

Addendum to the Draft

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Screening-Level Ecological Risk Assessment Problem Formulation (Step 1) and Exposure Estimate SWMUs 1 and 2

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



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TABLE OF CONTENTS

	<u>Page</u>
LIST OF ACRONYMS AND ABBREVIATIONS.....	iv
1.0 INTRODUCTION.....	1-1
1.1 Objectives.....	1-4
1.2 Report Organization	1-5
2.0 ENVIRONMENTAL SETTING.....	2-1
2.1 Site Description and History	2-1
2.2 Terrestrial and Marine Habitats.....	2-2
2.3 Biota	2-4
3.0 AVAILABLE ANALYTICAL DATA	3-1
3.1 Identification of Data Gaps	3-2
4.0 SCREENING LEVEL-PROBLEM FORMULATION	4-1
4.1 Preliminary Conceptual Model	4-1
4.1.1 Transport Pathways	4-2
4.1.2 Exposure Pathways and Routes.....	4-2
4.1.3 Endpoints and Risk Hypotheses	4-3
4.2 Fate and Transport Mechanisms.....	4-5
4.3 Mechanisms of Toxicity.....	4-6
5.0 SCREENING-LEVEL EFFECTS EVALUATION	5-1
5.1 Media-Specific Screening Values	5-1
5.1.1 Surface Soil Screening Values	5-1
5.1.2 Surface Water Screening Values.....	5-2
5.1.3 Sediment Screening Values.....	5-4
5.2 Ingestion Screening Values	5-4
6.0 SCREENING-LEVEL EXPOSURE ESTIMATION.....	6-1
6.1 Selection Criteria for Surface Soil, Surface Water, and Sediment Analytical Data.....	6-1
6.2 Selection of Ecological Receptors.....	6-2
6.3 Exposure Estimation.....	6-5
6.3.1 Exposure Point Concentrations	6-6
6.3.2 Dietary Intakes	6-11
6.3.3 Ingestion-Based Screening Values	6-12
7.0 REFERENCES	7-1

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

2-1	List of Birds Reported from Naval Station Roosevelt Roads
3-1	Summary of Sampling and Analytical Program - SWMU 1
3-2	Summary of Sampling and Analytical Program - SWMU 2
4-1	Preliminary Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
4-2	Log K_{ow} and K_{oc} Values for Organic Chemicals
5-1	Surface Soil Screening Values
5-2	Marine Surface Water Screening Values
5-3	Marine Sediment Screening Values
6-1	Conservative Soil Bioaccumulation Factors for Terrestrial Plants and Invertebrates
6-2	Conservative Soil Bioaccumulation Factors Used for Small Mammal Prey Items
6-3	Conservative Sediment Bioaccumulation Factors Used for Aquatic Invertebrates and Fish
6-4	Surface Water Bioaccumulation Factors Used for Saltwater Fish
6-5	Conservative Exposure Parameters for Upper Trophic Level Receptors
6-6	Dietary Composition for Upper Trophic Level Receptors
6-7	Ingestion-Based Screening Values for Birds
6-8	Ingestion-Based Screening Values for Mammals

LIST OF FIGURES

1-1	Navy Ecological Risk Assessment Tiered Approach
2-1	SWMU/AOC Location Map
2-2	Roosevelt Roads Naval Station, Wetlands Delineation
2-3	The Cowardin Wetland Classification System
3-1	SWMU 1 - Sampling Locations
3-2	SWMU 2 - Sampling Locations
4-1	Conceptual Model for SWMU 1
4-2	Conceptual Model for SWMU 2

LIST OF APPENDICES

A	Habitat Characterization Report
B	Additional Data Collection Work Plan in Support of Ecological Risk Assessment at SWMUs 1 and 2
C	Chemical Profiles
D	Equilibrium Partitioning Approach

LIST OF ACRONYMS AND ABBREVIATIONS

AET	Apparent Effects Threshold
ATSDR	Agency for Toxic Substances and Disease Registry
AQUIRE	Aquatic Toxicity Information Retrieval
AUF	Area Use Factor
BAF	Bioaccumulation Factor
BAF _{sed}	Sediment-to-Fish Bioaccumulation Factor
BAF _{sw}	Surface Water-to-Fish Bioaccumulation Factor
Baker	Baker Environmental, Inc.
BCF	Bioconcentration Factor
BCF _{sw}	Surface Water-to-Fish Bioconcentration Factor
bgs	below ground surface
BW	Body Weight
B _v	Soil to Plant BCF
CCC	Criteria Continuous Concentration
CMS	Corrective Measures Study
CNO	Chief of Naval Operations
COPC	Chemical of Potential Concern
C _{sed}	Concentration in Sediment
C _{sw}	Concentration in Surface Water
C _{xf}	Concentration of Chemical x in Whole-Body Fish
DDD	Tetrachlorodiphenylethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DI _x	Dietary Intake for chemical x
DRO	Diesel Range Organics
EC ₅₀	Median Effective Concentration
EPA	Environmental Protection Agency
EqP	Equilibrium-Partitioning
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
FCM	Food Chain Multiplier
FC _{xi}	Maximum Concentration of Chemical x in Food Item i
FIR	Food Ingestion Rate
GRO	Gasoline Range Organics
IAS	Initial Assessment Study
K _d	Adsorption coefficient
kg	Kilograms
kg/day	Kilograms per day
K _{oc}	Organic Carbon Partition Coefficient
K _{ow}	Octanol-Water Partition Coefficient

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

L/kg	Liter per kilogram
LD ₅₀	Median Lethal Dose
LC ₅₀	Median Lethal Concentration
LOAEL	Lowest Observed Adverse Effect Level
LOEL	Lowest Observable Effect Level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MHSPE	Ministry of Housing, Spatial Planning and Environment
NAWQC	National Ambient Water Quality Criteria
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
NSRR	Naval Station Roosevelt Roads
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PDF _f	Proportion of Diet Composed of Food Item i
PDF _i	Proportion of Diet Composed Food Item i
PDS	Proportion of Diet Composed of Soil/Sediment
ppt	parts per thousand
R	rejected
RAGS	Risk Assessment Guidelines
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SC _x	Concentration of Chemical in Soil/Sediment
SQUIRT	Screening Quick Reference Table
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TCDD	2,3,7,8-Tetrachlorodibenzo-p-Dioxin
TEL	Threshold Effect Level
TOC	Total Organic Carbon
ug/L	micrograms per liter
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOC	Volatile Organic Compound

1.0 INTRODUCTION

Methodology for conducting a screening-level ecological risk assessment (ERA) for Solid Waste Management Units (SWMUs) 1 and 2 was previously submitted as part of the Environmental Protection Agency (EPA)-approved document entitled Revised Final II Corrective Measures Study Work Plan, Army Cremator Disposal Site - SWMU 1 and Langley Drive Disposal Area - SWMU 2, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 2000). The methodology presented in the Revised Final II Corrective Measures Study (CMS) Work Plan followed the process outlined in the Chief of Naval Operations (CNO) document entitled Navy Policy for Conducting Ecological Risk Assessments (CNO 1999).

The Navy ERA process (see Figure 1-1) consists of eight steps organized into three tiers and represents a clarification and interpretation of the eight-step ERA process outlined in the EPA ERA guidance for the Superfund program (EPA 1997). The ERA methodology presented in the Revised Final II CMS Work Plan for SWMUs 1 and 2 covered Tier 1 (screening-level ERA) of the CNO guidance:

- Screening-level problem formulation and ecological effects evaluation (Step 1).
- Screening-level exposure estimate and risk calculation (Step 2).

A cursory comparison of available sediment analytical data for SWMUs 1 and 2 to marine and estuarine sediment quality guidelines developed by Long et al. (1995) was presented in the EPA-approved document entitled Revised Draft RCRA Facility Investigation Report for Operable Unit 3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 1999). The results of the comparison, also summarized in the Revised Final II CMS Work Plan for SWMUs 1 and 2, indicated that chemicals detected in sediment collected from a downgradient estuarine wetland system may present an unacceptable risk to benthic invertebrates.

Under Navy policy, if the results of Step 1 and Step 2 (Tier 1) 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 (EPA 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. Step 3a precedes the baseline risk assessment problem formulation (Step 3b). In Step 3a, the conservative exposure assumptions applied in Tier 1 are refined and risk estimates are recalculated using the same conceptual site model. The evaluation of risks in Step 3a may also include consideration of background data, chemical bioavailability, and the frequency of detection. Because the cursory comparison of sediment analytical data to marine and estuarine sediment quality guidelines indicated that chemicals may present an unacceptable risk to benthic invertebrates, the Revised Final II CMS Work Plan for SWMUs 1 and 2 also included methodology for conducting Step 3a of the Navy ERA process.

The Revised Final II CMS Work Plan for SWMUs 1 and 2 acknowledged that insufficient data exist to adequately characterize potential risks to ecological receptor species/communities at both SWMUs (see Section 3.0 for a description of available analytical data). Specific data gaps include the following:

- Lack of surface water analytical data for the Ensenada Honda, an open marine surface water body downgradient from SWMUs 1 and 2.
- Lack of background surface water and sediment data from an open water marine environment similar to the Ensenada Honda.
- Lack of surface water and sediment data that can be used in Step 3a to assess the bioavailability of the preliminary ecological COPCs identified by the screening-level risk calculation.

In addition to the above data gaps, several deficiencies are associated with the existing analytical data. These deficiencies include the following:

- The available surface water data for the estuarine wetland system downgradient from SWMUs 1 and 2 are from 1988. These data have not been validated. Furthermore, based on their age, these data are not representative of current surface water quality within the estuarine wetland system.

- The number of sediment samples collected from the estuarine wetland system downgradient from SWMUs 1 and 2 is insufficient to conclude that potential contamination within this system has been adequately characterized.

As discussed in the Revised Final II CMS Work Plan for SWMUs 1 and 2, analytical data gaps and deficiencies associated with the existing analytical data would be addressed following completion of Steps 1, 2, and 3a of the Navy ERA process through a focussed field sampling and analytical program. However, in lieu of conducting the screening-level risk calculation and Step 3a of the Navy ERA process prior to addressing data gaps and uncertainties, these components of the ERA at SWMUs 1 and 2 will be completed following the sampling and analytical program. This will eliminate the need to reevaluate risks once the data gaps and deficiencies have been addressed. As such, this document presents Step 1 of the Navy ERA process (screening-level problem formulation) and components of Step 2 (i.e., screening-level exposure estimate). A future risk assessment document will be prepared following completion of the field sampling and analytical program that will include the screening-level risk calculation and Step 3a of the Navy ERA process. The screening-level risk calculation and Step 3a will be performed in accordance with the EPA-approved Revised Final II CMS Work Plan for SWMUs 1 and 2. If methodology differs from the methodology presented in the work plan, justification with supporting documentation will be included within the risk assessment document.

Although the Revised Final II CMS Work Plan for SWMUs 1 and 2 included methodology for conducting Step 1 of the Navy ERA process, as well as methodology for conducting the screening-level exposure estimate, the methodology presented in this document incorporates the following:

- Revisions to methodology that reflect changes agreed upon by the Navy and EPA for a screening-level ERA at SWMU 9. Revisions will be incorporated into the ERA process at SWMUs 1 and 2 to ensure consistency in ERAs conducted at NSRR.
- Media-specific screening values for surface soil, surface water, and sediment and ingestion-based screening values for upper trophic level dietary intakes.

- Methodology for evaluating potential risks to the West Indian manatee and avian piscivores (e.g., exposure parameters, diet, and methodology for estimating exposure point concentrations in dietary food items).

1.1 Objectives

The objectives of this document are as follows:

- Expand upon the description of the environmental setting presented in the Revised Final II CMS Work Plan by incorporating information obtained during a habitat characterization conducted at SWMUs 1 and 2.
- Summarize existing analytical data and identify and discuss analytical data gaps.
- Present a preliminary conceptual model for SWMUs 1 and 2 that identifies potential sources of contaminants, transport pathways, exposure media, potential exposure routes and receptor groups.
- Identify preliminary assessment endpoints and measurement endpoints.
- Identify media-specific screening values for surface soil, surface water, and sediment, as well as ingestion-based screening values for upper trophic level receptor dietary exposures.
- Identify specific receptor species/groups that will be used in the evaluation of potential risks.
- Present methodology for estimating dietary intakes for upper trophic level receptor species, including exposure parameters, diet, and exposure point concentrations in dietary food items.

1.2 Report Organization

The organization of this document is as follows:

- **Section 1.0 - Introduction.** Describes the purpose, scope, and objectives of the ERA and outlines report organization.
- **Section 2.0 - Environmental Setting.** Describes the site history and presents information on regional and SWMU-specific habitats and biota.
- **Section 3.0 - Available Analytical Data and Data Gaps.** Describes existing analytical data for SWMUs 1 and 2 and identifies the specific data that will be used in the screening-level risk calculation and Step 3a of the Navy ERA process. Data gaps and deficiencies are also identified and discussed.
- **Section 4.0 - Screening-Level Problem Formulation.** Presents the preliminary conceptual model for SWMUs 1 and 2, including potential sources of contaminants, transport pathways, exposure media, potential exposure routes, and receptor groups. Preliminary assessment and measurement endpoints are also identified and discussed.
- **Section 5.0 - Screening-Level Ecological Effects Evaluation.** Identifies and describes media-specific screening values for surface soil, surface water, and sediment.
- **Section 6.0 - Screening-Level Exposure Estimation.** Identifies ecological receptor species/groups, methodology for estimating exposure point concentrations in upper trophic level receptor dietary food items, dietary intake models, and ingestion-based screening values.
- **Section 7.0 - References.** Lists the citations for all references cited in the document.

Supporting technical data are provided in appendices.

2.0 ENVIRONMENTAL SETTING

The sections that follow provide a brief description of the site history, as well as a description of SWMU habitats and biota. The description of habitats and biota, presented in Sections 2.2 and 2.3, respectively, relies on literature-based information for Puerto Rico and the entire landmass of Naval Station Roosevelt Roads (NSRR). This information is supplemented by observations recorded during a habitat characterization conducted at SWMUs 1 and 2 in May 2000. The habitat characterization report, prepared by Geo-Marine, Inc. (Plano, Texas), is included as Appendix A.

A description of regional and, where applicable, area-specific physiographic features, including climate, topography, geology, and hydrology was previously presented in the Draft Final RCRA Facility Investigation Report for Operable Unit 3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 1999). The reader is referred to this document for a discussion of these physiographic features.

2.1 Site Description and History

SWMU 1, located east of the Navy Lodge, encompasses an area of roughly 36 acres of land (see Figure 2-1). The site is bounded to the north by Kearsage Road leading to the Coast Guard Pier, Ensenada Honda to the east and south, and the Navy Lodge and Bowling Alley to the west. Based on previous reports, the Army Cremator Disposal Site operated from the early 1940s until the early 1960s and was the main station landfill during this period. Waste material was disposed of by piling, burning, and compacting (A.T. Kearney, Inc., 1988). According to the Naval Energy and Environmental Support Activity (NEESA), an estimated 100,000 tons of waste including scrap metal, inert ordnance, batteries, tires, appliances, cars, cables, dry cleaning solvent cans, paint cans, gas cylinders, construction debris, dead animals, and residential waste was disposed of at this site (NEESA, 1984). No reliable information exists regarding the amounts of material present in the disposal area that could be hazardous; however, in 1984, an Initial Assessment Study (IAS) team estimated that as much as 1,000 tons of hazardous material could be present (NEESA, 1984).

SWMU 2 is located along Langley Drive approximately 2,000 feet northeast of the Navy Exchange (see Figure 2-1). The site extends from Langley Drive to the estuarine wetland system

and has an estimated length of 1300 feet in a northeast-southwest direction. This site operated as a landfill from approximately 1939 to 1959 and is documented as having been used for the disposal of both hazardous and non-hazardous wastes (NEESA, 1984). Debris noted during the IAS included partially buried metal and concrete objects, old fuel lines, flexible metal hoses, sample containers containing pellets, steel cables, hardened tar, rubble, and ten to fifteen 55-gallon drums that were corroded. The drum contents, generally consisting of a whitish solid with a green outer crust, were exposed (NEESA, 1984). The IAS team estimated the volume of disposed waste to be approximately 1,700 cubic yards, of which approximately 20,000 pounds could be hazardous.

2.2 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.

Upland coastal forest is present at both SWMUs 1 and 2, while coastal scrub forest is present at SWMU 1 (Geo-Marine 2000). The upland coastal community at SWMU 1 consists of a shrub layer dominated by *Leucaena leucocephala*, *Bursera simaruba*, and *Randia aculeate*, trees (*Bucida buccera*, *Trichostigma octandrum*, and *Psidium guajava*), and herbaceous areas predominantly consisting of *Panicum maximum* (Geo-Marine, Inc. 2000). The coastal scrub forest at SWMU 1 consists of a shrub layer dominated by *Leucaena leucocephala* and a herbaceous layer dominated by *Panicum maximum*. No tree layer was present in the coastal scrub forest at SWMU 1 (Geo-Marine, Inc. 2000). The upland coastal community at SWMU 2 consists of shrub species (e.g., *Leucaena leucocephala*) and herbaceous species (e.g., *Panicum maximum*, *Sporobolus indicus*, and *Waltheria indica*). The frequency of occurrence of species such as *Bursera simaruba*, *Erthroxylum brevipes*, and *Capparis flexusa* increased farther from roadways at the site (Geo-Marine, Inc. 2000).

Stahlia monosperma, a federally threatened tree, is known to occur in coastal forests of southeastern Puerto Rico (Little and Wadsworth 1964). However, this species was not observed within SWMUs 1 and 2 during the habitat characterization (Geo-Marine, Inc. 2000), nor is it known to occur within the landmass encompassed by NSRR (Geo-Marine, Inc. 1998).

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 contiguous to NSRR is approximately 161 acres, 2,700 acres, and 1,900 acres, respectively (Geo-Marine, Inc. 1998). Seagrass beds are important grazing areas for the green sea turtle (*Chelonia mydas*) and the West Indian manatee (*Trichechus 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 in the marine environment surrounding NSRR.

A black mangrove (*Avicenia germinans*) and red mangrove (*Rhizophora mangle*) community occur within or downgradient from SWMU 1 (Geo-Marine, Inc. 2000). The red mangroves occur adjacent to the Ensenada Honda, while the black mangroves are located inland between the red mangrove and coastal upland forest community. Identical mangrove communities are present within or downgradient from SWMU 2. The red mangrove communities at each SWMU are sparsely vegetated and contain large pools of shallow water. Sea grass beds occur within the Ensenada Honda, immediately adjacent to the red mangrove communities.

A map showing the spatial relationship of SWMUs 1 and 2 to the estuarine wetland system (mangrove communities) and the Ensenada Honda is provided as Figure 2-2. Included on the map are wetland units 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 (USACE 1987). Based on the Cowardin Wetland Classification System [Cowardin et al. 1979 (see Figure 2-3)], the specific wetland units present within the environment offshore from SWMUs 1 and 2 include the following:

- Estuarine, intertidal, unconsolidated shore, mud (E2US3)
- Estuarine, intertidal, unconsolidated shore, organic (E2US4)

- Estuarine, intertidal, scrub-shrub, broad-leaved evergreen (E2SS3)

2.3 **Biota**

A total of 22 terrestrial mammal species are known historically from Puerto Rico; however, all mammals except bats (13 species) have been extirpated (USGS 1999). None of the bats found on Puerto Rico are exclusive to the island. Although the occurrence of bats at NSRR has not been documented, their presence is likely. The West Indian manatee is known to occur in the marine environment surrounding NSRR. As discussed in Section 2.2, seagrass is present within the Ensenada Honda. As such, this surface water body represents potential feeding habitat for the West Indian manatee.

Several mammals have been introduced in 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 several bird and reptile populations (USGS 1999 and 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 monachus*). 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 known to occur at NSRR is summarized in Table 2-1. The list 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 melanoleuca*), black-bellied plover (*Squatarola squatarola*), clapper rail (*Rallus longirostris*), Royal tern (*Thalasseus maximus*), sandwich tern (*Thalasseus sandvicensis*), least tern (*Sterna albifrons*), yellow warbler (*Dendroica petechia*), palm warbler (*Dendroica palmarum*), prairie warbler (*Dendroica discolor*), magnolia warbler (*Dendroica 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*). It is noted that the known avian occurrences compiled by Geo-Marine, Inc. (1998) is based on literature-based information that pre-dated 1990.

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 U.S. Fish and Wildlife Service 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. SWMUs 1 and 2 are located within the critical habitat designation 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).

Specific bird species observed within each vegetative community at SWMUs 1 and 2 are listed in the habitat characterization report (see Appendix A). Species common to both SWMUs included the red-tailed hawk, yellow warbler, Puerto Rican woodpecker, loggerhead kingbird (*Tyrannus caudifasciatus*), zenaida dove (*Zenaida aurita*), and pearly-eyed thrasher (*Margarops fuscatus*). An active Wilson's plover (*Charadrius wilsonia*) nest was observed within the black mangrove community at SWMU 1.

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. Only the Puerto Rican ridge-headed toad and the golden coqui have been listed as threatened under provisions of the Endangered Species Act of 1973. Their occurrence at NSRR is not known. 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. These three sea turtles, 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). They are known to occur or have the potential to occur at NSRR (Geo-Marine, Inc. 1998). It is noted that a comprehensive list of amphibians and reptiles present at NSRR, particularly frogs and lizards, was not available from the literature.

Several lizard species were observed at SWMUs 1 and 2 during the habitat characterization. The crested anole (*Anolis cristatellus*) was observed in upland habitat units at both SWMUs, *Anolis stratulus* was observed within the upland coastal scrub forest community at SWMU 1, while *Anolis pulchellus* was observed within the upland coastal forest community at SWMU 2. The Puerto Rican boa (*Epicrates inornatus*) utilizes a variety of habitats but is most commonly found in karst forest habitats. This species is not known to occur at NSRR, nor was it observed within the SWMUs 1 and 2 vegetative units during the habitat characterization. Given the presence of sea grass beds, the Ensenada Honda represents potential feeding habitat for sea turtles.

A diverse fish and invertebrate community can be found in the offshore 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. Although too numerous to list individually by species, 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 invertebrate community includes sponges, corals, anemones, sea cucumbers, urchins, and crabs. It is noted that a marine survey of the Ensenada Honda was not conducted as part of the habitat characterization at SWMUs 1 and 2. As such, a list of specific fish and invertebrate species within this water body is not known.

3.0 AVAILABLE ANALYTICAL DATA

Sampling activities at SWMUs 1 and/or 2 have previously been conducted under a Confirmation Study in 1985 (Round 01) and 1987 (Round 2) (SWMUs 1 and 2), a Supplemental Investigation in 1993 (SWMUs 1 and 2), a Relative Risk Ranking in 1995 (SWMUs 1 and 2), and a RFI field investigation in 1996 (SWMUs 1 and 2) and 1997 (SWMU 1). Environmental media collected during the various field investigations included surface soil, subsurface soil, groundwater, surface water, and sediment (see Table 3-1). Sampling locations are depicted on Figures 3-1 and 3-2 for SWMUs 1 and 2, respectively. The field investigations and associated analytical data was previously presented and discussed in the EPA-approved Revised Draft RFI for OU 3/5 (Baker, 1999). The reader is referred to this document for a detailed description of sampling activities and analytical data.

The quality of the data obtained during the Confirmation Study is questionable due to the unknown level of laboratory data quality objectives and the apparent lack of independent, third party data validation. Therefore, these data are not acceptable for use in the screening-level ERA for SWMUs 1 and 2.

The subsurface soil and groundwater analytical data collected during the Supplemental Investigation, Relative Risk Ranking, and RFI field investigations will not be used in the screening-level ERA. Subsurface soil data will be excluded because this media is not represented by a complete exposure pathway for the following reasons (Suter II 1993):

- The mass of most root systems is within the surface soil.
- Most soil heterotrophic activity is within the surface soil layer.
- Soil invertebrates occur on the surface or within the oxidized root zone.

Groundwater data will be excluded from the evaluation since groundwater is not inhabited by ecological receptors. While it is acknowledged that chemicals may migrate to surface water and sediment with groundwater, this transport pathway will be evaluated by existing and future surface water and/or sediment data for the downgradient surface water bodies (estuarine wetland system and Ensenada Honda).

3.1 Identification of Data Gaps

Based on the review of existing analytical data for SWMUs 1 and 2, the following data gaps and deficiencies have been identified that prevent completion of the screening-level risk calculation and/or Step 3a of the Navy ERA process:

- Surface water analytical data for the Ensenada Honda is not available for use in media-specific screening and the estimation of tissue concentrations in the prey of avian piscivores.
- The available surface water data for the estuarine wetland system downgradient from SWMUs 1 and 2 is from 1985 and 1987. These data have not been validated. Furthermore, based on their age, they are not representative of current surface water quality.
- Background surface water and sediment data from an open water marine environment similar to the Ensenada Honda is not available for use in Step 3a of the Navy ERA process.
- The available sediment data for the estuarine wetland system downgradient from SWMUs 1 and 2 does not include total organic carbon (TOC) data. As such, an evaluation of the bioavailability of organic chemicals in sediment can not be conducted as part of Step 3a of the Navy ERA process.
- Relatively few sediment samples have been collected from the estuarine wetland system downgradient from SWMUs 1 and 2. As such, potential contamination within this system has not been adequately characterized.

A field sampling and analytical program will be conducted to address the data gaps and deficiencies associated with existing data. The work plan describing this program is included as Appendix B.

4.0 SCREENING LEVEL-PROBLEM FORMULATION

Problem formulation establishes the goals, scope, and focus of the ERA. As part of problem formulation, a preliminary conceptual model is developed for the site that describes potential sources, transport pathways, exposure pathways and routes, and receptors, while taking into consideration the environmental setting of the site and the types and concentrations of chemicals present in ecologically relevant media. Assessment endpoints, measurement endpoints, and risk hypotheses are then selected to evaluate those receptors for which complete and potentially significant exposure pathways are likely to exist. The fate, transport, and toxicological properties of the chemicals present at a site are also considered during this process.

4.1 Preliminary Conceptual Model

Figures 4-1 and 4-2 show preliminary conceptual models for SWMUs 1 and 2, respectively. The model outlines potential sources of contaminants, transport pathways, exposure media, potential exposure routes and receptor groups. Exposure, and thus potential for risk, can only occur if the following conditions exist (EPA 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 the affected media.
- An exposure route must exist whereby the contaminant can be taken up by ecological receptors.

Components of the conceptual models (transport pathways, exposure pathways and routes, and assessment and measurement endpoints) are discussed in the sections that follow.

4.1.1 Transport Pathways

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media. As depicted in Figures 4-1 and 4-2, the primary mechanisms for contaminant transport from potential source areas at SWMUs 1 and 2 are believed to include the following:

- Overland transport of chemicals with surface soil via surface runoff to downgradient surface soil, surface water, and sediment.
- Leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport to surface water and sediment with groundwater.
- Uptake by biota from surface soil, surface water, and sediment, and trophic transfer to upper trophic levels.

4.1.2 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 4.1. As depicted on Figures 4-1 and 4-2, SWMUs 1 and 2 have potentially complete exposure pathways to ecological receptors.

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 soils through their root surfaces during water and nutrient uptake. Unrooted, floating aquatic plants, rooted submerged aquatic plants (e.g. sea grass), and algae may be exposed to chemicals directly from the water or (for rooted plants) from sediments.

Upper trophic level receptors (i.e., mammals and birds) 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. The exposure routes evaluated in the screening-level ERA for SWMUs 1 and 2 are as follows.

- Ingestion of contaminated plant and/or animal tissues.
- Incidental ingestion of surface soil and sediment.

Direct ingestion of drinking water is only considered if the salinity of the drinking water source is less than 15 parts per thousand (ppt), the approximate toxic threshold for wildlife receptors (Humphreys 1988). Given that the estuarine wetland system and Ensenada Honda represent marine environments, salinity levels are assumed to be well above the 15 ppt threshold value. This assumption will be verified during the sampling and analytical program presented in Appendix B by conducting salinity measurements at proposed surface water/sediment sampling within the estuarine wetland system and Ensenada Honda. Because there are no freshwater systems within or contiguous to SWMUs 1 and 2, drinking water ingestion is not considered a possible complete exposure pathway and will not be considered in risk calculations for upper trophic level receptors.

Based on the protection offered by feathers (birds) and the general fate properties (e.g. high adsorption to solids) of the majority of compounds associated with SWMUs 1 and 2, dermal exposures for upper trophic level receptor species are not considered significant relative to ingestion exposures. Furthermore, insufficient data is available in the literature to assess dermal exposure (e.g., surface areas of potential receptors). Therefore, dermal exposure for upper trophic level receptors will not be considered in future risk calculations. Direct contact is considered for the lower trophic level receptor groups (e.g., terrestrial invertebrates, fish, and benthic invertebrates). In addition to dermal contact, inhalation exposures will not be evaluated since many of the parameters required to determine exposure (e.g., respiration rates) have not been measured for wildlife species.

4.1.3. Endpoints and Risk Hypotheses

The conclusion of the screening-level problem formulation includes the selection of ecological endpoints. Two types of endpoints, assessment endpoints and measurement endpoints, are

defined as part of the ERA process as are risk hypotheses or risk questions (EPA 1997). 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 EPA (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 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 (EPA 1997). Assessment endpoints contain an entity (e.g., belted kingfisher 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 chemical 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 (EPA 1992). Effects on individuals are important for some receptors, such as rare and endangered species. Population- and community-level effects are typically more relevant to ecosystems. Population- and community-level effects are usually difficult to evaluate directly without long-term and extensive study. However, measurement endpoint evaluations at the individual level, such as an evaluation of the effects of chemical exposure on reproduction, can be used to predict effects on an assessment endpoint at the population or community level. In addition, use of criteria values designed to protect the vast majority (e.g., 95 percent) of the components of a community (e.g., Ambient Water Quality Criteria for the Protection of Aquatic Life) can be useful in evaluating potential community- and/or population-level effects.

Assessment endpoints, risk hypotheses, and measurement endpoints selected for the screening-level ERA for SWMUs 1 and 2 are presented in Table 4-1. Given the similarity of terrestrial and aquatic habitats within and contiguous to each SWMU (see Appendix A and Section 2.2),

identical endpoints and risk hypotheses have been selected for each SWMU. As evidenced by Table 4-1, the assessment endpoints selected were based on the survival, growth, and reproduction of terrestrial receptor groups (terrestrial plants and invertebrates), aquatic receptor groups (aquatic plants, benthic invertebrates, and fish), upper trophic level birds (herbivores, omnivores, and carnivores), and marine mammals (i.e., West Indian manatee). 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.

4.2 Fate and Transport Mechanisms

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

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

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

Octanol-water partitioning indicates whether a compound is hydrophilic or hydrophobic. The Octanol-water partition coefficient (K_{ow}) expresses the relative partitioning of a compound between octanol (lipids) and water. A high affinity for lipids equates to a high K_{ow} and vice versa. As discussed above, K_{ow} has been shown to correlate well with Bioconcentration Factors (BCFs) in aquatic organisms, adsorption to soil or sediment particles, and the potential to bioaccumulate in the food chain (Howard 1991). Typically expressed as $\log K_{ow}$, a value of three (3.0) or less generally indicates that the chemical will not bioconcentrate to a significant degree (Maki and Duthie 1978). $\log K_{ow}$ values for organic chemicals previously analyzed in environmental media collected from SWMUs 1 and/or 2 (Appendix IX VOCs, Appendix IX semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), organochlorine pesticides, organophosphorous pesticides, explosives, and dioxins/furans) are presented in Table 4-2. A $\log K_{ow}$ of three equates to an aquatic species BCF of about 100, using the following equation from Lyman et al. (1990):

$$\log BCF = (0.76) (\log K_{ow}) - 0.23 \quad (\text{Equation 4-1})$$

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

4.3 Mechanisms of Toxicity

Mechanisms of toxicity for chemicals previously analyzed in environmental media collected from SWMUs 1 and/or 2 (if available) are discussed in the chemical profiles provided as Appendix C.

5.0 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, surface water, and sediment. As evidenced by Table 4-1, these screening values were used as measurement endpoints for terrestrial and/or aquatic receptor groups. Ingestion-based screening values were used as measurement endpoints for upper trophic level receptors.

5.1 Media-Specific Screening Values

The sections that follow describe the various criteria and toxicological benchmarks that will be used as screening values (toxicological thresholds) for chemicals that were previously analyzed for or will be analyzed for in surface soil, surface water, and sediment samples collected from SWMUs 1 and/or 2. Chemical-specific surface soil, surface water and sediment screening values are summarized in Tables 5-1, 5-2, and 5-3, respectively. The screening values listed in the tables represent conservative exposure thresholds above which adverse ecological effects may occur.

5.1.1 Surface Soil Screening Values

The literature-based toxicological benchmarks listed below were preferentially selected for use as surface soil screening values.

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

For a given chemical, if more than one toxicological threshold was available from the sources listed above, the lowest value was selected as the surface soil screening value. For those chemicals lacking a literature-based toxicological threshold from Efroymson et. al 1997a and 1997b, toxicity reference values contained in EPA 1999 and Dutch Ministry of Housing, Spatial

Planning and Environment (MHSPE) soil standards (MHSPE 1994) were used as screening values. MHSPE standards were derived assuming a minimum default soil organic carbon content of 2.0 percent (MHSPE). For a given chemical, when more than one value was available from EPA 1999 and MHSPE 1994, the lowest value was conservatively selected as the surface soil screening value.

5.1.2 Surface Water Screening Values

Chronic saltwater National Ambient Water Quality Criteria (NAWQC) (EPA 2002) were selected for use as surface water screening values. The EPA NAWQC for cadmium, copper, chromium, lead, mercury, selenium, and zinc are expressed as dissolved concentrations. NAWQC for these metals were converted to total recoverable concentrations prior to using appropriate conversion factors (EPA 2002). For those chemicals lacking a saltwater NAWQC, surface water screening values were identified from the following information listed in their order of decreasing preference:

- Final Chronic Values (FCVs) for saltwater contained in Ecotox Thresholds (EPA 1996a)
- Chronic screening values for saltwater contained in Ecological Risk Assessment Bulletins – Supplement to Risk Assessment Guidelines (RAGS) (EPA 2001)
- Minimum chronic toxicity test endpoints (No Observed Effect Concentration [NOEC] and Maximum Acceptable Toxicant Concentration [MATC] values) for saltwater species reported in the ECOTOX Database System (Aquatic Toxicity Information Retrieval [AQUIRE] database) (EPA 2000)
- Chronic Lowest Observable Effect Levels (LOELs) for saltwater contained in National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQUIRTs) (Buchman 1999)

The order of preference was selected based on their level of protection. For example, FCVs would be expected to offer a greater degree of protection than a single species NOEC, MATC, or LOEL since their derivation considers a larger toxicological database. In the absence of a FCVs,

EPA Region IV chronic screening values, chronic test endpoints, and chronic LOELs, screening values were derived from the acute literature values listed below:

- Acute LOELs for saltwater contained in NOAA SQUIRTs (Buchman 1999)
- Acute toxicity test endpoints (NOEC, Lowest Observed Effect Concentration [LOECs], median lethal concentration [LC_{50}], and median effective concentration [EC_{50}] values) for saltwater species contained in the ECOTOX Database System (AQUIRE database) (EPA 2000).
- LC_{50} values for saltwater species contained in Superfund Chemical Matrix (EPA 1996b)

Chronic-based screening values were extrapolated from acute NOEC, LOEC, LOEL, LC_{50} , and EC_{50} values as follows:

- An uncertainty factor of 10 was used to convert an acute NOEC, LOEC, or LOEL to a chronic-based screening value.
- An uncertainty factor of 100 was used to convert an EC_{50} or LC_{50} to a chronic-based screening value.

When acute toxicity data were used to extrapolate a chronic screening value, NOECs were given preference over LOECs/LOELs, LOECs/LOELs were given preference over LC_{50} and EC_{50} values, and EC_{50} values were given preference over LC_{50} values. For a given test endpoint (e.g., NOEC), when more than one value was available from the literature, the minimum value was conservatively used to extrapolate a chronic screening value. In some cases, chronic and acute LOELs for chemical classes (e.g., PAHs) were available from Buchman (1999). A LOEL based on a chemical class was used to derive a chronic screening value only if that chemical lacked literature-based benchmarks and/or toxicity test endpoints.

For those chemicals lacking saltwater toxicological thresholds and literature values, surface water screening values were identified or developed from freshwater values using the sources and procedures discussed in the preceding paragraphs with one exception. This exception involved

the consideration of freshwater Secondary Chronic Values (SCVs) developed by the EPA (1996b) and Suter II (1996).

5.1.3 Sediment Screening Values

The literature-based toxicological benchmarks listed below, expressed as bulk sediment concentrations (dry weight), were used as sediment screening values.

- Effects-Range low (ER-L) marine and estuarine sediment quality guidelines (Long and Morgan 1991 and Long et al. 1995)
- Threshold Effects Level (TEL) sediment quality guidelines (MacDonald 1994)
- Apparent Effects Threshold (AET) sediment quality guidelines (Buchman 1999)

For a given chemical, when more than one sediment quality guideline was available from the sources listed above, the minimum value was selected as the sediment screening value.

For those organic chemicals lacking a literature-based toxicological benchmark, screening values were either derived using the EPA equilibrium partitioning (EqP) approach (EPA 1993a [see Appendix D]) or identified from the literature (Di Toro and McGrath 2000). For a given chemical, when an EqP-based value was derived in accordance with EPA 1993a and was also available from Di Toro and McGrath (2000), the minimum value was selected as the sediment screening value.

5.2 Ingestion Screening Values

Ingestion-based screening values for upper trophic level receptors are discussed in Section 6.3.3.

6.0 SCREENING-LEVEL EXPOSURE ESTIMATION

Maximum detected and non-detected concentrations in surface soil, surface water, and sediment (as appropriate) will be used to conservatively estimate potential chemical exposures for the terrestrial and aquatic receptor species/groups selected to represent assessment endpoints at SWMUs 1 and 2.

Exposures for upper trophic level receptor species via the food web will be determined by estimating chemical-specific concentrations in each dietary component using uptake and food web models. Incidental ingestion of soil or sediment will also be included when calculating the total level of exposure.

6.1 Selection Criteria for Surface Soil, Surface Water, and Sediment Analytical Data

Surface soil, surface water, and sediment data collected during the RFI field investigations and/or the sampling and analytical program presented in Appendix B will be combined into a unified database for evaluation of ecological risks. This section outlines the specific considerations and guidelines that will be followed to select data relevant to potential ecological exposure pathways.

- Data must be validated by a qualified data validator using acceptable data validation methods. Data with rejected (R) values will not be used in the risk calculations.
- For surface soil and sediment, samples collected to a maximum depth of 1 foot will be used since this depth range is the most active biological zone (Suter II 1995). In cases where available surface soil data are limited, samples collected to a maximum depth of 2 feet bgs will be considered for risk assessment purposes.
- For surface water screening, total (unfiltered) metal concentrations will be used. However, as discussed in Section 6.3.1, dissolved (filtered) metals data will be used in aquatic food web modeling.
- In some instances, duplicate samples were collected in the field during the RFI investigations or will be collected during the field investigation presented in

Appendix B. The maximum concentration of each contaminant (or the maximum non-detected value) in the original or duplicate sample will be used as a conservative estimate of contaminant concentration at a particular sampling point. Results from duplicate samples will not be evaluated individually.

