldrin	0/16	NA	3.6U - 430UJ	34.78	34.78	400	USEPA 2002	0.09	HQ<1.0
Endosulfan I	0/16	NA	1.9U - 220U	17.85	17.85	100	USEPA 2002	0.18	HQ<1.0
Endosulfan II	0/16	NA	3.6U - 430UJ	34.78	34.78	100	USEPA 2002	0.35	HQ<1.0
Endosulfan sulfate	0/16	NA	3.6UJ - 430U	34.78	34.78	100	USEPA 2002	0.35	HQ<1.0
Endrin	0/16	NA	3.6UJ - 430UJ	34.78	34.78	400	USEPA 2002	0.09	HQ<1.0
Endrin aldehyde	0/16	NA	3.6U - 430U	34.47	34.47	100	USEPA 2002	0.34	HQ<1.0
Heptachlor epoxide	6/21	0.43J - 160	1.9U - 220UJ	20.91	20.91	100	USEPA 2002	0.21	HQ<1.0
Kepone	2/4	380J - 440J	200U - 230U	258.75	258.75	100	USEPA 2002	2.59	HQ<1.0
Methoxychlor	0/16	NA	19U - 2200U	178.50	178.50	100	USEPA 2002	1.79	HQ>1.0
Toxaphene	0/16	NA	190U - 22000U	1,785.00	1,785.00	100	USEPA 2002	17.85	HQ>1.0
alpha-BHC	0/16	NA	1.9U - 220U	17.85	17.85	200	USEPA 2002	0.09	HQ<1.0
beta-BHC	0/16	NA	1.9U - 220U	17.85	17.85	200	USEPA 2002	0.09	HQ<1.0
delta-BHC	0/16	NA	1.9U - 220U	17.85	17.85	200	USEPA 2002	0.09	HQ<1.0
gamma-BHC(Lindane)	0/16	NA	1.9U - 220U	17.85	17.85	200	USEPA 2002	0.09	HQ<1.0
Inorganics (mg/kg):									
Antimony	9/12	0.53J - 6.1J	2UJ - 2.5UJ	2.21	2.21	5	Efroymson et al 1997b	0.44	HQ<1.0
Barium	12/12	68J - 670J	NA	245.67	245.67	500	Efroymson et al 1997b	0.49	HQ<1.0
Chromium	12/12	29J - 130J	NA	54.50	54.50	0.4	Efroymson et al 1997a	136.25	HQ>1
Cobalt	12/12	20 - 57	NA	33.25	33.25	20	Efroymson et al 1997b	1.66	HQ>1
Copper	27/27	39 - 120J	NA	80.04	80.04	50	Efroymson et al 1997a	1.60	HQ>1
Lead	27/27	2.6 - 3900	NA	534.95	534.95	50	Efroymson et al 1997b	10.70	HQ>1
Selenium	7/12	0.58J - 1.3	1U - 1.4U	0.71	0.71	1	Efroymson et al 1997b	0.71	HQ<1.0
Thallium	0/12	NA	1U - 1.4U	0.58	0.58	1	Efroymson et al 1997b	0.58	HQ<1.0
Vanadium	12/12	110 - 180	NA	152.50	152.50	2	Efroymson et al 1997b	76.25	HQ>1
Zinc	27/27	48 - 5800	NA	827.00	827.00	50	Efroymson et al 1997b	16.54	HQ>1

Notes:

COPC = Chemical of Potetnial Concern
SSSV = Surface Soil Screening Value
HQ = Hazard Quotient
NA = Not Applicable

J = value is estimated
U = Not detected
UJ = Not detected, value is estimated

[1] Mean concentration unless the mean exceeds the maximum concentration.

[2] The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used.

TABLE 3-19

FREQUENCY AND RANGE OF SWMU 53 SURFACE SOIL DATA COMPARED TO BASE BACKGROUND
SWMU 53 - (BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	SWMU 53 Surface Soil						Basewide Background Surface Soil					
Chemical	**No. of Positive Detects/ No. of Samples**	**Range of Non-Detects**	**Range of Positive Detections**	**Max. Detected Conc.**	**Arithmetic Mean (half Non-detects)**	**Standard Deviation**	**No. of Positive Detects/ No. of Samples**	**Range of Non-Detects**	**Range of Positive Detections**	**Max. Detected Conc.**	**Arithmetic Mean (half Non-detects)**	**Standard Deviation**
Antimony	9/12	0.53J - 6.1J	2UJ - 2.5UJ	6.1	2.21	1.92	0/4	2.2UJ - 2.4UJ	NA	NA	1.15	0.04
Arsenic	24/26	0.65J - 5.6	1.1U - 2.6U	5.6	2.03	1.61	4/4	NA	0.35J - 1.8	1.8	1.21	0.63
Barium	12/12	68J - 670J	NA	670	245.67	209.11	4/4	NA	35.6 - 169	169	90.60	57.47
Beryllium	12/12	0.16J - 0.38J	NA	0.38	0.24	0.07	3/4	0.1U - 0.1U	0.21 - 0.36	0.36	0.23	0.13
Cadmium	12/12	0.47J - 3.6	NA	3.6	1.55	0.99	0/4	0.26U - 0.28U	NA	NA	0.14	0.00
Chromium	12/12	29J - 130J	NA	130	54.50	28.58	4/4	NA	11J - 44.1J	44.1	29.65	13.81
Cobalt	12/12	20 - 57	NA	57	33.25	10.97	4/4	NA	9.5 - 30.2	30.2	21.98	9.11
Copper	27/27	39 - 120J	NA	120	80.04	16.36	4/4	NA	57 - 250	250	117.10	90.48
Lead	27/27	2.6 - 3900	NA	3,900	534.95	1,118.94	4/4	NA	2.4 - 11.9	11.9	7.63	4.10
Mercury	12/12	0.011J - 0.069J	NA	0.069	0.04	0.02	3/4	0.04U - 0.04U	0.06 - 0.07	0.07	0.06	0.02
Nickel	12/12	17 - 25	NA	25	20.75	3.47	4/4	NA	5.8 - 10.9	10.9	8.28	2.11
Selenium	7/12	0.58J - 1.3	1U - 1.4U	1.3	0.71	0.23	3/4	0.13UJ - 0.13UJ	0.56J - 1.2J	1.2	0.73	0.53
Silver	0/12	NA	1U - 1.4U	NA	0.58	0.06	0/4	0.35U - 0.39U	NA	NA	0.19	0.01
Thallium	0/12	NA	1U - 1.4U	NA	0.58	0.06	1/4	0.08U - 0.09UJ	0.1J - 0.1J	0.1	0.06	0.03
Tin	7/12	6.4 - 35	5U - 6.2U	35	9.55	9.79	2/4	1.2U - 1.3U	1.4 - 2.2	2.2	1.21	0.75
Vanadium	12/12	110 - 180	NA	180	152.50	21.37	4/4	NA	123 - 227	227	177.25	43.24
Zinc	27/27	48 - 5800	NA	5,800	827.00	1,374.30	4/4	NA	34.2J - 106J	106	62.58	31.90

Notes:

NA = Not Applicable
U = Not Detected
J = Estimated Value
UJ = Reported detection limit is qualified as estimated

TABLE 3-20

SUMMARY OF HAZARD QUOTIENTS FOR LESS CONSERVATIVE TERRESTRIAL FOOD WEB EXPOSURES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Hazard Quotient Values Based on Mean Exposure Doses								
	American robin			Mourning dove			Red-tailed hawk		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
Organochlorine Pesticides:									
4,4'-DDE	1.49	0.15	0.47	<0.01	<0.01	<0.01	0.09	<0.01	0.03
4,4'-DDT	0.34	0.03	0.11	0.03	<0.01	<0.01	0.03	<0.01	<0.01
Dieldrin	0.16	0.02	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endrin	0.17	0.02	0.05	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Endrin Aldehyde	0.17	0.02	0.05	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Kepone	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toxaphene	0.28	0.03	0.09	0.05	<0.01	0.02	0.02	<0.01	<0.01
Inorganics:									
Barium	0.26	0.13	0.18	0.27	0.14	0.19	0.03	0.01	0.02
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.37	0.03	0.10	0.07	<0.01	0.02	<0.01	<0.01	<0.01
Chromium	1.03	0.21	0.46	0.37	0.07	0.17	0.20	0.04	0.09
Cobalt	0.49	0.05	0.15	0.19	0.02	0.06	0.03	<0.01	<0.01
Lead	8.80	0.88	2.78	4.87	0.49	1.54	0.35	0.03	0.11
Mercury	0.36	0.04	0.11	0.27	0.03	0.09	0.02	<0.01	<0.01
Selenium	0.09	0.05	0.06	0.13	0.06	0.09	0.02	<0.01	0.01
Zinc	6.57	0.73	2.19	2.66	0.29	0.89	0.95	0.11	0.32

Notes

NOAEL = No Observed Adverse Effect Level
LOAEL = Lowest Observed Adverse Effect Level
MATC = Maximum Acceeptable Toxicant Concentration
HQ = hazard Quotient
NA = HQ value could not be calculated due to the lack of an ingestion-based screening value

TABLE 3-21

SUMMARY OF ECOLOGICAL CHEMICALS OF POTETNIAL CONCERN AND POTENTIAL RISK DRIVERS
SWMU 53 - BUILDING 53 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemcials	Terrestrial Habitats	
	Invertebrate and Plant Communites	**Upper Trophic Level Food Web Exposures**
Risk Drivers Recommended for CAO Development	4,4'-DDT Chlordane Kepone Chromium Lead Zinc	4,4'-DDE 4,4'-DDT Kepone Lead Zinc
Ecological Chemicals of Potential Concern Not Recommended for CAO Development	4,4'-DDE Chlorobenzilate Dieldrin Endosulfan I Endosulfan II Endosulfan sulfate Endrin Heptachlor epoxide Methoxychlor Toxaphene alpha-BHC beta-BHC delta-BHC gamma-BHC (Lindane) Antimony Barium Chromium Cobalt Copper Selenium Thallium Vanadium	Dieldrin Chlorobenzilate Endrin Endrin aldehyde Isodrin Toxaphene Barium Beryllium Cadmium Chromium Cobalt Mercury Selenium

FIGURES

Figure 3-1: 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)