6.2 Selection of Ecological 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., belted kingfisher) or species groups (e.g., fish) are often selected as surrogates to evaluate potential risks to larger components of the ecological community (e.g., piscivorous birds) that were selected to represent the assessment endpoints (e.g., survival, growth, and reproduction of piscivorous birds). Selection criteria typically include those species that:

- Are known to occur, or are likely to occur, at the site;
- Have a particular ecological, economic, or aesthetic value;
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present at the site for which complete exposure pathways are likely to exist;
- Can, because of toxicological sensitivity or potential exposure magnitude, be expected to represent potentially sensitive populations at the site; and
- Have sufficient ecotoxicological information available on which to base an evaluation.

Lower trophic level receptor species are evaluated based on those taxonomic groupings (e.g., terrestrial plants and invertebrates, fish, benthic invertebrates, and aquatic plants) for which screening values have been developed. These groupings and screening values are used in most ERAs. As such, specific species of terrestrial and aquatic biota are not chosen as receptor species because of the limited information available for specific species and because terrestrial and

aquatic biota are dealt with on a community level via a comparison to surface water and sediment screening values.

The upper trophic level receptor species listed below have been chosen for dietary exposure modeling based on the criteria listed above, the general guidelines presented in EPA (1991a), the assessment endpoints (see Table 4-1), and the description of SWMU habitats and biota contained within the habitat characterization report included as Appendix A.

Terrestrial species (SWMUs 1 and 2):

- American robin (*Turdus migratorius*) (avian omnivore)
- Mourning dove (*Zenaida macroura*) (avian herbivore)
- Red-tailed hawk (*Buteo jamaicensis*) (avian carnivore)

Aquatic/estuarine wetland system species (SWMUs 1 and 2):

- Great blue heron (*Ardea herodias*) (avian piscivore/carnivorous omnivore)
- Belted kingfisher (*Ceryle alcyon*) (avina piscivore/carnivorous omnivore)
- Spotted sandpiper (*Actitis macularia*) (Avian carnivore - invertebrates)

Aquatic/open water marine species (SWMUs 1 and 2):

- West Indian manatee (*Trichechus manatus*) (mammalian herbivore)
- Double-crested cormorant (*Phalacrocorax auritus*) (avian piscivore)

With the exception of the mourning dove and double-crested cormorant, the receptors listed above were identified as receptor species in the Revised Final II CMS Work Plan for SWMUs 1 and 2 (Baker 2000). The mourning dove was included as an ecological receptor species for terrestrial food web modeling for the following reasons:

- This species is known to occur at NSRR (see Table 2-1).
- Similar species were observed within terrestrial habitat at SWMUs 1 and 2 during the habitat characterization (see Section 2.3 and Appendix A).

The double-crested cormorant was added to the list of ecological receptor species for the open water marine habitat (i.e., Ensenada Honda) at each SWMU. Although the double-crested cormorant has not been reported at NSRR (see Table 2-1), this species is known to occur in Puerto Rico (Raffaele 1989).

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 nonindigenous terrestrial mammals present on the island (black rat, Norway rat and mongoose) are nuisance species that have been implicated in the decline of native reptile and bird populations.

Although exposure pathways to reptiles are likely to be complete, a reptilian species was not selected as a receptor species in this screening-level ERA because the life history and toxicological database concerning the effects of chemicals on reptiles is severely limited. It is assumed that reptiles present at SWMUs 1 and 2 (i.e., lizards) are not exposed to significantly higher concentrations of COPCs and are not more sensitive to chemicals than the other terrestrial receptor species evaluated in the risk assessment. This is likely to be a reasonable assumption since the limited available data indicate that this group is not generally more sensitive than the vertebrate group (aves) addressed in the screening-level ERA. This assumption will, however, be a source of uncertainty in the screening-level ERA.

6.3 Exposure Estimation

Chemical concentrations in surface soil will be used to estimate potential chemical exposures for the terrestrial receptor groups (terrestrial plants and invertebrates). Chemical concentrations in surface water and/or sediment will be used to estimate potential chemical exposures for the aquatic receptor groups (i.e., aquatic plants, benthic invertebrates, and fish). Upper trophic level receptor exposures to chemicals in surface soil, surface water, and/or sediment will be determined by estimating the concentration of each chemical in each relevant dietary component using uptake and food web models. Incidental ingestion of surface soil or sediment will be included when calculating the total exposure. As previously discussed, surface water ingestion is not considered an exposure route for chemicals in surface water.

Not all chemicals analyzed for in surface soil, surface water, and sediment will be evaluated for food web exposures. The organic chemicals evaluated for food web exposures will be limited to those organic chemicals listed in Table 4-2 with the potential to bioaccumulate to a significant extent. Bioaccumulating organic chemicals are defined as those with a maximum reported log octanol-water partition coefficient ($\log K_{ow}$) greater than or equal to 3.0. For conservatism, all inorganic chemicals will also be evaluated for food web exposures. The exception is cyanide, which is excluded from the evaluation of food web exposures because it is readily metabolized and does not bioaccumulate (Eisler 1991).

Dietary items for which tissue concentrations will be modeled will include terrestrial plants, soil invertebrates (earthworms are the standard surrogate), small mammals, aquatic plants, aquatic invertebrates, and fish. Specific small mammals species were not selected as dietary items for terrestrial avian carnivores (i.e., red-tailed hawk). Instead, a specific trophic level (omnivore) was used to represent the small mammals present on Puerto Rico that most likely represent small mammal dietary food items for the red-tailed hawk (Norway rat and black rat). Small mammal herbivores and insectivores were excluded as dietary items for terrestrial avian carnivores because they are not represented by the Puerto Rican mammalian fauna (see Section 2.3).

The methodologies used for estimation of tissue concentrations are outlined in the following section. The uptake of chemicals from the abiotic media into these food items is based (where available) on conservative (e.g., maximum or 90th percentile) Bioconcentration Factors (BCFs)

or Bioaccumulation Factors (BAFs) from the literature. Default factors of 1.0 are used only when data are unavailable for chemicals in the literature.

6.3.1 Exposure Point Concentrations

Exposure point concentrations for terrestrial receptor groups are maximum measured surface soil concentrations, while maximum surface water and/or sediment concentrations are used as exposure point concentrations for aquatic receptor groups. Maximum surface soil and sediment concentrations are also used as exposure point concentrations for incidental ingestion by upper trophic level terrestrial receptors and aquatic (estuarine wetland and open water) receptors, respectively.

Exposure point concentrations for upper trophic level terrestrial and aquatic dietary items will be estimated using BAF/BCF models and maximum measured media concentrations. The methodology and models used to derive these estimates are described below. 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. In the absence of tissue data for aquatic life, BCF values for organic chemicals can be estimated from their Log K_{ow} value. BCF values do not account for the uptake of chemicals from dietary exposures. BAF values consider both direct exposures to the surrounding media, as well as uptake from dietary exposures.

Terrestrial Plants. Tissue concentrations in the aboveground vegetative portion of terrestrial plants are 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 are 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 are 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 (1998a). For organic chemicals without literature based BCFs, soil-to-plant BCFs are estimated using the algorithm provided in Travis and Arms (1988):

$$\log B_v = 1.588 - (0.578) (\log K_{ow}) \quad (\text{Equation 6-1})$$

where:

- B_v = Soil-to-plant BCF (unitless; dry weight basis)
 K_{ow} = Octanol-water partitioning coefficient (unitless)

The log K_{ow} values used in the calculations were obtained primarily from EPA (1995a and 1996b) and are listed in Table 4-2. The soil-to-plant BCFs are summarized in Table 6-1.

Earthworms. Tissue concentrations in soil invertebrates (earthworms) are 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, 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 are 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) are given preference over undepurated analyses when selecting BAF values since direct ingestion of soil is accounted for separately in the food web model. BAFs for earthworms are those reported in Sample et al. 1998a.

The BCF/BAF values 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 are converted to a dry-weight basis by dividing the wet-weight BCF/BAF by the estimated solids content for earthworms (16 percent [0.16]; EPA 1993b). For inorganic chemicals without available measured BAFs or BCFs, an earthworm BAF of 1.0 is assumed. The soil-to-earthworm BCFs/BAFs are summarized in Table 6-1.

Small Mammals. Whole-body tissue concentrations in small mammals (omnivores) are estimated using one of two methodologies. For chemicals with literature-based soil-to-small mammal BAFs, the small mammal tissue concentration is 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 are converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for small mammals (32 percent [0.32]; EPA 1993b). BAFs for omnivores are those reported in Sample et al. (1998b) for omnivores (or for general small mammals if omnivore values were unavailable). The soil-to-small mammal BAFs that will be used in the screening-level ERA risk calculations are summarized in Table 6-2.

For those chemicals without soil-to-small mammal BAF values, an alternate approach is used to estimate whole-body tissue concentrations. Because most chemical exposure for these small mammal species is via the diet, it is assumed that the concentration of each chemical in the 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 is assumed. Resulting tissue concentrations (wet-weight) are then 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 dichlorodiphenyltrichloroethane (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 (EPA 1990).

Aquatic Plants. Tissue concentrations in the vegetative portion of aquatic plants are estimated using the same methodologies as described above for terrestrial plants except that maximum sediment (not soil) concentrations will be used in the calculation.

Aquatic Invertebrates. Tissue concentrations in aquatic invertebrates are estimated by multiplying the maximum measured sediment concentration for each chemical by chemical-specific sediment-to-invertebrate BAFs obtained from the literature. The BAF values are based on the ratio between dry-weight sediment and dry-weight invertebrate tissue. BAFs based on depurated analyses (sediment was purged from the gut of the organism prior to analysis) are

given preference over undepurated analyses when selecting BAF values since direct ingestion of sediment is accounted for separately in the food web model.

Literature values based on the ratio between dry-weight sediment and wet-weight invertebrate tissue are converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for aquatic invertebrates (21 percent [0.21]; EPA 1993b). For chemicals without literature based sediment-to-invertebrate BAFs, a BAF of 1.0 is assumed. The sediment-to-invertebrate BAFs are summarized in Table 6-3.

Fish. The estimation of tissue concentrations in whole-body fish will take into consideration bioaccumulation from surface water, as well as bioaccumulation from sediment. For a given chemical, the contribution that surface water bioaccumulation has on whole-body fish tissue concentrations is estimated by multiplying the maximum measured surface water concentration for each chemical by chemical-specific surface water-to-fish BAFs obtained from the literature. In the absence of surface water-to-fish BAFs, the following equation is used to estimate whole body fish tissue concentrations:

$$C_{xf} = [(C_{sw})(BCF_{sw})(FCM)] \quad (\text{Equation 6-2})$$

where C_{xf} is the concentration of chemical x in whole-body fish (mg/kg), C_{sw} is the maximum surface water concentration (mg/L), BCF_{sw} is the surface water-to-fish BCF (L/kg), and FCM is the food chain multiplier (unitless). For most metals, BCFs and BAFs are assumed to be equal (EPA 1991b, EPA 1995b, and Sample et al 1996). In this instance, an FCM of 1.0 is used to convert the surface water-fish BCF to a surface water-to-fish BAF. In the case of mercury and selenium, an FCM may be applicable since their organometallic forms biomagnify (Sample et al 1996).

The contribution that sediment bioaccumulation has on whole-body fish tissue concentrations is estimated by multiplying the maximum measured sediment concentration for each chemical by chemical-specific sediment-to-fish BAFs obtained from the literature. The sediment-fish BAF values used are based on the ratio between dry-weight sediment and dry-weight fish tissue. Literature values based on the ratio between dry-weight sediment and wet-weight fish tissue are converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content

for fish (25 percent [0.25]; EPA 1993b). For chemicals without literature based sediment-to-fish BAFs, a BAF of 1.0 is assumed.

The contribution of surface water-fish bioaccumulation on whole-body fish tissue concentrations and the contribution of sediment-fish bioaccumulation on whole-body fish tissue concentrations are summed to derive a final whole-body fish tissue concentration:

$$C_{xf} = [(C_{sw})(BCF_{sw})(FCM) + (C_{sed})(BAF_{sed})] \quad (\text{Equation 6-3})$$

where C_{sed} is the maximum sediment concentration (mg/kg), BAF_{sed} is the sediment-to-fish BAF (unitless), and C_{xf} , C_{sw} , BCF_{sw} , and FCM are as previously described.

For a given bioaccumulative organic chemical, surface water-to-fish bioaccumulation is only considered if that chemical is detected in surface water. If an organic chemical evaluated for food chain exposures is not detected in surface water, the contribution that surface water bioaccumulation has on the tissue concentration in whole-body fish is considered to be negligible. In this instance, only sediment bioaccumulation is considered in the estimation of whole-body fish tissue concentrations. Furthermore, the surface water concentration used for metals in the estimation of surface water-to-fish bioaccumulation is based on the dissolved (filtered) concentration in the water column. Dissolved metals data are used in place of total recoverable data since the dissolved fraction more closely approximates the bioavailable fraction of metals in the water column (EPA 1995b and 2002). If a metal is not detected in the dissolved (filtered) fraction, the contribution that surface water bioaccumulation has on the whole-body fish tissue concentration of that metal is considered negligible.

The sediment-to-fish BAFs are summarized in Table 6-3, while surface water-fish BAFs are summarized in Table 6-4. The surface water-to-fish BAFs shown in Table 6-4 for mercury and selenium are based on organometallic (methylated) forms. It is noted that the BAFs summarized in Table 6-4 are limited to inorganic chemicals. BAFs for bioaccumulative organic chemicals detected in surface water collected from the estuarine wetland system and/or the Ensenada Honda will be estimated by multiplying BCFs derived by equation 4-1 with FCM values listed in the EPA document entitled Final Water Quality Guidance for the Great Lakes System (EPA 1995b).

6.3.2 Dietary Intakes

Dietary intakes for each upper trophic level receptor species will be calculated using the following formula (Equation 6-4) modified from EPA (1993b).

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

(Equation 6-4)

where:

DI _x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR	=	Food ingestion rate (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 basis)
SC _x	=	Maximum concentration of chemical x in soil/sediment (mg/kg, dry weight)
PDS	=	Proportion of diet composed of soil/sediment (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) are provided in Table 6-5, while dietary compositions are provided in Table 6-6. As previously discussed, receptor exposures via surface water ingestion are not included in the estimation of dietary intakes. As such, drinking water ingestion rates for upper trophic level receptor species are not included in Table 6-5.

Although not evaluated for food web exposures, Table 6-6 contains a dietary composition for a small mammal omnivore. As discussed in Section 6-3, the diet of the red-tailed hawk in this risk assessment (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). A dietary composition is necessary when estimating small mammal omnivore whole body tissue concentrations for those chemicals that lack a literature-based soil-to-small mammal BAF. An assumed diet of 49 percent terrestrial vegetation, 49 percent terrestrial invertebrates, and 2 percent soil has been selected as the diet for a small mammal omnivore.

For the screening-level ERA, an AUF of 1.0 is assumed (i.e., each receptor is assumed to spend 100 percent of its time within SWMUs 1 or 2). As such, receptor-specific home ranges are not considered in the estimation of dietary intakes.

6.3.3 Ingestion-Based Screening Values

Ingestion-based screening values for dietary exposures are derived for each avian receptor species and chemical evaluated for food web exposures. Toxicological information from the literature for wildlife species most closely related to the receptor species is used, where available, but is also supplemented by laboratory studies of non-wildlife species (e.g., laboratory mice) when necessary. The ingestion-based screening values are expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day).

Growth and reproduction are emphasized as assessment endpoints since they are the most relevant, ecologically, to maintaining viable populations and because they are generally the most studied chronic toxicological endpoints for ecological receptors. If several chronic toxicity studies were available from the literature, the most appropriate study is selected for each receptor species based on study design, study methodology, study duration, study endpoint, and test species. No Observed Adverse Effect Levels (NOAELs) based on growth and reproduction are utilized, where available, as the screening values. When chronic NOAEL values are unavailable, estimates are derived or extrapolated from chronic Lowest Observed Adverse Effect Levels (LOAELs) or acute values as follows:

- When values for chronic toxicity were not available, the median lethal dose (LD₅₀) is used. An uncertainty factor of 100 is used to convert the acute LD₅₀ to a chronic NOAEL (i.e., the LD₅₀ was multiplied by 0.01 to obtain the chronic NOAEL).
- An uncertainty factor of 10 is used to convert a reported LOAEL to a NOAEL (EPA 1997).

Ingestion screening values for birds and mammals (West Indian manatee) are summarized in Tables 6-7 and 6-8, respectively. It is noted that the ingestion-based screening values summarized in Tables 6-7 and 6-8 are based on toxicological studies with avian or mammalian species other than those selected as receptor species for this investigation. NOAEL and LOAEL

values will not be adjusted in the screening-level risk calculations to reflect differences in body weights between test species and receptor species.

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TABLES

TABLE 2-1

**LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL SITE)
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 2-1 (Continued)

**LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS
SWMU 45 – AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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 3-1

**SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 1- ARMY CREMATOR DISPOSAL SITE
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Investigation	Sample Media	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
Confirmation Study *	Groundwater Round 01	5GW1	NA	3/6/86	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5GW2	NA	3/6/86	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5GW3	NA	3/6/86	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5GW4	NA	3/6/86	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5GW5	NA	3/12/86	VOCs, SVOCs, Pesticides/PCBs, Inorganics
	Surface Water Round 01	5SW1	NA	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium
		5SW2	NA	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium
		5SW3	NA	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium
		5SW4	NA	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium
		5SW5	NA	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium
		14SW9	NA	11/22/85	VOCs, Lead, Oil & Grease
	Sediment Round 01	5SE1	Unknown	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5SE2	Unknown	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5SE3	Unknown	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5SE4	Unknown	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5SE5	Unknown	11/28/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		14SE9	Unknown	11/22/85	VOCs, Lead, Oil & Grease
	Groundwater Round 02	5GW01	NA	10/12/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5GW02	NA	10/12/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5GW03	NA	10/13/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5GW04	NA	10/13/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		5GW05	NA	10/12/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
	Surface Water Round 02	5SW01	NA	10/7/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium
		5SW02	NA	10/6/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium
		5SW03	NA	10/6/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium
5SW04		NA	10/6/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium	
5SW05		NA	10/6/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium	
Sediment Round 02	5SE01	Unknown	10/7/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium	
	5SE02	Unknown	10/6/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium	
	5SE03	Unknown	10/6/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium	
	5SE04	Unknown	10/6/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium	
	5SE05	Unknown	10/6/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics, Chromium	

Notes: NA - Not Applicable
* - Pre-RFI Investigation

TABLE 3-1 (continued)

**SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 1- ARMY CREMATOR DISPOSAL SITE
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Investigation	Sample Media	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
Supplemental Investigation*	Groundwater	05GW101	NA	12/1/92	SVOCs, Pesticides/PCBs, Inorganics
	Surface Soil	05SS126	0.5-1.5	11/15/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS128	0.5-1.5	11/15/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS130	0.5-1.5	11/15/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS132	0.5-1.5	11/16/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS135	0.5-1.5	11/16/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS138	0.5-1.5	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
	Subsurface Soil	05SS127	1.5-2.67	11/15/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS129	1.5-2.67	11/15/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS131	1.5-2.67	11/15/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS133	1.5-2.67	11/16/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS134	1.5-2.67	11/16/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS136	1.5-2.67	11/16/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS137	1.5-2.67	11/16/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		05SS139	1.5-2.67	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
05SS140C		1.5-2.67	11/17/92	Pesticides/PCBs, Inorganics	
05SS140D	1.5-2.67	11/17/92	Pesticides/PCBs, Inorganics		
05SS140E	1.5-2.67	11/17/92	Pesticides/PCBs, Inorganics		
Relative Risk Ranking *	Sediment	1SD01	0.0-1.0	Oct. 1995	Appendix IX List, Sulfide
		1SD02	0.0-1.0	Oct. 1995	Appendix IX List, Sulfide
		1SD03	0.0-1.0	Oct. 1995	Appendix IX List, Sulfide

Notes: Appendix IX List consists of Appendix IX VOCs, SVOCs, Pesticides/PCBs, Dioxins, Chlorinated Herbicides, and Inorganics.

NA - Not Applicable

* - Pre-RFI Investigation

TABLE 3-1 (continued)

**SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 1- ARMY CREMATOR DISPOSAL SITE
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Investigation	Sample Media	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
RFI Investigation	Surface Soil	1SS01	0.0-1.0	10/3/96	Appendix IX List, Explosives, Asbestos
		1SS02	0.0-1.0	10/11/96	Appendix IX List, Explosives, Asbestos
		1SS02D	0.0-1.0	10/11/96	Appendix IX List, Explosives, Asbestos
		1SS03	0.0-1.0	10/10/96	Appendix IX List, Explosives, Asbestos
		1SS04	0.0-1.0	10/10/96	Appendix IX List, Explosives, Asbestos
		1SS05	0.0-1.0	10/11/96	Appendix IX List, Explosives, Asbestos
		1SS06	0.0-1.0	10/11/96	Appendix IX List, Explosives, Asbestos
		1SS07	0.0-1.0	10/13/96	Appendix IX List, Explosives, Asbestos
		1SS08	0.0-1.0	10/22/96	Appendix IX List, Explosives, Asbestos
		1SB01-00	0.0-1.0	10/13/96	Appendix IX List, Explosives, Asbestos
		1SB02-00	0.0-1.0	10/13/96	Appendix IX List, Explosives, Asbestos
		1SB03-00	0.0-1.0	10/11/96	Appendix IX List, Explosives, Asbestos
		1MW01-00	0.0-1.0	10/29/96	Appendix IX List, Explosives, Asbestos
		1MW02-00	0.0-1.0	10/11/96	Appendix IX List, Explosives, Asbestos
		1MW03-00	0.0-1.0	10/11/96	Appendix IX List, Explosives, Asbestos
	1MW04-00	0.0-1.0	10/13/96	Appendix IX List, Explosives, Asbestos	
	Sediment	1SD01	0.0-1.0	10/22/96	Appendix IX List, Explosives, Asbestos, TOC
		1SD02	0.0-1.0	10/22/96	Appendix IX List, Explosives, Asbestos, TOC
		1SD03	0.0-1.0	11/10/96	Appendix IX List, Explosives, Asbestos, TOC
	Subsurface Soil	1SB01-02/05	4.0-12.0	10/25/96	Appendix IX List, Explosives, Asbestos
		1SB02-03/04	6.0-10.0	10/26/96	Appendix IX List, Explosives, Asbestos
		1SB02-10/11/12	20.0-24.0	10/26/96	Appendix IX List, Explosives, Asbestos
		1SB03-03	6.0-8.0	10/24/96	Appendix IX List, Explosives, Asbestos
		1SB03-06	12.0-14.0	10/24/96	Appendix IX List, Explosives, Asbestos
		1MW01-02	4.0-6.0	10/29/96	Appendix IX List, Explosives, Asbestos
		1MW01-02D	4.0-6.0	10/29/96	Appendix IX List, Explosives, Asbestos
		1MW02-03	6.0-8.0	10/28/96	Appendix IX List, Explosives, Asbestos
		1MW02-03D	6.0-8.0	10/28/96	Appendix IX List, Explosives, Asbestos
		1MW02-11/12	22.0-26.0	10/28/96	Appendix IX List, Explosives, Asbestos
		1MW03-03	6.0-8.0	10/22/96	Appendix IX List, Explosives, Asbestos
		1MW03-05	10.0-12.0	10/22/96	Appendix IX List, Explosives, Asbestos
		1MW04-02	4.0-6.0	10/15/96	Appendix IX List, Explosives, Asbestos
		1MW04-04	8.0-10.0	10/15/96	Appendix IX List, Explosives, Asbestos
		5MW03R-03	5.0-7.0	9/18/97	Appendix IX List, Explosives, Asbestos
		5MW03R-05	10.0-12.0	9/18/97	Appendix IX List, Explosives, Asbestos
1MW05-01		1.0-3.0	9/18/97	Appendix IX List, Explosives, Asbestos	
1MW05-05	10.0-12.0	9/18/97	Appendix IX List, Explosives, Asbestos		

Notes: Appendix IX List consists of Appendix IX VOCs, SVOCs, Pesticides/PCBs, Dioxins, Chlorinated Herbicides, and Inorganics.

TABLE 3-1 (continued)

**SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 1- ARMY CREMATOR DISPOSAL SITE
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Investigation	Sample Media	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
RFI Investigation (cont.)	Groundwater	1MW01	NA	11/5/96	Appendix IX List, Explosives, Asbestos, Sodium
		1MW01D	NA	11/5/96	Appendix IX List, Explosives, Asbestos, Sodium
		1MW02	NA	11/5/96	Appendix IX List, Explosives, Asbestos, Sodium
		1MW03	NA	11/5/96	Appendix IX List, Explosives, Asbestos, Sodium
		1MW04	NA	11/5/96	Appendix IX List, Explosives, Asbestos, Sodium
		5GW01	NA	11/6/96	Appendix IX List, Explosives, Asbestos, Sodium
		5GW02	NA	11/5/96	Appendix IX List, Explosives, Asbestos, Sodium
		5GW04	NA	11/5/96	Appendix IX List, Explosives, Asbestos, Sodium
		5GW03R	NA	10/1/97	Appendix IX List, Explosives, Asbestos, Sodium
		1GW05	NA	10/1/97	Appendix IX List, Explosives, Asbestos, Sodium

Notes: Appendix IX List consists of Appendix IX VOCs, SVOCs, Pesticides/PCBs, Dioxins, Chlorinated Herbicides, and Inorganics.
NA - Not Applicable

TABLE 3-2

**SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 2 - LANGLEY DRIVE DISPOSAL SITE
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Investigation	Sample Media	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
Confirmation Study *	Surface Soil Round 01	R6S1A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S2A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S3A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S4A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S5A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S6A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S7A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S8A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S9A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S10A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics, EP TOX Lead
		R6S11A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S12A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S13A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S14A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6S15A	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
	Surface Water Round 01	R6SW1	NA	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6SW2	NA	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6SW3	NA	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		14SW10	NA	11/22/85	VOCs, Lead, Oil & Grease
	Sediment	R6SE1	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6SE2	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6SE3	0.0-1.0	12/5/85	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		14SE10	Unknown	11/22/85	VOCs, Lead, Oil & Grease
	Groundwater Round 02	R6GW01	NA	11/2/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
	Surface Soil Round 02	R6S04A	0.0-1.0	11/4/87	Lead
		R6S05A	0.0-1.0	11/4/87	Lead
		R6S09A	0.0-1.0	11/4/87	Lead, EP TOX Lead
		R6S10A	0.0-1.0	11/4/87	Lead
		R6S11A	0.0-1.0	11/4/87	Lead, EP TOX Lead
		R6S12A	0.0-1.0	11/4/87	Lead, EP TOX Lead
		R6S14A	0.0-1.0	11/4/87	Lead
		R6S15A	0.0-1.0	11/4/87	Lead
R6S16A		0.0-1.0	11/4/87	Lead	
R6S17A		0.0-1.0	11/4/87	Lead	
R6S18A		0.0-1.0	11/4/87	Lead	
R6S19A		0.0-1.0	11/4/87	Lead	
R6S20A	0.0-1.0	11/4/87	Lead		

Notes: NA - Not Applicable
* - Pre-RFI Investigation

TABLE 3-2 (continued)

**SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 2 - LANGLEY DRIVE DISPOSAL SITE
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Investigation	Sample Media	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
Confirmation Study * (cont.)	Subsurface Soil Round 02	R6S010B	1.0-2.0	11/4/87	Lead
		R6S010C	2.0-3.0	11/4/87	Lead
	Surface Water Round 2	R6SW01	NA	10/7/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6SW02	NA	10/7/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6SW03	NA	10/7/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
	Sediment Round 2	R6SE01	0.0-1.0	10/7/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6SE02	0.0-1.0	10/7/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		R6SE03	0.0-1.0	10/7/87	VOCs, SVOCs, Pesticides/PCBs, Inorganics
	Supplemental Investigation*	Groundwater	06GW101	NA	11/18/92
Surface Soil		06SS141	0.5-1.5	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS143	0.5-1.5	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS145	0.0-0.5	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS147	0.5-1.5	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS150	0.5-1.5	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS153	0.5-1.5	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
Subsurface Soil		06SS155D	0.5-1.67	11/17/92	Pesticides/PCBs, Inorganics
		06SS142	1.5-2.67	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS146	0.5-1.5	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS148	1.5-2.67	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS149	1.5-2.67	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS151	2.0-3.0	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics
		06SS152	2.0-3.0	11/17/92	Pesticides/PCBs
	06SS154	1.5-2.67	11/17/92	VOCs, SVOCs, Pesticides/PCBs, Inorganics	
Relative Risk Ranking *	Sediment	2SD01	0.0-1.0	Oct.1995	Appendix IX List, Sulfide
		2SD02	0.0-1.0	Oct.1995	Appendix IX List, Sulfide
		2SD03	0.0-1.0	Oct.1995	Appendix IX List, Sulfide
		2SD03D	0.0-1.0	Oct.1995	Appendix IX List, Sulfide

Notes: NA - Not Applicable
* - Pre-RFI Investigation

TABLE 3-2 (continued)

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
 SWMU 2 - LANGLEY DRIVE DISPOSAL SITE
 NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Investigation	Sample Media	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
RFI Investigation	Surface Soil	2SB01-00	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos
		2SB02-00	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos
		2SB02-00D	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos
		2SB03-00	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos
		2SB04-00	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos
		2SB05-00	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos
		2MW01-00	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos
		2MW02-00	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos
	2MW03-00	0.0-1.0	10/8/96	Appendix IX List, Explosives, Asbestos	
	Sediment	2SD01	0.0-1.0	11/11/96	Appendix IX List, Explosives, Asbestos, TOC
		2SD02	0.0-1.0	11/11/96	Appendix IX List, Explosives, Asbestos, TOC
		2SD03	0.0-1.0	11/11/96	Appendix IX List, Explosives, Asbestos, TOC
	Subsurface Soil	2SB01-02	4.0-6.0	11/18/96	Appendix IX List, Explosives, Asbestos
		2SB01-05	10.0-12.0	11/18/96	Appendix IX List, Explosives, Asbestos
		2SB04-02	4.0-6.0	11/10/96	Appendix IX List, Explosives, Asbestos
		2SB05-01/02	2.0-6.0	11/10/96	Appendix IX List, Explosives, Asbestos
		2SB05-01/02D	2.0-6.0	11/10/96	Appendix IX List, Explosives, Asbestos
		2MW01-01	2.0-4.0	11/8/96	Appendix IX List, Explosives, Asbestos
		2MW02-02	4.0-6.0	11/6/96	Appendix IX List, Explosives, Asbestos
		2MW02-05	10.0-12.0	11/6/96	Appendix IX List, Explosives, Asbestos
		2MW03-01	2.0-4.0	11/9/96	Appendix IX List, Explosives, Asbestos
		2MW03-01D	2.0-4.0	11/9/96	Appendix IX List, Explosives, Asbestos
	Groundwater	2MW01	NA	11/12/96	Appendix IX List, Explosives, Asbestos, Sodium
		2MW02	NA	11/12/96	Appendix IX List, Explosives, Asbestos, Sodium
		2MW03	NA	11/12/96	Appendix IX List, Explosives, Asbestos, Sodium
		6GW01	NA	11/12/96	Appendix IX List, Explosives, Asbestos, Sodium, TOC, COD, TSS

Notes: Appendix IX List consists of Appendix IX VOCs, SVOCs, Pesticides/PCBs, Dioxins, Chlorinated Herbicides, and Inorganics.
 TOC: Total Organic Carbon
 COD: Chemical Oxygen Demand
 TSS: Total Suspended Solids

TABLE 4-1
PRELIMINARY ASSESSMENT ENDPOINTS, RISK HYPOTHESES, AND MEASUREMENT ENDPOINTS
SWMU 1 (ARMY CREAMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Terrestrial Habitat: Survival, growth, and reproduction of terrestrial soil invertebrate communities.	Are site-related chemical concentrations in surface soil sufficient to adversely effect terrestrial 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 surface soil concentrations sufficient to adversely effect terrestrial 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 No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface soil.
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 soil invertebrates from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface soil.
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 No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface soil.
Aquatic Habitat: Survival, growth, and reproduction of benthic invertebrate communities.	Are site-related chemical concentrations in surface water/sediment sufficient to adversely effect benthic invertebrate communities?	Comparison of maximum chemical concentrations in surface water and sediment with surface water and sediment screening values, respectively.

TABLE 4-1 (continued)
PRELIMINARY ASSESSMENT ENDPOINTS, RISK HYPOTHESES, AND MEASUREMENT ENDPOINTS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Aquatic habitat (continued): Survival, growth, and reproduction of aquatic plant communities (i.e., algae)	Are site-related chemical concentrations in surface water sufficient to adversely effect aquatic plant communities?	Comparison of maximum chemical concentrations in surface water with surface water screening values.
Survival, growth, and reproduction of fish communities.	Are site-related chemical concentrations in surface water sufficient to adversely effect fish communities?	Comparison of maximum chemical concentrations in surface water with surface water screening values.
Survival, growth, and reproduction of avian carnivore communities (benthic invertebrate consumers).	Are site-related chemical concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume benthic invertebrates from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in sediment.
Survival, growth, and reproduction of avian piscivores/carnivorous omnivores (fish and benthic invertebrate consumers).	Are site-related chemical concentrations in surface water and sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume fish and benthic invertebrates from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface water and sediment.
Survival, growth, and reproduction of avian piscivores (fish consumers).	Are site-related chemical concentrations in surface water and sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume fish from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface water and sediment.
Survival, growth, and reproduction of mammalian herbivores (Order Sirenia).	Are site-related chemical concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to mammalian herbivores that may consume aquatic plants from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in sediment.

TABLE 4-2
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K _{ow} Range	Recommended Log K _{ow}	Reference	K _{oc} ⁽¹⁾ (L/Kg)	Bioaccumulative Chemical ⁽²⁾
Volatile Organics:					
1,1,1,2-Tetrachloroethane	2.63 to 3.03	2.63	EPA 1995a	385	Yes
1,1,1-Trichloroethane	2.47 to 2.51	2.48	EPA 1995a	274	No
1,1,2,2-Tetrachloroethane	2.31 to 2.64	2.39	EPA 1995a	224	No
1,1,2-Trichloroethane	2.03 to 2.07	2.05	EPA 1995a	104	No
1,1-Dichloroethane	1.78 to 1.85	1.79	EPA 1995a	57.5	No
1,1-Dichloroethene	2.13 to 2.37	2.13	EPA 1995a	124	No
1,1-Dichloropropene	Not Reported	2.53	SRC 1998	307	No
1,2,3-Trichloropropane	1.98 to 2.63	2.25	EPA 1995a	163	No
1,2-Dibromo-3-chloropropane	2.26 to 2.41	2.34	EPA 1995a	200	No
1,2-Dibromoethane	Not Reported	2.00	EPA 1996b	92.5	No
1,2-Dichloroethane	1.4 to 1.48	1.47	EPA 1995a	27.9	No
1,2-Dichloropropane	1.94 to 1.99	1.97	EPA 1995a	86.5	No
1,3-Dichloropropane	Not Reported	2.00	SRC 1998	92.5	No
2,2-Dichloropropane	Not Reported	2.92	SRC 1998	742	No
2-Butanone	0.28 to 0.69	0.28	EPA 1995a	1.89	No
2-Hexanone	Not Reported	1.38	EPA 1996b	22.7	No
2-Chloro-1,3-butadiene	2.03 to 2.13	2.08	EPA 1995a	111	No
3-Chloropropene	Not Reported	1.93	SRC 1998	79.0	No
Acetone	-0.21 to -0.24	-0.24	EPA 1995a	0.58	No
Acetonitrile	-0.34 to -0.39	-0.34	EPA 1995a	0.46	No
Acrolein	-0.01 to 0.90	-0.01	EPA 1995a	0.98	No
Acrylonitrile	-0.92 to 1.20	0.25	EPA 1995a	1.76	No
Benzene	1.83 to 2.50	2.13	EPA 1995a	124	No
Bromodichloromethane	1.88 to 2.14	2.10	EPA 1995a	116	No
Bromoform	2.30 to 2.38	2.35	EPA 1995a	204	No
Bromomethane	Not Reported	1.19	EPA 1996b	14.8	No
Carbon Disulfide	1.84 to 2.16	2.00	EPA 1995a	92.5	No
Carbon Tetrachloride	2.03 to 3.10	2.73	EPA 1995a	483	Yes
Chlorobenzene	2.56 to 3.79	2.86	EPA 1995a	648	Yes
Chloroethane	Not Reported	1.43	EPA 1996b	25.5	No
Chloroform	1.81 to 3.04	1.92	EPA 1995a	77.2	Yes
Chloromethane	Not Reported	0.91	EPA 1996b	7.85	No
cis-1,3-Dichloropropene	Not Reported	2.06	SRC 1998	106	No
cis-1,2-Dichloroethene	1.77 to 2.10	1.86	EPA 1995a	67.4	No
Dibromochloromethane	2.13 to 2.24	2.17	EPA 1995a	136	No
Dibromomethane	Not Reported	1.53	EPA 1996b	31.9	No
Dichlorodifluoromethane	2.0 to 2.37	2.16	EPA 1995a	133	No
Ethylbenzene	3.07 to 3.57	3.14	EPA 1995a	1,222	Yes
Ethyl methacrylate	1.59 to 1.65	1.59	EPA 1996b	36.6	No
Iodomethane	Not Reported	1.51	SRC 1998	30.5	No
Isobutanol (Isobutyl alcohol)	0.65 to 0.76	0.75	EPA 1995a	5.5	No
Methacrylonitrile	0.54 to 0.70	-0.54	EPA 1996b	0.29	No
Methylene Chloride	1.22 to 1.40	1.25	EPA 1995a	16.9	No
Methyl methacrylate	1.11 to 1.38	1.38	EPA 1995a	22.7	No
n-Butylbenzene	Not Reported	4.38	SRC 1998	20,222	Yes
n-Propylbenzene	Not Reported	3.69	SRC 1998	4,242	Yes
Pentachloroethane	Not Reported	3.06	EPA 1996b	1,019	Yes
Styrene	2.76 to 3.16	2.94	EPA 1995a	777	Yes

TABLE 4-2 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K _{ow} Range	Recommended Log K _{ow}	Reference	K _{oc} ⁽¹⁾ (L/Kg)	Bioaccumulative Chemical ⁽²⁾
Volatile Organics (cont.):					
Tetrachloroethene	2.53 to 2.98	2.67	EPA 1995a	422	No
Toluene	2.21 to 3.13	2.75	EPA 1995a	505	Yes
trans-1,3-Dichloropropene	Not Reported	2.03	SRC 1998	99.0	No
trans-1,4-Dichloro-2-butene	Not Reported	2.60	SRC 1998	360	No
trans-1,2-Dichloroethene	1.77 to 2.10	2.07	EPA 1995a	108	No
Trichloroethene	2.42 to 3.14	2.71	EPA 1995a	462	Yes
Trichlorofluoromethane	2.44 to 2.58	2.53	EPA 1995a	307	No
Vinyl Acetate	0.21 to 0.83	0.73	EPA 1995a	5.22	No
Vinyl Chloride	1.23 to 1.52	1.50	EPA 1995a	29.8	No
o-Xylene	2.77 to 3.54	3.13	EPA 1995a	1,194	Yes
m-Xylene	3.11 to 3.68	3.20	EPA 1995a	1,399	Yes
p-Xylene	3.13 to 3.65	3.17	EPA 1995a	1,307	Yes
Semi-Volatile Organics:					
1,2,4,5-Tetrachlorobenzene	4.51 to 4.83	4.64	EPA 1995a	36,425	Yes
1,2,4-Trichlorobenzene	3.89 to 4.23	4.01	EPA 1995a	8,752	Yes
1,2-Dichlorobenzene	3.20 to 3.61	3.43	EPA 1995a	2,355	Yes
1,2-Diphenylhydrazine	Not Reported	2.94	EPA 1996b	777	No
1,3,5-Trinitrobenzene	1.18 to 1.37	1.18	EPA 1995a	14.5	No
1,3-Dichlorobenzene	Not Reported	3.60	EPA 1996b	3,460	Yes
1,3-Dinitrobenzene	1.49 to 1.63	1.50	EPA 1995a	29.8	No
1,4-Dichlorobenzene	3.26 to 3.78	3.42	EPA 1995a	2,302	Yes
1,4-Dioxane	Not Reported	-0.27	EPA 1996b	0.54	No
1,4-Naphthoquinone	Not Reported	1.71	SRC 1998	48.0	No
1-Naphthylamine	2.09 to 2.40	2.24	EPA 1995a	159	No
2,2'-Oxybis(1-Chloropropane)	Not Reported	2.48	EPA 1996b	274	No
2,3,4,6-Tetrachlorophenol	Not Reported	4.45	EPA 1996b	23,694	Yes
2,4,5-Trichlorophenol	Not Reported	3.72	EPA 1996b	4,540	Yes
2,4,6-Trichlorophenol	3.29 to 4.05	3.70	EPA 1995a	4,339	Yes
2,4-Dichlorophenol	2.80 to 3.30	3.08	EPA 1995a	1,066	Yes
2,4-Dimethylphenol	1.99 to 2.49	2.36	EPA 1995a	209	No
2,4-Dinitrophenol	1.40 to 1.79	1.55	EPA 1995a	33.4	No
2,6-Dichlorophenol	Not Reported	2.75	SRC 1998	505	No
2-Acetylaminofluorene	Not Reported	3.12	SRC 1998	1,167	Yes
2-Chloronaphthalene	Not Reported	3.38	EPA 1996b	2,103	Yes
2-Chlorophenol	0.83 to 2.32	2.15	EPA 1995a	130	No
2-Methylnaphthalene	Not Reported	3.90	EPA 1996b	6,823	Yes
2-Methylphenol (o-cresol)	1.90 to 2.04	1.99	EPA 1995a	90.5	No
2-Naphthylamine	2.09 to 2.42	2.28	EPA 1995a	174	No
2-Nitroaniline	Not Reported	1.85	EPA 1996b	65.9	No
2-Nitrophenol	Not Reported	1.79	EPA 1996b	57.5	No
2-Picoline	Not Reported	1.11	SRC 1998	12.3	No
2-sec-butyl-4,6-Dinitrophenol	Not Reported	3.69	EPA 1996b	4,242	Yes
3,3'-Dichlorobenzidine	3.51 to 3.95	3.51	EPA 1995a	2,822	Yes
3,3'-Dimethylbenzidine	2.34 to 3.01	2.68	EPA 1995a	431	Yes
3-Methylcholanthrene	6.42 to 6.76	6.42	EPA 1995a	2,047,104	Yes
3-Methylphenol (m-cresol)	1.92 to 2.05	1.97	EPA 1995a	86.5	No
3-Nitroaniline	Not Reported	1.37	EPA 1996b	22.2	No
4,6-Dinitro-2-methylphenol	Not Reported	2.12	EPA 1996b	121	No

TABLE 4-2 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K _{ow} Range	Recommended Log K _{ow}	Reference	K _{oc} ⁽¹⁾ (L/Kg)	Bioaccumulative Chemical ⁽²⁾
Semi-Volatile Organics (continued)					
4-Aminobiphenyl	Not Reported	2.86	SRC 1998	648	No
4-Bromophenyl phenyl ether	4.89 to 5.24	5.00	EPA 1995a	82,277	Yes
4-Chloro-3-methylphenol	Not Reported	3.10	SRC 1998	1,116	Yes
4-Chloroaniline	1.57 to 2.02	1.85	EPA 1995a	65.9	No
4-Chlorophenyl-Phenylether	4.08 to 5.09	4.95	EPA 1995a	73,473	Yes
4-Methyl-2-pentanone	Not Reported	1.31	SRC 1998	19.4	No
4-Methylphenol (p-cresol)	1.38 to 2.04	1.95	EPA 1995a	82.6	No
4-Nitroaniline	Not Reported	1.39	EPA 1996b	23.3	No
4-Nitrophenol	Not Reported	1.91	SRC 1998	75.5	No
4-Nitroquinoline-1-oxide	Not Reported	1.09	SRC 1998	11.8	No
5-Nitro-o-toluidine	Not Reported	1.87	SRC 1998	68.9	No
7,12-Dimethylbenz(a)anthracene	5.98 to 6.66	6.62	EPA 1995a	3,219,141	Yes
Acenaphthene	3.77 to 4.49	3.92	EPA 1995a	7,139	Yes
Acenaphthylene	Not Reported	4.10	EPA 1996b	10,730	Yes
Acetophenone	1.55 to 1.72	1.64	EPA 1995a	41.0	No
A, A-Dimethylphenethylamine	Not Reported	1.90	EPA 1996b	73.8	No
Aniline	0.78 to 1.24	0.98	EPA 1995a	9.20	No
Anthracene	3.45 to 4.80	4.55	EPA 1995a	29,712	Yes
Aramite	Not Reported	4.82	SRC 1998	54,744	Yes
Benzidine	1.34 to 1.70	1.66	EPA 1995a	42.9	No
Benzo(a)anthracene	4.00 to 5.79	5.70	EPA 1995a	401,218	Yes
Benzo(a)pyrene	5.98 to 6.42	6.11	EPA 1995a	1,014,869	Yes
Benzo(b)fluoranthene	5.79 to 6.40	6.20	EPA 1995a	1,244,171	Yes
Benzo(g,h,i)perylene	6.63 to 7.05	6.70	EPA 1995a	3,858,158	Yes
Benzo(k)fluoranthene	6.12 to 6.27	6.20	EPA 1995a	1,244,171	Yes
Benzoic Acid	1.33 to 2.03	1.86	EPA 1995a	67.4	No
Benzyl Alcohol	0.87 to 1.22	1.11	EPA 1995a	12.3	No
Bis(2-chloroethoxy)methane	Not Reported	0.75	EPA 1996b	5.46	No
Bis(2-chloroethyl)ether	1.0 to 1.29	1.21	EPA 1995	15.5	No
Bis(2-ethylhexyl)phthalate	4.20 to 8.61	7.30	EPA 1995a	15,003,065	Yes
Butylbenzylphthalate	3.57 to 5.02	4.84	EPA 1995a	57,280	Yes
Carbazole	3.01 to 3.76	3.59	EPA 1995a	3,383	Yes
Chlorobenzilate	3.86 to 4.40	4.38	EPA 1995a	20,222	Yes
Chrysene	5.41 to 5.79	5.70	EPA 1995a	401,218	Yes
Diallate	3.79 to 5.23	4.49	EPA 1995a	25,939	Yes
Dibenzo(a,h)anthracene	6.50 to 6.88	6.69	EPA 1995a	3,771,812	Yes
Dibenzofuran	Not Reported	4.20	EPA 1996b	13,455	Yes
Diethylphthalate	1.40 to 3.00	2.50	EPA 1995a	287	Yes
Dimethylphthalate	1.34 to 1.90	1.57	EPA 1995a	35.0	No
Di-n-butylphthalate	3.74 to 4.79	4.61	EPA 1995a	34,034	Yes
Di-n-octylphthalate	8.03 to 9.49	8.06	EPA 1995a	83,803,084	Yes
Diphenylamine	2.37 to 3.72	3.48	EPA 1995a	2,637	Yes
Ethyl methanesulfonate	0.01 to 0.05	0.05	EPA 1995a	1.12	No
Fluoranthene	4.31 to 5.39	5.12	EPA 1995a	107,954	Yes
Fluorene	4.04 to 4.40	4.21	EPA 1995a	13,763	Yes
Hexachlorobenzene	5.00 to 7.42	5.89	EPA 1995a	616,808	Yes
Hexachlorobutadiene	4.74 to 5.16	4.81	EPA 1995a	53,519	Yes

TABLE 4-2 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K _{ow} Range	Recommended Log K _{ow}	Reference	K _{oc} ⁽¹⁾ (L/Kg)	Bioaccumulative Chemical ⁽²⁾
Semi-Volatile Organics (continued)					
Hexachlorocyclopentadiene	5.04 to 5.51	5.39	EPA 1995a	198,907	Yes
Hexachloroethane	3.82 to 4.14	4.00	EPA 1995a	8,556	Yes
Hexachlorophene	7.08 to 7.60	7.54	EPA 1995a	25,828,548	Yes
Hexachloropropene	Not Reported	4.38	SRC 1998	20,222	Yes
Indeno(1,2,3-cd)pyrene	6.58 to 6.72	6.65	EPA 1995a	3,445,323	Yes
Isophorone	1.67 to 1.90	1.70	EPA 1995a	46.9	No
Isosafrole	Not Reported	3.37	SRC 1998	2,056	Yes
Methapyrilene	Not Reported	2.87	SRC 1998	663	No
Methyl methanesulfonate	Not Reported	-0.66	SRC 1998	0.22	No
Naphthalene	3.01 to 4.70	3.36	EPA 1995a	2,010	Yes
n-Nitrosodiethylamine	0.29 to 0.56	0.48	EPA 1995a	2.97	No
n-Nitrosodimethylamine	-0.77 to -0.48	-0.57	EPA 1995a	0.28	No
n-Nitroso-di-n-butylamine	2.41 to 2.45	2.41	EPA 1995a	234	No
n-Nitroso-di-n-propylamine	1.31 to 1.45	1.40	EPA 1995a	23.8	No
n-Nitrosodiphenylamine	3.13 to 3.45	3.16	EPA 1995a	1,278	Yes
n-Nitrosomethylethylamine	-0.24 to 1.35	-0.12	EPA 1995a	0.76	No
n-Nitrosomorpholine	Not Reported	-0.44	SRC 1998	0.37	No
n-Nitrosopiperidine	0.25 to 0.63	0.63	EPA 1995a	4.16	No
n-Nitrosopyrrolidine	-0.29 to -0.19	-0.19	EPA 1995a	0.65	No
o-Toluidine	1.34 to 1.63	1.34	EPA 1995a	20.8	No
p-Dimethylaminoazobenzene	Not Reported	4.58	SRC 1998	31,799	Yes
Pentachlorobenzene	4.88 to 6.12	5.26	EPA 1995a	148,204	Yes
Pentachloronitrobenzene	4.18 to 4.64	4.64	EPA 1995a	36,425	Yes
Pentachlorophenol	3.29 to 5.24	5.09	EPA 1995a	100,867	Yes
Phenacetin	Not Reported	1.58	SRC 1998	35.8	No
Phenanthrene	4.28 to 4.57	4.55	EPA 1995a	29,712	Yes
Phenol	0.79 to 1.55	1.48	EPA 1995a	28.5	No
p-Phenylenediamine	Not Reported	-0.30	SRC 1998	0.51	No
Pronamide	3.26 to 3.86	3.51	EPA 1995a	2,822	Yes
Pryridine	0.62 to 1.28	0.67	EPA 1995a	4.56	No
Pyrene	4.76 to 5.52	5.11	EPA 1995a	105,538	Yes
Safrole	2.66 to 2.88	2.66	EPA 1995a	412	No
PCBs:					
Aroclor-1016	Not Reported	5.62	SRC 1998	334,765	Yes
Aroclor-1221	Not Reported	4.53	SRC 1998	28,397	Yes
Aroclor-1232	Not Reported	4.53	SRC 1998	28,397	Yes
Aroclor-1242	Not Reported	6.29	SRC 1998	1,525,281	Yes
Aroclor-1248	Not Reported	6.34	SRC 1998	1,708,048	Yes
Aroclor-1254	Not Reported	6.79	SRC 1998	4,729,879	Yes
Aroclor-1260	Not Reported	8.27	SRC 1998	134,800,033	Yes
Organochlorine Pesticides:					
4,4'-DDD	4.73 to 6.38	6.10	EPA 1995a	992,156	Yes
4,4'-DDE	5.63 to 6.94	6.76	EPA 1995a	4,419,366	Yes
4,4'-DDT	4.64 to 7.01	6.53	EPA 1995a	2,625,851	Yes
Aldrin	5.11 to 7.50	6.50	EPA 1995a	2,453,466	Yes
alpha-chlordane	5.80 to 6.41	6.32	EPA 1995a	1,632,450	Yes
gamma-chlordane	5.80 to 6.41	6.32	EPA 1995a	1,632,450	Yes

TABLE 4-2 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K _{ow} Range	Recommended Log K _{ow}	Reference	K _{oc} ⁽¹⁾ (L/Kg)	Bioaccumulative Chemical ⁽²⁾
Dieldrin	Not Reported	5.40	SRC 1998	203,460	Yes
Endosulfan I	Not Reported	4.10	EPA 1996b	10,730	Yes
Endosulfan II	Not Reported	4.10	EPA 1996b	10,730	Yes
Endosulfan sulfate	Not Reported	3.66	EPA 1996b	3,963	Yes
Endrin	2.92 to 5.20	5.06	EPA 1995a	94,245	Yes
Endrin aldehyde	Not Reported	4.00	EPA 1995a	8,556	Yes
Heptachlor	4.93 to 6.26	6.26	EPA 1995a	1,425,148	Yes
Heptachlor epoxide	3.50 to 5.40	5.00	EPA 1995a	82,277	Yes
Kepone	4.45 to 5.30	5.30	EPA 1995a	162,248	Yes
Isodrin	Not Reported	6.75	SRC 1998	4,320,460	Yes
Methoxychlor	3.31 to 5.60	5.08	EPA 1995a	98,610	Yes
Toxaphene	3.23 to 5.56	5.50	EPA 1995a	255,141	Yes
alpha-BHC	3.75 to 3.81	3.80	EPA 1995a	5,441	Yes
beta-BHC	3.75 to 3.84	3.81	EPA 1995a	5,566	Yes
delta-BHC	Not Reported	4.14	EPA 1996b	11,746	Yes
gamma-BHC (lindane)	3.00 to 4.95	3.73	EPA 1995a	4,644	Yes
Organophosphorous Pesticides:					
Dimethoate	0.50 to 0.79	0.69	EPA 1995a	4.77	No
Disulfoton	3.84 to 4.10	3.98	EPA 1995a	8,177	Yes
Famphur	Not Reported	2.23	SRC 1998	156	No
Methyl parathion	1.91 to 3.32	2.90	EPA 1995a	710	Yes
O,O,O-Triethylphosphorothioate	Not Reported	2.64	SRC 1998	394	No
Parathion	2.15 to 3.93	3.83	EPA 1995a	5,823	Yes
Phorate	2.92 to 4.26	3.81	EPA 1995a	5,566	Yes
Sulfotep	Not Reported	4.46	SRC 1998	24,236	Yes
Thionazin	Not Reported	1.86	SRC 1998	67.4	No
Chlorinated Herbicides:					
2,4,5-T	3.13 to 4.00	3.31	EPA 1995a	1,795	Yes
2,4,5-TP (Silvex)	3.41 to 3.80	3.41	EPA 1995a	2,251	Yes
2,4-D	2.50 to 3.06	2.70	EPA 1995a	451	Yes
Explosives:					
1,3,5-Trinitrobenzene	1.18 to 1.37	1.18	EPA 1995a	14.5	No
1,3-Dinitrobenzene	1.49 to 1.63	1.50	EPA 1995a	29.8	No
2,4,6-Trinitrotoluene	Not Reported	1.60	SRC 1998	37.4	No
2,4-Dinitrotoluene	1.98 to 2.05	2.01	EPA 1995a	94.6	No
2,6-Dinitrotoluene	1.72 to 2.03	1.87	EPA 1995a	68.9	No
2-Nitrotoluene	Not Reported	2.30	SRC 1998	182	No
3-Nitrotoluene	Not Reported	2.45	SRC 1998	256	No
4-Nitrotoluene	Not Reported	2.40	EPA 1996b	229	No
2-amino-4,6-Dinitrotoluene	Not Reported	1.84	SRC 1998	64.4	No
4-amino-4,6-Dinitrotoluene	Not Reported	1.84 ⁽⁷⁾	SRC 1998	64.4	No
HMX	Not Reported	0.82	SRC 1998	6.40	No
Methyl-2,4,6-trinitrophenylnitramine	Not Reported	1.64	SRC 1998	41.0	No
Nitrobenzene	Not Reported	1.84	EPA 1996b	64.4	No
RDX	Not Reported	0.87	SRC 1998	7.17	No
Tetryl (nitramine)	Not Reported	1.64	SRC 1998	41.0	No
Dioxins/Furans (ug/kg):					
2,3,7,8-TCDD	6.42 to 7.02	6.53	EPA 1995a	2,625,851	Yes

TABLE 4-2 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Notes:

K_{ow} = Octanol-Water Partition Coefficient

K_{oc} = Organic Carbon Partition Coefficient

- (1) K_{oc} values were estimated from the following equation: $\text{Log}K_{oc} = 0.00028 + (0.983)(\text{Log}K_{ow})$ (EPA 1993a and 1996a).
- (2) An organic chemical is considered a bioaccumulative chemical if its $\text{Log} K_{ow}$ value is greater than or equal to 3.0. When a range of $\text{Log} K_{ow}$ values is reported, the upper value within the range was conservatively used to identify bioaccumulative chemicals.

TABLE 5-1
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Volatile Organics (ug/kg):			
1,1,1,2-Tetrachloroethane	NA	---	---
1,1,1-Trichloroethane	NA	---	---
1,1,2,2-Tetrachloroethane	NA	---	---
1,1,2-Trichloroethane	NA	---	---
1,1-Dichloroethane	NA	---	---
1,1-Dichloroethene	NA	---	---
1,2,3-Trichloropropane	NA	---	---
1,2-Dibromo-3-chloropropane	NA	---	---
1,2-Dibromoethane	NA	---	---
1,2-Dichloroethane	401 ⁽¹⁾	MHSPE 1994	---
1,2-Dichloroethene (Total)	NA	---	---
cis-1,2-Dichloroethene	NA	---	---
trans-1,2-Dichloroethene	NA	---	---
1,2-Dichloropropane	700,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
2-Butanone	NA	---	---
2-Hexanone	NA	---	---
2-Chloro-1,3-butadiene (Chloroprene)	NA	---	---
3-Chloropropene (3-Chloro-1-propene)	NA	---	---
4-Methyl-2-pentanone (Methyl isobutyl ketone)	NA	---	---
Acetone	NA	---	---
Acetonitrile	NA	---	---
Acrolein	NA	---	---
Acrylonitrile	1,000,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Benzene	105 ⁽²⁾	MHSPE 1994	---
Bromodichloromethane	NA	---	---
Bromoform	NA	---	---
Bromomethane	NA	---	---
Carbon disulfide	NA	---	---
Carbon tetrachloride	1,000,000	Efroymson et. al. 1997a	Toxicological threshold for microbial processes
Chlorobenzene	40,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Chloroethane	NA	---	---
Chloroform	1,000 ⁽²⁾	MHSPE 1994	---

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Volatile Organics (ug/kg) (cont.):			
Chloromethane	NA	---	---
cis-1,3-Dichloropropene	NA	---	---
Dibromochloromethane	NA	---	---
Dibromomethane	NA	---	---
Dichlorodifluoromethane	NA	---	---
Ethylbenzene	5,005 ⁽²⁾	MHSPE 1994	---
Ethyl methacrylate	NA	---	---
Iodomethane	NA	---	---
Isobutanol (Isobutyl alcohol)	NA	---	---
Methacrylonitrile	NA	---	---
Methylene chloride	1,001 ⁽²⁾	MHSPE 1994	---
Methyl methacrylate	NA	---	---
Pentachloroethane	NA	---	---
Propionitrile (Ethyl cyanide)	NA	---	---
Styrene	10,010 ⁽²⁾	MHSPE 1994	---
Tetrachloroethene	401 ⁽²⁾	MHSPE 1994	---
Toluene	13,005 ⁽²⁾	MHSPE 1994	---
trans-1,3-Dichloropropene	NA	---	---
trans-1,4-Dichloro-2-butene	1,000,000	Efroymsen et. al. 1997a	Toxicological threshold for microbial processes
Trichloroethene	6,000 ⁽²⁾	MHSPE 1994	---
Trichlorofluoromethane	NA	---	---
Vinyl acetate	NA	---	---
Vinyl chloride	11 ⁽¹⁾	MHSPE 1994	---
m-Xylene	2,505 ⁽²⁾	MHSPE 1994	Total xylene value
o-Xylene	2,505 ⁽²⁾	MHSPE 1994	Total xylene value
p-Xylene	2,505 ⁽²⁾	MHSPE 1994	Total xylene value
Semi-Volatile Organics (ug/kg):			
1,2,4,5-Tetrachlorobenzene	NA	---	---
1,2,4-Trichlorobenzene	20,000	Efroymsen et. al. 1997a	Toxicological threshold for earthworms
1,2-Dichlorobenzene	3,001 ⁽¹⁾	MHSPE 1994	Value for total chlorobenzenes ⁽³⁾
1,2-Diphenylhydrazine	NA	---	---

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg) (cont.):			
1,3-Dichlorobenzene	3,001 ⁽¹⁾	MHSPE 1994	Value for total chlorobenzenes ⁽³⁾
1,4,-Dichlorobenzene	20,000	Efroymsen et. al. 1997a	Toxicological threshold for Earthworms
1,4-Dioxane	NA	---	---
1,4-Naphthoquinone	NA	---	---
1-Naphthylamine	NA	---	---
2,2'-Oxybis(1-Chloropropane)	NA	---	---
2,3,4,6-Tetrachlorophenol	1,001 ⁽¹⁾	MHSPE 1994	Value for total chlorophenols ⁽⁴⁾
2,4,5-Trichlorophenol	4,000	Efroymsen et. al. 1997b	Toxicological threshold for plants
2,4,6-Trichlorophenol	10,000	Efroymsen et. al. 1997a	Toxicological threshold for earthworms
2,4-Dichlorophenol	1,001 ⁽¹⁾	MHSPE 1994	Value for total chlorophenols ⁽⁴⁾
2,4-Dimethylphenol	NA	---	---
2,4-Dinitrophenol	20,000	Efroymsen et. al. 1997b	Toxicological threshold for plants
2,6-Dichlorophenol	1,001 ⁽¹⁾	MHSPE 1994	Value for total chlorophenols ⁽⁴⁾
2-Acetylaminofluorene	NA	---	---
2-Chloronaphthalene	NA	---	---
2-Chlorophenol	1,001 ⁽¹⁾	MHSPE 1994	Value for total chlorophenols ⁽⁴⁾
2-Methylphenol (o-Cresol)	NA	---	---
2-Methylnaphthalene	1,200	---	Value for benzo(a)pyrene used as a surrogate
2-Naphthylamine	NA	---	---
2-Nitroaniline	NA	---	---
2-Nitrophenol	NA	---	---
2-Picoline	NA	---	---
2-sec-butyl-4,6-Dinitrophenol (Dinoseb)	NA	---	---
3,3'-Dichlorobenzidine	NA	---	---
3,3'-Dimethylbenzidine	NA	---	---
3-Methylphenol (m-Cresol)	NA	---	---
3-Methylcholanthrene	NA	---	---
3-Nitroaniline	NA	---	---
4,6-Dinitro-2-methylphenol	NA	---	---
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	NA	---	---

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg) (cont.):			
4-Chloro-3-methylphenol	NA	---	---
4-Chloroaniline	NA	---	---
4-Chlorophenyl-Phenylether	NA	---	---
4-Methylphenol (p-Cresol)	NA	---	---
4-Nitroaniline	NA	---	---
4-Nitrophenol	7,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
4-Nitroquinoline-1-oxide	NA	---	---
5-Nitro-o-toluidine	NA	---	---
7,12-Dimethyl benz(a)anthracene	NA	---	---
Acenaphthene	20,000	Efroymson et. al. 1997b	Toxicological threshold for plants
Acenaphthylene	NA	---	---
Acetophenone	NA	---	---
alpha, alpha-Dimethylphenethylamine	NA	---	---
Aniline	NA	---	---
Anthracene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Aramite	NA	---	---
Benzidine	NA	---	---
Benzo(a)anthracene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Benzo(a)pyrene	1,200	EPA 1999	Toxicological threshold for plants
Benzo(b)fluoranthene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Benzo(g,h,i)perylene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Benzo(k)fluoranthene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Benzoic acid	NA	---	---
Benzyl alcohol	NA	---	---
Bis(2-chloroethoxy)methane	NA	---	---
Bis(2-chloroethyl)ether	NA	---	---
Bis(2-ethylhexyl)phthalate	6,010 ⁽²⁾	MHSPE 1994	Value for total phthalates ⁽⁵⁾
Butylbenzylphthalate	6,010 ⁽²⁾	MHSPE 1994	Value for total phthalates ⁽⁵⁾
Carbazole	NA	---	---
Chlorobenzilate	NA	---	---
Chrysene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Diallate	NA	---	---
Dibenzo(a,h)anthracene	NA	---	---

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg) (cont.):			
Dibenzofuran	NA	---	---
Diethylphthalate	100,000	Efroymsen et. al. 1997b	Toxicological threshold for plants
Dimethylphthalate	200,000	Efroymsen et. al. 1997a	Toxicological threshold for earthworms
Di-n-butylphthalate	200,000	Efroymsen et. al. 1997b	Toxicological threshold for plants
Di-n-octylphthalate	6,010 ⁽²⁾	MHSPE 1994	Value for total phthalates ⁽⁵⁾
Diphenylamine	NA	---	---
Ethyl methanesulfonate	NA	---	---
Fluoranthene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Fluorene	30,000	Efroymsen et. al. 1997a	Toxicological threshold for earthworms
Hexachlorobenzene	1,000,000	Efroymsen et al 1997a	Toxicological threshold for microbial processes
Hexachlorobutadiene	NA	---	---
Hexachlorocyclopentadiene	100	EPA 1999	Toxicological threshold for plants
Hexachloroethane	NA	---	---
Hexachlorophene	NA	---	---
Hexachloropropene	NA	---	---
Indeno(1,2,3-cd)pyrene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Isophorone	NA	---	---
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Naphthalene	1,200	---	Value for benzo(a)pyrene used as a surrogate
n-Nitrosodiethylamine	20,000	---	Value for n-Nitrosodiphenylamine used as a surrogate
n-Nitrosodimethylamine	20,000	---	Value for n-Nitrosodiphenylamine used as a surrogate
n-Nitroso-di-n-butylamine	20,000	---	Value for n-Nitrosodiphenylamine used as a surrogate
n-Nitroso-di-n-propylamine	20,000	---	Value for n-Nitrosodiphenylamine used as a surrogate
n-Nitrosodiphenylamine	20,000	Efroymsen et. al. 1997a	Toxicological threshold for earthworms
n-Nitrosomethylethylamine	20,000	---	Value for n-Nitrosodiphenylamine used as a surrogate
n-Nitrosomorpholine	NA	---	---
n-Nitrosopiperidine	NA	---	---
n-Nitrosopyrrolidine	NA	---	---
o-Toluidine	NA	---	---
p-Dimethylaminoazobenzene	NA	---	---
Pentachlorobenzene	1,150	EPA 1999	Toxicological threshold for earthworms

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg) (cont.):			
Pentachloronitrobenzene	NA	---	---
Pentachlorophenol	1,730	EPA 1999	Toxicological threshold for plants
Phenacetin	NA	---	---
Phenanthrene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Phenol	30,000	Efroymsen et. al. 1997a	Toxicological Threshold for Earthworms
p-Phenylenediamine	NA	---	---
Pronamide	NA	---	---
Pryridine	NA	---	---
Pyrene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Safrole	NA	---	---
sym-Trinitrobenzene	NA	---	---
PCBs (ug/kg):			
Aroclor-1016	2,510	EPA 1999	Toxicological threshold for earthworms
Aroclor-1221	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1232	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1242	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1248	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1254	2,510	EPA 1999	Toxicological threshold for earthworms
Aroclor-1260	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Organochlorine Pesticides (ug/kg):			
4,4'-DDD	400 ⁽²⁾	MHSPE 1994	Value for total DDD, DDE, and DDT
4,4'-DDE	400 ⁽²⁾	MHSPE 1994	Value for total DDD, DDE, and DDT
4,4'-DDT	400 ⁽²⁾	MHSPE 1994	Value for total DDD, DDE, and DDT
Aldrin	400 ⁽¹⁾	MHSPE 1994	Value for total aldrin, endrin and dieldrin
alpha-Chlordane	NA	---	---
gamma-Chlordane	NA	---	---
Dieldrin	400 ⁽¹⁾	MHSPE 1994	Value for total aldrin, endrin and dieldrin
Endosulfan I	NA	---	---
Endosulfan II	NA	---	---
Endosulfan sulfate	NA	---	---
Endrin	400 ⁽¹⁾	MHSPE 1994	Value for total aldrin, endrin and dieldrin
Endrin aldehyde	NA	---	---

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Organochlorine Pesticides (ug/kg) (cont.):			
Heptachlor	1,000	EPA 1999	Toxicological threshold for plants
Heptachlor epoxide	1,000	---	Value for heptachlor used as a surrogate
Kepone	NA	---	---
Isodrin	NA	---	---
Methoxychlor	NA	---	---
Toxaphene	NA	---	---
alpha-BHC	200 ⁽¹⁾	MHSPE 1994	Value for total BHC compounds
beta-BHC	200 ⁽¹⁾	MHSPE 1994	Value for total BHC compounds
delta-BHC	200 ⁽¹⁾	MHSPE 1994	Value for total BHC compounds
gamma-BHC (Lindane)	200 ⁽¹⁾	MHSPE 1994	Value for total BHC compounds
Organophosphorous Pesticides (ug/kg):			
Dimethoate	NA	---	---
Disulfoton	NA	---	---
Famphur	NA	---	---
Methyl parathion	NA	---	---
O,O,O-Triethylphosphorothioate	NA	---	---
Parathion	NA	---	---
Phorate	NA	---	---
Sulfotep	NA	---	---
Thionazin	NA	---	---
Chlorinated Herbicides (ug/kg):			
2,4,5-T	NA	---	---
2,4,5-TP (Silvex)	NA	---	---
2,4-D	NA	---	---
Explosives (ug/kg):			
1,3,5-Trinitrobenzene	2,260	---	Value for nitrobenzene used as a surrogate
1,3-Dinitrobenzene	2,260	---	Value for nitrobenzene used as a surrogate
2,4,6-Trinitrobenzene	2,260	---	Value for nitrobenzene used as a surrogate
2,4-Dinitrotoluene	NA	---	---
2,6-Dinitrotoluene	NA	---	---
2-Nitrotoluene	NA	---	---
3-Nitrotoluene	NA	---	---
4-Nitrotoluene	NA	---	---

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Explosives (ug/kg) (cont.):			
2-amino-4,6-Dinitrotoluene	NA	---	---
4-amino-4,6-Dinitrotoluene	NA	---	---
HMX	NA	---	---
Methyl-2,4,6-trinitrophenylnitramine	NA	---	---
Nitrobenzene	2,260	EPA 1999	Toxicological threshold for earthworms
RDX	NA	---	---
Tetryl (nitramine)	NA	---	---
Dioxins/Furans (ug/kg):			
2,3,7,8-TCDD	500	EPA 1999	Toxicological threshold for earthworms
Total HxCDD	NA	---	---
Total HxCDF	NA	---	---
Total PeCDD	NA	---	---
Total PeCDF	NA	---	---
Total TCDD	NA	---	---
Total TCDF	NA	---	---
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
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

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Notes:

NA = Not Available

MHSPE = Ministry of Housing, Spatial Planning and Environment

- ⁽¹⁾ The screening value shown is an average of the detection limit and the intervention soil standards. The value is based on a default organic carbon content of 0.02 (2.0 percent), which represents a minimum value (adjustment range is 2 to 30 percent).
- ⁽²⁾ The screening value shown is an average of the target and intervention soil standards. The value is based on a default organic carbon content of 0.02 (2.0 percent), which represents a minimum value (adjustment range is 2 to 30 percent).
- ⁽³⁾ The value represents a total concentration for chlorobenzenes (mono, di, tri, tetra, penta, and hexachlorobenzene).
- ⁽⁴⁾ The value represents a total concentration for all chlorophenols (mono, di, tri, tetra, and pentachlorophenol)
- ⁽⁵⁾ The value represents a total concentration for all phthalates.

TABLE 5-2
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value ⁽¹⁾	Reference	Comment
Volatile Organics (ug/L):			
1,1,1,2-Tetrachloroethane	902	Buchman 1999	Acute LOEL with a safety factor of 10
1,1,1-Trichloroethane	312	EPA 2001	EPA Region 4 chronic screening value
1,1,2,2-Tetrachloroethane	90.2	EPA 2001	EPA Region 4 chronic screening value
1,1,2-Trichloroethane	340	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
1,1-Dichloroethane	47 ⁽²⁾	EPA 1996a	Tier II Value
1,1-Dichloroethene	2,240	EPA 2001	EPA Region 4 chronic screening value
1,2,3-Trichloropropane	274 ⁽²⁾	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
1,2-Dibromo-3-chloropropane	100	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
1,2-Dibromoethane	48	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
1,2-Dichloroethane	1,130	EPA 2001	EPA Region 4 chronic screening value
1,2-Dichloropropane	2,400	EPA 2001	EPA Region 4 chronic screening value
2-Butanone	40,000	EPA 2000	Minimum acute value (NOEC) with a safety factor of 10
2-Hexanone	98.8 ⁽²⁾	Suter II 1996	Tier II secondary chronic value
2-Chloro-1,3-butadiene (Chloroprene)	NA	---	---
3-Chloropropene (3-Chloro-1-propene)	3.4 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
4-Methyl-2-pentanone (Methyl isobutylketone)	NA	---	---
Acetone	1,000	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Acetonitrile	NA	---	---
Acrolein	0.55	EPA 2001	EPA Region 4 chronic screening value
Acrylonitrile	58.1	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Benzene	109	EPA 2001	EPA Region 4 chronic screening value
Bromodichloromethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Bromoform	640	EPA 2001	EPA Region 4 chronic screening value
Bromomethane	120	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Carbon disulfide	650 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Carbon tetrachloride	1,500	EPA 2001	EPA Region 4 chronic screening value
Chlorobenzene	105	EPA 2001	EPA Region 4 chronic screening value
Chloroethane	NA	---	---
Chloroform	815	EPA 2001	EPA Region 4 chronic screening value
Chloromethane	2,700	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Volatile Organics (ug/L) (cont.):			
cis-1,3-Dichloropropene	7.9	EPA 2001	EPA Region 4 chronic screening value (cis and trans)
cis-1,2-Dichloroethene	22,400	Buchman 1999	Acute LOEL (cis and trans isomers) with a safety factor of 10
Dibromochloromethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Dibromomethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Dichlorodifluoromethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Ethylbenzene	4.3	EPA 2001	EPA Region 4 chronic screening value
Ethyl methacrylate	NA	---	---
Iodomethane	NA	---	---
Isobutanol (Isobutyl alcohol)	10,000	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Methacrylonitrile	NA	---	---
Methylene chloride	2,560	EPA 2001	EPA Region 4 chronic screening value
Methyl methacrylate	1,300 ⁽²⁾	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
Pentachloroethane	281	Buchman 1999	Chronic LOEL
Propionitrile (Ethyl cyanide)	15,200 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Styrene	510	EPA 2000	Minimum acute value (NOEC) with a safety factor of 10
Tetrachloroethene	45	EPA 2001	EPA Region 4 chronic screening value
Toluene	37	EPA 2001	EPA Region 4 chronic screening value
trans-1,2-dichloroethene	22,400	Buchman 1999	Acute LOEL (summation of all isomers) with a safety factor of 10
trans-1,3-Dichloropropene	7.9	EPA 2001	EPA Region 4 chronic screening value (cis and trans)
trans-1,4-Dichloro-2-butene	NA	---	---
Trichloroethene	200	Buchman 1999	Acute LOEL with a safety factor of 10
Trichlorofluoromethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Vinyl acetate	10,000	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Vinyl chloride	87.8 ⁽²⁾	Suter II 1996	Tier II secondary chronic value
o-Xylene	41	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
m-Xylene	120	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
p-Xylene	5,840	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Semi-Volatile Organics (ug/L):			
1,2,4,5-Tetrachlorobenzene	30	EPA 2000	Minimum acute value (NOEC) with a safety factor of 10
1,2,4-Trichlorobenzene	4.5	EPA 2001	EPA Region 4 chronic screening value
1,2-Dichlorobenzene	19.7	EPA 2001	EPA Region 4 chronic screening value