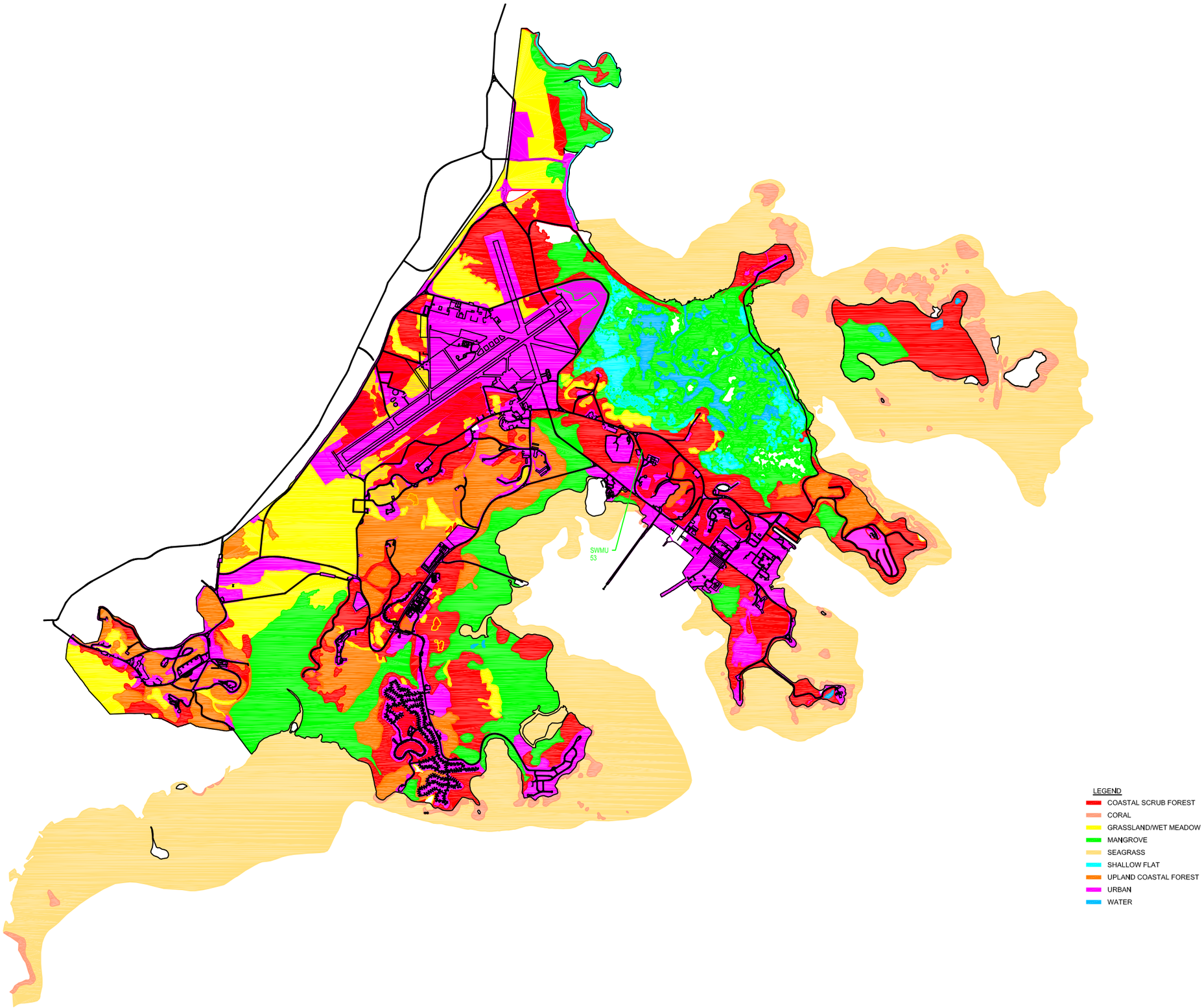
a. Develop site specific risk based cleanup values.

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.



SOURCE: GEO-MARINE, INC.

REVISIONS		NORTH		NAVAL STATION ROOSEVELT ROADS PUERTO RICO	Baker	"TERRESTRIAL AND AQUATIC HABITAT OCCURRING AT NAVAL STATION ROOSEVELT ROADS"	FIGURE
	DRAWN GLB/WJH REVIEWED MEK S.O.# 26007-099 CADD# 2099824W			BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania		SCALE 1" = 600' DATE JULY 2003	3-2

Source: Geo-Marine, Inc., September 6, 2000

Figure 3-3
Naval Station Roosevelt Roads Wetlands Delineation

North and East Sections

This certifies that this plat identifies potential waters and wetlands regulated persuant to Section 404 of the Clean Water Act. Wetlands were delineated in December, 1999 from 1993 color infrared and 1998 true color aerial photography. Twenty percent of the wetlands were field checked to verify the accuracy of the delineations. Field verification were based upon the 1987 Corps of Engineers Wetland Delineation Manual.

FIGURE 3-4
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
CORRECTIVE MEASURES STUDY FINAL REPORT
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

SYSTEM: M - MARINE

SUBSYSTEM	1 - SUBTIDAL					2 - INTERTIDAL			
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	RF - Reef	OW - Open Water (unknown bottom)	AB - Aquatic Bed	RF - Reef	RS - Rocky Shore	US - Unconsolidated Shore
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 3 Rooted Vasc 5 Unknown	1 Coral 3 Worm		1 Algal 3 Rooted Vasc 5 Unknown	1 Coral 3 Worm	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic

SYSTEM: E - ESTUARINE

SUBSYSTEM	1 - SUBTIDAL			2 - INTERTIDAL							
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	RF - Reef	OW - Open Water *(unknown bottom)*	AB - Aquatic Bed	RF - Reef	SB - Streambed	RS - Rocky Shore	US - Unconsolidated Shore	EM - Emergent	SS - Scrub-Shrub	FO - Forested
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	2 Mollusk 3 Worm		1 Algal 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	2 Mollusk 3 Worm	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Dead	1 Persistent 2 Nonpersistent	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*

SYSTEM: R - RIVERINE

SUBSYSTEM	1 - TIDAL	2 - LOWER PERENNIAL		3 - UPPER PERENNIAL		4 INTERMITTENT		5 - UNKNOWN PERENNIAL		
CLASS	RB - Rock	UB - Unconsolidated Bottom	SB - Streambed	AB - Aquatic Bed	RS - Rocky Shore	US - Unconsolidated Shore	OW - Open Water *(unknown bottom)*	**EM - Emergent	RB - Rock Bottom	UB - Unconsolidated Bottom
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble 3 Cobble - Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic		2 Nonpersistent	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic

SYSTEM: L - LACUSTRINE

SUBSYSTEM	1 - LIMNETIC		2 - LITTORAL						
CLASS	AB - Aquatic Bed	OW - Open Water *(unknown bottom)*	RB - Rock Bottom	RS - Rocky Shore	UB - Unconsolidated Bottom	AB - Aquatic Bed	US - Unconsolidated Shore	EM - Emergent	OW - Open Water *(unknown bottom)*
Subclass	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*		1 Bedrock 2 Rubble	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent	

SYSTEM: P - PALUSTRINE

CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	US - Unconsolidated Shore	ML - Moss-Lichen	EM - Emergent	SS - Scrub-Shrub	FO - Forested	OW - Open Water *(unknown bottom)*
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	1 Moss 2 Lichen	1 Persistent 2 Nonpersistent	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	

MODIFIERS

WATER REGIME

Non-Tidal

A Temp. Flooded
B Saturated
C Seasonally Flooded
D Seasonally Flooded/ Well Drained
E Seasonally Flooded/ Saturated
F Semipermanently Flooded
G Intermittently Exposed
H Permanently Flooded
J Intermittently Flooded
K Artificially Flooded
W Intermittently Flooded/ Temporary
Y Saturated/Semipermanent/ Seasonal
Z Intermittently Exposed Permanent
U Unknown

Tidal

K Artificially Flooded
L Subtidal
M Irregularly Flooded
N Regularly Flooded
P Irregularly Flooded
*S Temporary-Tidal
*R Seasonal-Tidal
*T Semipermanent- Tidal
*V Permanent-Tidal
U Unknown

* These water regimes are only used in tidally influenced, freshwater systems.

WATER CHEMISTRY

Coastal Halinity

1 Hyperhaline
2 Euhaline
3 Mixohaline
4 Polyhaline
5 Mesohaline
6 Oligohaline
0 Fresh

Inland Salinity

7 Hypersaline
8 Eusaline
9 Mixosaline
0 Fresh

pH (fresh water)

a Acid
t circumneutral
i Alkaline

SOIL

g Organic
n Mineral

SPECIAL

b Beaver
d partially drained/ditched
f Farmed
h Diked/Impounded
r Artificial Substrate
s Spoil
x Excavated

SOURCE: UNITED STATES, FISH AND WILDLIFE SERVICE. CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS OF THE UNITED STATES, 1985

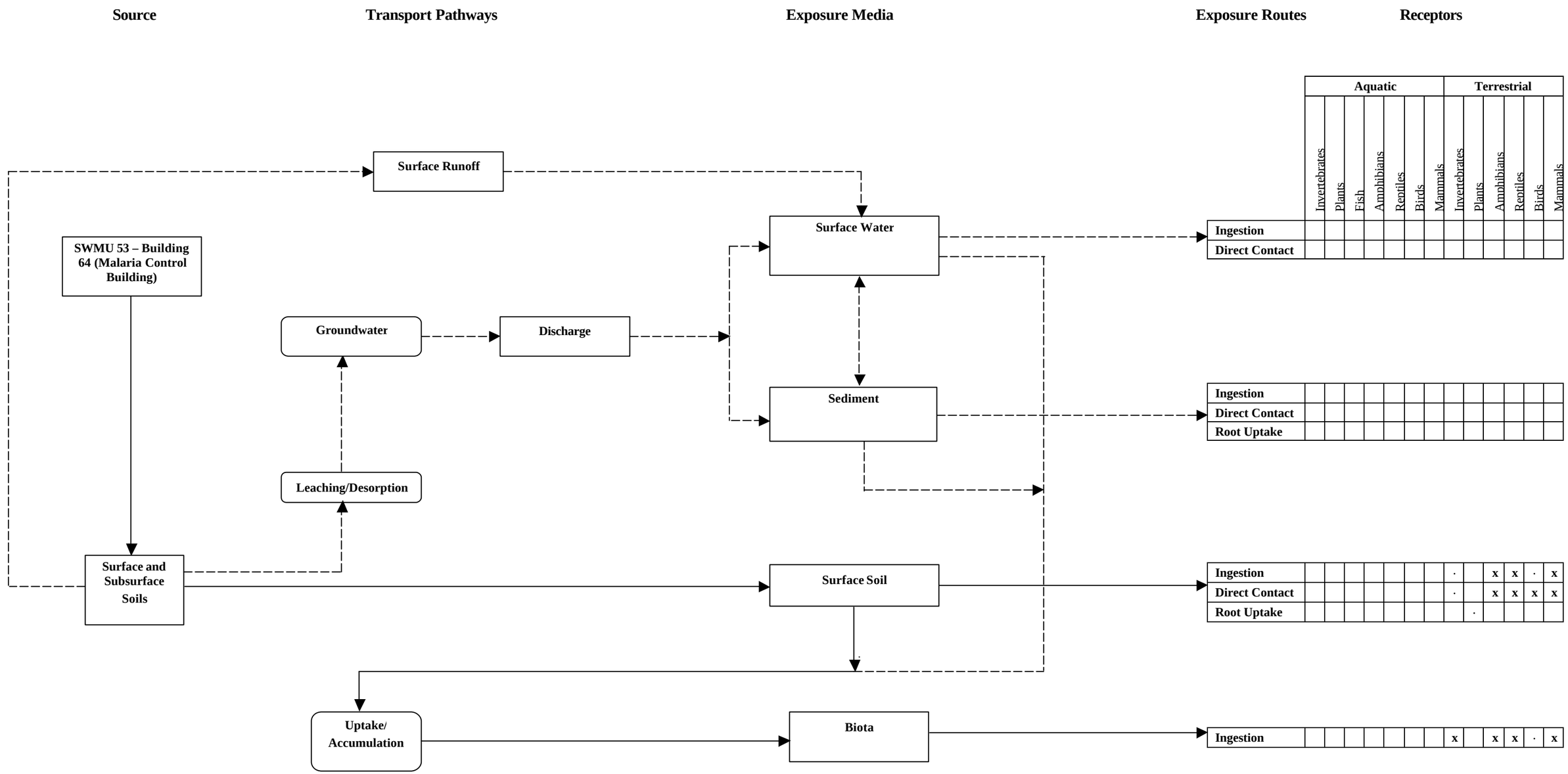
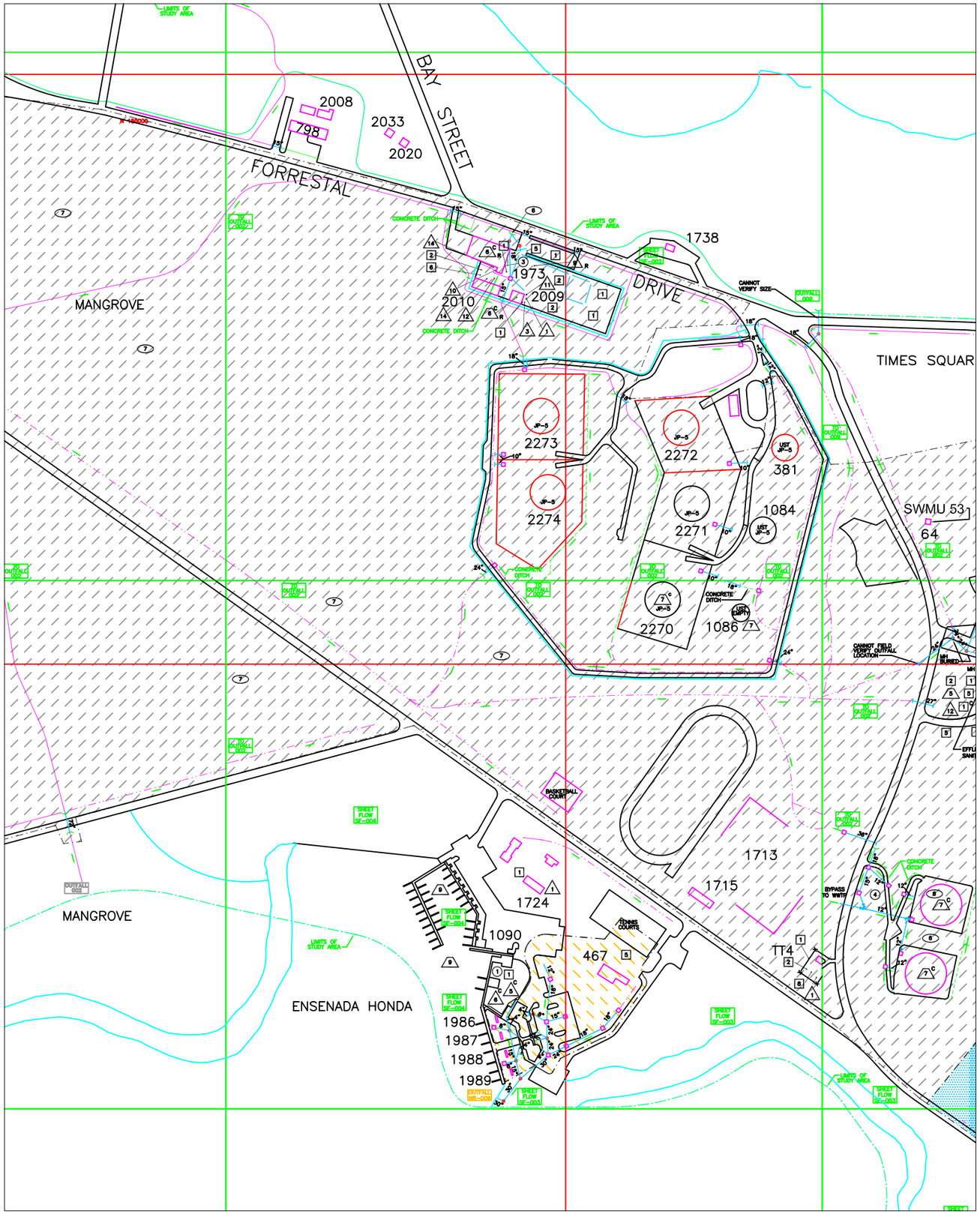