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Semi-Volatile Organics (ug/L) (cont.):			
1,2-Diphenylhydrazine	12 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
1,3-Dichlorobenzene	28.5	EPA 2001	EPA Region 4 chronic screening value
1,4,-Dichlorobenzene	19.9	EPA 2001	EPA Region 4 chronic screening value
1,4-Dioxane	67,000	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
1,4-Naphthoquinone	NA	---	---
1-Naphthylamine	NA	---	---
2,2'-Oxybis(1-Chloropropane)	NA	---	---
2,3,4,6-Tetrachlorophenol	44	Buchman 1999	Acute LOEL with a safety factor of 10
2,4,5-Trichlorophenol	11	Buchman 1999	Proposed CCC
2,4,6-Trichlorophenol	12.1	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
2,4-Dichlorophenol	5	EPA 2000	Minimum acute value (NOEC) with a safety factor of 10
2,4-Dimethylphenol	131	EPA 2000	Minimum chronic value (NOEC for survival)
2,4-Dinitrophenol	48.5	EPA 2001	EPA Region 4 chronic screening value
2,6-Dichlorophenol	54	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
2-Acetylaminofluorene	100 ⁽²⁾	EPA 2000	Minimum acute value (LOEC) with a safety factor of 10
2-Chloronaphthalene	0.75	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
2-Chlorophenol	53	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
2-Methylnaphthalene	6	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
2-Methylphenol (o-Cresol)	102	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
2-Naphthylamine	NA	---	---
2-Nitroaniline	48.9 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
2-Nitrophenol	10,000	EPA 2000	Minimum chronic value (MATC for survival)
2-Picoline	8,979 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
2-sec-butyl-4,6-Dinitrophenol (Dinoseb)	1.7	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
3,3'-Dichlorobenzidine	10.5 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
3,3'-Dimethylbenzidine	160 ⁽²⁾	EPA 2000	Minimum chronic value (NOEC for behavior)
3-Methylcholanthrene	NA	---	---
3-Methylphenol (m-Cresol)	300	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
3-Nitroaniline	9.8 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Semi-Volatile Organics (ug/L) (cont.):			
4,6-Dinitro-2-methylphenol	183 ⁽²⁾	EPA 2000	Minimum chronic value (NOEC for growth)
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	3.6 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
4-Chloro-3-methylphenol	1,300 ⁽²⁾	EPA 2000	Minimum chronic value (NOEC for reproduction)
4-Chloroaniline	129	Buchman 1999	Chronic LOEL for chemical class
4-Chlorophenyl phenyl ether	7.3 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
4-Methylphenol (p-Cresol)	50	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
4-Nitroaniline	170 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
4-Nitrophenol	71.7	EPA 2001	EPA Region 4 chronic screening value
4-Nitroquinoline-1-oxide	NA	---	---
5-Nitro-o-toluidine	225 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
7,12-Dimethyl benz(a)anthracene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Acenaphthene	9.7	EPA 2001	EPA Region 4 chronic screening value
Acenaphthylene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Acetophenone	1,550 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
A,A-Dimethylphenethylamine	NA	---	---
Aniline	294	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Anthracene	50	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
Aramite	0.6 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Benzidine	6 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
Benzo(a)anthracene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Benzo(a)pyrene	10	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
Benzo(b)fluoranthene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Benzo(g,h,i)perylene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Benzo(k)fluoranthene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Benzoic acid	1,800 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Benzyl alcohol	150	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Bis(2-chloroethoxy)methane	6,400	Buchman 1999	Chronic LOEL for the chemical class
Bis(2-chloroethyl)ether	910 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Semi-Volatile Organics (ug/L) (cont.):			
Bis(2-ethylhexyl)phthalate	360	Buchman 1999	Proposed CCC
Butylbenzylphthalate	29.4	EPA 2001	EPA Region 4 chronic screening value
Carbazole	9.3 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Chlorobenzilate	8.7 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
Chrysene	10	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
Diallate	82 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Dibenzo(a,h)anthracene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Dibenzofuran	100	EPA 2000	Minimum acute value (NOEC) with a safety factor of 10
Diethylphthalate	75.9	EPA 2001	EPA Region 4 chronic screening value
Dimethylphthalate	580	EPA 2001	EPA Region 4 chronic screening value
Di-n-butylphthalate	3.4	EPA 2001	EPA Region 4 chronic screening value
Di-n-octylphthalate	3,450	EPA 2000	Minimum acute value (NOEC) with a safety factor of 10
Diphenylamine	3.1 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
Ethyl methanesulfonate	NA	---	---
Fluoranthene	11	EPA 1996a	Final Chronic Value
Fluorene	10	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Hexachlorobenzene	10	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
Hexachlorobutadiene	0.32	EPA 2001	EPA Region 4 chronic screening value
Hexachlorocyclopentadiene	0.07	EPA 2001	EPA Region 4 chronic screening value
Hexachloroethane	9.4	EPA 2001	EPA Region 4 chronic screening value
Hexachlorophene	8.8 ⁽²⁾	EPA 2000	Minimum chronic value (NOEC for survival and growth)
Hexachloropropene	NA	---	---
Indeno(1,2,3-cd)pyrene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Isophorone	129	EPA 2001	EPA Region 4 chronic screening value
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Naphthalene	23.5	EPA 2001	EPA Region 4 chronic screening value
n-Nitrosodiethylamine	330,000	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
n-Nitrosodimethylamine	27,000	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
n-Nitroso-di-n-butylamine	330,000	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Semi-Volatile Organics (ug/L) (cont.):			
n-Nitroso-di-n-propylamine	330,000	Assumed	Acute LOEL for chemical class with a safety factor of 10
n-Nitrosodiphenylamine	33,000	EPA 2001	EPA Region 4 chronic screening value
n-Nitrosomethylethylamine	330,000	Assumed	Acute LOEL for chemical class with a safety factor of 10
n-Nitrosomorpholine	NA	---	---
n-Nitrosopiperidine	NA	---	---
n-Nitrosopyrrolidine	NA	---	---
o-Toluidine	400	EPA 2000	Minimum Acute value (LC ₅₀) with a safety factor of 100
p-Dimethylaminoazobenzene	NA	---	---
Pentachlorobenzene	129	EPA 2001	EPA Region 4 chronic screening value
Pentachloronitrobenzene	0.23	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Pentachlorophenol	7.9	EPA 2002	CCC
Phenacetin	NA	---	---
Phenanthrene	8.3	EPA 1996a	Final Chronic Value
Phenol	58	EPA 2001	EPA Region 4 chronic screening value
p-Phenylenediamine (1,4-Phenylenediamine)	200 ⁽²⁾	EPA 2000	Minimum Acute value (LC ₅₀) with a safety factor of 100
Pronamide	35	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Pryridine	500	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Pyrene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Safrole	NA	---	---
PCBs (ug/L):			
Aroclor-1016	0.03	EPA 2002	CCC based on Final Residual Value for total PCBs
Aroclor-1221	0.03	EPA 2002	CCC based on Final Residual Value for total PCBs
Aroclor-1232	0.03	EPA 2002	CCC based on Final Residual Value for total PCBs
Aroclor-1242	0.03	EPA 2002	CCC based on Final Residual Value for total PCBs
Aroclor-1248	0.03	EPA 2002	CCC based on Final Residual Value for total PCBs
Aroclor-1254	0.03	EPA 2002	CCC based on Final Residual Value for total PCBs
Aroclor-1260	0.03	EPA 2002	CCC based on Final Residual Value for total PCBs
Organochlorine Pesticides (ug/L):			
4,4'-DDD	0.025	EPA 2001	EPA Region 4 chronic screening value
4,4'-DDE	0.14	EPA 2001	EPA Region 4 chronic screening value
4,4'-DDT	0.001	EPA 2002	CCC based on Final Residual Value
Aldrin	0.13	EPA 2001	EPA Region 4 chronic screening value

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Organochlorine Pesticides (ug/L) (cont.):			
alpha-chlordane	0.004	EPA 2002	CCC based on Final Residual Value for total chlordane
gamma-chlordane	0.004	EPA 2002	CCC based on Final Residual Value for total chlordane
Dieldrin	0.11	EPA 1996a	Final Chronic Value
Endosulfan I	0.0087	EPA 2002	CCC derived from data for endosulfan
Endosulfan II	0.0087	EPA 2002	CCC derived from data for endosulfan
Endosulfan sulfate	NA	---	---
Endrin	0.01	EPA 1996a	Final Chronic Value
Endrin aldehyde	NA	---	---
Heptachlor	0.0036	EPA 2002	CCC based on Final Residual Value
Heptachlor epoxide	0.0036	EPA 2002	CCC based on Final Residual Value for heptachlor
Kepone	0.026	EPA 2000b	Minimum chronic value (MATC based on survival)
Isodrin	NA	---	---
Methoxychlor	0.03	EPA 2002	CCC
Toxaphene	0.21	EPA 1996a	Final Chronic Value
alpha-BHC	5	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
beta-BHC	NA	---	---
delta-BHC	0.125	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
gamma-BHC (lindane)	0.016	EPA 2001	EPA Region 4 chronic screening value
Chlorinated Herbicides (ug/L):			
2,4,5-T	100	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
2,4,5-TP (Silvex)	59	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
2,4-D	15	EPA 1996b	Acute value (LC ₅₀) with a safety factor of 100
Explosives (ug/L):			
1,3,5-Trinitrobenzene	80 ⁽²⁾	EPA 2000	Minimum chronic value (NOEC based on reproduction)
1,3-Dinitrobenzene (m-Dinitrobenzene)	500 ⁽²⁾	EPA 2000	Minimum chronic value (NOEC based on growth and reproduction)
2,4,6-Trinitrotoluene	4.6 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
2,4-Dinitrotoluene	370	Buchman 1999	Chronic LOEL
2,6-Dinitrotoluene	60 ⁽²⁾	EPA 2000	Minimum chronic value (NOEC based on reproduction)
2-Nitrotoluene	54 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100
3-Nitrotoluene	74 ⁽²⁾	EPA 2000	Minimum acute value (EC ₅₀) with a safety factor of 100

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Explosives (ug/L) (cont.):			
4-Nitrotoluene	75 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
2-amino-4,6-Dinitrotoluene	25.7 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
4-amino-4,6-Dinitrotoluene	25.7 ⁽²⁾	---	Screening value for 2-amino-4,6-dinitrotoluene used as a surrogate
HMX	150 ⁽²⁾	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Methyl-2,4,6-trinitrophenylnitramine	NA	---	---
Nitrobenzene	66.8	EPA 2001	EPA Region 4 chronic screening value
RDX	1,350 ⁽²⁾	EPA 2000	Minimum chronic value (NOEC based on growth)
Tetryl (nitramine)	NA	---	---
Dioxins/Furans (ug/kg):			
2,3,7,8-TCDD	0.00001	EPA 2001	EPA Region 4 chronic screening value based on the marketability of fish
Total HxCDD	NA	---	---
Total HxCDF	NA	---	---
Total PeCDD	NA	---	---
Total PeCDF	NA	---	---
Total TCDD	NA	---	---
Total TCDF	NA	---	---
Inorganics (ug/L):			
Antimony	500	Buchman 1999	Proposed CCC
Arsenic	36	EPA 2002	Total recoverable CCC for trivalent arsenic
Barium	50,000	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Beryllium	310	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Cadmium	8.9	EPA 2002	Total recoverable CCC
Chromium (total)	50.4	EPA 2002	Total recoverable CCC for hexavalent chromium
Cobalt	45	EPA 2000	Minimum acute value (LC ₅₀) with a safety factor of 100
Copper	3.7	EPA 2002	Total recoverable CCC
Lead	8.5	EPA 2002	Total recoverable CCC
Mercury	1.1	EPA 2002	Total recoverable CCC
Nickel	8.3	EPA 2002	Total recoverable CCC
Selenium	71.1	EPA 2002	Total recoverable CCC

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Inorganics (cont.) (ug/L) :			
Silver	0.23	EPA 2001	EPA Region 4 chronic screening value
Thallium	21.3	EPA 2001	EPA Region 4 chronic screening value
Tin	NA	---	---
Vanadium	NA	---	---
Zinc	85.6	EPA 2002	Total recoverable CCC

Notes:

NA = Not Available

CCC = Criteria Continuous Concentration

LOEL = Lowest Observed Effect Level

MATC = Maximum Acceptable Toxicant Concentration

NOEC = No Observed Effect Concentration

EC₅₀ = Median Effective Concentration

LC₅₀ = Median Lethal Concentration

⁽¹⁾ The values shown are marine/estuarine screening values unless otherwise noted.

⁽²⁾ The chemical lacks a marine/estuarine surface water screening value. The value shown is a freshwater screening value.

TABLE 5-3
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Volatile Organics (ug/kg):			
1,1,1,2-Tetrachloroethane	3,474	EPA 1993a	EqP-based screening value
1,1,1-Trichloroethane	856	EPA 1993a	EqP-based screening value
1,1,2,2-Tetrachloroethane	202	EPA 1993a	EqP-based screening value
1,1,2-Trichloroethane	352	EPA 1993a	EqP-based screening value
1,1-Dichloroethane	27	EPA 1993a	EqP-based screening value
1,1-Dichloroethene	2,782	EPA 1993a	EqP-based screening value
1,2,3-Trichloropropane	446	EPA 1993a	EqP-based screening value
1,2-Dibromo-3-chloropropane	200	EPA 1993a	EqP-based screening value
1,2-Dibromoethane	44.4	EPA 1993a	EqP-based screening value
1,2-Dichloroethane	315	EPA 1993a	EqP-based screening value
1,2-Dichloropropane	2,075	EPA 1993a	EqP-based screening value
2-Butanone	754	EPA 1993a	EqP-based screening value
2-Hexanone	22.5	EPA 1993a	EqP-based screening value
2-Chloro-1,3-butadiene (Chloroprene)	NA	---	---
3-Chloropropene (3-Chloro-1-propene)	2.69	EPA 1993a	EqP-based screening value
4-Methyl-2-pentanone (Methyl isobutyl ketone)	4,387	Di Toro and McGrath 2000	EqP-based screening value
Acetone	5.81	EPA 1993a	EqP-based screening value
Acetonitrile	NA	---	---
Acrolein	0.01	EPA 1993a	EqP-based screening value
Acrylonitrile	1.02	EPA 1993a	EqP-based screening value
Benzene	135	EPA 1993a	EqP-based screening value
Bromodichloromethane	7,426	EPA 1993a	EqP-based screening value
Bromoform	1,308	EPA 1993a	EqP-based screening value
Bromomethane	17.8	EPA 1993a	EqP-based screening value
Carbon disulfide	601	EPA 1993a	EqP-based screening value
Carbon tetrachloride	7,244	EPA 1993a	EqP-based screening value
Chlorobenzene	681	EPA 1993a	EqP-based screening value
Chloroethane	2,890	Di Toro and McGrath 2000	EqP-based screening value
Chloroform	629	EPA 1993a	EqP-based screening value
Chloromethane	212	EPA 1993a	EqP-based screening value

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Volatile Organics (ug/kg) (cont.):			
cis-1,3-Dichloropropene	8.37	EPA 1993a	EqP-based screening value
cis-1,2-Dichloroethene	15,098	EPA 1993a	EqP-based screening value
Dibromochloromethane	8,701	EPA 1993a	EqP-based screening value
Dibromomethane	2,039	EPA 1993a	EqP-based screening value
Dichlorodifluoromethane	5,864	Di Toro and McGrath 2000	EqP-based screening value
Ethylbenzene	4	Buchman 1999	AET
Ethyl methacrylate	NA	---	---
Iodomethane	NA	---	---
Isobutanol (Isobutyl alcohol)	546	EPA 1993a	EqP-based screening value
Methacrylonitrile	NA	---	---
Methylene Chloride	434	EPA 1993a	EqP-based screening value
Methyl methacrylate	296	EPA 1993a	EqP-based screening value
Pentachloroethane	2,864	EPA 1993a	EqP-based screening value
Propionitrile (Ethyl cyanide)	219	EPA 1993a	EqP-based screening value
Styrene	3,962	EPA 1993a	EqP-based screening value
Tetrachloroethene	57	Buchman 1999	AET
Toluene	187	EPA 1993a	EqP-based screening value
trans-1,2-dichloroethene	4,614	Di Toro and McGrath 2000	EqP-based screening value
trans-1,3-Dichloropropene	7.82	EPA 1993a	EqP-based screening value
trans-1,4-Dichloro-2-butene	NA	---	---
Trichloroethene	41	Buchman 1999	AET
Trichlorofluoromethane	6,786	Di Toro and McGrath 2000	EqP-based screening value
Vinyl acetate	522	EPA 1993a	EqP-based screening value
Vinyl chloride	26.2	EPA 1993a	EqP-based screening value
o-Xylene	4	Buchman 1999	AET value for total xylenes
m-Xylene	4	Buchman 1999	AET value for total xylenes
p-Xylene	4	Buchman 1999	AET value for total xylenes
Semi-Volatile Organics (ug/kg):			
1,2,4,5-Tetrachlorobenzene	10,928	EPA 1993a	EqP-based screening value
1,2,4-Trichlorobenzene	5	Buchman 1999	AET

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Semi-Volatile Organics (ug/kg) (cont.):			
1,2-Dichlorobenzene	13	Buchman 1999	AET
1,2-Diphenylhydrazine	93.2	EPA 1993a	EqP-based screening value
1,3-Dichlorobenzene	986	EPA 1993a	EqP-based screening value
1,4-Dichlorobenzene	110	Buchman 1999	AET
1,4-Dioxane	364	EPA 1993a	EqP-based screening value
1,4-Naphthoquinone	NA	---	---
1-Naphthylamine	NA	---	---
2,2'-Oxybis(1-Chloropropane)	NA	---	---
2,3,4,6-Tetrachlorophenol	10,425	EPA 1993a	EqP-based screening value
2,4,5-Trichlorophenol	3	Buchman 1999	AET
2,4,6-Trichlorophenol	6	Buchman 1999	AET
2,4-Dichlorophenol	5	Buchman 1999	AET
2,4-Dimethylphenol	18	Buchman 1999	AET
2,4-Dinitrophenol	16.2	EPA 1993a	EqP-based screening value
2,6-Dichlorophenol	273	EPA 1993a	EqP-based screening value
2-Acetylaminofluorene	1,167	EPA 1993a	EqP-based screening value
2-Chloronaphthalene	15.8	EPA 1993a	EqP-based screening value
2-Chlorophenol	8	Buchman 1999	AET
2-Methylnaphthalene	20.2	MacDonald 1994	TEL
2-Methylphenol (o-Cresol)	8	Buchman 1999	AET
2-Naphthylamine	NA	---	---
2-Nitroaniline	32.2	EPA 1993a	EqP-based screening value
2-Nitrophenol	5,752	EPA 1993a	EqP-based screening value
2-Picoline	1,104	EPA 1993a	EqP-based screening value
2-sec-butyl-4,6-Dinitrophenol	72.1	EPA 1993a	EqP-based screening value
3,3'-Dichlorobenzidine	296	EPA 1993a	EqP-based screening value
3,3'-Dimethylbenzidine	690	EPA 1993a	EqP-based screening value
3-Methylcholanthrene	NA	EPA 1993a	EqP-based screening value
3-Methylphenol (m-Cresol)	259	EPA 1993a	EqP-based screening value

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Semi-Volatile Organics (ug/kg) (cont.):			
3-Nitroaniline	2.18	EPA 1993a	EqP-based screening value
4,6-Dinitro-2-methylphenol	222	EPA 1993a	EqP-based screening value
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	312	Di Toro and McGrath 2000	EqP-based screening value
4-Chloro-3-methylphenol	14,508	EPA 1993a	EqP-based screening value
4-Chloroaniline	85.0	EPA 1993a	EqP-based screening value
4-Chlorophenyl-phenyl ether	287	Di Toro and McGrath 2000	EqP-based screening value
4-Methylphenol (p-Cresol)	100	Buchman 1999	AET
4-Nitroaniline	39.5	EPA 1993a	EqP-based screening value
4-Nitrophenol	54.1	EPA 1993a	EqP-based screening value
4-Nitroquinoline-1-oxide	NA	---	---
5-Nitro-o-toluidine	155	EPA 1993a	EqP-based screening value
7,12-Dimethyl benz(a)anthracene	965,742	EPA 1993a	EqP-based screening value
Acenaphthene	6.71	MacDonald 1994	TEL
Acenaphthylene	5.87	MacDonald 1994	TEL
Acetophenone	635	EPA 1993a	EqP-based screening value
A,A-Dimethylphenethylamine	NA	---	---
Aniline	27.0	EPA 1993a	EqP-based screening value
Anthracene	46.9	MacDonald 1994	TEL
Aramite	328	EPA 1993a	EqP-based screening value
Benzidine	2.57	EPA 1993a	EqP-based screening value
Benzo(a)anthracene	74.8	MacDonald 1994	TEL
Benzo(a)pyrene	88.8	MacDonald 1994	TEL
Benzo(b)fluoranthene	1,800	Buchman 1999	AET
Benzo(g,h,i)perylene	670	Buchman 1999	AET
Benzo(k)fluoranthene	1,800	Buchman 1999	AET
Benzoic acid	65	Buchman 1999	AET
Benzyl alcohol	52	Buchman 1999	AET
Bis(2-chloroethoxy)methane	350	EPA 1993a	EqP-based screening value
Bis(2-chloroethyl)ether	141	EPA 1993a	EqP-based screening value

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Semi-Volatile Organics (ug/kg) (cont.):			
Bis(2-ethylhexyl)phthalate	182	MacDonald 1994	TEL
Butylbenzylphthalate	63	Buchman 1999	AET
Carbazole	315	EPA 1993a	EqP-based screening value
Chlorobenzilate	1,759	EPA 1993a	EqP-based screening value
Chrysene	108	MacDonald 1994	TEL
Diallate	21,270	EPA 1993a	EqP-based screening value
Dibenzo(a,h)anthracene	6.22	MacDonald 1994	TEL
Dibenzofuran	110	Buchman 1999	AET
Diethylphthalate	6	Buchman 1999	AET
Dimethylphthalate	6	Buchman 1999	AET
Di-n-butylphthalate	58	Buchman 1999	AET
Di-n-octylphthalate	61	Buchman 1999	AET
Diphenylamine	81.7	EPA 1993a	EqP-based screening value
Ethyl methanesulfonate	NA	---	---
Fluoranthene	113	MacDonald 1994	TEL
Fluorene	21.2	MacDonald 1994	TEL
Hexachlorobenzene	6	Buchman 1999	AET
Hexachlorobutadiene	1	Buchman 1999	AET
Hexachlorocyclopentadiene	139	EPA 1993a	EqP-based screening value
Hexachloroethane	73	Buchman 1999	AET
Hexachlorophene	2,272,912	EPA 1993a	EqP-based screening value
Hexachloropropene	NA	---	---
Indeno(1,2,3-cd)pyrene	600	Buchman 1999	AET
Isophorone	60.5	EPA 1993a	EqP-based screening value
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Naphthalene	34.6	MacDonald 1994	TEL
n-Nitrosodiethylamine	9,787	EPA 1993a	EqP-based screening value
n-Nitrosodimethylamine	74.4	EPA 1993a	EqP-based screening value

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Semi-Volatile Organics (ug/kg) (cont.):			
n-Nitroso-di-n-butylamine	772,367	EPA 1993a	EqP-based screening value
n-Nitroso-di-n-propylamine	78,522	EPA 1993a	EqP-based screening value
n-Nitrosodiphenylamine	28	Buchman 1999	AET
n-Nitrosomethylethylamine	2,517	EPA 1993a	EqP-based screening value
n-Nitrosomorpholine	NA	---	---
n-Nitrosopiperidine	NA	---	---
n-Nitrosopyrrolidine	NA	---	---
o-Toluidine	83.1	EPA 1993a	EqP-based screening value
p-Dimethylaminoazobenzene	NA	---	---
Pentachlorobenzene	191,183	EPA 1993a	EqP-based screening value
Pentachloronitrobenzene	15,811	Di Toro and McGrath 2000	EqP-based screening value
Pentachlorophenol	17	Buchman 1999	AET
Phenacetin	NA	---	---
Phenanthrene	86.7	MacDonald 1994	TEL
Phenol	130	Buchman 1999	AET
p-Phenylenediamine	1.01	EPA 1993a	EqP-based screening value
Pronamide	988	EPA 1993a	EqP-based screening value
Pryridine	22.8	EPA 1993a	EqP-based screening value
Pyrene	153	MacDonald 1994	TEL
Safrole	NA	---	---
sym-Trinitrobenzne	NA	---	---
PCBs (ug/kg):			
Aroclor-1016	21.6	MacDonald 1994	TEL
Aroclor-1221	21.6	MacDonald 1994	TEL
Aroclor-1232	21.6	MacDonald 1994	TEL
Aroclor-1242	21.6	MacDonald 1994	TEL
Aroclor-1248	21.6	MacDonald 1994	TEL
Aroclor-1254	21.6	MacDonald 1994	TEL
Aroclor-1260	21.6	MacDonald 1994	TEL

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Organochlorine Pesticides (ug/kg):			
4,4'-DDD	1.22	MacDonald 1994	TEL
4,4'-DDE	2.07	MacDonald 1994	TEL
4,4'-DDT	1.0	Long and Morgan 1991	ER-L
Aldrin	10	Buchman 1999	AET
alpha-chlordane	0.50	Long and Morgan 1991	ER-L value for total chlordane
gamma-chlordane	0.50	Long and Morgan 1991	ER-L value for total chlordane
Dieldrin	0.02	Long and Morgan 1991	ER-L
Endosulfan I	0.93	EPA 1993a	EqP-based screening value
Endosulfan II	0.93	EPA 1993a	EqP-based screening value
Endosulfan sulfate	NA	---	---
Endrin	0.02	Long and Morgan 1991	ER-L
Endrin aldehyde	NA	---	---
Heptachlor	0.3	Buchman 1999	AET
Heptachlor epoxide	2.96	EPA 1993a	EqP-based screening value
Kepone	42.2	EPA 1993a	EqP-based screening value
Isodrin	NA	---	---
Methoxychlor	29.6	EPA 1993a	EqP-based screening value
Toxaphene	536	EPA 1993a	EqP-based screening value
alpha-BHC	272	EPA 1993a	EqP-based screening value
beta-BHC	NA	---	---
delta-BHC	14.7	EPA 1993a	EqP-based screening value
gamma-BHC (lindane)	0.32	MacDonald 1994	TEL
Organophosphorous Pesticides (ug/kg):			
Dimethoate	0.0001	EPA 1993a	EqP-based screening value
Disulfoton	605	EPA 1993a	EqP-based screening value
Famphur	NA	---	---
Methyl parathion	NA	---	---
O,O,O-Triethylphosphorothioate	NA	---	---
Parathion	10.4	EPA 1993a	EqP-based screening value
Thionazin	NA	---	---

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Organophosphorous Pesticides (ug/kg)(cont.):			
Phorate	5.01	EPA 1993a	EqP-based screening value
Sulfotep	NA	---	---
Chlorinated Herbicides (ug/kg):			
2,4,5-T	1,795	EPA 1993a	EqP-based screening value
2,4,5-TP (Silvex)	1,328	EPA 1993a	EqP-based screening value
2,4-D	67.7	EPA 1993a	EqP-based screening value
Explosives (ug/kg):			
1,3,5-Trinitrobenzene	11.6	EPA 1993a	EqP-based screening value
1,3-Dinitrobenzene (m-Dinitrobenzene)	149	EPA 1993a	EqP-based screening value
2,4,6-Trinitrotoluene	1.72	EPA 1993a	EqP-based screening value
2,4-Dinitrotoluene	350	EPA 1993a	EqP-based screening value
2,6-Dinitrotoluene	41.4	EPA 1993a	EqP-based screening value
2-Nitrotoluene	98.5	EPA 1993a	EqP-based screening value
3-Nitrotoluene	190	EPA 1993a	EqP-based screening value
4-Nitrotoluene	172	EPA 1993a	EqP-based screening value
2-amino-4,6-Dinitrotoluene	16.6	EPA 1993a	EqP-based screening value
4-amino-4,6-Dinitrotoluene	16.6	EPA 1993a	EqP-based screening value
HMX	9.60	EPA 1993a	EqP-based screening value
Methyl-2,4,6-trinitrophenylnitramine	NA	---	---
Nitrobenzene	21	Buchman 1999	AET
RDX	NA	EPA 1993a	EqP-based screening value
Tetryl (nitramine)	NA	---	---
Dioxins/Furans (ug/kg):			
2,3,7,8-TCDD	0.0036	Buchman 1999	AET
Total HxCDD	NA	---	---
Total HxCDF	NA	---	---
Total PeCDD	NA	---	---
Total PeCDF	NA	---	---
Total TCDD	NA	---	---
Total TCDF	NA	---	---

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Inorganics (mg/kg):			
Antimony	2.0	Long and Morgan 1991	ER-L
Arsenic	7.24	MacDonald 1994	TEL
Barium	48	Buchman 1999	AET
Beryllium	NA	---	---
Cadmium	0.68	MacDonald 1994	TEL
Chromium (total)	52.3	MacDonald 1994	TEL
Cobalt	10	Buchman 1999	AET
Copper	18.7	MacDonald 1994	TEL
Lead	30.2	MacDonald 1994	TEL
Mercury	0.13	MacDonald 1994	TEL
Nickel	15.9	MacDonald 1994	TEL
Selenium	1	Buchman 1999	AET
Silver	0.73	MacDonald 1994	TEL
Thallium	NA	---	---
Tin	3	Buchman 1999	AET
Vanadium	57	Buchman 1999	AET
Zinc	124	MacDonald	TEL

Notes:

NA = Not Available

EqP = Equilibrium Partitioning

ER-L = Effects Range-Low

AET = Apparent Effects Threshold

TEL Threshold Effects Level

⁽¹⁾ EqP-based sediment screening values from EPA (1993a) were calculated from the following equation:
 $SV_{sed} = (K_{oc})(f_{oc})(SV_{sw})$ where K_{oc} is the organic carbon partition coefficient (L/kg), f_{oc} is the fraction of organic carbon (unitless), and SV_{sw} is the surface water screening value (ug/L). An F_{oc} of 0.01 was assumed.

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Volatile Organics (ug/kg) (cont.):			
cis-1,3-Dichloropropene	8.37	EPA 1993a	EqP-based screening value
cis-1,2-Dichloroethene	NA	---	---
Dibromochloromethane	8,701	EPA 1993a	EqP-based screening value
Dibromomethane	2,039	EPA 1993a	EqP-based screening value
Dichlorodifluoromethane	8,506	EPA 1993a	EqP-based screening value
Ethylbenzene	4.0	Buchman 1999	AET
Ethyl methacrylate	NA	---	---
Iodomethane	NA	---	---
Isobutanol	328	EPA 1993a	EqP-based screening value
Methacrylonitrile	NA	---	---
Methylene Chloride	434	EPA 1993a	EqP-based screening value
Methyl methacrylate	NA	---	---
Pentachloroethane	2,864	EPA 1993a	EqP-based screening value
Propionitrile	NA	---	---
Styrene	707	EPA 1993a	EqP-based screening value
Tetrachloroethene	57	Buchman 1999	AET
Toluene	187	EPA 1993a	EqP-based screening value
trans-1,2-dichloroethene	NA	---	---
trans-1,3-Dichloropropene	7.82	EPA 1993a	EqP-based screening value
trans-1,4-Dichloro-2-butene	NA	---	---
Trichloroethene	41	Buchman 1999	AET
Trichlorofluoromethane	19,654	EPA 1993a	EqP-based screening value
Vinyl Acetate	522	EPA 1993a	EqP-based screening value
Vinyl Chloride	NA	---	---
o-Xylene	4	Buchman 1999	AET value for total xylenes
m-Xylene	4	Buchman 1999	AET value for total xylenes
p-Xylene	4	Buchman 1999	AET value for total xylenes
Semi-Volatile Organics (ug/kg):			
1,2,4,5-Tetrachlorobenzene	46,988	EPA 1993a	EqP-based screening value
1,2,4-Trichlorobenzene	4.8	Buchman 1999	AET

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Semi-Volatile Organics (ug/kg) (cont.):			
1,2-Dichlorobenzene	13	Buchman 1999	AET
1,2-Diphenylhydrazine	NA	---	---
1,3-Dichlorobenzene	986	EPA 1993a	EqP-based screening value
1,4-Dichlorobenzene	110	Buchman 1999	AET
1,4-Dioxane	364	EPA 1993a	EqP-based screening value
1,4-Naphthoquinone	NA	---	---
1-Naphthylamine	NA	---	---
2,2'-Oxybis(1-Chloropropane)	NA	---	---
2,3,4,6-Tetrachlorophenol	10,425	EPA 1993a	EqP-based screening value
2,4,5-Trichlorophenol	3	Buchman 1999	AET
2,4,6-Trichlorophenol	6	Buchman 1999	AET
2,4-Dichlorophenol	5	Buchman 1999	AET
2,4-Dimethylphenol	18	Buchman 1999	AET
2,4-Dinitrophenol	16.2	EPA 1993a	EqP-based screening value
2,6-Dichlorophenol	273	EPA 1993a	EqP-based screening value
2-Acetylaminofluorene	NA	---	---
2-Chloronaphthalene	3.01	EPA 1993a	EqP-based screening value
2-Chlorophenol	8	Buchman 1999	AET
2-Methylnaphthalene	20.2	MacDonald 1994	TEL
2-Methylphenol (o-cresol)	8	Buchman 1999	AET
2-Naphthylamine	NA	---	---
2-Nitroaniline	NA	---	---
2-Nitrophenol	5,752	EPA 1993a	EqP-based screening value
2-Picoline	NA	---	---
2-sec-butyl-4,6-Dinitrophenol	1,103	EPA 1993a	EqP-based screening value
3,3'-Dichlorobenzidine	NA	---	---
3,3'-Dimethylbenzidine	NA	---	---
3-Methylcholanthrene	NA	---	---
3-Methylphenol (m-cresol)	259	EPA 1993a	EqP-based screening value

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Semi-Volatile Organics (ug/kg) (cont.):			
3-Nitroaniline	NA	---	---
4,6-Dinitro-2-methylphenol	NA	---	---
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	NA	---	---
4-Chloro-3-methylphenol	NA	---	---
4-Chloroaniline	85.0	EPA 1993a	EqP-based screening value
4-Chlorophenyl-Phenylether	NA	---	---
4-Methylphenol (p-cresol)	100	Buchman 1999	AET
4-Nitroaniline	NA	---	---
4-Nitrophenol	54.1	EPA 1993a	EqP-based screening value
4-Nitroquinoline-1-oxide	NA	---	---
5-Nitro-o-toluidine	NA	---	---
7,12-Dimethyl benz(a)anthracene	965,742	EPA 1993a	EqP-based screening value
Acenaphthene	6.71	MacDonald 1994	TEL
Acenaphthylene	5.87	MacDonald 1994	TEL
Acetophenone	NA	---	---
A,A-Dimethylphenethylamine	NA	---	---
Aniline	27.0	EPA 1993a	EqP-based screening value
Anthracene	46.9	MacDonald 1994	TEL
Aramite	NA	---	---
Benzidine	NA	---	---
Benzo(a)anthracene	74.8	MacDonald 1994	TEL
Benzo(a)pyrene	88.8	MacDonald 1994	TEL
Benzo(b)fluoranthene	1,800	Buchman 1999	AET
Benzo(g,h,i)perylene	670	Buchman 1999	AET
Benzo(k)fluoranthene	1,800	Buchman 1999	AET
Benzoic Acid	65	Buchman 1999	AET
Benzyl Alcohol	52	Buchman 1999	AET
Bis(2-chloroethoxy)methane	350	EPA 1993a	EqP-based screening value
Bis(2-chloroethyl)ether	NA	---	---

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Semi-Volatile Organics (ug/kg) (cont.):			
Bis(2-ethylhexyl)phthalate	182	MacDonald 1994	TEL
Butylbenzylphthalate	63	Buchman 1999	AET
Carbazole	NA	---	---
Chlorobenzilate	NA	---	---
Chrysene	108	MacDonald 1994	TEL
Diallate	NA	---	---
Dibenzo(a,h)anthracene	6.22	MacDonald 1994	TEL
Dibenzofuran	110	Buchman 1999	AET
Diethylphthalate	6	Buchman 1999	AET
Dimethylphthalate	6	Buchman 1999	AET
Di-n-butylphthalate	58	Buchman 1999	AET
Di-n-octylphthalate	61	Buchman 1999	AET
Diphenylamine	NA	---	---
Ethyl methanesulfonate	NA	---	---
Fluoranthene	113	MacDonald 1994	TEL
Fluorene	21.2	MacDonald 1994	TEL
Hexachlorobenzene	6	Buchman 1999	AET
Hexachlorobutadiene	1.3	Buchman 1999	AET
Hexachlorocyclopentadiene	139	EPA 1993a	EqP-based screening value
Hexachloroethane	73	Buchman 1999	AET
Hexachlorophene	NA	---	---
Hexachloropropene	NA	---	---
Indeno(1,2,3-cd)pyrene	600	Buchman 1999	AET
Isophorone	60.5	EPA 1993a	EqP-based screening value
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Naphthalene	34.6	MacDonald 1994	TEL
n-Nitrosodiethylamine	9,787	EPA 1993a	EqP-based screening value
n-Nitrosodimethylamine	90.9	EPA 1993a	EqP-based screening value

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Semi-Volatile Organics (ug/kg) (cont.):			
n-Nitroso-di-n-butylamine	772,367	EPA 1993a	EqP-based screening value
n-Nitroso-di-n-propylamine	78,522	EPA 1993a	EqP-based screening value
n-Nitrosodiphenylamine	28	Buchman 1999	AET
n-Nitrosomethylethylamine	2,517	EPA 1993a	EqP-based screening value
n-Nitrosomorpholine	NA	---	---
n-Nitrosopiperidine	NA	---	---
n-Nitrosopyrrolidine	NA	---	---
o-Toluidine	83.1	EPA 1993a	EqP-based screening value
p-Dimethylaminoazobenzene	NA	---	---
Pentachlorobenzene	191,183	EPA 1993a	EqP-based screening value
Pentachloronitrobenzene	91.1	EPA 1993a	EqP-based screening value
Pentachlorophenol	17	Buchman 1999	AET
Phenacetin	NA	---	---
Phenanthrene	86.7	MacDonald 1994	TEL
Phenol	130	Buchman 1999	AET
p-Phenylenediamine	NA	---	---
Pronamide	988	EPA 1993a	EqP-based screening value
Pryridine	22.8	EPA 1993a	EqP-based screening value
Pyrene	153	MacDonald 1994	TEL
Safrole	NA	---	---
sym-Trinitrobenzne	NA	---	---
PCBs (ug/kg):			
Aroclor-1016	21.6	MacDonald 1994	TEL
Aroclor-1221	21.6	MacDonald 1994	TEL
Aroclor-1232	21.6	MacDonald 1994	TEL
Aroclor-1242	21.6	MacDonald 1994	TEL
Aroclor-1248	21.6	MacDonald 1994	TEL
Aroclor-1254	21.6	MacDonald 1994	TEL
Aroclor-1260	21.6	MacDonald 1994	TEL

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Organochlorine Pesticides (ug/kg):			
4,4'-DDD	1.22	MacDonald 1994	TEL
4,4'-DDE	2.07	MacDonald 1994	TEL
4,4'-DDT	1.0	MacDonald 1994	ER-L
Aldrin	9.5	Buchman 1999	AET
alpha-chlordane	0.5	MacDonald 1994	ER-L value for total chlordane
gamma-chlordane	0.5	MacDonald 1994	ER-L value for total chlordane
Dieldrin	0.02	MacDonald 1994	ER-L
Endosulfan I	0.9	EPA 1993a	EqP-based screening value
Endosulfan II	0.9	EPA 1993a	EqP-based screening value
Endosulfan sulfate	NA	---	---
Endrin	9.4	EPA 1993a	EqP-based screening value
Endrin aldehyde	NA	---	---
Heptachlor	0.3	Buchman 1999	AET
Heptachlor epoxide	2.96	EPA 1993a	EqP-based screening value
Kepone	42.2	EPA 1993a	EqP-based screening value
Isodrin	NA	---	---
Methoxychlor	29.6	EPA 1993a	EqP-based screening value
Toxaphene	536	EPA 1993a	EqP-based screening value
alpha-BHC	272	EPA 1993a	EqP-based screening value
beta-BHC	NA	---	---
delta-BHC	14.7	EPA 1993a	EqP-based screening value
gamma-BHC (lindane)	0.32	MacDonald 1994	TEL
Organophosphorous pesticides (ug/kg):			
Dimethoate	0.0001	EPA 1993a	EqP-based screening value
Disulfoton	605	EPA 1993a	EqP-based screening value
Famphur	NA	---	---
Methyl parathion	NA	---	---
O,O,O-Triethylphosphorothioate	NA	---	---
Parathion	10.4	EPA 1993a	EqP-based screening value
Thionazin	NA	---	---

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Organophosphorous pesticides (ug/kg)(cont.):			
Phorate	5.01	EPA 1993a	EqP-based screening value
Sulfotep	NA	---	---
Chlorinated Herbicides (ug/kg):			
2,4,5-T	1,795	EPA 1993a	EqP-based screening value
2,4,5-TP (Silvex)	1,328	EPA 1993a	EqP-based screening value
2,4-D	67.7	EPA 1993a	EqP-based screening value
Explosives (ug/kg):			
1,3,5-Trinitrobenzene	NA	---	---
1,3-Dinitrobenzene	NA	---	---
2,4,6-Trinitrotoluene	NA	---	---
2,4-Dinitrotoluene	350	EPA 1993a	EqP-based screening value
2,6-Dinitrotoluene	NA	---	---
2-Nitrotoluene	NA	---	---
3-Nitrotoluene	NA	---	---
4-Nitrotoluene	NA	---	---
2-amino-4,6-Dinitrotoluene	NA	---	---
4-amino-4,6-Dinitrotoluene	NA	---	---
HMX	NA	---	---
Methyl-2,4,6-trinitrophenylnitramine	NA	---	---
Nitrobenzene	21	Buchman 1999	AET
RDX	NA	---	---
Tetryl (nitramine)	NA	---	---
Dioxins/Furans (ug/kg):			
2,3,7,8-TCDD	0.0036	Buchman 1999	AET
Total HxCDD	NA	---	---
Total HxCDF	NA	---	---
Total PeCDD	NA	---	---
Total PeCDF	NA	---	---
Total TCDD	NA	---	---
Total TCDF	NA	---	---

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment ⁽¹⁾
Inorganics (mg/kg):			
Antimony	2.00	Long and Morgan 1991	ER-L
Arsenic	7.24	MacDonald 1994	TEL
Barium	48	Buchman 1999	AET
Beryllium	NA	---	---
Cadmium	0.68	MacDonald 1994	TEL
Chromium (total)	52.3	MacDonald 1994	TEL
Cobalt	10	Buchman 1999	AET
Copper	18.7	MacDonald 1994	TEL
Lead	30.2	MacDonald 1994	TEL
Mercury	0.13	MacDonald 1994	TEL
Nickel	15.9	MacDonald 1994	TEL
Selenium	1.0	Buchman 1999	AET
Silver	0.73	MacDonald 1994	TEL
Thallium	NA	---	---
Tin	3.4	Buchman 1999	AET
Vanadium	57	Buchman 1999	AET
Zinc	124	MacDonald	TEL

Notes:

NA = Not Available

EqP = Equilibrium Partitioning

ER-L = Effects Range-Low

AET = Apparent Effects Threshold

TEL Threshold Effects Level

⁽¹⁾ EqP-based sediment screening values were calculated from the following equation:

$SV_{sed} = (K_{oc})(f_{oc})(SV_{sw})$ where K_{oc} is the organic carbon partition coefficient (L/kg), f_{oc} is the fraction of organic carbon (unitless), and SV_{sw} is the surface water screening value (ug/L). An F_{oc} of 0.01 was assumed.

TABLE 6-1
CONSERVATIVE SOIL BIOACCUMULATION FACTORS FOR TERRESTRIAL PLANTS AND INVERTEBRATES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Volatile Organics:				
1,1,1,2-Tetrachloroethane	1.1691	Travis and Arms 1988	1	Assumed
Carbon Tetrachloride	1.0234	Travis and Arms 1988	1	Assumed
Chlorobenzene	0.8608	Travis and Arms 1988	1	Assumed
Chloroform	3.0077	Travis and Arms 1988	1	Assumed
Ethylbenzene	0.593	Travis and Arms 1988	1	Assumed
n-Butylbenzene	0.1139	Travis and Arms 1988	1	Assumed
n-Propylbenzene	0.2852	Travis and Arms 1988	1	Assumed
Pentachloroethane	0.6597	Travis and Arms 1988	1	Assumed
Styrene	0.7739	Travis and Arms 1988	1	Assumed
Toluene	0.9966	Travis and Arms 1988	1	Assumed
Trichloroethene	1.051	Travis and Arms 1988	1	Assumed
o-Xylene	0.601	Travis and Arms 1988	1	Assumed
m-Xylene	0.5475	Travis and Arms 1988	1	Assumed
p-Xylene	0.5698	Travis and Arms 1988	1	Assumed
Semi-Volatile Organics:				
1,2,4,5-Tetrachlorobenzene	0.0806	Travis and Arms 1988	1	Assumed
1,2,4-Trichlorobenzene	0.1863	Travis and Arms 1988	0.56	Beyer 1996
1,2-Dichlorobenzene	0.4031	Travis and Arms 1988	1	Assumed
1,3-Dichlorobenzene	0.3673	Travis and Arms 1988	1	Assumed
1,4,-Dichlorobenzene	0.4085	Travis and Arms 1988	1	Assumed
2,3,4,6-Tetrachlorophenol	0.1037	Travis and Arms 1988	1	Assumed
2,4,5-Trichlorophenol	0.2157	Travis and Arms 1988	8.4	van Gestel and Ma 1988
2,4,6-Trichlorophenol	0.2814	Travis and Arms 1988	1	Assumed
2,4-Dichlorophenol	0.6423	Travis and Arms 1988	1	Assumed
2-Acetylaminofluorene	0.609	Travis and Arms 1988	1	Assumed
2-Chloronaphthalene	0.1653	Travis and Arms 1988	1	Assumed
2-Methylnaphthalene	0.2157	Travis and Arms 1988	0.2	Beyer and Stafford 1993
2-sec-butyl-4,6-Dinitrophenol	0.2852	Travis and Arms 1988	1	--
3,3'-Dichlorobenzidine	0.3624	Travis and Arms 1988	1	--

TABLE 6-1
CONSERVATIVE SOIL BIOACCUMULATION FACTORS FOR TERRESTRIAL PLANTS AND INVERTEBRATES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Semi-Volatile Organics (cont.):				
3,3'-Dimethylbenzidine	1.0938	Travis and Arms 1988	1	Assumed
3-Methylcholanthrene	0.0075	Travis and Arms 1988	1	Assumed
4-Bromophenyl phenyl ether	0.0499	Travis and Arms 1988	1	Assumed
4-Chloro-3-methylphenol	0.6255	Travis and Arms 1988	1	Assumed
4-Chlorophenyl-Phenylether	0.0533	Travis and Arms 1988	1	Assumed
7,12-Dimethylbenz(a)anthracene	0.0058	Travis and Arms 1988	1	Assumed
Acenaphthene	0.21	Travis and Arms 1988	0.3	Beyer and Stafford 1993
Acenaphthylene	0.1653	Travis and Arms 1988	0.22	Beyer and Stafford 1993
Anthracene	0.0908	Travis and Arms 1988	0.32	Beyer and Stafford 1993
Aramite	0.0634	Travis and Arms 1988	1	Assumed
Benzo(a)anthracene	0.0197	Travis and Arms 1988	0.27	Beyer and Stafford 1993
Benzo(a)pyrene	0.0114	Travis and Arms 1988	0.34	Beyer and Stafford 1993
Benzo(b)fluoranthene	0.0101	Travis and Arms 1988	0.21	Beyer and Stafford 1993
Benzo(g,h,i)perylene	0.0052	Travis and Arms 1988	0.15	Beyer and Stafford 1993
Benzo(k)fluoranthene	0.0101	Travis and Arms 1988	0.21	Beyer and Stafford 1993
Bis(2-ethylhexyl)phthalate	0.0023	Travis and Arms 1988	1	Assumed
Butylbenzylphthalate	0.0617	Travis and Arms 1988	1	Assumed
Carbazole	0.3258	Travis and Arms 1988	1	Assumed
Chlorobenzilate	0.1139	Travis and Arms 1988	1	Assumed
Chrysene	0.0197	Travis and Arms 1988	0.44	Beyer and Stafford 1993
Diallate	0.0983	Travis and Arms 1988	1	Assumed
Dibenzo(a,h)anthracene	0.0053	Travis and Arms 1988	0.49	Beyer and Stafford 1993
Dibenzofuran	0.1447	Travis and Arms 1988	1	Assumed
Diethylphthalate	1.39	Travis and Arms 1988	1	Assumed
Di-n-butylphthalate	0.0838	Travis and Arms 1988	1	Assumed
Di-n-octylphthalate	0.0008	Travis and Arms 1988	1	Assumed
Diphenylamine	0.3772	Travis and Arms 1988	1	Assumed
Fluoranthene	0.0425	Travis and Arms 1988	0.37	Beyer and Stafford 1993
Fluorene	0.1428	Travis and Arms 1988	0.2	Beyer and Stafford 1993
Hexachlorobenzene	0.0153	Travis and Arms 1988	1.69	Beyer 1996

TABLE 6-1
CONSERVATIVE SOIL BIOACCUMULATION FACTORS FOR TERRESTRIAL PLANTS AND INVERTEBRATES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Semi-Volatile Organics (cont.):				
Hexachlorobutadiene	0.0642	Travis and Arms 1988	1	Assumed
Hexachlorocyclopentadiene	0.0297	Travis and Arms 1988	1	Assumed
Hexachloroethane	0.1888	Travis and Arms 1988	1	Assumed
Hexachlorophene	0.0017	Travis and Arms 1988	1	Assumed
Hexachloropropene	0.1139	Travis and Arms 1988	1	Assumed
Indeno(1,2,3-cd)pyrene	0.0056	Travis and Arms 1988	0.41	Beyer and Stafford 1993
Isosafrole	0.4367	Travis and Arms 1988	1	Assumed
Naphthalene	0.4425	Travis and Arms 1988	0.21	Beyer and Stafford 1993
n-Nitrosodiphenylamine	0.5775	Travis and Arms 1988	1	Assumed
p-Dimethylaminoazobenzene	0.0872	Travis and Arms 1988	1	Assumed
Pentachlorobenzene	0.0353	Travis and Arms 1988	1	Assumed
Pentachloronitrobenzene	0.0806	Travis and Arms 1988	1	Assumed
Pentachlorophenol	0.0443	Travis and Arms 1988	8	van Gestel and Ma 1988
Phenanthrene	0.0908	Travis and Arms 1988	0.28	Beyer and Stafford 1993
Pronamide	0.3624	Travis and Arms 1988	1	Assumed
Pyrene	0.0431	Travis and Arms 1988	0.39	Beyer and Stafford 1993
PCBs:				
Aroclor-1016	0.0224	Travis and Arms 1988	15.91	Sample et al. 1998a
Aroclor-1221	0.0744	Travis and Arms 1988	15.91	Sample et al. 1998a
Aroclor-1232	0.0437	Travis and Arms 1988	15.91	Sample et al. 1998a
Aroclor-1242	0.0224	Travis and Arms 1988	15.91	Sample et al. 1998a
Aroclor-1248	0.0101	Travis and Arms 1988	15.91	Sample et al. 1998a
Aroclor-1254	0.0068	Travis and Arms 1988	15.91	Sample et al. 1998a
Aroclor-1260	0.0045	Travis and Arms 1988	15.91	Sample et al. 1998a
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
alpha-chlordane	0.0086	Travis and Arms 1988	3	Menzie et al. 1992

TABLE 6-1
CONSERVATIVE SOIL BIOACCUMULATION FACTORS FOR TERRESTRIAL PLANTS AND INVERTEBRATES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Organochlorine Pesticides (cont.):				
gamma-chlordane	0.0086	Travis and Arms 1988	3	Menzie et al. 1992
Dieldrin	0.0305	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	0.2814	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
Kepone	0.0335	Travis and Arms 1988	1	Assumed
Isodrin	0.0049	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	0.1653	Travis and Arms 1988	1	Assumed
gamma-BHC (lindane)	0.2704	Travis and Arms 1988	1	Assumed
Organophosphorous Pesticides:				
Disulfoton	0.1934	Travis and Arms 1988	1	Assumed
Methyl parathion	0.8162	Travis and Arms 1988	1	Assumed
Parathion	0.8162	Travis and Arms 1988	1	Assumed
Phorate	0.2431	Travis and Arms 1988	1	Assumed
Sulfotep	0.1024	Travis and Arms 1988	1	Assumed
Chlorinated Herbicides:				
2,4,5-T	0.4730	Travis and Arms 1988	1	Assumed
2,4,5-TP (Silvex)	0.4140	Travis and Arms 1988	1	Assumed
2,4-D	1.0651	Travis and Arms 1988	1	Assumed

TABLE 6-1
CONSERVATIVE SOIL BIOACCUMULATION FACTORS FOR TERRESTRIAL PLANTS AND INVERTEBRATES
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Dioxins (ug/kg):				
2,3,7,8-TCDD	0.002	Travis and Arms 1988	22.23	Sample et al. 1998a
Total HxCDD	1	Travis and Arms 1988	1	Assumed
Total HxCDF	1	Travis and Arms 1988	1	Assumed
Total PeCDD	1	Travis and Arms 1988	1	Assumed
Total PeCDF	1	Travis and Arms 1988	1	Assumed
Total TCDD	0.002	Travis and Arms 1988	22.23	Sample et al. 1998a
Total TCDF	1	Travis and Arms 1988	1	Assumed
Inorganics (mg/kg):				
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
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 6-2
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Omnivore BCF (dry weight)	
	Value	Reference
Volatile Organics:		
1,1,1,2-Tetrachloroethane	---	see text
Carbon Tetrachloride	---	see text
Chlorobenzene	---	see text
Chloroform	---	see text
Ethylbenzene	---	see text
n-Butylbenzene	---	see text
n-Propylbenzene	---	see text
Pentachloroethane	---	see text
Styrene	---	see text
Toluene	---	see text
Trichloroethene	---	see text
o-Xylene	---	see text
m-Xylene	---	see text
p-Xylene	---	see text
Semi-Volatile Organics:		
1,2,4,5-Tetrachlorobenzene	---	see text
1,2,4-Trichlorobenzene	---	see text
1,2-Dichlorobenzene	---	see text
1,3-Dichlorobenzene	---	see text
1,4,-Dichlorobenzene	---	see text
2,3,4,6-Tetrachlorophenol	---	see text
2,4,5-Trichlorophenol	---	see text
2,4,6-Trichlorophenol	---	see text
2,4-Dichlorophenol	---	see text
2-Acetylaminofluorene	---	see text
2-Chloronaphthalene	---	see text
2-Methylnaphthalene	---	see text
2-sec-butyl-4,6-Dinitrophenol	---	see text
3,3'-Dichlorobenzidine	---	see text
3,3'-Dimethylbenzidine	---	see text
3-Methylcholanthrene	---	see text
4-Bromophenyl phenyl ether	---	see text
4-Chloro-3-methylphenol	---	see text
4-Chlorophenyl-Phenylether	---	see text
7,12-Dimethylbenz(a)anthracene	---	see text
Acenaphthene	---	see text
Acenaphthylene	---	see text
Anthracene	---	see text
Aramite	---	see text
Benzo(a)anthracene	---	see text
Benzo(a)pyrene	---	see text
Benzo(b)fluoranthene	---	see text
Benzo(g,h,i)perylene	---	see text

TABLE 6-2
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Omnivore BCF (dry weight)	
	Value	Reference
Semi-Volatile Organics (cont.):		
Benzo(k)fluoranthene	---	see text
Bis(2-ethylhexyl)phthalate	---	see text
Butylbenzylphthalate	---	see text
Carbazole	---	see text
Chlorobenzilate	---	see text
Chrysene	---	see text
Diallate	---	see text
Dibenzo(a,h)anthracene	---	see text
Dibenzofuran	---	see text
Diethylphthalate	---	see text
Di-n-butylphthalate	---	see text
Di-n-octylphthalate	---	see text
Diphenylamine	---	see text
Fluoranthene	---	see text
Fluorene	---	see text
Hexachlorobenzene	---	see text
Hexachlorobutadiene	---	see text
Hexachlorocyclopentadiene	---	see text
Hexachloroethane	---	see text
Hexachlorophene	---	see text
Hexachloropropene	---	see text
Indeno(1,2,3-cd)pyrene	---	see text
Isosafrole	---	see text
Naphthalene	---	see text
n-Nitrosodiphenylamine	---	see text
p-Dimethylaminoazobenzene	---	see text
Pentachlorobenzene	---	see text
Pentachloronitrobenzene	---	see text
Pentachlorophenol	---	see text
Phenanthrene	---	see text
Pronamide	---	see text
Pyrene	---	see text
PCBs:	---	see text
Aroclor-1016	---	see text
Aroclor-1221	---	see text
Aroclor-1232	---	see text
Aroclor-1242	---	see text
Aroclor-1248	---	see text
Aroclor-1254	---	see text
Aroclor-1260	---	see text
Organochlorine Pesticides:		
4,4'-DDD	---	see text
4,4'-DDE	---	see text
4,4'-DDT	---	see text

TABLE 6-2
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Omnivore BCF (dry weight)	
	Value	Reference
Organochlorine Pesticides (cont.):		
Aldrin	---	see text
alpha-chlordane	---	see text
gamma-chlordane	---	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
Kepone	---	see text
Isodrin	---	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
Organophosphorous Pesticides:		
Disulfoton	---	see text
Methyl parathion	---	see text
Parathion	---	see text
Phorate	---	see text
Sulfotep	---	see text
Chlorinated Herbicides:		
2,4,5-T	---	see text
2,4,5-TP (Silvex)	---	see text
2,4-D	---	see text
Dioxins (ug/kg):		
2,3,7,8-TCDD	2.2	Sample et al. 1998b
Total HxCDD	---	see text
Total HxCDF	---	see text
Total PeCDD	---	see text
Total PeCDF	---	see text
Total TCDD	2.2	Sample et al. 1998b
Total TCDF	---	see text

TABLE 6-2
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Omnivore BCF (dry weight)	
	Value	Reference
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:

BCF = Bioconcentration Factor

BAF = Bioaccumulation Factor

TABLE 6-3
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS FOR AQUATIC INVERTEBRATES AND FISH
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Volatile Organics:				
1,1,1,2-Tetrachloroethane	1	Assumed	1	Assumed
Carbon Tetrachloride	1	Assumed	1	Assumed
Chlorobenzene	1	Assumed	1	Assumed
Chloroform	1	Assumed	1	Assumed
Ethylbenzene	1	Assumed	1	Assumed
n-Butylbenzene	1	Assumed	1	Assumed
n-Propylbenzene	1	Assumed	1	Assumed
Pentachloroethane	1	Assumed	1	Assumed
Styrene	1	Assumed	1	Assumed
Toluene	1	Assumed	1	Assumed
Trichloroethene	1	Assumed	1	Assumed
o-Xylene	1	Assumed	1	Assumed
m-Xylene	1	Assumed	1	Assumed
p-Xylene	1	Assumed	1	Assumed
Semi-Volatile Organics:				
1,2,4,5-Tetrachlorobenzene	1	Assumed	1	Assumed
1,2,4-Trichlorobenzene	1	Assumed	1	Assumed
1,2-Dichlorobenzene	1	Assumed	1	Assumed
1,3-Dichlorobenzene	1	Assumed	1	Assumed
1,4,-Dichlorobenzene	1	Assumed	1	Assumed
2,3,4,6-Tetrachlorophenol	1	Assumed	1	Assumed
2,4,5-Trichlorophenol	1	Assumed	1	Assumed
2,4,6-Trichlorophenol	1	Assumed	1	Assumed
2,4-Dichlorophenol	1	Assumed	1	Assumed
2-Acetylaminofluorene	1	Assumed	1	Assumed
2-Chloronaphthalene	1	Assumed	1	Assumed
2-Methylnaphthalene	1	Assumed	1	Assumed
2-sec-butyl-4,6-Dinitrophenol	1	Assumed	1	Assumed
3,3'-Dichlorobenzidine	1	Assumed	1	Assumed

TABLE 6-3
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS FOR AQUATIC INVERTEBRATES AND FISH
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Semi-Volatile Organics (cont.):				
3,3'-Dimethylbenzidine	1	Assumed	1	Assumed
3-Methylcholanthrene	1	Assumed	1	Assumed
4-Bromophenyl phenyl ether	1	Assumed	1	Assumed
4-Chloro-3-methylphenol	1	Assumed	1	Assumed
4-Chlorophenyl-Phenylether	1	Assumed	1	Assumed
7,12-Dimethylbenz(a)anthracene	1	Assumed	1	Assumed
Acenaphthene	2.04	Maruya et al. 1997	1	Assumed
Acenaphthylene	1	Assumed	1	Assumed
Anthracene	0.271	Maruya et al. 1997	1	Assumed
Aramite	1	Assumed	1	Assumed
Benzo(a)anthracene	1.4	Maruya et al. 1997	1	Assumed
Benzo(a)pyrene	0.191	Maruya et al. 1997	1	Assumed
Benzo(b)fluoranthene	0.16	Maruya et al. 1997	1	Assumed
Benzo(g,h,i)perylene	0.295	Maruya et al. 1997	1	Assumed
Benzo(k)fluoranthene	0.421	Maruya et al. 1997	1	Assumed
Bis(2-ethylhexyl)phthalate	1	Assumed	1	Assumed
Butylbenzylphthalate	1	Assumed	1	Assumed
Carbazole	1	Assumed	1	Assumed
Chlorobenzilate	1	Assumed	1	Assumed
Chrysene	0.335	Maruya et al. 1997	1	Assumed
Diallate	1	Assumed	1	Assumed
Dibenzo(a,h)anthracene	1	Assumed	1	Assumed
Dibenzofuran	1	Assumed	1	Assumed
Diethylphthalate	1	Assumed	1	Assumed
Di-n-butylphthalate	1	Assumed	1	Assumed
Di-n-octylphthalate	1	Assumed	1	Assumed
Diphenylamine	1	Assumed	1	Assumed
Fluoranthene	0.312	Maruya et al. 1997	1	Assumed
Fluorene	1.13	Maruya et al. 1997	1	Assumed
Hexachlorobenzene	1	Assumed	1	Assumed

TABLE 6-3
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS FOR AQUATIC INVERTEBRATES AND FISH
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Semi-Volatile Organics (cont.):				
Hexachlorobutadiene	1	Assumed	1	Assumed
Hexachlorocyclopentadiene	1	Assumed	1	Assumed
Hexachloroethane	1	Assumed	1	Assumed
Hexachlorophene	1	Assumed	1	Assumed
Hexachloropropene	1	Assumed	1	Assumed
Indeno(1,2,3-cd)pyrene	0.355	Maruya et al. 1997	1	Assumed
Isosafrole	1	Assumed	1	Assumed
Naphthalene	1	Assumed	1	Assumed
n-Nitrosodiphenylamine	1	Assumed	1	Assumed
p-Dimethylaminoazobenzene	1	Assumed	1	Assumed
Pentachlorobenzene	1	Assumed	1	Assumed
Pentachloronitrobenzene	1	Assumed	1	Assumed
Pentachlorophenol	1	Assumed	1	Assumed
Phenanthrene	0.652	Maruya et al. 1997	1	Assumed
Pronamide	1	Assumed	1	Assumed
Pyrene	0.803	Maruya et al. 1997	1	Assumed
PCBs:				
Aroclor-1016	21.89	Bechtel Jacobs 1998b	11.24	Oliver and Niimi 1988
Aroclor-1221	21.89	Bechtel Jacobs 1998b	11.24	Oliver and Niimi 1988
Aroclor-1232	21.89	Bechtel Jacobs 1998b	11.24	Oliver and Niimi 1988
Aroclor-1242	21.89	Bechtel Jacobs 1998b	11.24	Oliver and Niimi 1988
Aroclor-1248	21.89	Bechtel Jacobs 1998b	11.24	Oliver and Niimi 1988
Aroclor-1254	21.89	Bechtel Jacobs 1998b	11.24	Oliver and Niimi 1988
Aroclor-1260	21.89	Bechtel Jacobs 1998b	11.24	Oliver and Niimi 1988
Organochlorine Pesticides:				
4,4'-DDD	0.5	Oliver 1987	2.61	Oliver and Niimi 1988
4,4'-DDE	4.3	Oliver 1987	20.39	Oliver and Niimi 1988
4,4'-DDT	0.5	Oliver 1987	9.11	Oliver and Niimi 1988
Aldrin	1	Assumed	1	Assumed
alpha-chlordane	1	Assumed	1	Assumed

TABLE 6-3
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS FOR AQUATIC INVERTEBRATES AND FISH
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Organochlorine Pesticides (cont.):				
gamma-chlordane	1	Assumed	1	Assumed
Dieldrin	1	Assumed	1	Assumed
Endosulfan I	1	Assumed	1	Assumed
Endosulfan II	1	Assumed	1	Assumed
Endosulfan sulfate	1	Assumed	1	Assumed
Endrin	1	Assumed	1	Assumed
Endrin aldehyde	1	Assumed	1	Assumed
Heptachlor	1	Assumed	1	Assumed
Heptachlor epoxide	1	Assumed	1	Assumed
Kepone	1	Assumed	1	Assumed
Isodrin	1	Assumed	1	Assumed
Methoxychlor	1	Assumed	1	Assumed
Toxaphene	1	Assumed	1	Assumed
alpha-BHC	1	Assumed	1	Assumed
beta-BHC	1	Assumed	1	Assumed
delta-BHC	1	Assumed	1	Assumed
gamma-BHC (lindane)	1	Assumed	1	Assumed
Organophosphorous Pesticides:				
Disulfoton	1	Assumed	1	Assumed
Methyl parathion	1	Assumed	1	Assumed
Parathion	1	Assumed	1	Assumed
Phorate	1	Assumed	1	Assumed
Sulfotep	1	Assumed	1	Assumed
Chlorinated Herbicides:				
2,4,5-T	1	Assumed	1	Assumed
2,4,5-TP (Silvex)	1	Assumed	1	Assumed
2,4-D	1	Assumed	1	Assumed

TABLE 6-3
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS FOR AQUATIC INVERTEBRATES AND FISH
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Dioxins (ug/kg):				
2,3,7,8-TCDD	0.3868	USEPA 1990	0.3868	USEPA 1990
Total HxCDD	1	Assumed	1	Assumed
Total HxCDF	1	Assumed	1	Assumed
Total PeCDD	1	Assumed	1	Assumed
Total PeCDF	1	Assumed	1	Assumed
Total TCDD	0.3868	USEPA 1990	0.3868	USEPA 1990
Total TCDF	1	Assumed	1	Assumed
Inorganics:				
Antimony	1	Assumed	1	Assumed
Arsenic	0.675	Bechtel Jacobs 1998b	0.126	Pascoe et al. 1996
Barium	1	Assumed	1	Assumed
Beryllium	1	Assumed	1	Assumed
Cadmium	3.073	Bechtel Jacobs 1998b	0.164	Pascoe et al. 1996
Chromium (total)	0.186	Bechtel Jacobs 1998b	0.038	Krantzberg and Boyd 1992
Cobalt	1	Assumed	1	Assumed
Copper	7.957	Bechtel Jacobs 1998b	0.1	Krantzberg and Boyd 1992
Lead	0.326	Bechtel Jacobs 1998b	0.07	Krantzberg and Boyd 1992
Mercury	1.735	Bechtel Jacobs 1998b	4.58	Cope et al. 1990
Nickel	0.214	Bechtel Jacobs 1998b	1	Assumed
Selenium	1	Assumed	1	Assumed
Silver	0.18	Hirsch 1998	1	Assumed
Thallium	1	Assumed	1	Assumed
Tin	1	Assumed	1	Assumed
Vanadium	1	Assumed	1	Assumed
Zinc	4.759	Bechtel Jacobs 1998b	0.147	Pascoe et al. 1996

Notes:

BAF = Bioaccumulation Factor

TABLE 6-4
SURFACE WATER BIOACCUMULATION FACTORS USED FOR SALTWATER FISH
WMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical ⁽¹⁾	Water-Fish BAF (dry weight)	
	Value	Reference
Inorganics:		
Antimony	1 ⁽²⁾	Sample et al. 1996
Arsenic	4 ⁽²⁾	EPA 1985a
Barium	95 ⁽²⁾	SRC 2000
Beryllium	19	Sample et al. 1996
Cadmium	2,213	EPA 1985b
Chromium	3 ⁽²⁾	Sample et al. 1996
Cobalt	190 ⁽²⁾	EPA 2000b
Copper	290 ⁽²⁾	Sample et al. 1996
Lead	45	Sample et al. 1996
Mercury	27,900 ⁽³⁾	Sample et al. 1996
Nickel	106	Sample et al. 1996
Selenium	2,600 ⁽³⁾	Sample et al. 1996
Silver	150	EPA 1987
Thallium	34	Sample et al. 1996
Tin	85	SRC 2000
Vanadium	153	SRC 2000
Zinc	966 ⁽³⁾	Sample et al. 1996

Notes:

BAF = Bioaccumulation Factor

- ⁽¹⁾ The chemicals shown are limited to the Appendix IX metals. For metals, only those detected in the dissolved (filtered) fraction will be evaluated for food web exposures.
- ⁽²⁾ The BAF value shown is based on a surface water BCF and a food chain multiplier of 1.0.
- ⁽³⁾ The value shown is a literature-based BAF for an organometallic (methylated) form.

TABLE 6-5
CONSERVATIVE EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Receptor	Habitat	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Area Use Factor
		Value	Reference	Value	Reference	
Birds: American robin	Terrestrial	0.0635	EPA 1993b	0.00735	Levey and Karasov 1989	1.0
Belted kingfisher	Aquatic	0.125	Dunning 1993	0.02666	EPA 1993b	1.0
Great blue heron	Aquatic	2.1	Butler 1992	0.43894	Allometric equation from Kushlan 1978 for wading birds	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	EPA 1993b	0.04308	Sample and Suter II 1994	1.0
Spotted sandpiper	Aquatic	0.0294	Dunning 1993	0.00930	Allometric equation from Nagy 1987 for all birds	1.0

TABLE 6-6
DIETARY COMPOSITION FOR UPPER TROPHIC LEVEL RECEPTORS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Receptor	Dietary Composition (percent)						Soil/ Sediment Ingestion (percent)		
	Terr. Plants	Soil Invert.	Small Mammals	Fish	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
Belted kingfisher	0	0	0	92.6	0	4.9	EPA 1993b	2.5	Assumed
Double-crested cormorant	0	0	0	100	0	0	Bivings et al. 1989	0	Assumed
Great blue heron	0	0	0	93.6	0	3.9	EPA 1993b	2.5	Assumed
Mourning dove	95	0	0	0	0	0	Tomlinson et al. 1994	5	Assumed
Red-tailed hawk	0	0	97.5	0	0	0	EPA 1993b; Sample and Suter II 1994	2.5	Assumed
Spotted sandpiper	0	0	0	0	0	81.9	EPA 1993b	18.1	Beyer et al. 1994
Mammal:									
West indian Manatee	0	0	0	0	99	0	USFWS 1986 and Odell 1992	1	USGS 2000
Mammals (Prey Items):									
Small Mammal Omnivore	49	49	0	0	0	0	Assumed	2	Assumed

Notes:

⁽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).

TABLE 6-7
INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
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
Volatile Organics:										
1,1,1,2-Tetrachloroethane	---	---	---	---	---	---	NA	NA	---	---
Carbon tetrachloride	---	---	---	---	---	---	NA	NA	---	---
Chlorobenzene	---	---	---	---	---	---	NA	NA	---	---
Chloroform	---	---	---	---	---	---	NA	NA	---	---
Ethylbenzene	---	---	---	---	---	---	NA	NA	---	---
n-Butylbenzene	---	---	---	---	---	---	NA	NA	---	---
n-Propylbenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachloroethane	---	---	---	---	---	---	NA	NA	---	---
Styrene	---	---	---	---	---	---	NA	NA	---	---
Toluene	---	---	---	---	---	---	NA	NA	---	---
Trichloroethene	---	---	---	---	---	---	NA	NA	---	---
o-Xylene	Quail	0.191	Subacute	?	"Toxicity"	---	405	40.5	Hill and Camardese 1986	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
m-Xylene	Quail	0.191	Subacute	?	"Toxicity"	---	405	40.5	Hill and Camardese 1986	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
p-Xylene	Quail	0.191	Subacute	?	"Toxicity"	---	405	40.5	Hill and Camardese 1986	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Semi-Volatile Organics:										
1,2,4,5-Tetrachlorobenzene	---	---	---	---	---	---	NA	NA	---	---
1,2,4-Trichlorobenzene	---	---	---	---	---	---	NA	NA	---	---
1,2-Dichlorobenzene	Northern bobwhite	0.157	14 days	Oral (gavage)	Growth/mortality	?	2,500	250	Grimes and Jaber 1989	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
1,3-Dichlorobenzene	Northern bobwhite	0.157	14 days	Oral (gavage)	Growth/mortality	?	2,500	250	Grimes and Jaber 1989	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
1,4-Dichlorobenzene	Northern bobwhite	0.157	14 days	Oral (gavage)	Growth/mortality	?	2,500	250	Grimes and Jaber 1989	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
2,3,4,6-Tetrachlorophenol	---	---	---	---	---	---	NA	NA	---	---
2,4,5-Trichlorophenol	---	---	---	---	---	---	NA	NA	---	---
2,4,6-Trichlorophenol	---	---	---	---	---	---	NA	NA	---	---
2,4-Dichlorophenol	---	---	---	---	---	---	NA	NA	---	---
2-Acetylaminofluorene	---	---	---	---	---	---	NA	NA	---	---
2-Chloronaphthalene	---	---	---	---	---	---	NA	NA	---	---
2-Methylnaphthalene	---	---	---	---	---	---	NA	NA	---	---
2-sec-butyl-4,6-dinitrophenol	---	---	---	---	---	---	NA	NA	---	---
3,3'-Dichlorobenzidine	---	---	---	---	---	---	NA	NA	---	---
3,3-Dimethylbenzidine	---	---	---	---	---	---	NA	NA	---	---
3-Methylcholanthrene	---	---	---	---	---	---	NA	NA	---	---
4-Bromophenyl phenyl ether	---	---	---	---	---	---	NA	NA	---	---
4-Chloro-3-methylphenol	---	---	---	---	---	---	NA	NA	---	---
4-Chlorophenyl phenyl ether	---	---	---	---	---	---	NA	NA	---	---
7-12-Dimethyl benz(a)anthracene	---	---	---	---	---	---	NA	NA	---	---
Acenaphthene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Acenaphthylene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Anthracene	Mallard duck	1.043	7 months	Oral in diet	Hepatic	Not Applicable	228	22.8	Patton and Dieter 1980	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant

TABLE 6-7
INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight		Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Ecological Receptors
		(kg)	Duration							
Semi-Volatile Organics (cont.):										
Aramite	---	---	---	---	---	---	NA	NA	---	---
Benzo(a)anthracene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Benzo(a)pyrene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Benzo(b)fluoranthene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Benzo(g,h,i)perylene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Benzo(k)fluoranthene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Bis(2-Ethylhexyl)phthalate	Ringed dove	0.155	4 weeks	Oral in diet	Reproduction	Not Applicable	11	1.1	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Butylbenzylphthalate	---	---	---	---	---	---	NA	NA	---	---
Carbazole	---	---	---	---	---	---	NA	NA	---	---
Chlorobenzilate	---	---	---	---	---	---	NA	NA	---	---
Chrysene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Diallate	---	---	---	---	---	---	NA	NA	---	---
Dibenz(a,h)anthracene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Dibenzofuran	---	---	---	---	---	---	NA	NA	---	---
Diethylphthalate	---	---	---	---	---	---	NA	NA	---	---
Di-n-butylphthalate	Ringed dove	0.155	4 weeks	Oral in diet	Reproduction	Not Applicable	1.1	0.11	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Di-n-octylphthalate	Ring-necked pheasant	1	?	?	Mortality	Not Applicable	500	50	TERRTOX 1998	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Diphenylamine	---	---	---	---	---	---	NA	NA	---	---
Fluoranthene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Fluorene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Hexachlorobenzene	Japanese quail	0.19	90 days	Oral	Reproduction	Not Applicable	0.8	0.08	Coulston and Kolbye 1994	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
	Coturnix quail	?	5 days	Oral	?	Not Applicable	2,250	225	USEPA 1999	---
Hexachlorobutadiene	Japanese quail	0.19	?	Oral	Reproduction	Not Applicable	8	2.5	Coulston and Kolbye 1994	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
	Japanese quail	?	3 months	Oral	?	Not Applicable	31,850	3,185	USEPA 1999	---
Hexachlorocyclopentadiene	---	---	---	---	---	---	NA	NA	---	---
Hexachloroethane	---	---	---	---	---	---	NA	NA	---	---
Hexachlorophene	---	---	---	---	---	---	NA	NA	---	---
Hexachloropropene	---	---	---	---	---	---	NA	NA	---	---
Indeno(1,2,3-cd)pyrene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Isosafrole	---	---	---	---	---	---	---	---	---	---

TABLE 6-7
INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight		Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Ecological Receptors
		(kg)	Duration							
Semi-Volatile Organics (cont.): Naphthalene	Mallard duck	1.04	7 months	Oral in diet	Hepatic	Not Applicable	228	22.8	Patton and Dieter 1980	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
N-Nitrosodiphenylamine	---	---	---	---	---	---	NA	NA	---	---
p-Dimethylaminoazobenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachlorobenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachloronitrobenzene	Chicken	1.5	35 weeks	Oral in diet	Reproduction	Not Applicable	70.7	7.07	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Pentachlorophenol	Chicken	1.5	8 weeks	Oral	Growth	Not Applicable	200	100	Eisler 1989	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
	Quail	?	5 days	Oral	?	Not Applicable	40,300	4,030	USEPA 1999	---
Phenanthrene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Pronamide	---	---	---	---	---	---	NA	NA	---	---
Pyrene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
PCBs:										
Aroclor-1016	Screech owl	0.181	2 generations	Oral in diet	Reproduction	Not Applicable	4.1	0.41	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Aroclor-1221	Screech owl	0.181	2 generations	Oral in diet	Reproduction	Not Applicable	4.1	0.41	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Aroclor-1232	Screech owl	0.181	2 generations	Oral in diet	Reproduction	Not Applicable	4.1	0.41	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Aroclor-1242	Screech owl	0.181	2 generations	Oral in diet	Reproduction	Not Applicable	4.1	0.41	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Aroclor-1248	Ring-necked pheasant	1	17 weeks	Oral	Reproduction	Not Applicable	1.8	0.18	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Aroclor-1254	Ring-necked pheasant	1	17 weeks	Oral	Reproduction	Not Applicable	1.8	0.18	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Aroclor-1260	Ring-necked pheasant	1	17 weeks	Oral	Reproduction	Not Applicable	1.8	0.18	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
4,4'-DDE	Brown pelican	3.5	Chronic	Oral	Reproduction	Not Applicable	1.31	0.131	Beyer et al. 1996	Double-crested cormorant
	American kestrel	0.115	2 years	Oral	Reproduction	Not Applicable	0.5	0.05	McLane and Hall 1972	American robin, mourning dove, red-tailed hawk, belted kingfisher, and great blue heron
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Aldrin	Mallard duck	1.134	Chronic	Oral	Mortality	Not Applicable	5	0.5	Tucker and Crabtree 1970	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
alpha-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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
gamma-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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant

TABLE 6-7
INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight		Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Ecological Receptors
		(kg)	Duration							
Organochlorine Pesticides (cont.):										
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Endosulfan 1	Grey partridge	0.4	4 weeks	Oral in diet	Reproduction	Not Applicable	100	10	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Endosulfan 11	Grey partridge	0.4	4 weeks	Oral in diet	Reproduction	Not Applicable	100	10	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Endosulfan sulfate	Grey partridge	0.4	4 weeks	Oral in diet	Reproduction	Not Applicable	100	10	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Heptachlor	Quail	0.191	5 days	Oral in diet	Mortality	Not Applicable				
Heptachlor epoxide	Quail	0.191	5 days	Oral in diet	Mortality	Not Applicable				
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
gamma-BHC (lindane)	Mallard duck	1	8 weeks	Oral (intubation)	Reproduction	Not Applicable	20	2	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Organophosphorous Pesticides:										
Disulfoton	---	---	---	---	---	---	NA	NA	---	---
Methyl parathion	---	---	---	---	---	---	NA	NA	---	---
Parathion	---	---	---	---	---	---	NA	NA	---	---
Phorate	---	---	---	---	---	---	NA	NA	---	---
Sulfotep	---	---	---	---	---	---	NA	NA	---	---
Chlorinated Herbicides:										
2,4,5-T	---	---	---	---	---	---	NA	NA	---	---
2,4,5-TP (Silvex)	---	---	---	---	---	---	NA	NA	---	---
2,4-D	---	---	---	---	---	---	NA	NA	---	---
Dioxins/Furans (ug/kg):										
2,3,7,8-TCDD	Ring-necked pheasant	1	10 weeks	Intraperitoneal injection	Mortality/weight gain	Not Applicable	0.00001	0.000001	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant

TABLE 6-7
INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight		Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Ecological Receptors
		(kg)	Duration							
Inorganics:										
Antimony	---	---	---	---	---	---	NA	NA	---	---
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
	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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Cobalt	Chicken	1.8	14 Days	Oral in diet	Growth	?	14.7	1.47	Diaz et al. 1994	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Lead	Japanese quail	0.15	12 weeks	Oral in diet	Reproduction	Lead acetate	11.3	1.13	Sample et al. 1996	American robin, mourning dove, belted kingfisher, great kingfisher, blue heron, and double-crested cormorant
	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	0.9	0.45	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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
	Coturnix quail	?	5 days	Oral	?	?	650	65	USEPA 1999	---
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 kingfisher, and double-crested cormorant
	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	Great blue heron
Silver	Mallard duck	?	14 days	Oral	?	?	1780	178	EPA 1999b	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
Thallium	European starling	?	acute	Oral	?	?	3.5	0.35	EPA 1999b	American robin, mourning dove, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant
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, red-tailed hawk, belted kingfisher, great blue heron, and double-crested cormorant

Notes:

NA = Not Available

NOAEL = No Observed Adverse Effect Level

LOAEL = Lowest Observed Adverse Effect Level

TABLE 6-8
INGESTION-BASED SCREENING VALUES FOR MAMMALS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
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 Receptor
Volatile Organics:										
1,1,1,2-Tetrachloroethane	---	---	---	---	---	---	---	---	---	---
Carbon tetrachloride	Rat	0.35	2 years	Oral in diet	Reproduction	Not Applicable	160	16	Sample et al. 1996	West Indian manatee
Chlorobenzene	Dog	12.7	chronic	?	Liver	Not Applicable	273	27.3	IRIS 1998	West Indian manatee
Chloroform	Rat	0.35	13 weeks	Oral (intubation)	Systemic	Not Applicable	41	15	Sample et al. 1996	West Indian manatee
	Mouse	0.03	80 weeks	Oral in diet	?	Not Applicable	600	60	USEPA 1999	---
Ethylbenzene	Rat	0.35	chronic	?	Liver/kidney	Not Applicable	971	97.1	Wolf et al. 1956	West Indian manatee
n-Butylbenzene	---	---	---	---	---	---	NA	NA	---	---
n-Propylbenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachloroethane	---	---	---	---	---	---	NA	NA	---	---
Styrene	Rat	0.35	90 days	Oral	Reproduction	Not Applicable	350	35	Beliles et al. 1985	West Indian manatee
Toluene	Mouse	0.03	GD 6-12	Oral (gavage)	Reproduction	Not Applicable	260	26	Sample et al. 1996	West Indian manatee
Trichloroethene	Mouse	0.03	6 weeks	Oral (gavage)	hepatotoxicity	Not Applicable	7	0.7	Sample et al. 1996	West Indian manatee
o-Xylene	Mouse	0.03	GD 6-15	Oral (gavage)	Reproduction	Not Applicable	2.6	2.1	Sample et al. 1996	West Indian manatee
m-Xylene	Mouse	0.03	GD 6-15	Oral (gavage)	Reproduction	Not Applicable	2.6	2.1	Sample et al. 1996	West Indian manatee
p-Xylene	Mouse	0.03	GD 6-15	Oral (gavage)	Reproduction	Not Applicable	2.6	2.1	Sample et al. 1996	West Indian manatee
Semi-Volatile Organics:										
1,2,4,5-Tetrachlorobenzene	---	---	---	---	---	---	NA	NA	---	---
1,2,4-Trichlorobenzene	Rat	0.35	3 generations	Oral in water	Reproduction	Not Applicable	106	53	Coulston and Kolbye 1994	West Indian manatee
1,2-Dichlorobenzene	Rat	0.35	chronic	Oral (gavage)	Liver/kidney	Not Applicable	857	85.7	Coulston and Kolbye 1994	West Indian manatee
1,3-Dichlorobenzene	Rat	0.35	chronic	Oral (gavage)	Liver/kidney	Not Applicable	857	85.7	Coulston and Kolbye 1994	West Indian manatee
1,4-Dichlorobenzene	Rat	0.35	GD 6-15	Oral (gavage)	Reproduction	Not Applicable	500	250	Coulston and Kolbye 1994	West Indian manatee
2,3,4,6-Tetrachlorophenol	---	---	---	---	---	---	NA	NA	---	---
2,4,5-Trichlorophenol	Rat	0.35	98 days	Oral in diet	Hepatic/renal	Not Applicable	800	80	McCullister et al. 1961	West Indian manatee
2,4,6-Trichlorophenol	Rat	0.35	98 days	Oral in diet	Hepatic/renal	Not Applicable	800	80	McCullister et al. 1961	West Indian manatee
2,4-Dichlorophenol	Rat	0.35	103 weeks	Oral in diet	Reproduction	Not Applicable	4,400	440	NTP 1989	West Indian manatee
2-Acetylaminofluorene	---	---	---	---	---	---	NA	NA	---	---
2-Chloronaphthalene	---	---	---	---	---	---	NA	NA	---	---
2-Methylnaphthalene	Mouse	0.03	81 weeks	Oral in diet	Systemic	Not Applicable	1,437	143.7	ATSDR 1995a	West Indian manatee
2-sec-butyl-4, 6-dinitrophenol	---	---	---	---	---	---	NA	NA	---	---
3,3'-Dichlorobenzidine	---	---	---	---	---	---	NA	NA	---	---
3,3'-Dimethylbenzidine	---	---	---	---	---	---	NA	NA	---	---
3-Methylcholanthrene	---	---	---	---	---	---	NA	NA	---	---
4-Bromophenyl phenyl ether	---	---	---	---	---	---	NA	NA	---	---
4-Chloro-3-methylphenol	---	---	---	---	---	---	NA	NA	---	---
4-Chlorophenyl phenyl ether	---	---	---	---	---	---	NA	NA	---	---
7,12-Dimethylbenz(a)anthracene	---	---	---	---	---	---	NA	NA	---	---
Acenaphthene	Mouse	0.03	13 weeks	Oral (gavage)	Reproduction	Not Applicable	3,500	350	ATSDR 1995a	West Indian manatee
Acenaphthylene	Mouse	0.03	13 weeks	Oral (gavage)	Reproduction	Not Applicable	2,500	350	ATSDR 1995a	West Indian manatee
Anthracene	Mouse	0.03	13 weeks	Oral (gavage)	Reproduction	Not Applicable	10,000	1000	ATSDR 1995a	West Indian manatee
Aramite	---	---	---	---	---	---	NA	NA	---	---
Benzo(a)anthracene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Benzo(a)pyrene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Benzo(b)fluoranthene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Benzo(g,h,i)perylene	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1330	133	ATSDR 1995a	West Indian manatee

TABLE 6-8
INGESTION-BASED SCREENING VALUES FOR MAMMALS
SWMU 1(ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
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 Receptor
Semi-Volatile Organics (cont.):										
Benzo(k)fluoranthene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Bis(2-Ethylhexyl)phthalate	Mouse	0.03	105 days	Oral in diet	Reproduction	Not Applicable	183.3	18.3	Sample et al. 1996	West Indian manatee
	Rat	0.35	2 years	Oral	?	Not Applicable	600	60		
Butylbenzylphthalate	Rat	0.35	2 years	Oral in diet	Hepatic	Not Applicable	2,400	240	NTP 1997	West Indian manatee
Carbazole	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1,330	133	ATSDR 1995a	West Indian manatee
Chlorobenzilate	---	---	---	---	---	---	NA	NA	---	---
Chrysene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Diallate	---	---	---	---	---	---	NA	NA	---	---
Dibenz(a,h)anthracene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Dibenzofuran	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1,330	133	ATSDR 1995a	West Indian manatee
Diethylphthalate	Mouse	0.03	105 days	Oral in diet	Reproduction	Not Applicable	45,830	4,583	Sample et al. 1996	West Indian manatee
Di-n-butylphthalate	Mouse	0.03	105 days	Oral in diet	Reproduction	Not Applicable	1,833	550	Sample et al. 1996	West Indian manatee
Di-n-octylphthalate	Mouse	0.03	105 days	Oral in diet	Reproduction	Not Applicable	550	55	Sample et al. 1996	West Indian manatee
Diphenylamine	---	---	---	---	---	---	NA	NA	---	---
Fluoranthene	Mouse	0.03	13 weeks	Oral (gavage)	Hepatic	Not Applicable	1,250	125	ATSDR 1995a	West Indian manatee
Fluorene	Mouse	0.03	13 weeks	Oral (gavage)	Hematological	Not Applicable	1,250	125	ATSDR 1995a	West Indian manatee
Hexachlorobenzene	Rat	0.35	2 years	Oral	Reproduction	Not Applicable	16	1.6	ATSDR 1989	West Indian manatee
Hexachlorobutadiene	Rat	0.35	90 days +	Oral	Reproduction	Not Applicable	20	2	IPCS 1994	West Indian manatee
Hexachlorocyclopentadiene	Rat	0.35	GD 6-15	Oral	Reproduction	Not Applicable	30	10	EPA 1984	West Indian manatee
	Rat	0.35	13 weeks	Oral (gavage)	?	Not Applicable	38	3.8	EPA 1999	---
Hexachloroethane	---	---	---	---	---	---	NA	NA	---	---
Hexachlorophene	Rat	0.35	?	Oral	Mortality	Not Applicable	56	5.6	EPA 1999	West Indian manatee
Hexachloropropene	---	---	---	---	---	---	NA	NA	---	---
Indeno(1,2,3-cd)pyrene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Isosafrole	---	---	---	---	---	---	NA	NA	---	---
Naphthalene	Mouse	0.03	13 weeks	Oral (gavage)	Reproduction	Not Applicable	1,400	140	ATSDR 1995b	West Indian manatee
N-Nitrosodiphenylamine	Rat	0.35	8 to 11 weeks	Oral in diet	Systemic	Not Applicable	1,500	150	ATSDR 1993b	West Indian manatee
p-Dimethylaminoazobenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachlorobenzene	Rat	0.35	180 days	Oral	?	Not Applicable	72.5	7.25	EPA 1999	---
Pentachloronitrobenzene	Mouse	0.35	2 years	Oral	?	Not Applicable	4,583.3	458.3	EPA 1999	---
Pentachlorophenol	Rat	0.35	up to 24 months	Oral in diet	Reproduction	Not Applicable	30	3	Coulston and Kolbye 1994	West Indian manatee
Phenanthrene	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1,330	133	ATSDR 1995a	West Indian manatee
Pronamide	---	---	---	---	---	---	NA	NA	---	---
Pyrene	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1,330	133	ATSDR 1995a	West Indian manatee
PCBs:										
Aroclor-1016	Mink	1	18 months	Oral in diet	Reproduction	Not Applicable	3.43	1.37	Sample et al. 1996	West Indian manatee
Aroclor-1221	Mink	1	7 months	Oral in diet	Reproduction	Not Applicable	0.69	0.069	Sample et al. 1996	West Indian manatee
Aroclor-1232	Mink	1	7 months	Oral in diet	Reproduction	Not Applicable	0.69	0.069	Sample et al. 1996	West Indian manatee
Aroclor-1242	Mink	1	7 months	Oral in diet	Reproduction	Not Applicable	0.69	0.069	Sample et al. 1996	West Indian manatee
Aroclor-1248	Rhesus monkey	5	14 months	Oral in diet	Reproduction	Not Applicable	0.1	0.01	Sample et al. 1996	West Indian manatee
	Mouse	0.03	5 weeks	Oral in diet	Immunological	Not Applicable	13	1.3	ATSDR 1995c	---
Aroclor-1254	Oldfield mouse	0.014	12 months	Oral in diet	Reproduction	Not Applicable	0.68	0.068	Sample et al. 1996	West Indian manatee
Aroclor-1254	Mink	1	4.5 months	Oral in diet	Reproduction	Not Applicable	0.69	0.14	Sample et al. 1996	---
Aroclor-1260	Oldfield mouse	0.014	12 months	Oral in diet	Reproduction	Not Applicable	0.68	0.068	Sample et al. 1996	West Indian manatee
Aroclor-1260	Mink	1	4.5 months	Oral in diet	Reproduction	Not Applicable	0.69	0.14	Sample et al. 1996	---

TABLE 6-8
INGESTION-BASED SCREENING VALUES FOR MAMMALS
SWMU 1(ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
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 Receptor
Organochlorine Pesticides:										
4,4'-DDD	Rat	0.35	2 years	Oral in diet	Reproduction	Not Applicable	4	0.8	Sample et al. 1996	West Indian manatee
	Dog	10	2 generations	Oral	Reproduction	Not Applicable	5	1	ATSDR 1994	
4,4'-DDE	Rat	0.35	2 years	Oral in diet	Reproduction	Not Applicable	4	0.8	Sample et al. 1996	West Indian manatee
	Dog	10	2 generations	Oral	Reproduction	Not Applicable	5	1	ATSDR 1994	
4,4'-DDT	Rat	0.35	2 years	Oral in diet	Reproduction	Not Applicable	4	0.8	Sample et al. 1996	West Indian manatee
	Dog	10	2 generations	Oral	Reproduction	Not Applicable	5	1	ATSDR 1994	
Aldrin	Rat	0.35	>1 year	Oral in diet	Reproduction	Not Applicable	1	0.2	Sample et al. 1996	West Indian manatee
alpha-chlordane	Mouse	0.03	>1 year	Oral in diet	Reproduction	Not Applicable	9.2	4.6	Sample et al. 1996	West Indian manatee
gamma-chlordane	Mouse	0.03	>1 year	Oral in diet	Reproduction	Not Applicable	9.2	4.6	Sample et al. 1996	West Indian manatee
Dieldrin	Rat	0.35	> 1 year	Oral in diet	Reproduction	Not Applicable	0.2	0.02	Sample et al. 1996	West Indian manatee
Endosulfan 1	Rat	0.35	30 days	Oral (intubation)	Reproduction	Not Applicable	1.5	0.15	Sample et al. 1996	West Indian manatee
Endosulfan 11	Rat	0.35	30 days	Oral (intubation)	Reproduction	Not Applicable	1.5	0.15	Sample et al. 1996	West Indian manatee
Endosulfan sulfate	Rat	0.35	30 days	Oral (intubation)	Reproduction	Not Applicable	1.5	0.15	Sample et al. 1996	West Indian manatee
Endrin	Mouse	0.03	120 days	Oral in diet	Reproduction	Not Applicable	0.92	0.092	Sample et al. 1996	West Indian manatee
Endrin aldehyde	Mouse	0.03	120 days	Oral in diet	Reproduction	Not Applicable	0.92	0.092	Sample et al. 1996	West Indian manatee
Heptachlor	Mink	1	181 days	Oral in diet	Reproduction	Not Applicable	1	0.1	Sample et al. 1996	West Indian manatee
Heptachlor epoxide	Mink	1	181 days	Oral in diet	Reproduction	Not Applicable	1	0.1	Sample et al. 1996	West Indian manatee
Kepone	---	---	---	---	---	---	NA	NA	---	---
Isodrin	---	---	---	---	---	---	NA	NA	---	---
Methoxychlor	Rat	0.35	11 months	Oral in diet	Reproduction	Not Applicable	8	4	Sample et al. 1996	West Indian manatee
Toxaphene	Rat	0.35	> 1 year	Oral in diet	Reproduction	Not Applicable	80	8	Sample et al. 1996	West Indian manatee
alpha-BHC	Mink	1	331 days	Oral in diet	Reproduction	Not Applicable	0.14	0.014	Sample et al. 1996	West Indian manatee
	Rat	0.35	> 1 year	Oral in diet	Reproduction	Not Applicable	3.2	1.6	Sample et al. 1996	---
beta-BHC	Rat	0.35	13 weeks	Oral in diet	Reproduction	Not Applicable	2	0.4	Sample et al. 1996	West Indian manatee
delta-BHC	Mink	1	331 days	Oral in diet	Reproduction	Not Applicable	0.14	0.014	Sample et al. 1996	West Indian manatee
	Rat	0.35	> 1 year	Oral in diet	Reproduction	Not Applicable	3.2	1.6	Sample et al. 1996	---
gamma-BHC (lindane)	Rat	0.35	> 1 year	Oral in diet	Reproduction	Not Applicable	80	8	Sample et al. 1996	West Indian manatee
Organophosphorous Pesticides:										
Disulfoton	---	---	---	---	---	---	NA	NA	---	---
Methyl parathion	---	---	---	---	---	---	NA	NA	---	---
Parathion	---	---	---	---	---	---	NA	NA	---	---
Phorate	---	---	---	---	---	---	NA	NA	---	---
Sulfotep	---	---	---	---	---	---	NA	NA	---	---
Chlorinated Herbicides:										
2,4,5-T	---	---	---	---	---	---	NA	NA	---	---
2,4,5-TP (Silvex)	---	---	---	---	---	---	NA	NA	---	---
2,4-D	---	---	---	---	---	---	NA	NA	---	---
Dioxins/Furans (ug/kg):										
2,3,7,8-TCDD	Rat	0.35	> 1 year	Oral in diet	Reproduction	Not Applicable	0.00001	0.000001	Sample et al. 1996	West Indian manatee
Inorganics:										
Antimony	Mouse	0.03	lifetime	Oral in water	Lifespan/longevity	Antimony Potassium Tartrate	1.25	0.125	Sample et al. 1996	---
	Rat	0.35	lifetime	Oral in water	Lifespan/longevity	?	0.66	0.066	EPA 1999	West Indian manatee
Arsenic	Mouse	0.03	3 generations	Oral in water	Reproduction	Arsentie (As ³⁺)	1.26	0.126	Sample et al. 1996	West Indian manatee
	Dog	?	2 years	Oral	?	?	12.5	1.25	USEPA 1999	---
Barium	Rat	0.435	16 months	Oral in water	Growth/hypertension	Barium Chloride	51	5.1	Sample et al. 1996	---
	Rat	0.35	10 days	Oral in water	Mortality	Barium Chloride	19.8	1.98	Sample et al. 1996	West Indian manatee

TABLE 6-8
INGESTION-BASED SCREENING VALUES FOR MAMMALS
SWMU 1(ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
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 Receptor
Beryllium	Rat	0.35	lifetime	Oral in water	Longevity/weight loss	Beryllium Sulfate	6.6	0.66	Sample et al. 1996	West Indian manatee
Cadmium	Rat	0.303	6 weeks	Oral (gavage)	Reproduction	Cadmium chloride (CdCl ₂)	10	1	Sample et al. 1996	---
	Dog	10	3 months	Oral (gavage)	Reproduction	?	7.5	0.75	ATSDR 1993a	---
	Mouse	0.03	2 generations	Oral in water	Reproduction	? (soluble salt)	2.52	0.252		West Indian manatee
Chromium	Rat	0.35	2 years	Oral in diet	Reproduction and longevity	Cr ⁺³ as Cr ₂ O ₃	27,370	2,737	Sample et al. 1996	---
	Rat	0.35	1 year	Oral in water	Body weight and food consumption	Cr ⁺⁶ as K ₂ Cr ₂ O ₄	32.8	3.28	Sample et al. 1996	---
	Rat	0.35	3 months	Oral in water	Mortality	Cr ⁺⁶	13.14	1.314	Sample et al. 1996	West Indian manatee
Cobalt	Rat	0.35	69 days	Oral in diet	Reproduction	?	50	5	ATSDR 1992a	West Indian manatee
Copper	Mink	1	357 days	Oral in diet	Reproduction	Copper Sulfate	15.14	11.7	Sample et al. 1996	West Indian manatee
Lead	Rat	0.35	3 generations	Oral in diet	Reproduction	Lead Acetate	80	8	Sample et al. 1996	West Indian manatee
Mercury	Mink	1	6 months	Oral in diet	Reproduction	Mercuric Chloride	10	1.0	Sample et al. 1996	---
	Mouse	0.03	20 months	Oral in diet	Reproduction	Mercuric sulfide	132	13.2	Sample et al. 1996	---
	Mink	1	93 days	Oral in diet	Mortality/weight loss	Methyl Mercury Chloride (CH ₃ HgCl)	0.025	0.015	Sample et al. 1996	West Indian manatee
	Rat	0.35	3 generations	Oral in diet	Reproduction	Methyl Mercury Chloride (CH ₃ HgCl)	0.16	0.032	Sample et al. 1996	---
Nickel	Rat	0.35	3 generations	Oral in diet	Reproduction	Nickel Sulfate Hexahydrate	80	40	Sample et al. 1996	West Indian manatee
Selenium	Rat	0.35	1 year	Oral in water	Reproduction	Potassium Selenate (SeO ₄)	0.33	0.2	Sample et al. 1996	West Indian manatee
	Mouse	0.03	3 generations	Oral in water	Mortality	Selenate (SeO ₄)	0.76	0.076	EPA 1999	---
Silver	Rat	0.35	2 weeks	Oral in water	Mortality	?	181	18.1	ATSDR 1990	West Indian manatee
	Mouse	0.03	125 days	Oral	Hypoactivity	?	3.75	0.375	EPA 1999	---
Thallium	Rat	0.365	60 days	Oral in water	Reproduction	Thallium Sulfate	0.74	0.074	Sample et al. 1996	West Indian manatee
Tin	Mouse	0.03	6-15 days	Oral intubation	Reproduction	bis(Tributyltin)oxide	35	23.4	Sample et al. 1996	West Indian manatee
Vanadium	Rat	0.26	>60 days	Oral intubation	Reproduction	Sodium Metavanadate (NaVO ₃)	2.1	0.21	Sample et al. 1996	West Indian manatee
Zinc	Rat	0.35	GD 1-16	Oral in diet	Reproduction	Zinc Oxide	320	160	Sample et al. 1996	---
	Mink	1	25 weeks	Oral	Reproduction	?	208	20.8	ATSDR 1992b	West Indian manatee
	Mouse	0.03	13 weeks	Oral	?	?	100.4	10.4	EPA 1999	---

Notes:

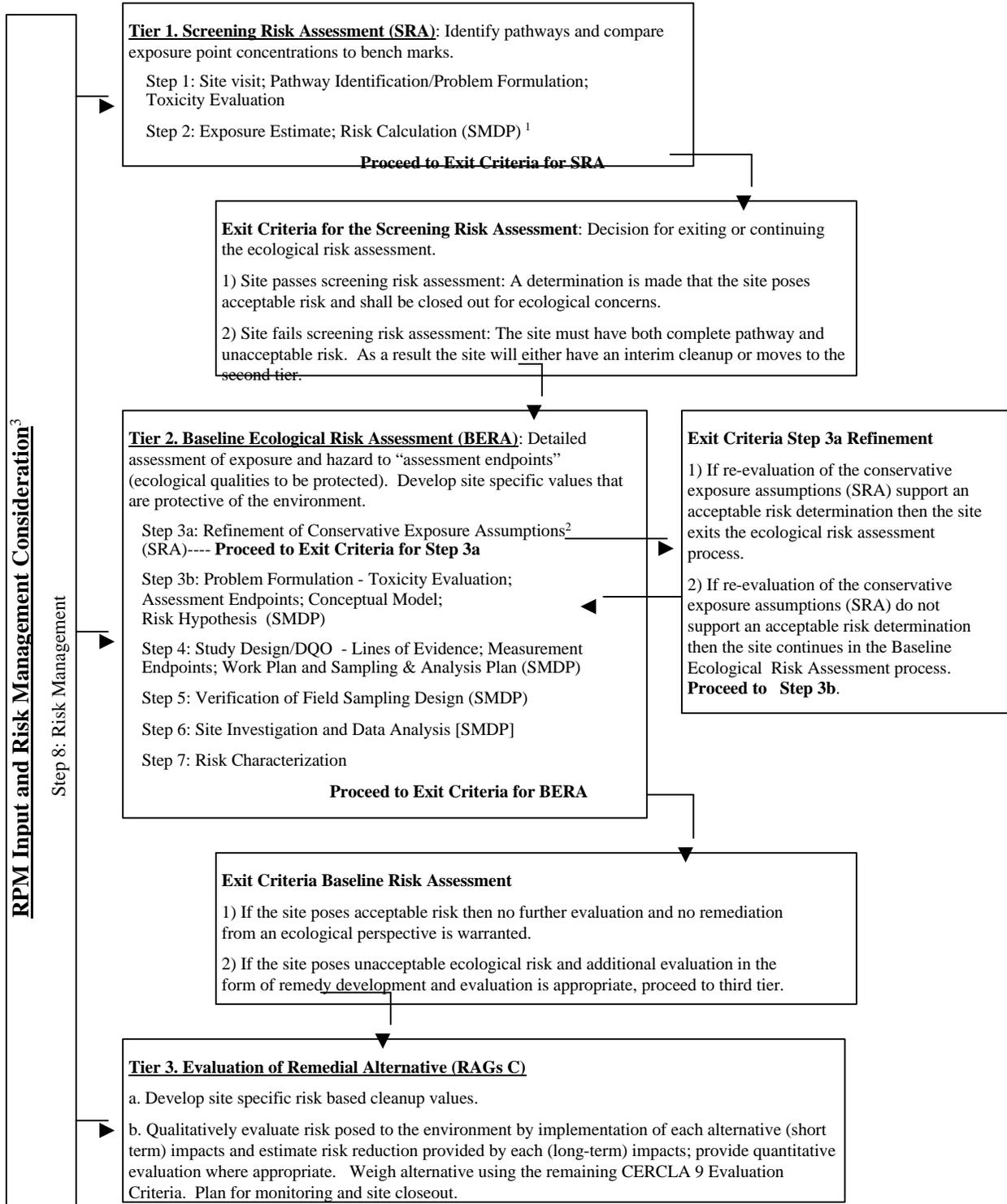
NA = Not Available

NOAEL = No Observed Effect Level

LOAEL = Lowest Observed Effect Level

FIGURES

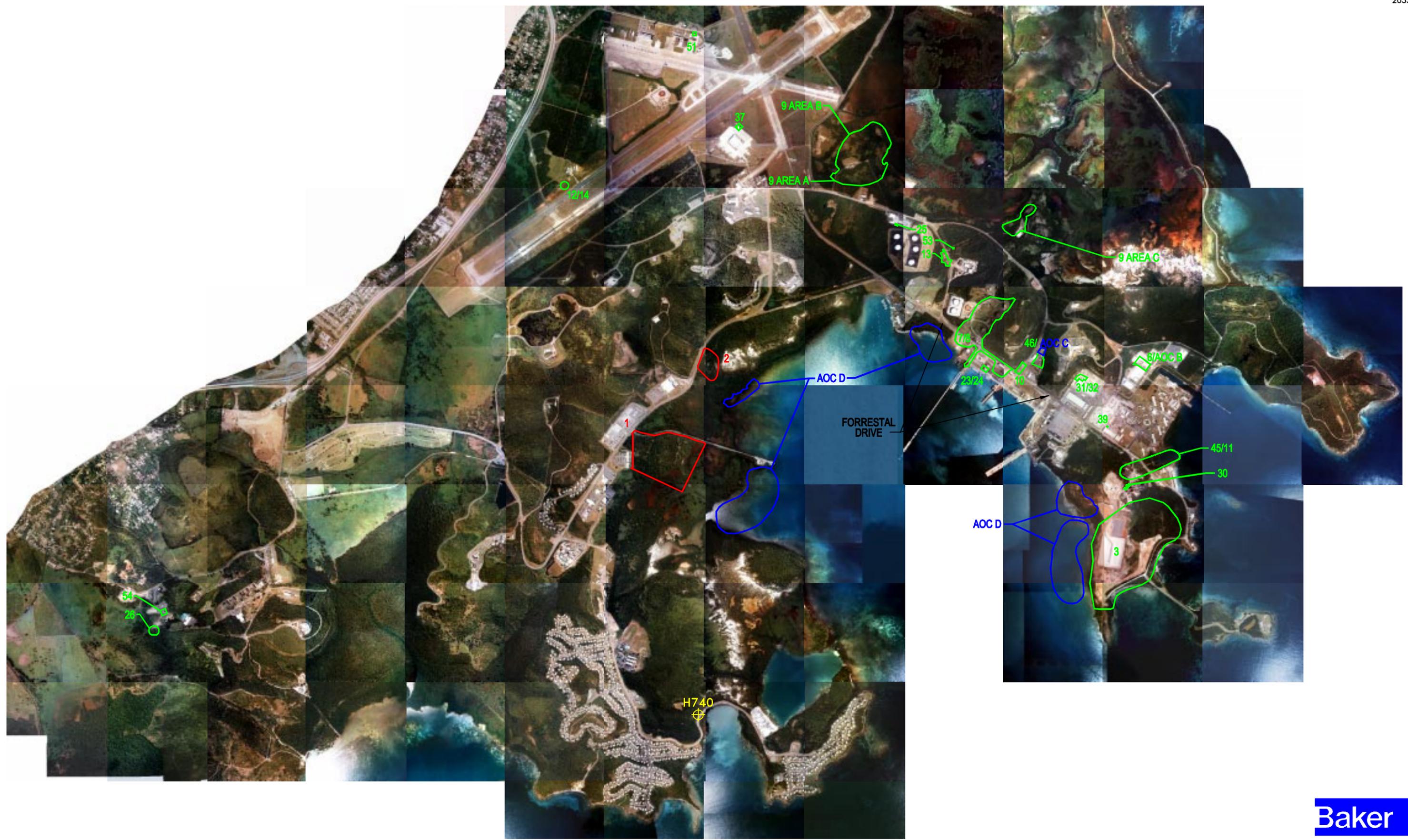
Figure 1-1: Navy Ecological Risk Assessment Tiered Approach



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.



LEGEND

- 9 - SWMUs
- AOC D - AOCs
- 1 - AREA OF WHICH THIS INVESTIGATION PERTAINS TO

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

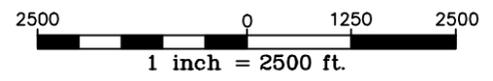


FIGURE 2-1
SWMU/AOC LOCATION MAP
 NAVAL STATION ROOSEVELT ROADS
 PUERTO RICO

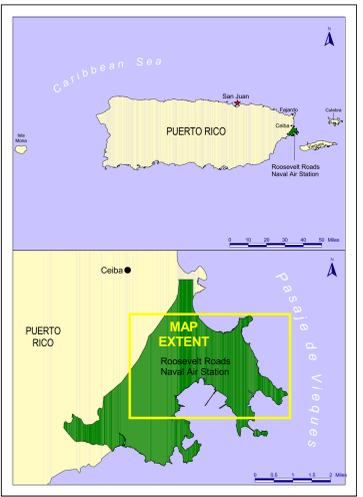
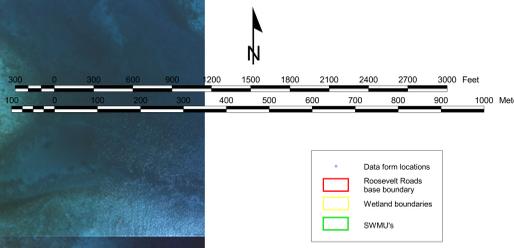


Figure 2-2
Roosevelt Roads Naval Air Station
Wetlands Delineation

North and East Sections

This certifies that this plat identifies potential waters and wetlands regulated pursuant 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.



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

**FIGURE 2-3
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
SWMUs 1 and 2
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO**

SYSTEM	M - MARINE										E - ESTUARINE																																																																																																			
SUBSYSTEM	1 - SUBTIDAL					2 - INTERTIDAL					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	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																																																																																								
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SOURCE: UNITED STATES, FISH AND WILDLIFE SERVICE. CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS OF THE UNITED STATES, 1985



LEGEND

- ① - SWMU
- E2SS3 - E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 2-3 FOR CLASSIFICATIONS)
- ⊞ - SEDIMENT SAMPLE LOCATION (1996 RFI)
- ⊞ - REPORTED LOCATION OF 5GW03 (NOT LOCATED DURING 1996 RFI FIELD INVESTIGATION)
- ⊞ - SOIL BORING LOCATION (1996 RFI)
- ⊞ - MONITOR WELL LOCATION (1996 RFI)
- ⊞ - EXISTING MONITOR WELL LOCATION (CONFIRMATION STUDY)
- ⊞ - SURFACE SOIL SAMPLE LOCATION (1996 RFI)
- ⊞ - SEDIMENT SAMPLE LOCATION (RELATIVE RISK RANKING)
- ⊞ - SURFACE WATER/SEDIMENT SAMPLE LOCATION (CONFIRMATION STUDY)
- - SOIL SAMPLE LOCATION (SUPPLEMENTAL INVESTIGATION)

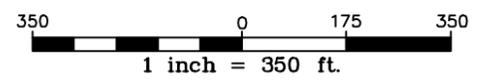
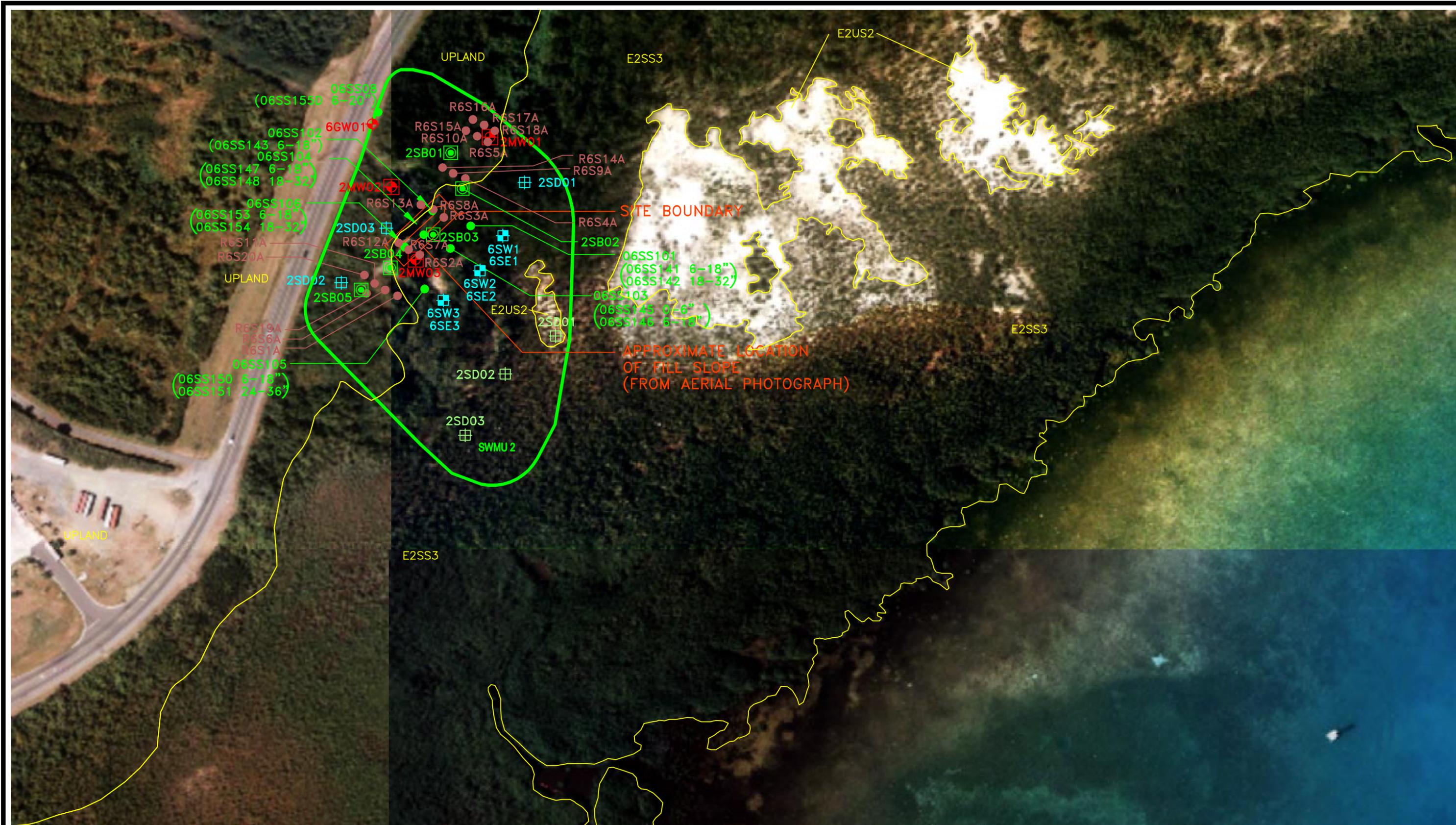


FIGURE 3-1
 SWMU 1 SAMPLING LOCATIONS
 NAVAL STATION ROOSEVELT ROADS
 PUERTO RICO



LEGEND

- SWMU
- E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 2-3 FOR CLASSIFICATIONS)
- SEDIMENT SAMPLE LOCATION (1996 RFI)
- SEDIMENT SAMPLE LOCATION (RELATIVE RISK RANKING)
- SURFACE WATER/SEDIMENT SAMPLE LOCATION (CONFIRMATION STUDY)
- SOIL SAMPLE LOCATION (APPROXIMATE) (SUPPLEMENTAL INVESTIGATION)
- SOIL BORING LOCATION (1996 RFI)
- SOIL SAMPLE LOCATION (APPROXIMATE) (CONFIRMATION STUDY)
- MONITOR WELL LOCATION (1996 RFI)
- EXISTING MONITOR WELL LOCATION (CONFIRMATION STUDY)