FIGURE 3-5
PRELIMINARY CONCEPTUAL MODEL
SWMU 53 – BUILDING 64 (MALARIA CONTROL BUILDING)
CORECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO



NOTES:

1. $\triangle^{C}$ THE SUPERSCRIPT "C" ON THE OUTSIDE OF A SYMBOL INDICATES SECONDARY CONTAINMENT.

2. $\triangle_{R}$ THE SUBSCRIPT "R" ON THE OUTSIDE OF A SYMBOL INDICATES THE AREA IS COVERED BY A ROOF.

HM/HW/POL STORAGE

1. FLAMMABLES IN METAL CABINETS/ STORAGE BUILDINGS
2. FLAMMABLES IN DRUMS
3. PETROLEUM OILS AND LUBRICANTS (POL'S) DRUM/TANK STORAGE
4. ABOVEGROUND JP-4, 5 TANKS
5. ABOVEGROUND DIESEL TANKS
6. ABOVEGROUND UNLEADED GAS TANKS
7. ABOVEGROUND WASTE OIL/JP-5 TANKS
8. ETHYLENE GLYCOL
9. COMPRESSED GAS CYLINDERS/TANKS
10. SOLVENTS/CLEANING COMPOUNDS
11. CORROSIVES
12. BATTERIES
13. PAINT AND PAINT RELATED MATERIALS/WASTE
14. WASTE IN DRUMS
15. SATELLITE HAZARDOUS WASTE ACCUMULATION
16. PCB CONTAINMENT/STORAGE
17. RADIOACTIVE MATERIAL
18. CHEMICAL AST

REGULATED INDUSTRIAL CATEGORIES

1. AIRPORTS/FLIGHT LINES
2. MARINE CARGO HANDLING
3. SEWAGE TREATMENT PLANTS>1 MGD
4. ACTIVE LANDFILLS
5. SOLID WASTE TRANSFER
6. HAZARDOUS WASTE STORAGE AREA
7. PETROLEUM BULK STORAGE
8. U.S. POSTAL SERVICE WITH VEHICLE MAINTENANCE FACILITIES
9. MARINA
10. SCRAP AND WASTE MATERIALS
11. PESTICIDE FORMULATION
12. SHIP REPAIR
13. IR PROGRAM SITE
14. VEHICLE WASHDOWN

MATERIAL STORAGE AREAS

1. VEHICLE/EQUIPMENT STORAGE
2. MISCELLANEOUS METALS
3. PLASTIC/RUBBER STORAGE
4. TIRE STORAGE
5. GARBAGE DUMPSTERS
6. EMPTY DRUMS
7. AGGREGATE STORAGE
8. WOOD/LUMBER STORAGE
9. MISCELLANEOUS CONSTRUCTION MATERIAL STORAGE
10. PORTABLE TOILET
11. AFFF

MATERIALS LOADING AND ACCESS AREAS

1. FUELING STATIONS
2. BULK FUEL TRANSFER
3. WAREHOUSE LOADING/ UNLOADING AREAS
4. CHEMICAL TRANSFER

LEAKS AND SPILLS

1. PETROLEUM FUELS
2. WASTE OIL

EXISTING BEST MANAGEMENT PRACTICES (BMP'S)

1. OIL/WATER SEPARATOR
2. OIL SPILL RECOVERY BOAT
3. ABSORBENT MATERIALS
4. BOOMS
5. SKIMMER DAM
6. SPILL CONTROL GATE/VALVE
7. VEGETATIVE FILTERS

CHEMICAL APPLICATION AREAS

1. PESTICIDES
2. HERBICIDES
3. FERTILIZERS

LEGEND

- PIPE
- DRAINAGE BOUNDARY
- STUDY AREA
- DITCH
- UNDER DRAIN
- CONCRETE DITCH
- DROP INLET
- MANHOLE
- OUTFALL XXX — REGULATED OUTFALL
- OUTFALL NR-XXX — NON-REGULATED OUTFALL
- SHEET FLOW SF-XXX — SHEET FLOW DISCHARGE

REVISIONS

DRAWN	/RRR
REVIEWED	MEKJCE
S.O.#	26007-033
CADD#	R/2033038

ATLANTIC DIVISION
DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

Michael Baker, Inc.
Coraopolis, Pennsylvania

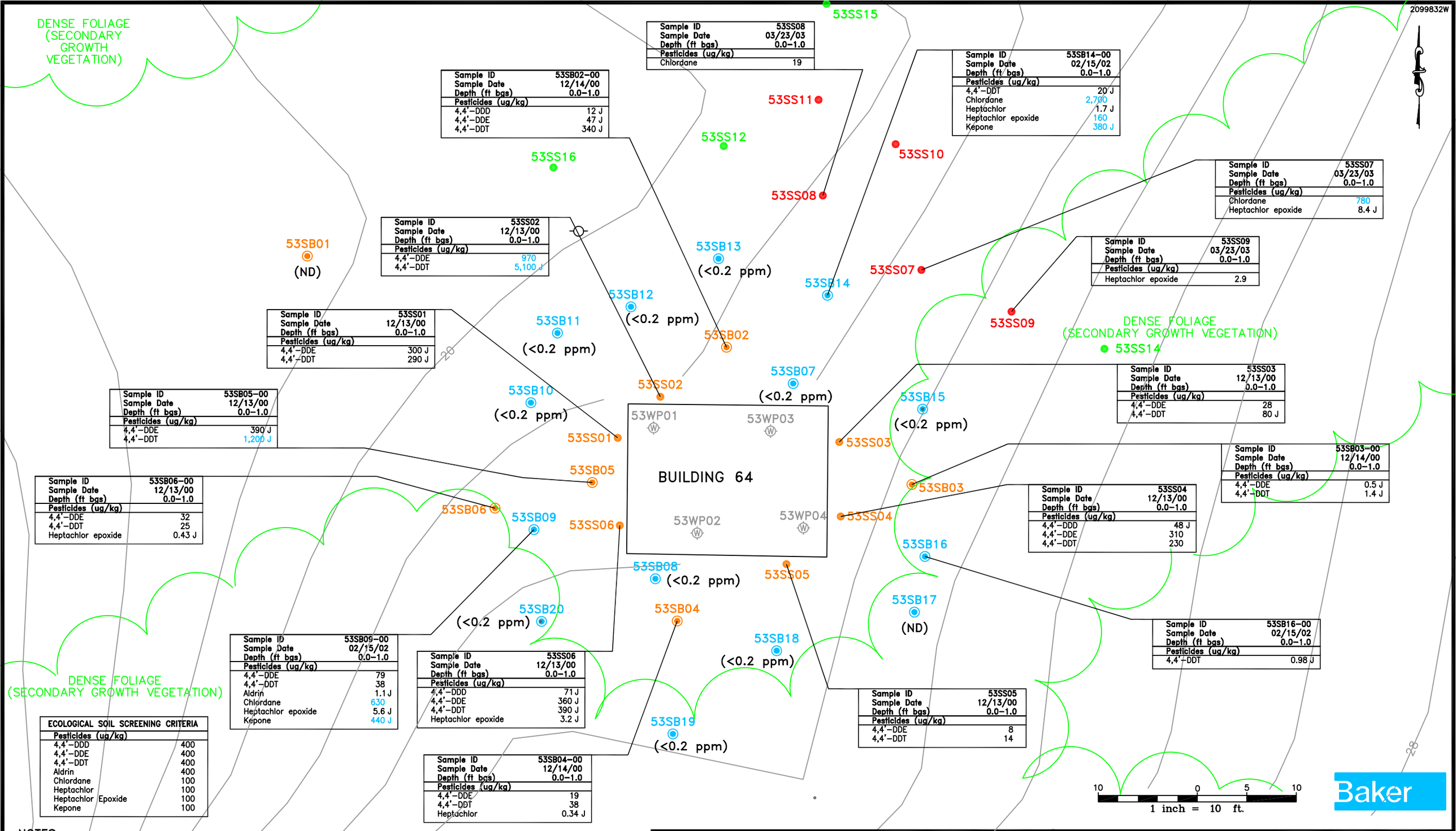
Baker

STORMWATER DRAINAGE MAP

DATE	6/11/02
SCALE	1" = 15'

FIGURE
3-6

2099832W



Sample ID	53SS08
Sample Date	03/23/03
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
Chlordane	19

Sample ID	53SB02–00
Sample Date	12/14/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDD	12 J
4,4'–DDE	47 J
4,4'–DDT	340 J

Sample ID	53SB14–00
Sample Date	02/15/02
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDT	20 J
Chlordane	2,700
Heptachlor	1.7 J
Heptachlor epoxide	160
Kepone	380 J

Sample ID	53SS07
Sample Date	03/23/03
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
Chlordane	780
Heptachlor epoxide	8.4 J

Sample ID	53SS02
Sample Date	12/13/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	970
4,4'–DDT	5,100 J

Sample ID	53SS09
Sample Date	03/23/03
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
Heptachlor epoxide	2.9

Sample ID	53SS01
Sample Date	12/13/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	300 J
4,4'–DDT	290 J

Sample ID	53SS03
Sample Date	12/13/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	28
4,4'–DDT	80 J

Sample ID	53SB05–00
Sample Date	12/13/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	390 J
4,4'–DDT	1,200 J

Sample ID	53SB03–00
Sample Date	12/14/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	0.5 J
4,4'–DDT	1.4 J

Sample ID	53SB06–00
Sample Date	12/13/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	32
4,4'–DDT	25
Heptachlor epoxide	0.43 J

Sample ID	53SS04
Sample Date	12/13/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDD	48 J
4,4'–DDE	310
4,4'–DDT	230

Sample ID	53SB09–00
Sample Date	02/15/02
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	79
4,4'–DDT	38
Aldrin	1.1 J
Chlordane	630
Heptachlor epoxide	5.6 J
Kepone	440 J

Sample ID	53SS06
Sample Date	12/13/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDD	71 J
4,4'–DDE	360 J
4,4'–DDT	390 J
Heptachlor epoxide	3.2 J

Sample ID	53SB16–00
Sample Date	02/15/02
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDT	0.98 J

Sample ID	53SS05
Sample Date	12/13/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	8
4,4'–DDT	14

Sample ID	53SB04–00
Sample Date	12/14/00
Depth (ft bgs)	0.0–1.0
Pesticides (ug/kg)	
4,4'–DDE	19
4,4'–DDT	38
Heptachlor	0.34 J

ECOLOGICAL SOIL SCREENING CRITERIA	
Pesticides (ug/kg)	
4,4'–DDD	400
4,4'–DDE	400
4,4'–DDT	400
Aldrin	400
Chlordane	100
Heptachlor	100
Heptachlor Epoxide	100
Kepone	100

NOTES:

53SS12 ADDITIONAL SURFACE SOIL SAMPLE LOCATION COLLECTED DURING CMS INVESTIGATION BUT NOT ANALYZED DUE TO DELINEATION OF PESTICIDES IN SAMPLES 53SS09, 53SS10, AND 53SS11.