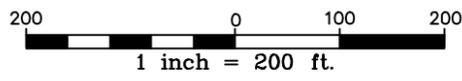
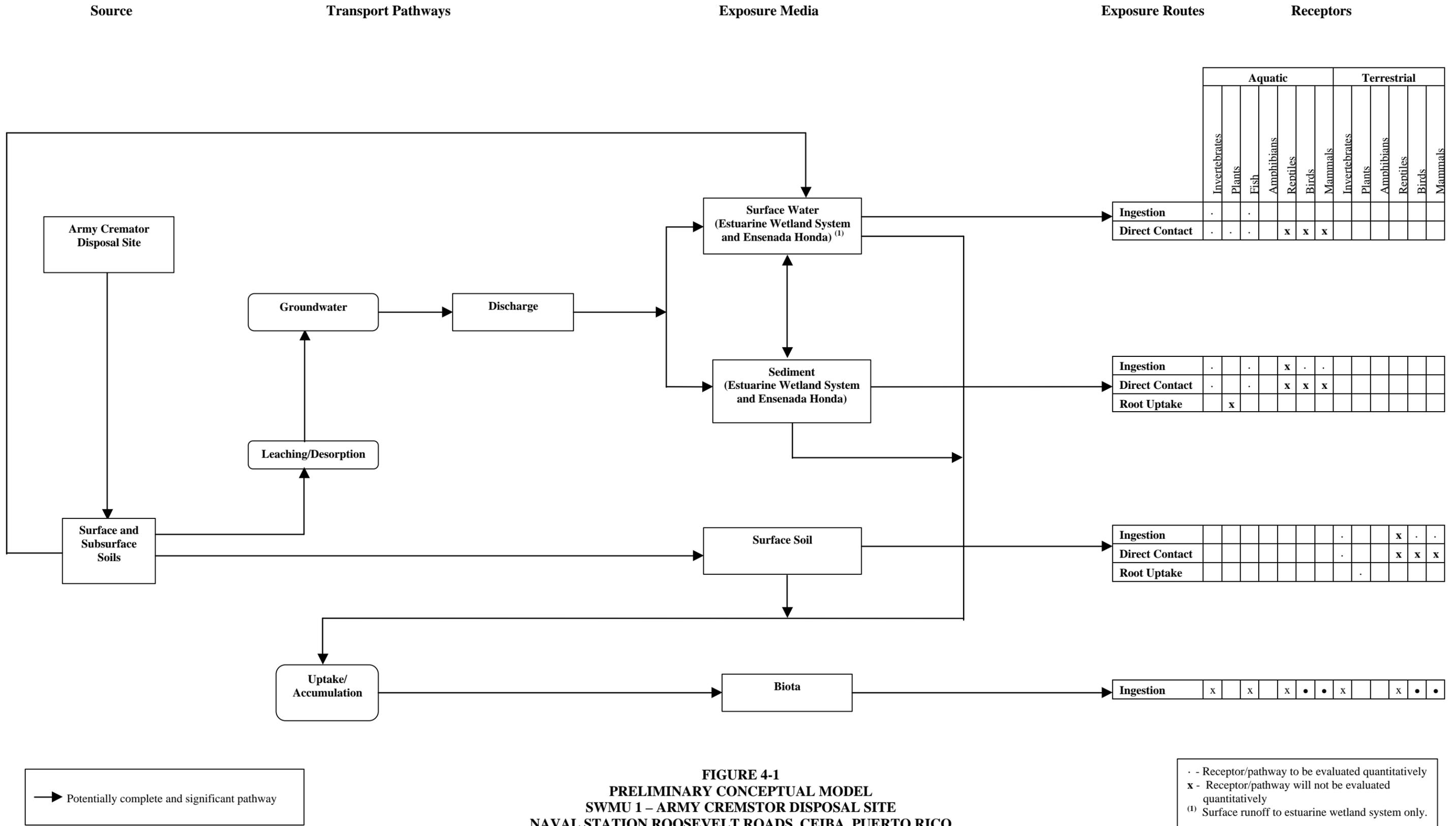
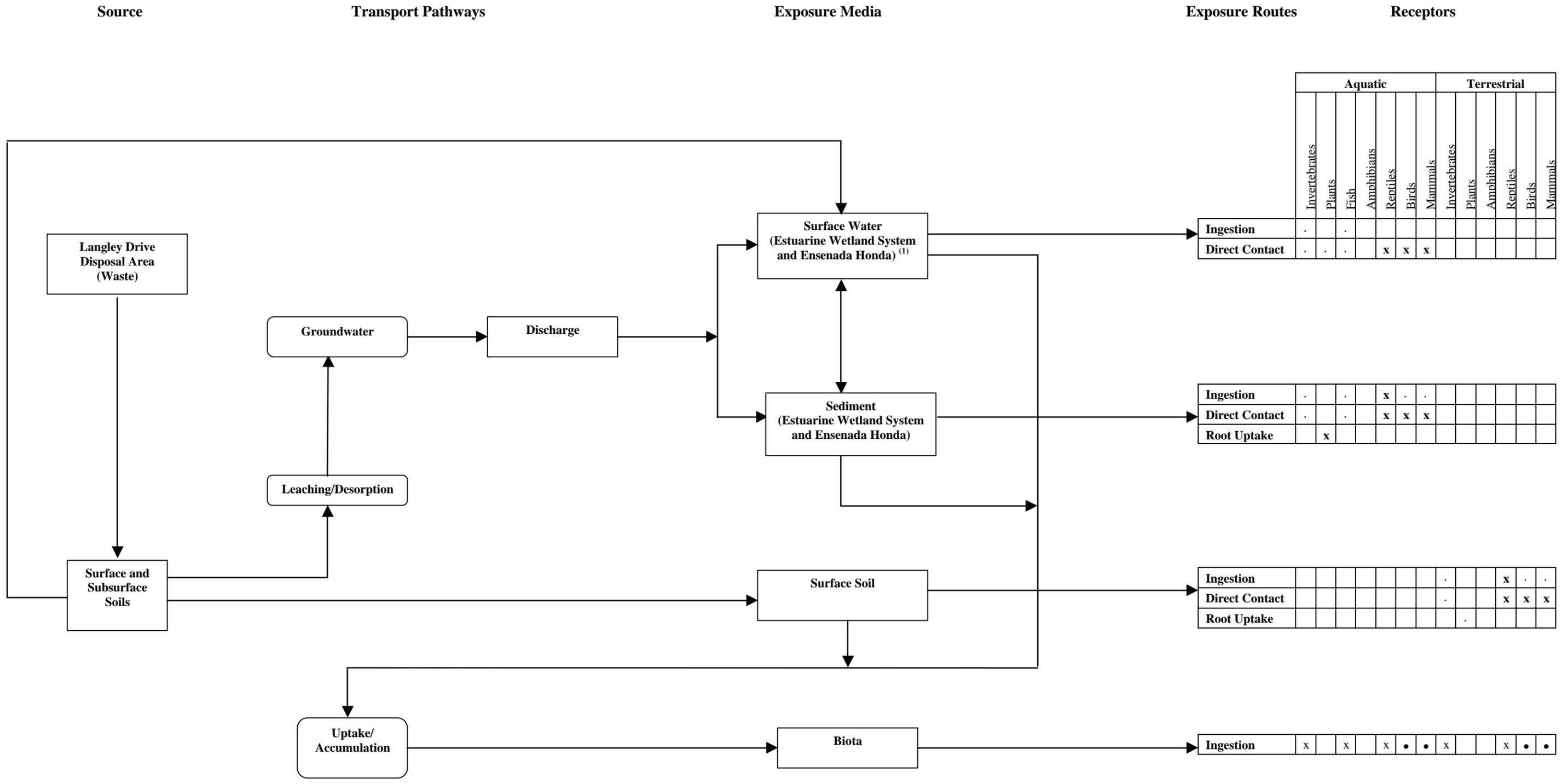


FIGURE 3-2
 SWMU 2 SAMPLING LOCATIONS
 NAVAL STATION ROOSEVELT ROADS
 PUERTO RICO

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





→ Potentially complete and significant pathway

FIGURE 4-2
PRELIMINARY CONCEPTUAL MODEL
SWMU 2 – LANGLEY DRIVE DISPOSAL AREA
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

. - Receptor/pathway to be evaluated quantitatively
 x - Receptor/pathway will not be evaluated quantitatively
 (1) Surface runoff to estuarine wetland system only.

APPENDIX A
HABITAT CHARACTERIZATION REPORT

**HABITAT CHARACTERIZATION OF SOLID WASTE
MANAGEMENT UNITS (SWMU) 1, SWMU 2, AND SWMU 45,
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Prepared for:

CH2M Hill

Prepared by:

**Dr. Dan L. Wilkinson, Rudi Reinecke, Melissa Lopez-Rodriguez,
Manuel Figueroa-Pagan, and Donna DeYoung**

**Geo-Marine, Inc.
550 E. 15th Street
Plano, Texas 75074**

October 11, 2000

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
SITE LOCATION	1
METHODS	1
RESULTS AND DISCUSSION	5
SWMU 1	5
Vegetation Community Description	5
Plant Community Health	6
Wildlife Description	10
Protected Species	10
Food Web	12
SWMU 2	14
Vegetation Community Description	14
Plant Community Health	14
Wildlife Description	15
Protected Species	15
Food Web	15
SWMU 45	19
Terrestrial Area	19
Vegetation Community Description	19
Plant Community Health	19
Wildlife Description	22
Protected Species	22
Food Web	22
Marine Area	22
CONCLUSION	23
LITERATURE CITED	24
APPENDIX A	A-1
APPENDIX B	B-1

LIST OF FIGURES

	<u>Page</u>
1	General Location of NAVSTA Roosevelt Roads, Puerto Rico2
2	Location Map of SWMU 1, 2, and 45 Roosevelt Roads Puerto3
3	Location of SWMU 1, Roosevelt Roads, Puerto Rico7
4	SWMU 1, Red Mangrove Community (<i>Rhizophora mangle</i>) with Upland Coastal Forest in Background.....8
5	SWMU 1, Coastal Scrub Forest Community8
6	Generalized Food Web for the Upland Coastal Forest and Coastal Scrub Forest Communities at NAVSTA Roosevelt Roads..... 13
7	Generalized Food Web for Mangrove Communities at NAVSTA Roosevelt Roads 13
8	Location of SWMU 2, Roosevelt Roads, Puerto Rico17
9	SWMU 2, Un-maintained Road in Center of Photograph within the Upland Coastal Forest Community. 18
10	SWMU 2, Typical Vegetation Showing Upland Coastal Forest Species..... 18
11	Location of SWMU 45, Roosevelt Roads, Puerto Rico20
12	SWMU 45, Along the Shoreline of the Cove, Killdeer (<i>Charadrius vociferous</i>) Foraging Among Washed-up Seagrass21

LIST OF TABLES

	<u>Page</u>
1	Federally Listed Species Occurring or Potentially Occurring at NAVSTA Roosevelt Roads4
2	Vegetation Observed at SWMU 19
3	Wildlife Observed at SWMU 1 11
4	Vegetation Observed at SWMU 2 15
5	Wildlife Observed at SWMU 2 16
6	Vegetation Observed at SWMU 4521
7	Wildlife Observed at SWMU 4522

INTRODUCTION

As part of a Resource Conservation and Recovery Act (RCRA) facility investigation at Naval Station (NAVSTA) Roosevelt Roads, Puerto Rico, ecological risk assessments were conducted at 3 solid waste management unit (SWMU) sites. A habitat characterization was conducted at each SWMU in order to determine the presence of plant and animal species and to determine whether preferred habitat was present for any federally endangered or threatened plant and animal species.

SITE LOCATION

NAVSTA Roosevelt Roads (approximately 8,627 acres) is located in the municipality of Ceiba on the southeastern coast of Puerto Rico (Figure 1). This report covers three SWMU sites located at NAVSTA Roosevelt Roads (Figure 2). SWMU 1 and SWMU 2 were located near each other and both had been used as disposal sites and contained similar debris. SWMU 1, an abandoned Army Cremation Disposal Site, is located east of the Navy Lodge with Kearsage Road to the north. Ensenada Honda is to the east and south of SWMU 1, and the Bowling Alley is to the west. SWMU 2 (Langley Drive Disposal Site) is located along Langley Drive and is approximately 2,000 feet northwest of the Navy Exchange. SWMU 2 extends from Langley Drive towards a mangrove community and has an estimated length of 1,300 feet in a northeast-southeast direction. SWMU 45 includes areas outside of Building 38, ground above the cooling water tunnels, and a cove in Puerca Bay. Building 38 is located along a dirt access road south of Forrestal Drive. Associated with Building 38 is a cooling tower intake tunnel that runs from the north end of the building to a small cove in Puerca Bay.

METHODS

Vegetation communities were initially characterized into broad community types based on the color signatures from 1998 true-color and 1993 color infrared (CIR) aerial photographs. Vegetation communities were delineated based on species composition and structure by viewing magnified stereo pairs of aerial photography. The community types were marked on overlying acetate for use in the field (May 15 to 19, 2000). Personnel walked transects through each of these SWMU to:

1. verify that the community types were identified and delineated correctly from the true color and CIR aerial photography;
2. identify the species composition of the dominant vegetation;
3. identify the wildlife species present in the SWMU sites;
4. identify habitat that may potentially support federally designated threatened and endangered species within and contiguous to each SWMU; and
5. identify any obvious impacts potentially related to previous waste management activities.



Figure 1. General Location of NAVSTA Roosevelt Roads, Puerto Rico.

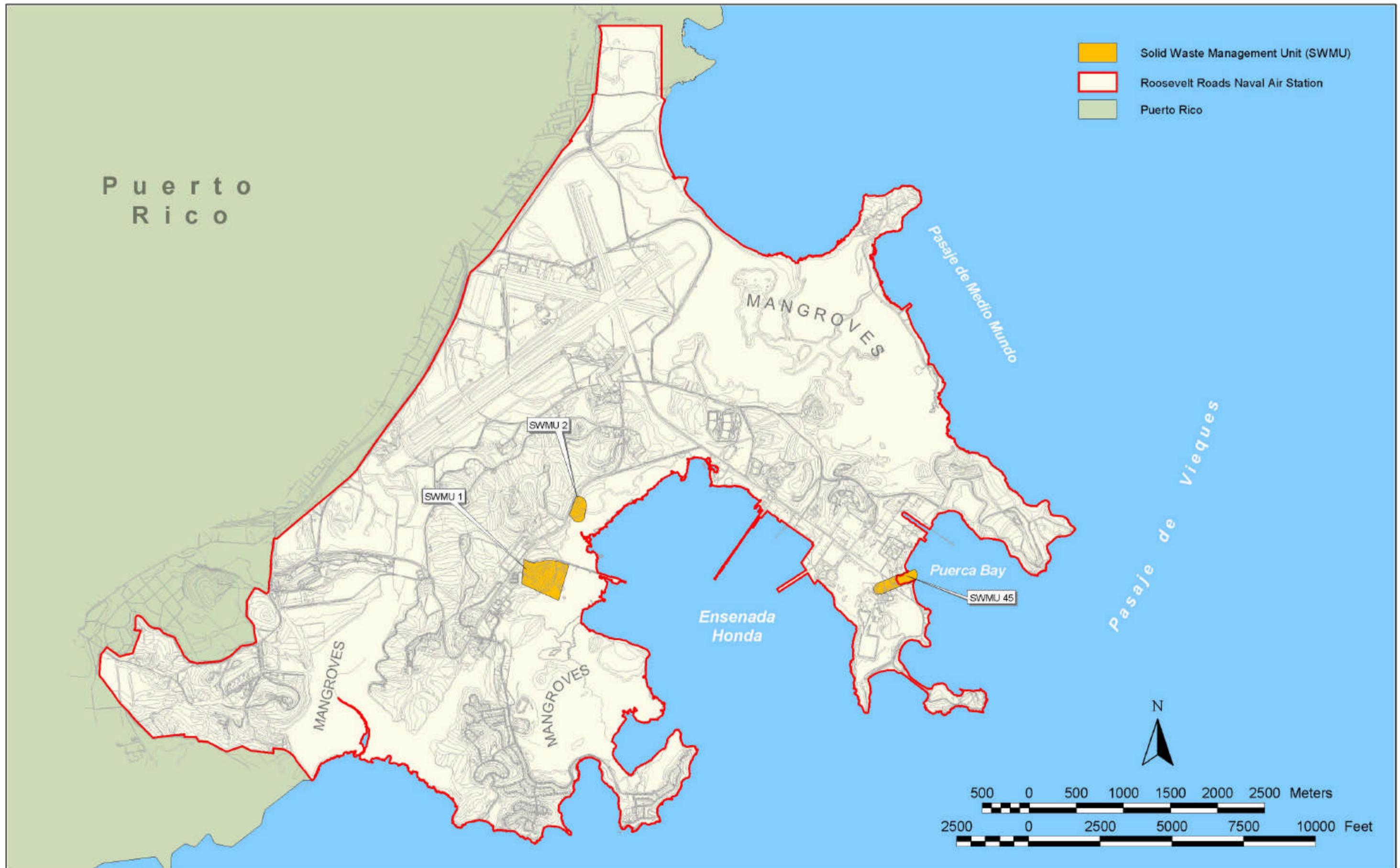


Figure 2. Location of SWMU 1,2 and 45, Roosevelt Roads, Puerto Rico.

The vegetation communities were verified by walking surveys through each community type previously identified with aerial photography. Most species were identified in the field; however, some specimens were collected for identification using reference books (Liogier 1985, 1988, 1994, 1995, 1997; Little and Wadsworth 1964; Little et al. 1964; and Acevedo-Rodriguez 1996) and herbarium specimens. Relative dominance and species structure were characterized from the visual observations within each community type and SWMU.

Wildlife species residing within or utilizing each SWMU habitat, and wildlife habitat were identified during the vegetation field surveys. A wildlife biologist characterized the habitats and determined the types of wildlife that could potentially inhabit the plant communities or SWMU sites. Any wildlife species that were observed were identified in the field with the use of 8 x 40 binoculars and reference guides (Raffaele 1989 and Raffaele et al 1998).

Eleven federally listed species are known to occur or have the potential to occur on NAVSTA Roosevelt Roads (Table 1). The entire NAVSTA Roosevelt Roads was designated as critical habitat in 1976 for the endangered yellow-shouldered blackbird (*Agelaius xanthomus*). However, a 1980 agreement with the USFWS exempted certain areas on the station from this categorization. SWMU 45 is outside this area, while SWMUs 1 and 2 are included within the critical habitat designation.

Prior to conducting the fieldwork, a literature search was conducted for each federally protected species. During the May 15 to 19, 2000 surveys, biologists walked transects through each site and identified any federally protected species seen and noted the presence or absence of preferred habitat for the species.

Table 1

Federally Listed Species Occurring or Potentially Occurring at NAVSTA Roosevelt Roads

Scientific Name (Common Name)	Federal Status
Plants	
<i>Stahlia monosperma</i> (Cobana negra)	Threatened
Reptiles and Amphibians	
<i>Caretta caretta</i> (Loggerhead sea turtle)	Threatened
<i>Chelonia mydas</i> (Green sea turtle)	Threatened
<i>Dermochelys coriacea</i> (Leatherback sea turtle)	Endangered
<i>Eretmochelys imbricata</i> (Hawksbill sea turtle)	Endangered
<i>Epicrates inornatus</i> (Puerto Rican Boa)	Endangered
Birds	
<i>Agelaius xanthomus</i> (Yellow-shouldered blackbird)	Endangered
<i>Falco peregrinus tundrius</i> (Arctic peregrine)	Threatened
<i>Pelecanus occidentalis occidentalis</i> (Brown pelican)	Endangered
<i>Sterna dougalli dougalli</i> (Roseate tern)	Endangered
Mammals	
<i>Trichechus manatus</i> (West Indian manatee)	Endangered

Source: U.S. Navy 1998b

Past management activities at the SWMU sites may have potentially impacted the current vegetation communities. During the field surveys the biologists made visual observations to characterize the health of the plants in the SWMU sites. Indications of altered plant communities include; chlorotic leaves, epinasty (deformities of leaves and stems), patches of altered plant growth, absence of plants (bare ground), and changes in species composition. To determine if the SWMU sites contained altered plant communities, a nearby representative site was selected as a control. When altered plant communities were identified, the biologists made an effort to determine and record the probable cause (i.e., chemical, soil compaction, natural causes, etc.).

In addition to identification of wildlife in the field, existing literature sources were used to identify any additional species that may have occurred on the SWMU sites but were not observed. Most of the wildlife occurring in the area is bird species and these are presented in Appendix A. Species information and field data was used to generate a simplified food web for the sites. A food web is an interlocking pattern of several to many food chains that is helpful in determining ecosystem processes including those that may occur when a contaminant is introduced to a system.

A reconnaissance survey of SWMU 45 was conducted June 19, 2000 by Dial Cordy and Associates, Inc. to define the marine habitat and associated flora and fauna of the outfall structure and surrounding embayment and shore. Results are presented in the SWMU 45 section.

RESULTS AND DISCUSSION

SWMU 1

Vegetation Community Description

SWMU 1 (an abandoned Army Cremation Disposal Site) is located east of the Navy Lodge (Figure 3). There were four plant communities identified at this site. Geology and human disturbances, to a lesser extent, have influenced the types of plants occurring at this site. The communities included red mangrove (*Rhizophora mangle*), black mangrove, (*Avicennia germinans*), coastal upland forest, and coastal scrub forest. These communities were identified in the NAVSTA Roosevelt Roads Integrated Natural Resources Management Plan (U.S. Navy 1998b) and brief descriptions follow.

The mangrove communities were located farthest east of the Navy lodge in SWMU 1 and had little evidence of human disturbance. Both red and black mangrove communities had sparse cover consisting of low growing shrubs. The red mangroves occurred adjacent to Ensenada Honda and the community was sparsely vegetated (approximately 25 percent cover) with large pools of water present. Nearly all vegetation included short shrubs of red mangrove and numerous red mangrove seedlings were observed.

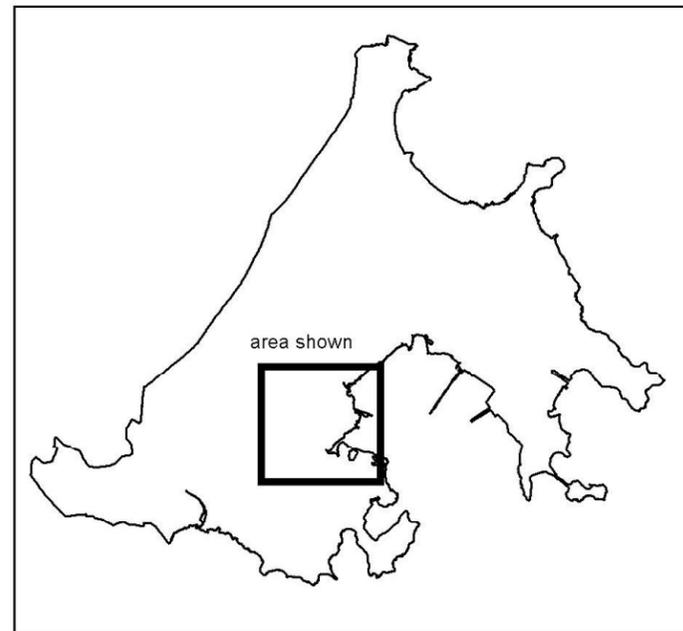
The black mangroves were located inland between the red mangroves and the coastal upland forest community. Species composition consisted of saline tolerant plants as the result of periodic saturation with highly saline water. The site had sparse vegetation cover (approximately 25 percent) and plants were predominately short shrubs (8 to 15 feet). In addition, there was some herbaceous vegetation near the inland boundary. Black mangrove trees and shrubs dominated the shrub vegetation. The herbaceous vegetation was dominated by *Batis maritima*, with *Sporobolus virginicus* and *Sesuvium portulacastrum* also present.

An upland coastal forest community was located on the southern portion of the hill to the east of the Navy lodge. The upland coastal forest served as the upland boundary of the black mangrove community. Soil disturbance, debris, and an un-maintained road for access to several monitoring wells were observed. Tree cutting may have occurred in this area in the past; however, relatively large trees were observed. Shrubs with scattered large trees (8 to 14 inches in diameter breast height) and grassy areas dominated the community. There was approximately 80 to 90 percent vegetation cover with multiple layers of stratification. *Leucaena leucocephala*, *Bursera simaruba*, and *Randia aculeata* dominated the shrub layer. *Bucida buceras*, *Trichostigma octandrum*, and *Psidium guajava* were the only trees present, and these were confined to the ridges and steep hillsides. Patches of herbaceous areas were dominated by *Panicum maximum*.

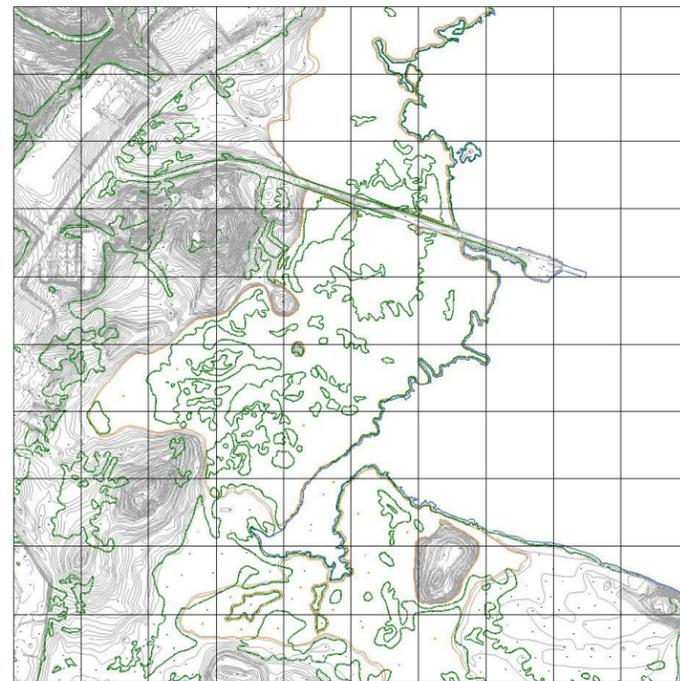
The coastal scrub forest community also showed signs of soil disturbance and had vegetation similar to the upland forest community. However, the coastal scrub had less topographic relief, fewer trees, and larger grassy patches than the upland forest. Vegetation cover in the coastal scrub was approximately 80 to 95 percent and was limited to two strata (shrub and herbaceous). The lack of tree cover had probably occurred due to slope exposure to hurricane force winds. *Leucaena leucocephala* and *Panicum maximum* dominated the shrub and herbaceous strata, respectively. Vegetation photos for SWMU 1 are presented in Figures 4 and 5. The vegetation observed at SWMU 1 is presented in Table 2.

Plant Community Health

The control for SWMU 1 was carefully chosen in order to represent the different plant communities present. Factors needed for the control included a protected hillside community adjacent to mangroves and proximity to SWMU 1. The control that was chosen had upland coastal forest, coastal scrub forest, and mangroves similar to SWMU 1 and was located on the south side of Langley Drive between the elementary school and South Princeton Road.



U.S. Naval Station Roosevelt Roads, Puerto Rico



Topography

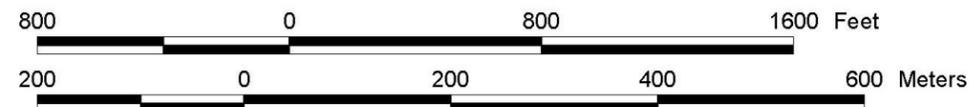


Figure 3. Location of SWMU 1, Roosevelt Roads, Puerto Rico



Figure 4. SWMU 1, Red Mangrove Community (*Rhizophora mangle*) with Upland Coastal Forest in Background.



Figure 5. SWMU 1, Coastal Scrub Forest Community

Table 2
Vegetation Observed at SWMU 1

Common Name	Scientific Name	Stratum
Black Mangrove		
black mangrove	<i>Avicenia germinans</i>	S
salt plant, saltwort	<i>Batis maritima</i>	H
white mangrove	<i>Laguncularia racemosa</i>	S
verdolaga rosada, pink purslane	<i>Sesuvium portulacastrum</i>	H
None	<i>Sporobolus virginicus</i>	H
Red Mangrove		
red mangrove	<i>Rhizophora mangle</i>	S
Upland Coastal Forest		
crab's eye, jumbie bead, rosary bead	<i>Abrus precatorius</i>	S
none	<i>Acacia westiana</i>	S
none	<i>Bothriochloa ichaemum</i>	H
Ucar, oxhorn bucida	<i>Bucida buceras</i>	T
almácigo	<i>Bursera simaruba</i>	S/T
bottle wiss	<i>Capparis flexusa</i>	S
French grass	<i>Commelina erect</i>	H
Bermuda grass	<i>Cynodon dactylon</i>	H
none	<i>Ipomea spp.</i>	V
none	<i>Lasiacis divaricata</i>	H
none	<i>Leptochloa ichaemum</i>	H
tan tan, tanty, wild tamarind, lead tree	<i>Leucaena leucocephala</i>	S
none	<i>Panicum maximum</i>	H
guayaba, common guayaba	<i>Psidium guajava</i>	T
Christmas tree, tintillo	<i>Randia aculeata</i>	S
none	<i>Sporobolus indicus</i>	H
none	<i>Tragia volubilis</i>	H
basket wiss	<i>Trichostigma octandrum</i>	S/T
marsh-mallow	<i>Waltheria indica</i>	H
Coastal scrub forest		
none	<i>Asystasia gangetica</i>	H
almácigo	<i>Bursera simaruba</i>	S
bottle wiss	<i>Capparis flexusa</i>	S
none	<i>Cissus obovata</i>	V
palma de coco	<i>Cocos nucifera</i>	S
rattle box, yellow lupine	<i>Crotalaria retusa</i>	H
flamboyant tree, Poinciana	<i>Delonix regia</i>	S
brazilette	<i>Erythroxylum brevipes</i>	S
none	<i>Forestiera eggersiana</i>	S
black mampoo, wild mampoo	<i>Guapira fragans</i>	S
none	<i>Ipomea spp.</i>	H
tan tan, tanty, wild tamarind, lead tree	<i>Leucaena leucocephala</i>	S
cat claw, cat paw, monkey earring	<i>Macfadyena unguis-cati</i>	S
none	<i>Panicum maximum</i>	H
none	<i>Pinzona coriacea</i>	H
Christmas tree, tintillo	<i>Randia aculeata</i>	S
royal palm	<i>Roystonea borinquena</i>	S
basket wiss, white root, black or white wist	<i>Serjania polyphylla</i>	V
basket wiss	<i>Trichostigma octandrum</i>	S/T

S = shrub
T = tree
H = herbaceous
V = vine

There were no noticeable differences in plant community species composition between the control and the SWMU 1 site. However, the structure of the plant communities was somewhat different. SWMU 1 had more grassy areas within the coastal scrub forest community than the control. The increase in grassy areas was probably the result of past dirt-moving activities at SWMU 1. There were also more large trees at SWMU 1 in the upland coastal forest community than the control. It appeared that the control hillside had been more exposed to hurricane force winds thus resulting in fewer large trees.

The SWMU 1 plant communities seemed to be growing healthy and vigorously. The mangrove communities had a low vegetation cover; however, depending upon their position in the landscape, this is not uncommon. Debris and evidence of dirt-moving activities were observed in the upland coastal forest and the coastal scrub forest communities, but ecological succession was occurring and the existing forest communities had no evidence of stress.

Wildlife Description

During the short duration of wildlife surveys conducted on this site, numerous wildlife species such as birds and lizards (*Anolis* species) were observed utilizing the habitat of this site. An active Wilson's plover (*Charadrius wilsonia*) nest was found in the black mangrove community. The mangrove communities also had significant crab activity. The red mangrove community, with more water present, had more crab holes than the black mangroves. There was no evidence that the SWMU site had an impact on the wildlife diversity or its habitat. Wildlife that was observed at SWMU 1 is presented in Table 3.

Protected Species

Stahlia monosperma (Cobana negra), a federally threatened tree, has been found between the boundary of black mangrove communities and coastal upland forest communities. This species is also known to occur in coastal forests of southeastern Puerto Rico (Little and Wadsworth 1964). However, this species has not been verified as occurring on NAVSTA Roosevelt Roads by past surveys (U.S. Navy 1998b) and was not observed during the surveys.

The Puerto Rican boa (*Epicrates inornatus*) utilizes a variety of habitats but is most commonly found in karst forest habitats. The coastal upland forest community habitat at SWMU 1 is similar to karst habitat due to the steep topography and presence of large stature trees (an indicator of minimal recent disturbance). Occurrence of the boa at NAVSTA Roosevelt Roads has not been verified and due to the disturbance at SWMU 1, there is a low probability of occurrence for the species at this site.

Table 3
Wildlife Observed at SWMU 1

English Name	Scientific Name	Local Name
Red and Black Mangrove Communities		
Birds		
Green Mango	<i>Anthracothorax viridis</i>	Zumbador Verde de P.R.
Red-tailed Hawk	<i>Buteo jamaicensis</i>	Guaraguao de Cola Roja
Wilson's Plover	<i>Charadrius wilsonia</i>	Playero Marítimo
Yellow Warbler	<i>Dendroica petechia</i>	Canario de Mangle
Common Moorhen	<i>Gallinula chloropus</i>	Gallareta Común
Ruddy Quail-Dove	<i>Geotrygon montana</i>	Perdiz Pequeña
Puerto Rico Woodpecker	<i>Melanerpes portoricensis</i>	Carpintero de Puerto Rico
Northern Mockingbird	<i>Mimus polyglottos</i>	Ruiseñor
Cave Swallow	<i>Pterochelidon fulva</i>	Golondrina de Cuevas
Greater Antillean Grackle	<i>Quiscalus niger</i>	Mozambique (Chango)
Louisiana Waterthrush	<i>Seiurus motacilla</i>	Pizpita de Rio
Loggerhead Kingbird	<i>Tyrannus caudifasciatus</i>	Clérigo
Gray Kingbird	<i>Tyrannus dominicensis</i>	Pitirre
Upland Coastal Forest		
Reptiles and Amphibians		
Crested Anole	<i>Anolis cristatellus</i>	not known
Birds		
Red-tailed Hawk	<i>Buteo jamaicensis</i>	Guaraguao de Cola Roja
Bananaquit	<i>Coereba flaveola</i>	Reinita Común
Yellow Warbler	<i>Dendroica petechia</i>	Canario de Mangle
Ruddy Quail-Dove	<i>Geotrygon montana</i>	Perdiz Pequeña
Pearly-eyed Thrasher	<i>Margarops fuscatus</i>	Zorzal Pardo
Northern Mockingbird	<i>Mimus polyglottos</i>	Ruiseñor
Greater Antillean Grackle	<i>Quiscalus niger</i>	Mozambique (Chango)
Coastal Scrub Forest		
Reptiles and Amphibians		
Brown Lizard	<i>Anolis cristatellus</i>	not known
Lizard	<i>Anolis stratulus</i>	not known
Birds		
Bananaquit	<i>Coereba flaveola</i>	Reinita Común
Ruddy Quail-Dove	<i>Geotrygon montana</i>	Perdiz Pequeña
Grackle	<i>Quiscalus niger</i>	Mozambique (Chango)
Loggerhead Kingbird	<i>Tyrannus caudifasciatus</i>	Clérigo
Gray Kingbird	<i>Tyrannus dominicensis</i>	Pitirre
Black-Whiskered Vireo	<i>Vireo altiloquus</i>	Bien-te-veo
Zenaida Dove	<i>Zenaida aurita</i>	Tórtola cardosantera

Federally threatened and endangered sea turtles such as the Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*), Loggerhead (*Caretta caretta*) and Leatherback sea turtles (*Dermochelys coriacea*) and the endangered West Indian Manatee (*Trichechus manatus*) would not occur at this site because they require marine habitats. There is potential for some of the species to occur in nearby Ensenada Honda, however most of the site considered here contained terrestrial habitat.

Federally endangered marine birds such as the Brown pelican (*Pelecanus occidentalis occidentalis*) and the Roseate tern (*Sterna dougalli dougalli*) would most likely not occur at this terrestrial site due to the absence of preferred habitat. The Roseate tern has not been observed on or adjacent to the NAVSTA Roosevelt Roads (U.S. Navy 1998b), although it has been observed recently at Vieques Island. Brown pelicans prefer more coastal areas.

Potential upland feeding habitat (shrubland) was present for the yellow-shouldered blackbird (*Agelaius xanthomus*). However, nesting habitat for the species (mature mangroves and Royal Palm [*Roystonea borinquena*]) was not present. Some nesting habitat may have been located adjacent to the site (U.S. Navy 1998a). A pair of yellow-shouldered blackbirds was observed near the site, although only seven sightings in all have been reported at NAVSTA Roosevelt Roads from 1986 to 1996.

The Arctic peregrine falcon (*Falco peregrinus tundrius*) has been observed at NAVSTA Roosevelt Roads (U.S. Navy 1998b). This species utilizes open grassland areas for potential feeding areas. This type of habitat was not present at or near this site.

Food Web

The information in a food web is very important when considering the potential for contaminants existing in the ecosystem. Many contaminants are passed from one trophic level to the next. A contaminant at the soil surface goes through a different process than a contaminant that has leached into the soil. The surface contaminant may be ingested by a decomposer such as a hermit crab and then passed on to the secondary consumer (i.e., a carnivorous bird). Leached contaminants are picked up by the primary producers and are then passed upwards in the food chain.

Figure 6 presents a generalized food web for the upland coastal forest and the coastal scrub forest communities. Figure 7 presents a food web for the mangrove communities. The abundance within each of the food groups is represented by the size of their polygon in the figure. Dominant species are listed in each of the food groups except for plants, which were provided previously in this section.

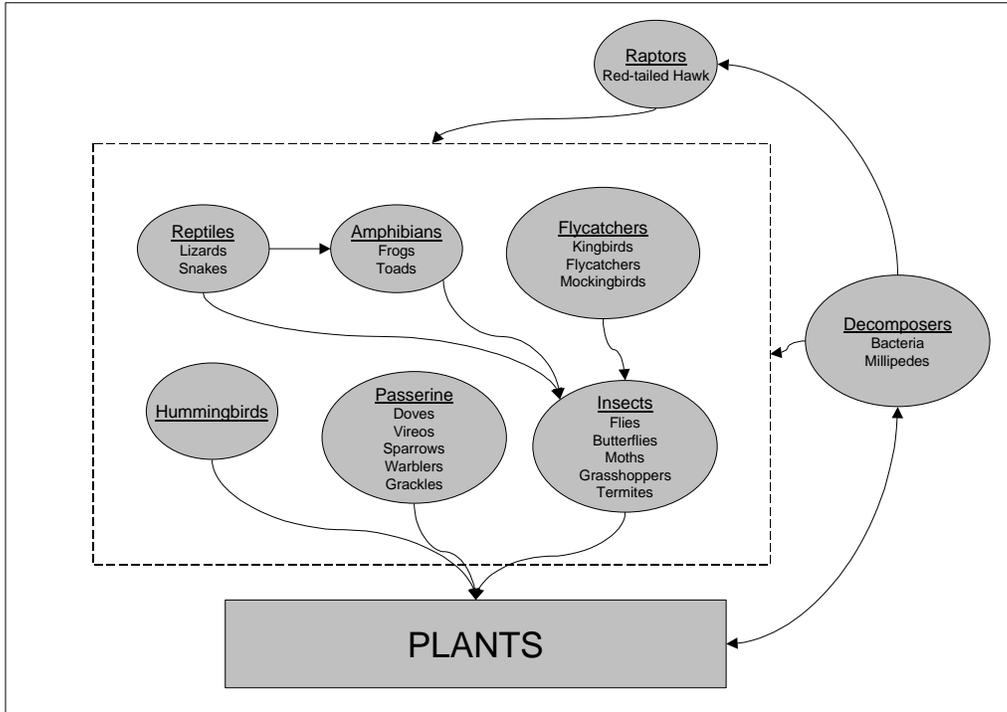


Figure 6. Generalized Food Web for the Upland Coastal Forest and Coastal Scrub Forest Communities at NAVSTA Roosevelt Roads.