(ND) NOT DETECTED FOR 4,4'–DDD, 4,4'–DDE, 4,4'–DDT, ALDRIN, CHLORDANE, HEPTACHLOR, HEPTACHLOR EPOXIDE, AND KEPONE.

(<0.2 ppm) THIS SAMPLE WAS FIELD ANALYZED FOR 4,4'–DDT ONLY. THE RESULT OF THE FIELD ANALYSIS INDICATED <0.2 ppm FOR 4,4'–DDT.

EXCEEDS ECOLOGICAL SOIL SCREENING CRITERIA

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)
- ADDITIONAL SURFACE SOIL SAMPLE LOCATION (CMS INVESTIGATION, 2003)
- 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 3–7
PESTICIDE DETECTIONS IN SURFACE SOIL
CORRECTIVE MEASURES STUDY FINAL REPORT
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Baker

2099833W

EXCEEDS THE ECOLOGICAL SURFACE SOIL SCREENING VALUE.
(ND) THIS SAMPLE WAS ONLY ANALYZED FOR ARSENIC WHICH CONTAINED A NON-DETECTION.

ECOLOGICAL SOIL SCREENING CRITERIA	
Inorganics - Total (mg/kg)	
Antimony	5
Arsenic	10
Barium	500
Beryllium	10
Cadmium	4
Chromium	0.4
Cobalt	20
Copper	50
Lead	50
Mercury	0.1
Nickel	30
Selenium	1
Tin	50
Vanadium	2
Zinc	50

Sample ID	53SB02-00
Sample Date	12/14/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	1.2 J
Arsenic	3.4 J
Barium	120 J
Beryllium	0.24 J
Cadmium	1.5 J
Chromium	33 J
Cobalt	20
Copper	85
Mercury	0.047 J
Nickel	17
Selenium	1 J
Tin	16 J
Vanadium	110
Zinc	1,000 J

Sample ID	53SS13
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	82
Lead	8.4
Zinc	99

Sample ID	53SB12-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	3
Lead	12

Sample ID	53SS02
Sample Date	12/13/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	0.97 J
Arsenic	1.5
Barium	110 J
Beryllium	0.38 J
Cadmium	0.81
Chromium	59 J
Cobalt	57
Copper	84 J
Lead	120
Mercury	0.056 J
Nickel	23
Vanadium	180
Zinc	350

Sample ID	53SS07
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	79
Lead	46
Zinc	100

Sample ID	53SB14-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	0.8 J

Sample ID	53SB07-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	1.1
Lead	200

Sample ID	53SS27
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	82
Lead	12
Zinc	93

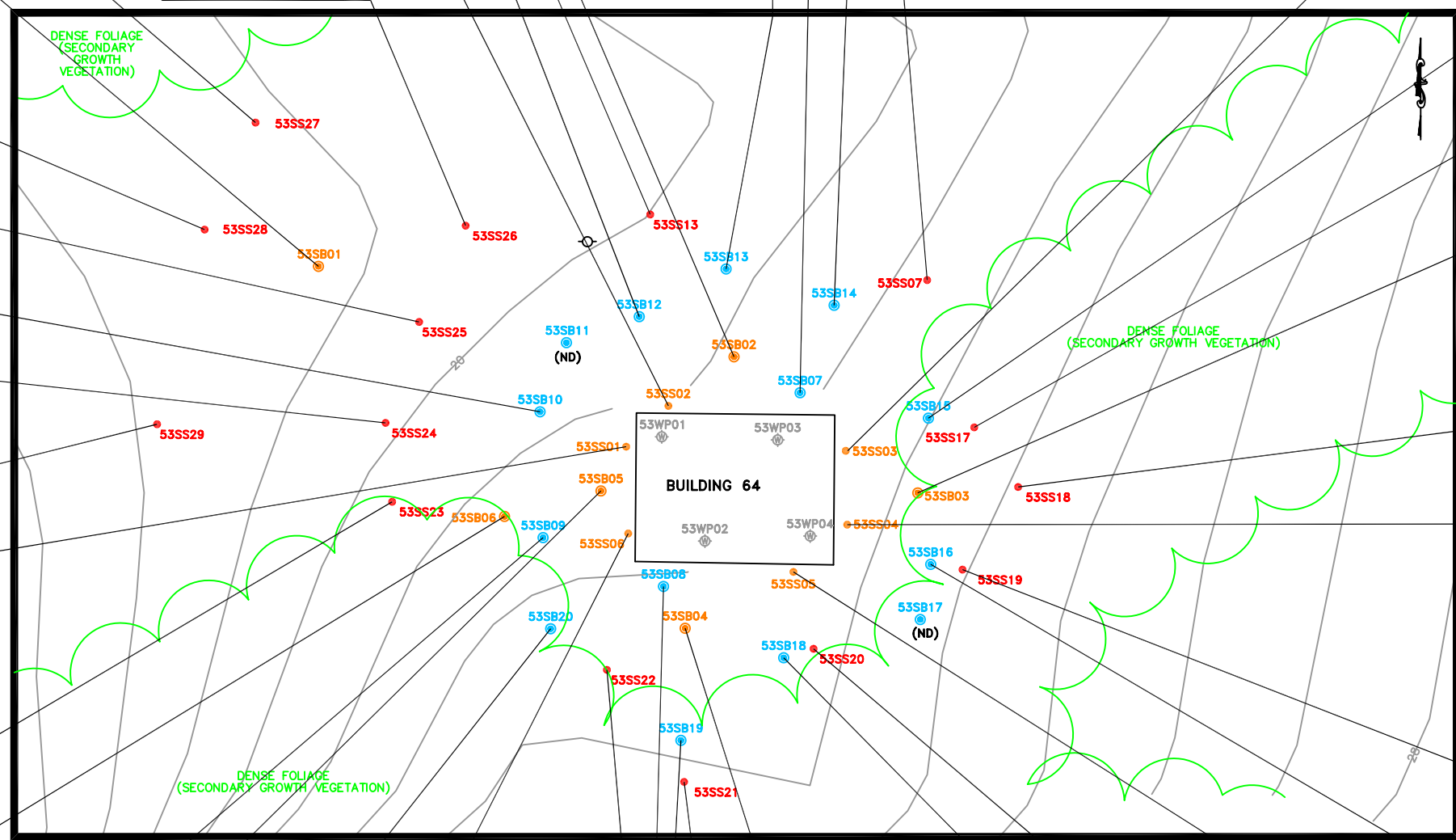
Sample ID	53SS26
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	100
Lead	19
Zinc	160

Sample ID	53SB13-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	0.66 J

Sample ID	53SB01-00
Sample Date	12/14/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Arsenic	2.3 J
Barium	100 J
Beryllium	0.28 J
Cadmium	0.54 J
Chromium	45 J
Cobalt	38
Copper	83
Mercury	0.018 J
Nickel	24
Vanadium	170
Zinc	83 J

Sample ID	53SS03
Sample Date	12/13/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	3.1 J
Arsenic	3.1
Barium	390 J
Beryllium	0.33 J
Cadmium	1.6
Chromium	87 J
Cobalt	47
Copper	79 J
Lead	2,500
Mercury	0.046 J
Nickel	25
Selenium	1
Tin	20
Vanadium	170
Zinc	2,200

Sample ID	53SB15-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	0.79 J
Lead	3.7



Sample ID	53SS17
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	71
Lead	34
Zinc	100

Sample ID	53SS28
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	62
Lead	7.1
Zinc	58

Sample ID	53SB03-00
Sample Date	12/14/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Arsenic	0.86 J
Barium	120 J
Beryllium	0.25 J
Cadmium	0.48 J
Chromium	42 J
Cobalt	27
Copper	68
Mercury	0.028 J
Nickel	17
Selenium	0.58 J
Vanadium	150
Zinc	300 J

Sample ID	53SS25
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	64
Lead	7.1
Zinc	65

Sample ID	53SB10-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	0.97 J

Sample ID	53SS24
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	72
Lead	100
Zinc	220

Sample ID	53SS18
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	61
Lead	53
Zinc	130

Sample ID	53SS29
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	39
Lead	2.6
Zinc	48

Sample ID	53SS04
Sample Date	12/13/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	6.1 J
Arsenic	3.1
Barium	670 J
Beryllium	0.29 J
Cadmium	2.1
Chromium	130 J
Cobalt	40
Copper	70 J
Lead	3,600
Mercury	0.061 J
Nickel	24
Selenium	0.71 J
Tin	10
Vanadium	160
Zinc	3,100

Sample ID	53SS01
Sample Date	12/13/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	0.53 J
Arsenic	5.6
Barium	170 J
Beryllium	0.2 J
Cadmium	0.94
Chromium	39 J
Cobalt	35
Copper	87 J
Lead	300
Mercury	0.021 J
Nickel	25
Vanadium	170
Zinc	580

Sample ID	53SS19
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	98
Lead	24
Zinc	100

Sample ID	53SS23
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	86
Lead	2.7
Zinc	63

Sample ID	53SB16-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	0.78 J

Sample ID	53SB06-00
Sample Date	12/13/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Arsenic	1.1
Barium	68 J
Beryllium	0.16 J
Cadmium	0.47 J
Chromium	29 J
Cobalt	22
Copper	76 J
Lead	55
Mercury	0.011 J
Nickel	17
Vanadium	130
Zinc	120

Sample ID	53SB04-00
Sample Date	12/14/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	1.1 J
Arsenic	4.7
Barium	100 J
Beryllium	0.19 J
Cadmium	1.5 J
Chromium	38 J
Cobalt	24
Copper	86
Mercury	0.043 J
Nickel	18
Selenium	0.72 J
Tin	6.7 J
Vanadium	130
Zinc	750 J

Sample ID	53SS20
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	74
Lead	70
Zinc	240

Sample ID	53SS05
Sample Date	12/13/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	1.5 J
Arsenic	1.3
Barium	200 J
Beryllium	0.21 J
Cadmium	2.8
Chromium	52 J
Cobalt	33
Copper	120 J
Lead	900
Mercury	0.027 J
Nickel	23
Selenium	0.72 J
Tin	35
Vanadium	170
Zinc	3,300

Sample ID	53SB09-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	1.7

Sample ID	53SB18-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	1.6

Sample ID	53SS22
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	91
Lead	190
Zinc	670

Sample ID	53SB08-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	0.65 J

Sample ID	53SB05-00
Sample Date	12/13/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	2.8 J
Arsenic	5.6
Barium	270 J
Beryllium	0.17 J
Cadmium	2.3
Chromium	38 J
Cobalt	25
Copper	89 J
Lead	2,200
Mercury	0.037 J
Nickel	18
Selenium	1.3
Tin	6.4
Vanadium	140
Zinc	2,400

Sample ID	53SB20-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	0.79 J

Sample ID	53SS06
Sample Date	12/13/00
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Antimony	5.9 J
Arsenic	4.7
Barium	630 J
Beryllium	0.21
Cadmium	3.6
Chromium	62 J
Cobalt	31
Copper	110 J
Lead	3,900
Mercury	0.069 J
Nickel	18
Selenium	0.59 J
Tin	6.5
Vanadium	150
Zinc	5,800

Sample ID	53SB19-00
Sample Date	2/15/02
Sample Depth (ft bgs)	0.0 - 1.0
Inorganics - Total (mg/kg)	
Arsenic	0.81 J
Lead	23

Sample ID	53SS21
Sample Date	3/23/03
Sample Depth (ft bgs)	0.0-1.0
Inorganics - Total (mg/kg)	
Copper	63
Lead	54
Zinc	200

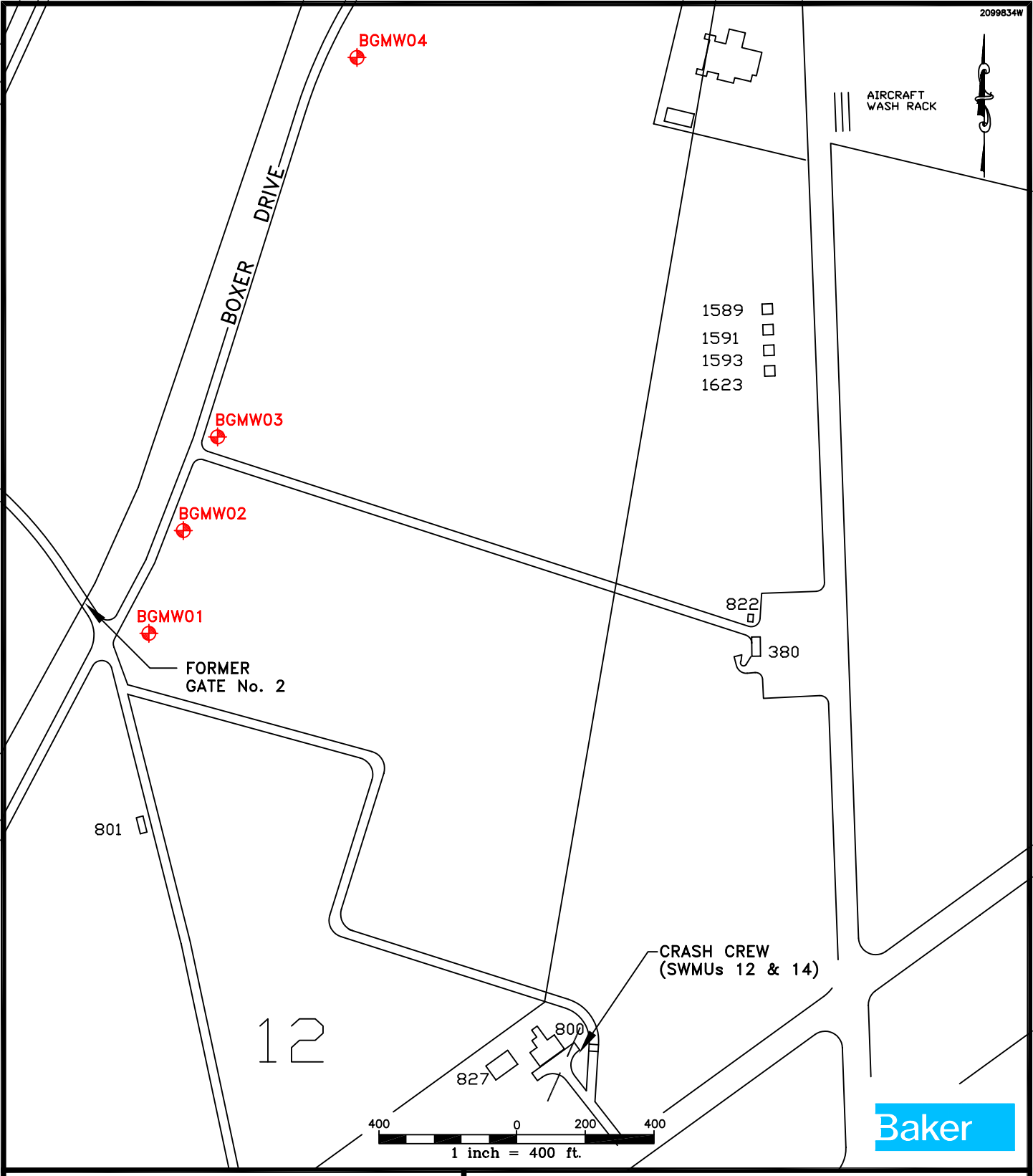
10 0 5 10
1 inch = 10 ft.

Baker

LEGEND
- WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- ADDITIONAL SURFACE SOIL SAMPLE LOCATION (CMS INVESTIGATION, 2003)
- 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, SEPTEMBER 1999.

FIGURE 3-8
INORGANIC DETECTIONS IN SURFACE SOIL
CORRECTIVE MEASURES STUDY FINAL REPORT
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



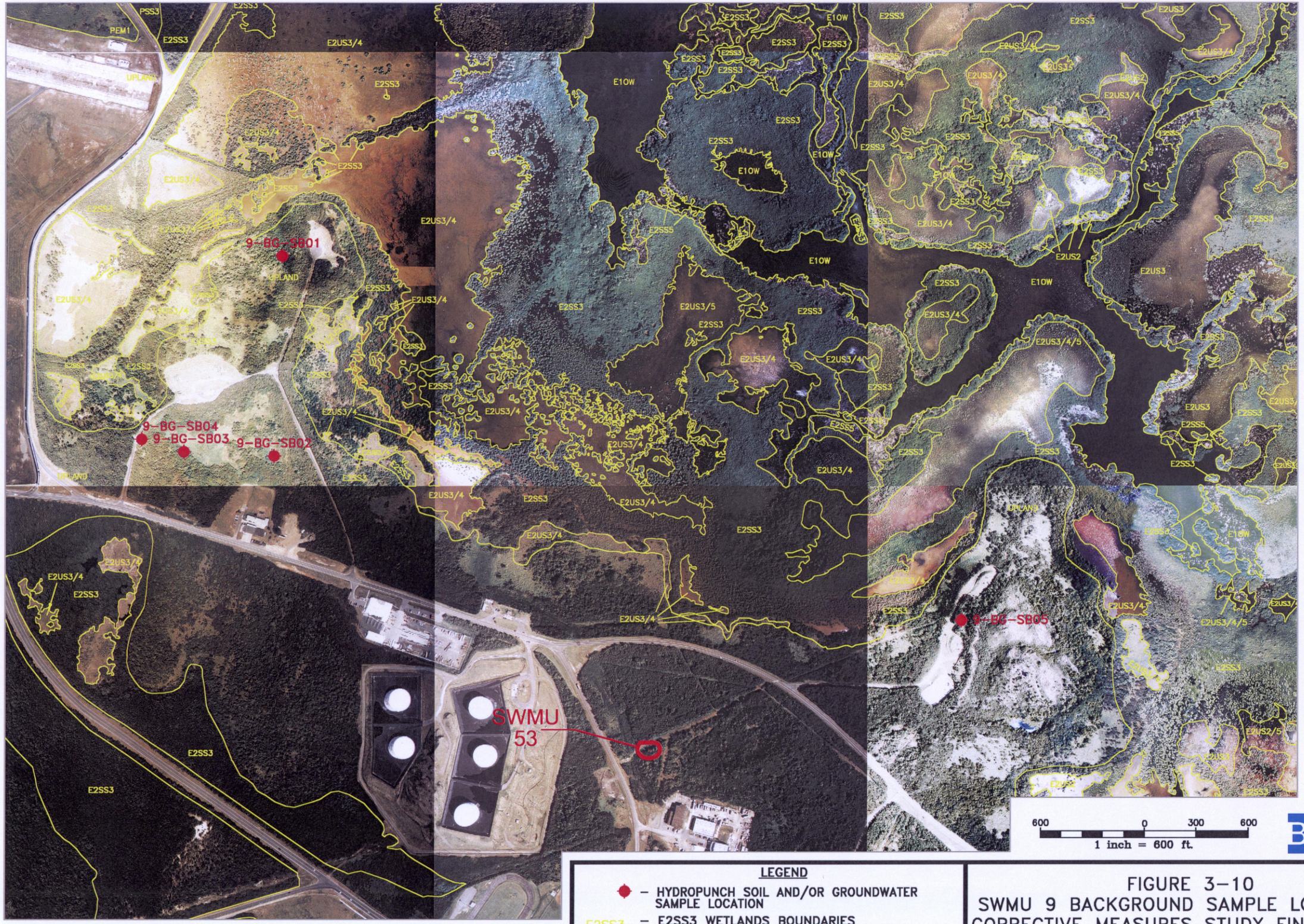
LEGEND

BGMW01 – BACKGROUND MONITOR WELL, BACKGROUND SOIL, AND BACKGROUND GROUNDWATER SAMPLE LOCATIONS

FIGURE 3–9
BASE BACKGROUND SURFACE SOIL AND GROUNDWATER SAMPLE LOCATIONS
CORRECTIVE MEASURES STUDY FINAL REPORT

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

2099836W



Baker

LEGEND

- HYDROPUNCH SOIL AND/OR GROUNDWATER SAMPLE LOCATION
- E2SS3 — E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 3-3 FOR CLASSIFICATIONS)

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

FIGURE 3-10
SWMU 9 BACKGROUND SAMPLE LOCATIONS
CORRECTIVE MEASURES STUDY FINAL REPORT

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

4.0 DEVELOPMENT OF ECOLOGICAL CORRECTIVE ACTION OBJECTIVES

This section presents the methodology used to develop surface soil CAOs for potential risk drivers identified by the ERA presented in Section 3.0. The application of the CAOs to corrective actions at the site are also discussed

4.1 Methodology for CAO Development

4,4'-DDT, chlordane, kepone, chromium, lead, and zinc were identified as potential risk drivers for terrestrial invertebrates and plants. 4,4'-DDE, 4,4'-DDT, kepone, lead, and zinc were identified as potential risk drivers for American robin food web exposures, while lead and zinc were identified as potential risk drivers for mourning dove food web exposures. The sections that follow present the methodology used to develop CAOs protective of these chemical-receptor combinations, as well as the methodology used to develop CAOs based on background concentrations.

4.1.1 Terrestrial Invertebrates and Plants

HQ values for surface soil were derived in Step 3a of the baseline ERA using the following equation:

$$HQ_x = (CS_x)/(SSSV_x) \qquad \text{(Equation 4-1)}$$

Where HQ_x is the hazard quotient for chemical x (unitless), CS_x is the mean concentration of chemical x in surface soil, and $SSSV_x$ is the surface soil screening value for chemical x.

A concentration in surface soil can be calculated that would represent an upper concentration limit (CAO) that would be protective of terrestrial invertebrates and plants. This can be accomplished by setting HQ_x equal to 0.99 and rearranging Equation 4-1 as follows:

$$CS_x = (0.99)(SSSV_x) \qquad \text{(Equation 4-2)}$$

Equation 4-2 was used to derive CAOs for 4,4'-DDT, chlordane, kepone, chromium, lead, and zinc protective of terrestrial invertebrate and plant communities.

4.1.2 Terrestrial Avian Receptors

HQ values for terrestrial avian receptor exposure doses were derived in Step 3a of the baseline ERA using the following equation:

$$HQ_x = (DI_x)/(NOAEL_x) \qquad \text{(Equation 4-3) :}$$

Where HQ_x is the hazard quotient for chemical x (unitless), DI_x is the dietary intake for chemical x (mg chemical/kg BW/day), and $NOAEL_x$ is the ingestion-based screening value for chemical x (mg chemical/kg BW/day). DI_x was derived by the following equation (Equation 4-4):

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

where:

DI_x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR	=	Mean food ingestion rate (kilograms per day [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 (mg/kg, dry weight)
SC_x	=	Mean concentration of chemical x in surface soil (mg/kg, dry weight)
PDS	=	Proportion of diet composed of surface soil (dry weight basis)
BW	=	Mean body weight (kg, wet weight)
AUF	=	Area Use Factor (unitless)

Combining equation 4-3 and 4-4 yields the following (Equation 4-5):

$$HQ_x = \frac{[[[\quad_i(FIR)(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)]][AUF]]/(BW)}{NOAEL_x}$$

Setting HQ_x equal to 0.99 and manipulating Equation 4-5 using the procedures presented in USEPA (2000), a concentration of chemical x in surface soil can be calculated that represents an upper concentration limit (CAO) that would be protective of upper trophic level receptors (Equation 4-6):

$$SC_x = \frac{(0.99)(NOAEL_{xj})(BW_j)}{[[\quad_i(FIR_j)(FC_{xi})(PDF_{ij})] + [(FIR_j)(PDS_j)]][AUF]}$$

where:

SC_x	=	CAO for chemical x (mg/kg, dry weight)
$NOAEL_{ij}$	=	Ingestion-based screening value for chemical i applied to receptor j (mg chemical/kg body weight/day)
BWj	=	Mean body weight for receptor j (kg, wet weight)
FIR_j	=	Mean food ingestion rate for receptor j (kg/day, dry-weight)
FC_{xi}	=	Concentration of chemical x in food item I (mg/kg, dry weight)
PDF_i	=	Proportion of receptor j diet composed of food item i (mg/kg, dry weight)
PDS	=	Proportion of diet composed of surface soil (dry weight basis)
AUF	=	Area Use Factor (unitless)

Equation 4-6 was used to derive CAOs for American robin exposures to 4,4'-DDE, 4,4'-DDT, kepone, lead, and zinc and CAOs for mourning dove exposures to kepone, lead, and zinc. Receptor-specific input parameters applied to Equation 4-6 are summarized in Table 3-6 (ingestion-based screening values), Table 3-10 (dietary compositions), and Table 3-16 (mean body weights, mean food ingestion rates, and AUFs). BAF values used in the estimation of food item tissue concentrations are summarized in Table 3-14.

As discussed in Section 3.7.1.2, an ingestion-based screening value for kepone is not available from the literature. As a measure of conservatism, the minimum CAO developed by Equation 4-6 for either American robin 4,4'-DDE or 4,4'-DDT exposure doses was used as the kepone CAO for both species.

4.1.3 Background

Background-based CAOs were developed for the inorganic chemicals identified as potential risk drivers in Step 2 of the ERA (chromium, lead, and zinc). The CAOs were developed by taking the maximum reported background concentration for base and SWMU 9 background samples.

4.2 Identification of Corrective Action Objectives

A summary of the CAOs developed for terrestrial invertebrate and plants, terrestrial avian receptors, and background are presented in Table 4-1. For the organochlorine pesticides, when more than one CAO was developed for a given chemical, the minimum value was selected as the final CAO. An identical approach was used to identify CAOs for chromium, lead, and zinc with one exception. If the maximum background concentration exceeded the terrestrial invertebrate and plant CAO, American robin CAO, and/or mourning dove CAO, the background-based CAO was selected as the final CAO. As evidenced by Table 4-1, CAOs based on background concentrations were selected for chromium and zinc.

The selected corrective measure for the potential risk drivers identified by the ERA (excavation and off site disposal [see Section 6.0]) will reduce risks for co-located chemicals that were identified as ecological COPCs in Step 2 but not risk drivers in Step 3a. For example, selenium was identified as an ecological COPC in Step 2 based on a comparison of the maximum surface soil concentration (1.3 mg/kg) to the surface soil screening value (1.0 mg/kg). Although selenium was not identified as a potential risk driver in Step 3a due to a mean HQ less than 1.0 and the low spatial coverage and magnitude of detections above the surface soil screening value, potential risks (based on maximum exposure point concentrations) will be reduced since the maximum detection for this metal occurred at a location that will undergo the selected corrective measure due to the presence of 4'4-DDT at a concentration above the CAO.

TABLES

TABLE 4-1

ECOLOGICAL CORRECTIVE ACTION OBJECTIVES
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Corrective Action Objectives			Maximum Background Concentration [2]	Final CAO
	Terrestrial Invertebrates and Plants	American Robin [1]	Mourning Dove [1]		
Organochlorine Pesticides (ug/kg):					
4,4'-DDE	NA	106	NA	NA	106
4,4'-DDT	396	1,400	NA	NA	396
Chlordane	99	NA	NA	NA	99
Kepone	99	106 [3]	106 [3]	NA	99
Metals (mg/kg):					
Chromium	0.396	NA	NA	44.1	44.1
Lead	49.5	60	109	21	49.5
Zinc	49.5	125	307	106	106

Notes:

NA - Not Applicable

[1] CAOs derived using NOAEL-based screening values.

[2] Maximum concentration reported from base and SWMU 9 background data.

[3] A CAO for this chemical-receptor combination could not be calculated due to the lack of an ingestion-based screening value. The CAO shown represents the minimum organochlorine CAO for American robin mean exposure doses.

5.0 ESTABLISHMENT OF CORRECTIVE ACTION OBJECTIVES

5.1 Introduction

The results from the Sampling and Analysis Report for SWMUs 53 and 54 (Baker, 2001), the Draft RCRA Facility Investigation Report for SWMUs 53 and 54 (Baker, 2002), and the CMS Investigation Report for SWMU 53 (Baker, 2003b) indicated that several constituents exceeded listed criteria and therefore are considered chemicals of potential concern. The COPCs for SWMUs 53 include chlordane, heptachlor epoxide, heptachlor, 4,4-DDT, arsenic, copper, zinc, lead, and chromium for surface and subsurface soil. Of these COPCS, only chlordane, 4,4-DDT, heptachlor epoxide, arsenic, and lead are based on human health.

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.

The CAOs are based on land use and potential receptor assumptions (Section 5.2), summary of the human health RA and selection of contaminants of potential concern (Section 5.3), exposure assessment and methodology (Section 5.4), and toxicity evaluation (Section 5.5). They were developed in accordance with the USEPA guidance (USEPA, 1989a, 1991a, and others).

5.2 Land Use and Potentially Exposed Receptors

To focus on developing practicable and cost-effective corrective measures alternatives and to streamline the environmental cleanup process, EPA guidance ("Land Use in the CERCLA Remedy Selection Process," (USEPA, 1995)) and U.S. Department of Defense (Longuemare, 1997) direct that CAOs should reflect the reasonably anticipated land use.

SWMU 53 (Malaria Control Building) is an industrial area of NSRR. Future property use of this site is expected to remain industrial for the duration of Naval operations of NSRR. As a result, likely potential human exposure is limited to industrial or commercial property use, now and in the foreseeable future. However, current legislation before the U.S. Congress includes a proposal for NSRR to be a candidate for base closure. Therefore, unrestricted, residential exposure is also considered reasonably anticipated and is evaluated here.

Based on the EPA and Department of Defense guidance that CAOs should reflect actual anticipated land use, the assumed land use for SWMU 53 is 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 contaminants present in soil from the surface to a depth of ten feet below ground surface. However, because no additional COPCs (or higher concentrations of surface soil COPCs) were identified in subsurface soil, the construction worker exposure scenario is not evaluated here. It is unlikely that SWMU 53 would ever be developed

into a residential area, but due to potential base closure, an unrestricted, residential scenario is included.

5.3 Selection of Contaminants of Potential Concern

The COPC selection process has been performed in Section 2.0 using all of the data collected at SWMU 53. 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 for human health are USEPA Region III 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 2003 (USEPA, 2003a) and are based on conservative residential exposure for soil. (The target risk used to calculate the RBCs is $1x10^{-6}$, while the target HQ is 0.1 to account for cumulative effects.) RBCs are not available for lead due to its unique toxicological characteristics (see Section 5.5.2). EPA's residential action level of 400 mg/kg (USEPA, 1994) for soil is used as the COPC screening criterion for lead.

Based on a comparison of the data to these screening criteria as shown in Section 2.0, the COPCs in soil are chlordane, 4,4-DDT, heptachlor epoxide, arsenic, and lead. Of these five COPCs, only arsenic is detected in the subsurface soil at a concentration that exceeds its screening criterion, and the maximum detected concentration of arsenic in subsurface soil was only 1.6 mg/kg. Therefore, subsurface soil will not be evaluated separately as there is essentially no contamination and exposure is less likely.

5.4 Exposure Assessment and Methodology for Development of CAOs

5.4.1 Qualitative CAOs

Under the continued military land use and residential scenarios, contact with contaminants may occur from both surface and subsurface soil at SWMU 53. However, as demonstrated in Section 2.0 and 5.3, subsurface soil is not of concern to human health (based on comparison to RBCs) and will not be discussed further. Section 5.4.2 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).

5.4.2 Quantitative CAOs

Quantitative CAOs are acceptable residual contaminant concentrations. The following components of the human health RA are 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 5.5).

Assumed target cancer risk level and noncancer HQ.

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 used in the human health RA is:

$$Intake(mg/kg\text{-}day) = \frac{C \quad IR \quad EF \quad ED \quad CF}{BW \quad AT} \qquad \text{(Eq 5-1)}$$

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:

$$Risk = Intake \times SF \qquad \text{(Eq 5-2)}$$

$$HQ = Intake/RfD \qquad \text{(Eq 5-3)}$$

where:

Risk	=	target risk level ($1x10^{-6}$, 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 SWMU 53, the industrial worker is used to characterize potential future exposure to contaminated soil. Industrial worker exposure is limited to surface soil (defined as zero to two feet). For the residential exposure scenario, a young child (age 1 to 6) and an adult for total exposure duration of 30 years are combined to characterize exposure to contaminated soil from a depth of zero to two foot deep.

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

Appendices D.1 to D.6 in Appendix D quantitatively summarize each of these exposure pathways. The exposure pathway equations and variable values are generally directly from EPA guidance documents and the rationale for their selection is explained in the tables. Those exposure variable value assumptions based on professional judgment or that are not based on standard EPA defaults are discussed further below.

Target risk levels. It should be noted that, in the absence of regulatory criteria, EPA recommends use of the 1 10^{-6} cancer risk level as a starting point for analysis of remedial alternatives. This reflects EPA's preference for managing risks at the more protective end of the risk range (USEPA, 1991a; (National Contingency Plan) NCP preamble, 55 *Federal Register* 8718-9). This same EPA guidance presents some flexibility in target risk levels ("Preliminary and final remediation goals, i.e., target risk levels, however, may vary from the point of departure depending upon site-specific circumstances.") A $1x10^{-6}$ target risk level is assumed for all COPCs, with the exception of arsenic. A $1x10^{-6}$ target risk level for arsenic is used for the RBC (0.43 mg/kg) that is less than its detection limit by standard analytical methods (ranging from 1 to 2.6 mg/kg at SWMU 53) and less than background concentrations. Therefore, the arsenic CAO is based on a $1x10^{-5}$ target risk level to produce an achievable concentration that is still within what is considered an acceptable risk.

Volatilization Factor Parameters. The inhalation of volatiles emitted from soil exposure pathway applied to industrial workers uses a soil-to-air volatilization factor (VF) from EPA's "Soil Screening Guidance" (USEPA, 2001b). Appendix D.4 presents the calculation for VF. Default values were used for the VF parameters with the following exceptions. The Q/C term, based on meteorological modeling performed by EPA for a variety of cities throughout the U.S., has been changed from the default value to the value for modeled Zone IX represented by Miami in accordance with EPA guidance (USEPA, 2001b). The variable for total exposure time (T) has been changed from 30 years to 25 years to reflect the difference between industrial and residential exposure. The porosity terms for water- and air-filled porosity have been changed from the default of 0.15 and 0.28, respectively, to 0.20 and 0.23, respectively, to conform to the default values used in the Johnson and Ettinger (1991; USEPA, 2000) model for volatiles emitted from groundwater at other NSRR sites.

The VF equation is only applicable for sufficiently volatile COPCs. At SWMU 53, this excludes the inorganic COPCs, arsenic and lead, and 4,4'-DDT (USEPA, 2001b). Therefore, only chlordane and heptachlor epoxide was evaluated using this pathway.

Appendix D.4 includes the equation for the soil saturated concentration or C_{sat}. The VF equation is not applicable if the soil concentration is greater than C_{sat} because the model does not include free-phase contamination. C_{sat} was calculated for volatile COPCs in soil at SWMU 53 and it exceeded the VF-based CAOs for all COPCs. Therefore, the VF model is applicable for chlordane and heptachlor epoxide at SWMU 53.

Dermal Exposure to Contaminants in Soil. Recommended default values for workers' skin surface area (SA) and soil adherence factors (AF) have recently changed to 3,300 cm^2 and 0.2, respectively, based on new EPA guidance (USEPA, 2001a). These two default values applied to industrial workers are based on a reinterpretation of data presented in the "Exposure Factors Handbook" (USEPA, 1997a). Chemical-specific dermal absorption factors (ABS) are from EPA guidance (USEPA, 2001a). Appendix E.4 presents the ABS values used for SWMU 53 COPCs.

5.5 Toxicity Evaluation

For the development of quantitative CAOs based on exposure to chemicals, the following health effects criteria are 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).

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 cubic meters per day (m^3/day) and dividing by the reference BW of 70 kilograms.

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.

The primary source of chemical-specific health effects criteria is EPA's Integrated Risk Information System (IRIS) database (USEPA, 2003b). 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.

Appendix D.7 presents the toxicological criteria used to calculate CAOs for SWMU 53 COPCs.

5.5.1 Modification to Dermal Exposure Route

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). As presented in Appendix D.6, the equation for dermal contact exposures defines absorbed dose rather than intake. Thus, the administered dose health effects criteria must be converted to absorbed dose criteria in accordance with EPA methodology (USEPA, 1989a; 1992).

This adjustment is 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 is 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, 2001a) recommends adjusting health effects criteria only if gastrointestinal absorption is less than 50 percent. This source summarizes the available gastrointestinal absorption data in Exhibit 4-1 and these values are used here. A gastrointestinal absorption of 100 percent is assumed as recommended for COPCs not included in Exhibit 4-1 from this source (USEPA, 2001a) or compounds with greater than 50 percent absorption. Appendices E.4 and E.9 present the CAOs based on the dermal absorption pathway and the gastrointestinal absorption data used to develop CAOs.

5.5.2 Noncancer Effects Associated with Lead

The evaluation of the potential for noncancer effects associated with exposure to lead is different from that of other chemicals for two reasons:

> Although many studies have evaluated the effects of low-level exposure to lead, EPA study groups have not reached a consensus on a threshold level for lead exposure. It appears that some of lead's effects, particularly those associated with certain blood enzymes and neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold. As a result, no RfD is established for lead, even though adverse effects are well known.
>
> Lead in the environment originates from a variety of sources, including air pollution, diet, water pipes, soil, and paints. Because exposure is rarely limited to one pathway, the hazards associated with lead cannot be fully evaluated without considering other environmental contributors.

To adjust for these factors, EPA developed the integrated exposure uptake/biokinetic model (IEUBK), which combines the various exposure pathways to calculate blood lead levels in a given population of children. The results of this model, preformed by EPA using default variable values, produces an acceptable soil concentration of 400 mg/kg (USEPA, 1994). This value will be used as the CAO for lead in soil at SWMU 53

5.6 <u>Quantitative CAOs</u>

Quantitative CAOs are calculated based on the exposure methodology, contaminants, and health effects criteria presented in Sections 5.4 and 5.5. Appendix D.8 presents the quantitative soil

CAOs for the military and residential land use scenarios for comparison with site data. These values represent the concentrations at which a target risk level of $1 \ 10^{-6}$ (or $1x10^{-5}$ in the case of arsenic) or a target HQ of 1.0 for individual COPCs is achieved by exposure via the exposure pathways presented in Section 5.4.

With the exception of lead, the quantitative CAOs in Appendix D.8 follow this risk-based approach. The lead CAO for soil is based on the IEUBK-based screening concentrations as discussed in Section 5.5.2.

Appendices E.1 through E.4 and E.6 through E.9 present pathway- and medium-specific CAOs based on a target risk level of $1 \ 10^{-6}$ and a target HQ of 1.0. These tables also list the CAOs for target cancer risk levels of $1 \ 10^{-5}$ and $1 \ 10^{-4}$ for comparison.

Appendices E.5 and E.10 summarize the CAOs for individual pathways, assuming a chemical-specific target risk of $1 \ 10^{-6}$ (or $1x10^{-5}$ for arsenic) and a target HQ of 1.0 for each pathway, and resulting CAOs assuming exposure via all pathways (i.e., the column headed "Combination" in the summary tables). Note that the combination CAO is less than the individual pathway CAO because it is based on a total target risk or target HQ posed to a receptor via all of the pathways. Pathway-specific CAOs are algebraically combined using a relationship of the reciprocal of the sum of the reciprocal of the pathway-specific CAOs.

5.7 References

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6.0 RECOMMENDATIONS AND JUSTIFICATION OF THE FOCUSED REMEDY

The selected corrective measure for the clean up of soil at SWMU 53 is presented in the sections that follow. The remedies are described, and human health and environmental considerations are discussed.

6.1 Description of the Remedy

The selected corrective measure for SWMU 53 is discussed in the paragraphs that follow.

The selected remedy for the soil contamination at SWMU 53 is excavation and off site disposal. Soil will be removed from areas where pesticide and metals contaminant concentrations exceed the established ecological and human health corrective action objectives as determined in Sections 4.0 and 5.0 of this document, respectively.

There were eight contaminants of concern (COCs) established by the ecological and human health risk screenings. These were 4,4'-DDE, 4,4'-DDT, chlordane, kepone, heptachlor epoxide, arsenic, chromium, lead and zinc. The established CAOs for these COCs for both ecological and human health risk management are given in Table 6-1. Remediation goals for the soil contamination at SWMU 53 were determined from these CAOs. Where there were two CAOs established for a COC, the lesser of the two was chosen as the remedial goal for that COC. Remediation goals are also given in Table 6-1.

The proposed clean-up levels are the following:

4,4'-DDE (106 µg/kg),
4,4'-DDT (396 µg/kg),
chlordane (99 µg/kg),
heptachlor epoxide (53 µg/kg),
kepone (99 µg/kg),
arsenic (3.9 mg/kg),
lead (50 mg/kg),
zinc (106 mg/kg).
chromium (44.1 mg/kg)

The extent of the contamination of the combined COCs above the proposed remediation levels is shown for the surface soil in Figure 6-1. The outermost extent will govern the extent of the remedial action, excavation and disposal. For the case of SWMU 53, the zinc CAO primarily determines the excavation limit. Chlordane, chromium, and kepone also have a slight influence on the excavation extent.

Only surface soil will be addressed. As shown in Section 2.0, there are no COCs in the subsurface soil at levels above the CAOs for those COCs. Surface soil will be established as that soil lying at the ground surface and to a depth of one foot. This distinction is made based on sampling protocol followed during the various investigations. The surface soil samples were taken from the 0.0 – 1.0 foot depth.

The contaminated soil will be transported to an on-island, permitted, disposal facility, unless confirmatory testing indicates levels exceeding landfill acceptance criteria. The on-island disposal facilities are located in Ponce and Penuelas. Licensed waste haulers are available and will be used to transport the soil to the disposal facility.

6.2 Justification of the Corrective Measure

The justification for the selection of excavation and disposal as the corrective measure is provided in this section. The corrective measure is evaluated based upon technical, human health, and environmental considerations.

6.2.1 Technical Considerations

Excavation and off-site disposal is proven and is commonly used at general construction and remediation sites. Because the contamination will be removed from SWMU 53, it is a permanent corrective measure. In terms of reliability, the contaminated media will be disposed in a permitted landfill, which is considered a commonly accepted treatment alternative. With respect to implementability, this corrective measure requires commonly used earth moving equipment and disposal facilities. If confirmatory testing conducted during the excavation yields contaminant concentrations exceeding local landfill acceptance criteria, the media will require off-island transportation (i.e., barged to the United States) and disposal. In general, SWMU 53 is easily accessible and has limited site features that would interfere with excavation. Safety concerns while implementing the corrective measure are anticipated to be minimal due to the limited areas of excavation, the shallow depths of excavation, and the low population density adjacent to the sites. In general, this technology will be effective, reliable, and easily implementable.

6.2.2 Human Health Considerations

Cleanup goals were established in Sections 4.0 and 5.0 of this report. The proposed corrective measures will meet the cleanup goals since the contaminated media will be excavated and removed from the site. Therefore, the selected corrective measure is protective of human health and will reduce human health risk to an acceptable level.

6.2.3 Environmental Considerations

Removing the contaminated media from the SWMU 53 will provide an immediate benefit to the environment. Potential terrestrial receptors will no longer be in contact with the environmental media containing levels of hazardous constituents that exceed the cleanup goals.

TABLES

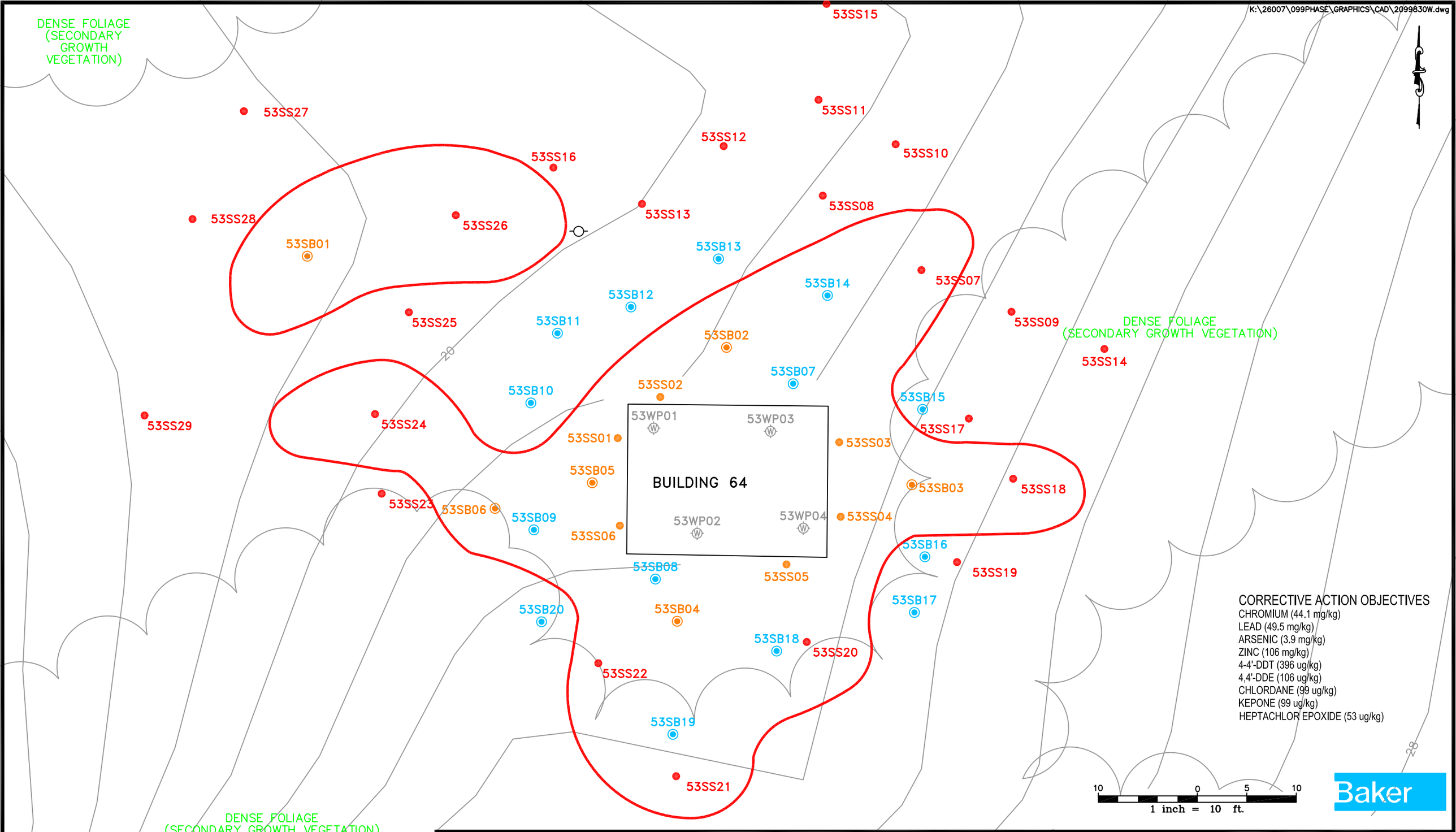
TABLE 6-1

PROPOSED REMEDIATION GOALS
SWMU 53 - BUILDING 64 (MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CIEBA, PUERTO RICO

Contaminant of Concern	Ecological Risk Management Level	Rationale	Human Health Risk Management Level [1]	Rationale	Proposed Remediation Goal
Pesticides					
4,4'-DDT	396 ug/kg	Surface Soil Screening level	1,700 ug/kg	$1x10^{-6}$ ILCR	**396 ug/kg**
4,4'-DDE	106 ug/kg	Food web based screening for omnivorous bird	NA	NA	**106 ug/kg**
chlordane	99 ug/kg	Surface Soil Screening level	1,600 ug/kg	$1x10^{-6}$ ILCR	**99 ug/kg**
heptachlor epoxide	NA	NA	53 ug/kg	$1x10^{-6}$ ILCR	**53 ug/kg**
kepone	99 ug/kg	Surface Soil Screening level	NA	NA	**99 ug/kg**
Metals					
Lead	49.5 mg/kg	Surface Soil Screening level	400 mg/kg	Residential Screening Level	**49.5 mg/kg**
Arsenic	NA	NA	3.9 mg/kg	$1x10^{-5}$ ILCR	**3.9 mg/kg**
Zinc	106 mg/kg	Maximum detected background level for NSRR	NA	NA	**106 mg/kg**
Chromium	44.1 mg/kg	Maximum detected background level for NSRR	NA	NA	**44.1 mg/kg**

Notes: ug/kg--micrograms per kilogram
mg/kg--milligrams per kilogram
NA-Not applicable
[1] - Based on a residential exposure scenario.

FIGURES



LEGEND

- WIPE SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- ADDITIONAL SURFACE SOIL SAMPLE LOCATION (CMS INVESTIGATION, 2003)
- 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
- APPROXIMATE EXTENT OF SOIL CONTAMINATION ABOVE CORRECTIVE ACTION OBJECTIVES
- GROUND SURFACE CONTOUR LINE
- TREE LINE

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 6-1
EXTENT OF SOIL CONTAMINATION ABOVE CORRECTIVE ACTION OBJECTIVES
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

7.0 TECHNICAL APPROACH TO THE CORRECTIVE MEASURE IMPLEMENTATION

This section details the selected remedies for impacted soil at SWMU 53. The layout of the conceptual design, design considerations, planning documents, and confirmatory sampling are presented in Section 7.1. The reporting requirements are presented in Section 7.2.

7.1 Conceptual Design

The design considerations and the technical approach are discussed in the paragraphs that follow.

7.1.1 Design Considerations

Many factors affect the ease with which a corrective measure can be performed at a site. Some of these items include site access, existing structures, disruption of adjacent facilities, available utilities, utility clearance, determination of extent of contamination, adequate space for staging areas, and availability of off-site waste disposal. Each of these design considerations with respect to SWMU 53, are presented in Table 7-1.

7.1.2 Description of the Approach

The proposed approach for the corrective measure design, with respect to the technical approach and the required planning documents, is discussed in the subsections that follow.

7.1.2.1 Technical Approach

The anticipated technical approach for the remediation of SWMU 53 is detailed below. Figure 7-1 shows conceptual design plans for the area at this site where a corrective measure will be implemented. All remedial wastes generated, as part of the clean up of SWMU 53, will be managed in accordance with applicable federal, state, and local guidelines. The processes to be followed are:

mobilization of a small backhoe or gradeall, small front end loader, and roll-off boxes
construction of a decontamination pad and equipment laydown areas
installation of erosion controls
location by survey of excavation limits
demolition of Building 64 and the removal of the concrete pad under the building
excavation of one foot (1 ft) of soil from delineated areas, including the soil exposed after removal of the concrete pad
Confirmation sampling of the outer edge of the excavation every 25 feet
transportation of the excavated soil to lined roll-off boxes. (The roll-off boxes will be placed so that they slope to drain to one corner of the box)
transportation of the demolished building material and concrete pad to lined roll-off boxes. (The roll-off boxes will be placed so that they slope to drain to one corner of the box)
collection and analysis of representative soil samples for toxicity characteristics in accordance with 40 Code of Federal Regulations (CFR), Part 261.24.
collection, analysis, and disposal of water from the roll-off boxes
transportation and disposal of soil to an approved disposal facility

backfill existing excavated areas with clean fill to match existing grade.
revegetation of any disturbed areas
demobilization of all equipment, etc.
removal of erosion and sediment control structures

The area to be excavated is approximately 4200 square feet (400 square meters), resulting in approximately 4200 cubic feet (120 cubic meters) of excavated soil. It is expected that no special handling requirements will be necessary during the demolition of Building 64 and its concrete pad.

7.1.2.2 Required Planning Documents

As part of the corrective measure design, the remedial contractor will be required to prepare a work plan documenting the proposed corrective measure. This work plan will include, at a minimum, an Environmental Protection Plan, an Accident and Analysis Plan, a Stormwater Pollution Prevention Plan, a Health and Safety Plan, and a Permitting Plan for the Transportation and Disposal of Hazardous Waste. Since the area to be excavated is less than 900 square meters, an air permit for fugitive dust is not required. A brief description of elements of the work plan is provided below.

Environmental Protection Plan

The Environmental Protection Plan should list the hazardous materials that may be brought onto the station. The Material Safety Data Sheets (MSDSs) for each material will be included. The contractor will also include employee training documentation, a hazardous waste storage plan, and a listing of hazardous waste to be generated on site. The contractor will be required to conduct a preconstruction survey of the results of which will be included in this plan.

Accident and Analysis Plan

This plan will identify the protocol for any and all potential accidents that may occur during the implementation of the proposed remedy.

Stormwater Pollution Prevention Plan

The Stormwater Pollution Prevention Plan will detail all erosion control measures to be in place during the proposed remediation.

Health and Safety Plan

The Health and Safety Plan will be site specific and will include, but not be limited to: the names of the health and safety officer and alternates; the requirements of 29 CFR 1910 and 1926; and the National Fire Protection Act (NFPA) 241.

Permitting Plan

The Permitting Plan will detail all permits that will be required for implementing the remedial action, including excavation, transportation of hazardous materials, and disposal of hazardous materials.

7.1.3 Confirmatory Sampling Plan

Confirmatory sampling will be conducted at SWMU 53 to verify that all COCs with concentrations higher than their respective clean up levels, have been removed from the site. A comparison of the proposed area of excavation presented on Figure 7-1, with the lateral extent of soil impacted by the previously mentioned COCs shown on Figure 6-1, illustrates that the areas of soil with pesticide and metal concentrations above their respective clean up level, will be removed. Confirmatory sampling will occur every 25 linear feet outside the edge of the excavation sidewalls in the upper one foot of the undisturbed soil. Confirmatory sampling will occur along the bottom of the excavation with a frequency of one sample per each 25-foot grid spacing. In addition, confirmation samples will be collected from the bottom of the excavation in known areas of uncertainty, to ensure adequate vertical delineation of the excavation. The total number of samples is estimated to be twenty-five. The sampling methods will be identical to those used in previous investigations (Baker, 2002, 2003a). Soil samples will be submitted to the laboratory for quick turnaround analysis of the COCs mentioned in this report. Should additional contamination be detected above the cleanup goals, the excavation will expand in small increments as directed by the Navy's Technical Representative.

A third party, independent, data validation firm will validate all confirmatory data. Data validation procedures will be identical to those followed for the Sampling and Analysis Report, the RFI Report, as well as the CMS Investigation Report, as these represent USEPA Region II protocol. The Quality Assurance Project Plan prepared for the base will be used to dictate quality control/quality assurance throughout the duration of the confirmatory sampling program.

7.2 Reporting

To implement the corrective measure for SWMU 53, documents are required to report the progression of the sites from investigation to remediation. These documents include the CMS, the Corrective Measures Implementation (CMI) Design, and the CMI Final Report. This document is the CMS. The CMI design and CMI Final Report are discussed in the following sections.

7.2.1 Presumptive Remedy Design

Designs must be prepared for SWMU 53 to detail the proposed corrective measure. Because the corrective measure is an accepted construction practice (dig and haul), it is anticipated that the design will not be complicated. A draft and final design submittal should be adequate to document the proposed remedy. A list detailing the proposed corrective measure at this site is shown in Section 7.1.2.1.

7.2.2 CMI Final Report

The CMI Final Report will be provided at the completion of the corrective measure. The report will include an introduction, summary of action, final health and safety report, summary of record documents, summary of field changes and contract modifications, final documents, a complete set of analytical laboratory results, a complete set of validation reports, documentation of offsite transportation and disposal of soil and building materials including the concrete pad, a quality control summary report, and final cost data. The CMI Final report will also include an evaluation of the corrective measure including the quantities of impacted media removed, problems encountered, and solutions implemented.

TABLES

TABLE 7-1

DESIGN CONSIDERATIONS
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Design Consideration	Remedial Area	Applicability
Site Access	SWMU 53	Site accessible from power line off of Forrestal Road.
Existing Structures	SWMU 53	Above ground electrical lines and electrical poles along power line could cause some potential interference. Building 64 will be demolished during the proposed remedial investigation, along with the concrete pad located within the building.
Disruption of Adjacent Facilities	SWMU 53	No adjacent facilities exist. Adjacent SWMU 13 should not be affected by remedial activities.
Available Utilities	SWMU 53	Utilities are unavailable at this site.
Utility Clearance	SWMU 53	Utility clearance will be coordinated with the station's public works department prior to starting excavations.
Extent of Contamination	SWMU 53	The extent of contamination in the areas to be remediated has been fully defined by previous investigations. Contaminant removal will be verified with confirmatory testing.
Staging Areas	SWMU 53	The brush around the perimeter of Building 64 within SWMU 53 will need to be cleared to make adequate room for staging and decontamination areas.
Off-Site Disposal	SWMU 53	Off-site disposal could include disposal at the station's landfill, disposal at a permitted on-island facility, or disposal at a permitted facility in the continental United States.

FIGURES

K:\26007\099PHASE\SWMUs53&54\2099739W

BUILDING 64

DENSE FOLIAGE
(SECONDARY GROWTH VEGETATION)

--DEMOLISH BUILDING 64 AND REMOVE
--DEMOLISH CONCRETE AND REMOVE
--CLEAR AND GRUB AS REQUIRED
--EXCAVATE TOP 1 FOOT OF SOIL

SOIL STAGING
AREA, IF REQUIRED

13MW07

13MW06

EQUIPMENT
LAYDOWN
AND DECONTAMINATION
AREA

40 0 20 40
1 inch = 40 ft.

Baker

LEGEND

– PROPOSED EXCAVATION BOUNDARY

SOURCE: DEPT. OF THE NAVY, SEPEMBER 1999.

FIGURE 7–1
SWMU 53 CONCEPTUAL DESIGN PLAN
SWMU 53, BUILDING 64
(MALARIA CONTROL BUILDING)
CORRECTIVE MEASURES STUDY FINAL REPORT
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

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