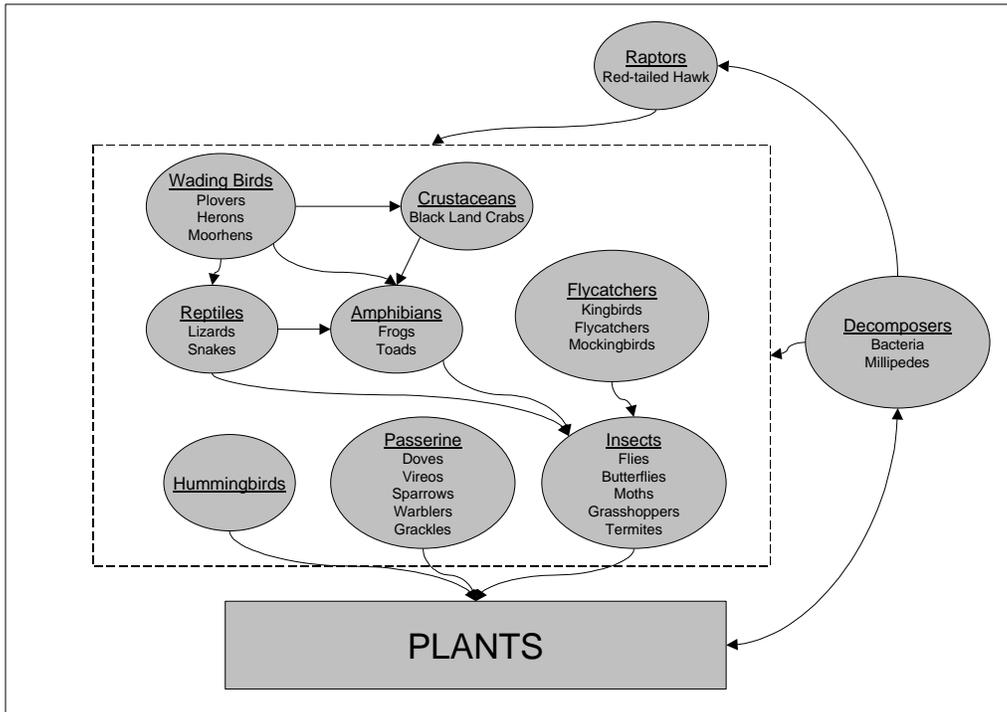


Figure 7. Generalized Food Web for Mangrove Communities at NAVSTA Roosevelt Roads.

SWMU 2

Vegetation Community Description

SWMU 2, Langley Drive Disposal Site, is located along Langley Drive and is approximately 2,000 feet northwest of the Navy Exchange. SWMU 2 extends from Langley Drive in a gentle slope towards a mangrove community and has an estimated length of 1,300 feet in a northeast-southeast direction. Disturbances consisted of an un-maintained road that led to a monitoring well. There was a small earthen berm running parallel to the mangrove boundary. The dominant vegetation was upland coastal forest; however, the adjacent black mangrove community was also described.

Various stages of ecological succession were observed throughout the upland coastal forest community and canopy cover approached 100 percent. The dominant plant community along the monitoring well road was herbaceous vegetation with *Leucaena leucocephala* shrubs, *Panicum maximum*, *Sporobolus indicus*, and *Waltheria indica*. Road edges were a nearly monotypic stand of *Leucaena leucocephala* shrubs. Further from the monitoring well road, there were fewer individuals of *Leucaena leucocephala* and more upland coastal forest plant community species such as *Bursera simaruba*, *Erthroxylum brevipes*, and *Capparis flexusa*.

Although the mangrove community was limited within SWMU 2, it is described here and included in Table 4. The mangrove community formed the boundary for SWMU 2 and contained a number of additional species that are not typically found in mangrove communities. Because the area described was in the upland/wetland boundary (ecotone) of the community and there was adjacent road disturbance, higher species richness would be expected. Dominant plants included black mangrove, *Leucaena leucocephala*, and *Randia aculeata*. Vegetation photos are presented in Figures 9 and 10. The vegetation observed at SWMU 2 is presented in Table 4.

Plant Community Health

The control for SWMU was a similar plant community found on the eastern boundary of SWMU 2 along Langley Road. The control had similar topography, soils, position in landscape, and it was located between a paved road and a mangrove community. The only difference between the control and SWMU 2 was that SWMU 2 contained a road that had created an opening in the plant community. This opening had allowed an herbaceous stratum to establish and *Leucaena leucocephala* dominated the road edges. No other vegetation stresses were observed throughout the SWMU 2 community when compared to the control.

Table 4
Vegetation Observed at SWMU 2

Common Name	Scientific Name	Stratum
Upland Coastal Forest		
aroma, sweet acacia	<i>Acacia farnesiana</i>	S
none	<i>Bothriochloa ichaemum</i>	H
bottle wiss	<i>Capparis flexusa</i>	S
none	<i>Cissus obovata</i>	V
none	<i>Ipomea spp.</i>	V
tan tan, tanty, wild tamarind, zarcilla	<i>Leucaena leucocephala</i>	S
none	<i>Macfadyena unguis-cati</i>	S
none	<i>Panicum maximum</i>	H
cattle tongue, sweet scent	<i>Pluchea carolinensis</i>	H
none	<i>Sporobolus indicus</i>	H
yerba socialista, socialist herb	<i>Vernonia cinerea</i>	H
marsh mallow	<i>Waltheria indica</i>	H
Black mangrove		
black mangrove	<i>Avicenia germinans</i>	S/T
almácigo, turpentine-tree	<i>Bursera simaruba</i>	S/T
bottle wiss	<i>Capparis flexuosa</i>	S
Black willie, Jamaican caper	<i>Capparis cynophallophora</i>	S/T
brazillette	<i>Erythroxylum brevipes</i>	S
none	<i>Foresteria eggersiana</i>	S
black mampoo, wild mampoo	<i>Guapira fragans</i>	S
none	<i>Lasiacis divaricata</i>	H
tan tan, tanty, wild tamarind, lead tree	<i>Leucaena leucocephala</i>	S
none	<i>Panicum maximum</i>	H
Christmas tree, tintillo	<i>Randia aculeata</i>	S
none	<i>Sporobolus indicus</i>	H

S = shrub
T = tree
H = herbaceous
V = vine

Wildlife Description

During the short duration of wildlife surveys conducted on this site, numerous wildlife species including birds, lizards, frogs, and crabs were observed utilizing the habitat of this site (Table 5). A large land crab (*Ucar* species) was observed in the mangrove community. There was no evidence that the SWMU site had an impact on the wildlife or its habitat.

Protected Species

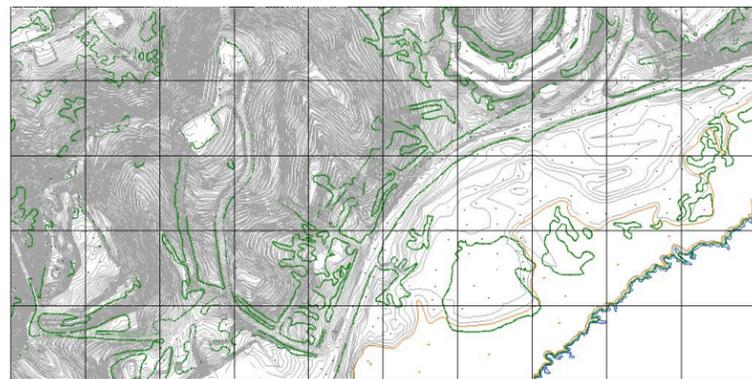
SWMU 2 was in close proximity and had similar habitat as SWMU 1. There were no federally protected species or preferred habitat observed at SWMU 2. See the discussion on protected species for SWMU 1 for information on potentially occurring species and their habitat.

Food Web

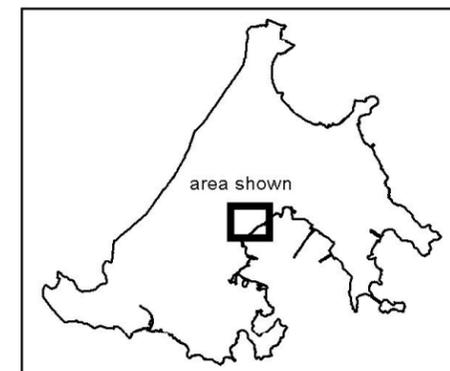
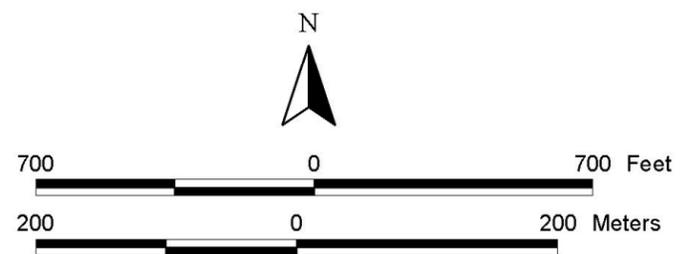
Figures 6 and 7 present generalized food webs for the upland coastal forest and mangrove communities, respectively.

Table 5
Wildlife Observed at SWMU 2

English Name	Scientific Name	Local Name
Upland Coastal Forest		
Reptiles and Amphibians		
Lizard	<i>Anolis cristatellus</i>	not known
Lizard	<i>Anolis pulchellus</i>	not known
Frog	<i>Eleutherodactylus sp.</i>	not known
Frog	<i>Leptodactylus albilabris</i>	not known
Birds		
Red-tailed Hawk	<i>Buteo jamaicensis</i>	Guaraguao de Cola Roja
Yellow Warbler	<i>Dendroica petechia</i>	Canario de Mangle
Pearly-eyed Thrasher	<i>Margarops fuscatus</i>	Zorzal Pardo
Puerto Rico Woodpecker	<i>Melanerpes portoricensis</i>	Carpintero de Puerto Rico
Northern Mockingbird	<i>Mimus polyglottos</i>	Ruiseñor
Greater Antillean Grackle	<i>Quiscalus niger</i>	Mozambique (Chango)
Gray Kingbird	<i>Tyrannus dominicensis</i>	Pitirre
Black-Whiskered Vireo	<i>Vireo altiloquus</i>	Bien-te-veo
Zenaida Dove	<i>Zenaida aurita</i>	Tórtola Cardosanterera
Mangrove		
Crustacean		
Land Crab	<i>Ucar sp.</i>	Ucar
Birds		
Bananaquit	<i>Coereba flaveola</i>	Reinita Común
Loggerhead Kingbird	<i>Tyrannus caudifasciatus</i>	Clérigo
Black-Whiskered Vireo	<i>Vireo altiloquus</i>	Bien-te-veo
Zenaida Dove	<i>Zenaida aurita</i>	Tórtola Cardosanterera



Topography



U.S. Naval Station Roosevelt Roads, Puerto Rico

Figure 8. Location of SWMU 2, Roosevelt Roads, Puerto Rico



Figure 9. SWMU 2, Un-maintained Road in Center of Photograph within the Upland Coastal Forest Community.



Figure 10. SWMU 2, Typical Vegetation Showing Upland Coastal Forest Species

SWMU 45

Terrestrial Area

Vegetation Community Description

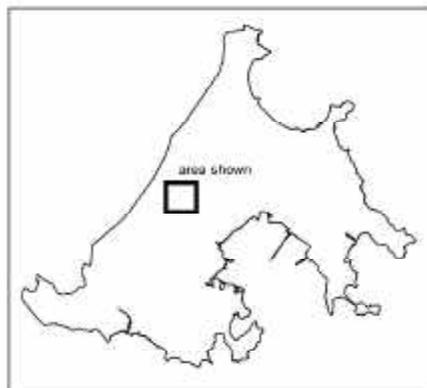
SWMU 45 included areas outside of Building 38, the right-of-way for the cooling water tunnels, and a small cove in Puerca Bay (Figure 11). Building 38 is located along a dirt access road south of Forrestal Drive. Grounds maintenance and building maintenance activity appeared to have been abandoned a few years ago. NAVSTA Roosevelt Roads INRMP indicated that the general cover type for the terrestrial portion of SWMU is urban/developed (U.S. Navy, 1998b). However, observations of the present species composition indicated that the site was in the early ecological succession stages of an upland coastal forest community. In addition to the vegetation around the building and the cooling water tunnel right-of-way, there was a fringe of mangroves along the cove of Puerca Bay. The marine environment at the small cove within Puerca Bay is discussed later.

The majority of the site was located on nearly level upland terrain with almost 100 percent vegetation cover. Shrubs dominated the site, except where road corridors occurred. Maintained grasses such as *Bothriochloa ischaemum*, *Chloris barbata*, and *Digitaria* sp. dominated the road corridors while 10 to 15-foot tall *Leucaena leucocephala* shrubs dominated the un-maintained areas.

The small cove at Puerca Bay was shallow and had been excavated for the water cooling tunnels. The fringe of the bay had near 100 percent shrub cover and little to no herbaceous vegetation. *Thespesia populnea* shrubs dominated the community. There were also sparse black mangroves, *Stachytarpetta jamaicensis*, and *Heliotropium curassavicum* present. A wildlife photo along the cove shoreline is presented in Figure 12. The vegetation observed at SWMU 45 is presented in Table 6.

Plant Community Health

Because SWMU 45 was very similar to SWMU 2 in species composition, community structure, and topography, the same control plot was used for both sites. The control was located along Langley Road adjacent to the eastern boundary of SWMU 2. There were minimal differences between the control and SWMU 45. Most of SWMU 45 had been well maintained, but it appeared that recent lack of maintenance had allowed *Leucaena leucocephala*, an invasive species, to increase. Besides mowing and other grounds maintenance practices at SWMU 45, there were no other plant community stresses observed.



U.S. Naval Station Roosevelt Roads, Puerto Rico



Figure 11. Location of SWMU 45, Roosevelt Roads, Puerto Rico



Figure 12. SWMU 45, Along the Shoreline of the Cove, Killdeer (*Charadrius vociferous*) Foraging Among Washed-up Seagrass.

Table 6
Vegetation Observed at SWMU 45

Common Name	Scientific Name	Stratum
Upland Coastal Forest		
bay flower	<i>Blutaparon vermiculare</i>	H
almácigo, turpentine-tree	<i>Bursera simaruba</i>	S/T
Barbados pride, dwarf poinciana	<i>Caesalpinia pulcherrima</i>	S
bottle wiss	<i>Capparis flexusa</i>	S
conchita de Virginia	<i>Centrosema virginianum</i>	V
none	<i>Chloris barbata</i>	H
péndula de sierra, fiddlewood	<i>Citharexylum caudatum</i>	S/T
copper	<i>Cordia alliodora</i>	S
none	<i>Dalbergia ecastaphyllum</i>	S
cotton	<i>Gossypium barbadense</i>	H
bay vine	<i>Ipomea pes-caprae</i>	V
willy vine	<i>Ipomea tiliacea</i>	V
tan tan, tanty, wild tamarind	<i>Leucaena leucocephala</i>	S
batatilla blanca	<i>Merremia quinquefolia</i>	V
Bellyache balsam, bitter bushplant	<i>Oncimum campechianum</i>	S
Prickly mampoo	<i>Pisonia aculeata</i>	S
guamá americano, guamuchil	<i>Pithcellobium dulce</i>	S
Christmas tree, tintillo	<i>Randia aculeata</i>	S
royal palm	<i>Roystonea borinquena</i>	S
bay flower, sea purslane, sea pusley	<i>Sesuvium portulacastrum</i>	H
None	<i>Sida rhombifolia</i>	S
Mangrove		
sea pusley	<i>Heliotropium curassavicum</i>	H
black mangrove	<i>Laguncularia racemosa</i>	S/T
None	<i>Stachytarpetta jamaicensis</i>	H/S
seaside mahoe, emajaguilla, portiatree	<i>Thespesia populnea</i>	S

S = shrub T = tree
H = herbaceous V = vine

Wildlife Description

During the short duration of wildlife surveys conducted on this site, numerous wildlife species such as birds and lizards were observed utilizing the habitat of this site (Table 7). Bird species were typical of coastal forest and shore species due to the proximity of the site to the open waters of Puerca Bay. There was no evidence that the SWMU site had an impact on the wildlife or habitat.

Protected Species

There were no federally protected species or preferred habitat observed at this site. The federally threatened plant *Stahlia monosperma* and the endangered Puerto Rican boa (*Epicrates inornatus*) would not be expected to inhabit the area since the site has been disturbed. Intact coastal forest habitat is not present (preferred habitat for the Puerto Rican boa) and only sparse black mangroves were present along the fringe of the Puerca Bay cove, so *Stahlia monosperma* would probably not occur. SWMU 45 is outside the area of critical habitat designation, although potential feeding habitat (shrubland) for the Yellow-shouldered blackbird was present at the site.

Table 7
Wildlife Observed at SWMU 45

English Name	Scientific Name	Local Name
Reptiles and Amphibians		
Lizard	<i>Anolis cristatellus</i>	Not known
Birds		
Killdeer	<i>Charadrius vociferous</i>	Playero Sabanero
Common-ground Dove	<i>Columbina passerina</i>	Rolita
Yellow Warbler	<i>Dendroica petechia</i>	Canario de Mangle
Magnificent Frigatebird	<i>Fregata magnificens</i>	Tijerilla (Rabijunco)
Pearly-eyed Thrasher	<i>Margarops fuscatus</i>	Zorzal Pardo
Northern Mockingbird	<i>Mimus polyglottos</i>	Ruiseñor
Cave Swallow	<i>Pterochelidon fulva</i>	Golondrina de Cuevas
Greater Antillean Grackle	<i>Quiscalus niger</i>	Mozambique (Chango)
Gray Kingbird	<i>Tyrannus dominicensis</i>	Pitirre
White-winged Dove	<i>Zenaida asiatica</i>	Tórtola Aliblanca
Zenaida Dove	<i>Zenaida aurita</i>	Tórtola Cardosanterera

Food Web

A generalized food web for the upland coastal forest community is provided in Figure 6.

Marine Area

A reconnaissance survey of SWMU 45 was conducted June 19, 2000 (Dial Cordy and Associates Inc., 2000) to define the marine habitat and associated flora and fauna of the outfall structure and surrounding embayment and shore. Marine habitats observed in the study area included: rocky rubble subtidal zone,

shallow subtidal sandy shelf, shelf slope, deep level bottom of embayment, and the outfall structure. A complete list of the marine flora and fauna observed at SWMU 45 is given in the Dial Cordy report (Dial Cordy and Associates Inc., 2000), which is included in Appendix B.

The rocky subtidal zone was located along the shoreline of the embayment and served as a means of shore protection. The rocky habitat was occupied by marine algal species (*Halimeda tuna*, *H. opuntia*, *Penicillus pyriformis*, and *Udotea* species), invertebrates such as sea urchins (*Echinometra lucunter* and *E. viridis*), encrusting fire coral (*Millipora alcicornus*), common sea fan (*Gorgonia ventalina*), and starlet coral (*Siderastrea radians*). Sixteen fish species were seen and common species included sergeant major (*Abudefduf saxatilis*), dusky damselfish (*Stegastes fuscus*), tomtate (*Haemulon aurolineatum*), gray snapper (*Lutjanus griseus*), and squirrelfish (*Holocentrus* species). Most of the fish species were using the rocky zone for food and refuge from predators.

The shallow subtidal sandy shelf was characterized as a seagrass/algal bed dominated by turtle grass (*Thalassia testudinum*). Seagrass cover ranged from approximately 50 to 75 percent. Marine invertebrates included pincushion starfish (*Oreaster reticulatus*), several species of sea cucumbers, and the corkscrew anemone (*Bartholomea annulatta*). Common fish included the tomtate and gray snappers.

The shelf slope was devoid of seagrass and was characterized by marine algae. Fish observed included the yellowfin mojarra (*Gerres cinereus*) and silver jenny (*Eucinostomus gula*). The level sand bottom around the mouth of the outfall structure was un-vegetated and due to low visibility and depth, no large invertebrates or fish were observed.

The outfall structure itself supported a hardbottom community dominated by soft corals (*Leptogorgia* species, *Muricea elongata*, *Gorgonia ventalina*), marine algae (*Caulerpa racemosa* and *Cladophora* species), sponges (*Cliona* species), and fire coral.

CONCLUSION

The past activities at all to the SWMU sites presented in this report have some degree of impacts on their ecosystems. However, these impacts appear to be limited to changes in species composition based on physical disturbances. The construction of roads, rounds maintenance, and the addition of an outfall structure to the cove at Puerca Bay were only disturbances that have caused noticeable differences. Wildlife at these sites seems to be healthy and utilizing the habitats to their fullest extent. Through these surveys, no federally protected species were identified at these sites.

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APPENDIX A

Birds Potentially Occurring at NAVSTA Roosevelt Roads

Pied-billed grebe (*Podilymbus podiceps*)
Red-billed tropicbird (*Phaethon aethereus*)
Brown pelican (*Pelecanus occidentalis*)
Brown booby (*Sula leucogaster*)
Magnificent frigatebird (*Fregata magnificens*)
Great blue heron (*Ardea herodias*)
Louisiana heron (*Hydranassa tricolor*)
Snowy egret (*Egretta thula*)
Great egret (*Egretta alba*)
Striated heron (*Butorides striatus*)
Little blue heron (*Florida caerulea*)
Cattle egret (*Bubulcus ibis*)
Least bittern (*Ixobrychus exilis*)
Yellow-crowned night heron (*Nyctanassa violacea*)
Black-crowned night heron (*Nycticorax nycticorax*)
White-cheeked pintail (*Anas bahamensis*)
Blue-winged teal (*Anas discors*)
American widgeon (*Anas americana*)
Red-tailed hawk (*Buteo jamaicensis*)
Osprey (*Pandion haliaetus*)
Merlin (*Falcon columbarius*)
Clapper rail (*Rallus longirostris*)
American coot (*Fulica americana*)
Caribbean coot (*Fulica caribaea*)
Common gallinule (*Gallinula chloropus*)
Piping plover (*Charadrius melodus*)
Semipalmated plover (*Charadrius semipalmatus*)
Black-bellied plover (*Squatarola squatarola*)
Wilson's plover (*Charadrius wilsonia*)
Killdeer (*Charadrius vocifera*)
Ruddy turnstone (*Arenaria interpres*)
Black-necked stilt (*Himantopus himantopus*)
Whimbrel (*Numenius phaeopus*)
Spotted sandpiper (*Actitis macularia*)
Semipalmated sandpiper (*Calidris pusilla*)
Short-billed dowitcher (*Limnodromus griseus*)
Greater yellowlegs (*Tringa melanoleuca*)
Lesser yellowlegs (*Tringa flavipes*)
Willet (*Catoptrophorus semipalmatus*)
Stilt sandpiper (*Micropalama himantopus*)
Pectoral sandpiper (*Calidris melanotos*)
Laughing gull (*Larus atricilla*)
Royal tern (*Thalasseus maximus*)
Sandwich tern (*Thalasseus sandvicensis*)
Bridled tern (*Sterna anaethetus*)
Least tern (*Sterna albifrons*)
Brown noddy (*Anous stolidus*)
White-winged dove (*Zenaida asiatica*)
Zenaida dove (*Zenaida aurita*)
White-crowned pigeon (*Columba leucocephala*)
Mourning dove (*Zenaida macroura*)
Red-necked pigeon (*Columba squamosa*)
Common ground dove (*Columba passerina*)
Bridled quail dove (*Geotrygon mystacea*)

Birds Potentially Occurring at NAVSTA Roosevelt Roads (Continued)

Ruddy quail dove (*Geotrygon montana*)
Caribbean parakeet (*Aratinga pertinax*)
Smooth-billed ani (*Crotophaga ani*)
Yellow-billed cuckoo (*Coccyzus americanus*)
Mangrove cuckoo (*Coccyzus minor*)
Short-eared owl (*Asio flammeus*)
Chuck-will's-widow (*Caprimulgus carolinensis*)
Common nighthawk (*Chordeiles minor*)
Antillean crested hummingbird (*Orthorhynchus cristatus*)
Green-throated carib (*Sericotes holosericeus*)
Antillean mango (*Anthracothorax dominicus*)
Belted kingfisher (*Ceryle alcyon*)
Gray kingbird (*Tyrannus dominicensis*)
Loggerhead kingbird (*Tyrannus caudifasciatus*)
Stolid flycatcher (*Myiarchus stolidus*)
Caribbean elaenia (*Elaenia martinica*)
Purple martin (*Progne subis*)
Cave swallow (*Petrochelidon fulva*)
Barn swallow (*Hirundo rustica*)
Northern mockingbird (*Mimus polyglottos*)
Pearly-eyed thrasher (*Maragarops fuscatus*)
Red-legged thrush (*Mimocichla plumbea*)
Black-whiskered vireo (*Vireo altiloquus*)
American redstart (*Setaophaga ruticilla*)
Parula warbler (*Parula americana*)
Prairie warbler (*Dendroica discolor*)
Yellow warbler (*Dendroica petechia*)
Magnolia warbler (*Dendroica magnolia*)
Cape May warbler (*Dendroica tigrina*)
Black-throated blue warbler (*Dendroica caerulescens*)
Adelaide's warbler (*Dendroica adelaidae*)
Palm warbler (*Dendroica palmarum*)
Black and white warbler (*Mniotilta varia*)
Ovenbird (*Seiurus aurocapillus*)
Northern water thrush (*Seiurus noveboracensis*)
Bananaquit (*Coerba flaveola*)
Striped-headed tanager (*Spindalis zena*)
Shiny cowbird (*Molothrus bonariensis*)
Black-cowled oriole (*Icterus dominicensis*)
Greater Antillean grackle (*Quiscalis niger*)
Yellow-shouldered blackbird (*Agelaius xanthomus*)
Hooded mannikin (*Lonchura cucullata*)
Yellow-faced grassquit (*Tiaris olivacea*)
Black-faced grassquit (*Tiaris bicolor*)
Least sandpiper (*Calidris minutilla*)
Western sandpiper (*Calidris mauri*)
Puerto Rican woodpecker (*Melanerpes portoricensis*)
Rock dove (*Columba livia*)
Puerto Rican emerald (*Chlorostilbon maugeus*)
Puerto Rican flycatcher (*Myiarchus antillarum*)
Pin-tailed whydah (*Vidua macroura*)
Spice finch (*Lonchura punctulata*)
Ruddy duck (*Oxyura jamaicensis*)
Peregrine falcon (*Falco peregrinus*)

Birds Potentially Occurring at NAVSTA Roosevelt Roads (Continued)

Marbled godwit (*Limosa fedoa*)
Puerto Rican lizard cuckoo (*Saurothera vieilloti*)
Prothonotary warbler (*Protonotaria citrea*)
Green-winged teal (*Anas carolinensis*)
Orange-cheeked waxbill (*Estrilda melpoda*)
Least grebe (*Tachybaptus dominicus*)
West Indian whistling duck (*Dendrocygna arborea*)
Puerto Rican screech owl (*Otus nudipes*)
Puerto Rican tody (*Todus mexicanus*)

Source: U.S. Navy 1998b.

APPENDIX B

**Marine Resource Survey of SWMU Site
NAS Roosevelt Roads, Puerto Rico**

July 18, 2000

**Prepared for:
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TABLE OF CONTENTS

	Page
LIST OF TABLES	II
1.0 INTRODUCTION	1
2.0 HABITAT DESCRIPTION	1
2.1 Rocky Subtidal Zone	1
2.2 Shallow Subtidal Shelf	4
2.3 Shelf Slope	4
2.4 Level Sandy Bottom	4
2.5 Outfall Structure	4
3.0 INDICATOR SPECIES	5
4.0 REFERENCES	6
APPENDIX A Photographs	

LIST OF TABLES

	Page
Table 1 Marine Flora and Fauna Observed at SWMU Site on June 19, 2000	2

1.0 INTRODUCTION

Dial Cordy and Associates Inc. conducted a reconnaissance survey of the SWMU 45 Site at NAS Roosevelt Roads on June 19, 2000. The marine biological survey was conducted for Geo-Marine, Inc. in support of their Ecological Risk Assessment for the installation. Objectives of the brief survey included defining the marine habitats and associated flora and fauna and identifying species observed which may be indicators of present conditions. Representative still photographs and video documentation of the site were also completed.

2.0 HABITAT DESCRIPTION

Marine habitats observed in the study area included a rocky-rubble subtidal zone located around most of the embayment, a shallow subtidal sandy shelf located seaward of the rocky shore, a shelf slope extending to the base of the slope, a deeper level bottom, and the outfall structure. A brief description of the biological communities observed within these habitat types is provided below.

2.1 Rocky Subtidal Zone

Rock rip-rap is located along the shoreline on both sides of the embayment, principally to serve as means of shore protection. The riprap extends from above MHW to approximately 3 feet below MLW. This rock habitat is occupied by a myriad of marine algal species attached to the rocks, as well as numerous sessile and motile epibiota and marine fish (Table 1, Photographs 1-4). Dominant algal species include *Halimeda tuna*, *H. opuntia*, *Penicillus pyriformis*, and *Udotea sp.* Common marine invertebrates observed included sea urchins (*Echinometra lucunter* and *E. viridis*), encrusting fire coral (*Millipora alcornus*), common sea fan (*Gorgonia ventalina*), and starlet coral (*Siderastrea radians*). Sixteen species of marine fish were observed within the rocky zone. Many of these are species are more common to seagrass beds, but move to this zone for food and refugia from predators. Common species observed include sergeant major (*Abudefduf saxatilis*), dusky damselfish (*Stegastes fuscus*), tomtate (*Haemulon aurolineatum*), gray snapper (*Lutjanus griseus*), and squirrelfish (*Holocentrus sp.*). As shown in Table 1, 11 species of fish are classified as rarely observed. Of the 16 species observed, five were juveniles, which often reside in shallow interior seagrass beds or reefs during their earlier life stages, prior to moving to offshore reef environments upon reaching maturity.

Table 1 Marine Flora and Fauna Observed at SWMU Site on June 19, 2000

			Rocky Subtidal	Sandy Shelf	Shelf Slope	Outfall Structure
MARINE FLOWERING PLANTS						
	<i>Thalassia testudinum</i>		x	x	x	
	<i>Syringodium filiforme</i>			x		
ALGAE						
Green Algae						
	<i>Acetabularia calyculus</i>		x			
	<i>Penicillus pyriformis</i>		x			
	<i>Cladophora sp.</i>		x			x
	<i>Caulerpa sertularioides</i>		x			
	<i>Caulerpa racemosa</i>		x			x
	<i>Dictyosphaeria ocellata</i>		x			
	<i>Udotea sp.</i>		x	x	x	
	<i>Avrainvillea nigricans</i>		x			
	<i>Halimeda tuna</i>		x			
	<i>Halimeda opuntia</i>		x	x	x	
	<i>Penicillus capitatus</i>			x		
	<i>Halimeda incrassata</i>			x	x	
Brown Algae						
	<i>Dictyota cervicornis</i>		x			
	<i>Dictyopteris sp.</i>		x			
	<i>Padina sp.</i>		x	x	x	
Red Algae						
	<i>Wrangelia argus</i>		x			x
	<i>Laurencia papillosa</i>		x	x		
INVERTEBRATES						
c	<i>Cliona sp.</i>	red boring sponge	x			x
r	<i>Holopsamma sp.</i>	lumpy overgrowing sponge	x	x		
r	<i>Bartholomea annulata</i>	corkscrew anemone	x	x		
r	<i>Condylactis gigantea</i>	giant anemone	x			
c	<i>Millepora alcicornis</i>	branching fire coral	x			x
r	<i>Muricea elongata</i>	orange spiny sea rod				x
c	<i>Gorgonia ventalina</i>	common sea fan	x			x
c	<i>Leptogorgia sp.</i>	sea whip				x
c	<i>Siderastrea radians</i>	lesser starlet coral	x			x
c	<i>Sabellastarte magnifica</i>	feather duster	x			
r	<i>Cyphoma macgintyi</i>	spotted cyphoma	x			
r	<i>Oreaster reticulatus</i>	cushon sea star		x	x	
ab	<i>Echinometra lucunter</i>	rock boring urchin	x			
ab	<i>Echinometra viridis</i>	reef urchin	x			
r	<i>Actinopyga agassizii</i>	five-toothed sea cucumber		x	x	
c	<i>Holothuria mexicana</i>	donkey dung sea cucumber		x		
FISH						
r	<i>Chaetodon ocellatus</i>	spotfin butterflyfish	x			

			Rocky Subtidal	Sandy Shelf	Shelf Slope	Outfall Structure
r	<i>Pomacantus paru</i>	French angelfish (juv)	x			
r	<i>Acanthurus coeruleus</i>	blue tang (juv)	x			
r	<i>Sphyræna barracuda</i>	great baracuda		x		
c	<i>Gerres cinereus</i>	yellowfin mojarra (juv)		x	x	
r	<i>Archosargus rhomboidalis</i>	sea bream				x
c	<i>Calamus penna</i>	sheepshead porgy (adult)		x		
c	<i>Eucinostomus gula</i>	silver jenny (juv)		x	x	
c	<i>Haemulon aurolineatum</i>	tomtate (juv)	x	x		
c	<i>Lutjanus griseus</i>	gray snapper (juv)	x			x
r	<i>Lutjanus aoidus</i>	schoolmaster snapper	x	x		
c	<i>Stegastes fuscus</i>	dusky damselfish (adult)	x			x
r	<i>Stegastes leucostictus</i>	Beaugregory	x			
ab	<i>Abudefduf saxatilis</i>	sergeant major	x			x
r	<i>Serranus tigrinus</i>	harlequin bass	x			
r	<i>Sparisoma aurofrenatum</i>	redband parrotfish (juv)	x	x		
r	<i>Halichoeres bivittatus</i>	slippery dick	x	x		
c	<i>Holocentrus sp.</i>	squirrelfish	x			
r	<i>Coryphopterus glaucofraenum</i>	bridled goby	x			
r	<i>Aulostomus maculatus</i>	trumpetfish	x			
r	<i>Sphoeroides spengleri</i>	bandtail puffer	x			

r = rare
ab = abundant
c = commom

2.2 Shallow Subtidal Shelf

This zone occurs between the rocky subtidal zone and the deeper shelf slope, from 3-10 feet below MSL. The shelf is characterized as a seagrass/ algal bed dominated by turtle grass (*Thalassia testudinum*) and marine algae including *Halimeda incrassata*, *H. opuntia*, *Udotea* sp., *Padina* sp., and *Penicillus capitatus*. (Photographs 5 & 8). Seagrass cover values based on the Braun Blanquet Method (Braun-Blanquet, 1965) ranged from 50% to greater than 75% for the turtle grass beds. Marine invertebrates observed included the pin cushion star fish (*Oreaster reticulatus*), sea cucumbers (*Actinopyga agassizii*, *Holothuria mexicana*), and the corkscrew anemone (*Bartholomea annulatta*) (Table 1). Fish common to the seagrass habitat included tomtate (*Haemulon aurolineatum*, gray snapper (*Lutjanus griseus*), and several species of mojarras.

The shelf area at the back end of the basin is a sandy bottom habitat with little to no seagrass or algae present. The bottom is covered with active mounds created by callianassid burrowing shrimp. Mojarras were the only family of fish observed in this area. An abundance of drift algae was observed covering the bottom.

2.3 Shelf Slope

The shelf slope ranged from 10-15 feet below MSL around the perimeter of the basin. This area was void of seagrass and characterized by marine algae including *Padina* sp, *Udotea* sp., and *Halimeda* spp (Photographs 7 & 8). No conspicuous motile epibenthic species were observed in this habitat. Fish observed included yellowfin mojarrra (*Gerres cinereus*) and silver jenny (*Eucinostomus gula*).

2.4 Level Sandy Bottom

The interior of the basin from the mouth to and around the outfall structure is unvegetated sand to silty-sand bottom. Due to low visibility and depth (15-20 feet), no large invertebrates or fish were observed.

2.5 Outfall Structure

The concrete side walls of the outfall structure support a hardbottom community dominated by soft corals (*Leptogorgia* sp., *Muricea elongata*, *Gorgonia ventalina*), marine algae (*Caulerpa racemosa*, *Cladophora* sp.), sponges (*Cliona* sp.), and fire coral (*Millipora alcicornus*). A list of species observed is provided in Table 1. Representative species are illustrated in Photographs 9 and 10.

3.0 INDICATOR SPECIES

Species which may serve as indicators of the present environmental quality of the site are listed below. The absence of seagrass and selected invertebrate species in the future would serve to indicate a change in the quality of the habitat and associated water quality in the embayment. Fish species selected are mobile and their absence may not reflect a significant change. The absence of many of the common species observed in association with the rocky shoreline would indicate a significant change had occurred.

Indicator Species	
<i>Thalassia testudinum</i>	turtle grass
<i>Condylactis gigantea</i>	giant anemone
<i>Echinometra viridis</i>	reef urchin
<i>Siderastrea radians</i>	lesser starlet coral
<i>Chaetodon ocellatus</i>	spotfin butterflyfish
<i>Stegastes fuscus</i>	dusky damselfish

4.0 REFERENCES

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APPENDIX A

Photographs



Photograph 1. Rocky subtidal habitat with squirrelfish (*Holocentrus adensionis*).



Photograph 2. Rocky subtidal habitat and seagrass bed interface with calcareous green algae (*Halimeda incrassata*), turtle grass (*Thalassia testudinum*) and porous sea rods (*Pseudoplexaura sp.*).



Photograph 3. Rocky subtidal habitat with calcareous green algae (*Halimeda incrassata*), turtle grass (*Thalassia testudinum*) and giant sea anemone (*Condylactis gigantea*).



Photograph 4. Rocky subtidal habitat with red-boring sponge (*Cliona sp.*), porous sea rod (*Pseudoplexaura sp.*) and knobby brain coral (*Diploria clivosa*).



Photograph 5. Seagrass habitat on shallow shelf dominated by turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*).



Photograph 6. Seagrass habitat with turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) and green algae (*Halimeda incrassata*).



Photograph 7. Shelf slope habitat characterized by green algae (*Halimeda incrassata* and *H. opuntia*).



Photograph 8. Shelf slope habitat characterized by green algae (*Halimeda incrassata* and *H. opuntia*) and scattered turtle grass (*Thalassia testudinum*).



Photograph 9. Hard substrate community on outfall structure with red boring sponge (*Cliona* sp.) and feather duster worm.



Photograph 10. Gorgonian soft corals located on outfall structure.

APPENDIX B
ADDITIONAL DATA COLLECTION WORK PLAN
IN SUPPORT OF ECOLOGICAL RISK ASSESSMENT
AT SWMUS 1 AND 2

Draft

Additional Data Collection Work Plan in Support of
Ecological Risk Assessment at
SWMUs 1 and 2

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
CTO-0033

August 10, 2001

Prepared by



Baker
Environmental, Inc.

CDM
Federal Programs Corp.

TABLE OF CONTENTS

	<u>Page</u>
LIST OF ACRONYMS AND ABBREVIATIONS	iii
1.0 INTRODUCTION	1-1
1.1 Basis for the Work Plan	1-1
1.2 Objectives	1-1
1.3 Site Status Summary	1-1
1.4 Organization of the CMS Work Plan	1-2
2.0 SCOPE OF THE INVESTIGATIONS	2-1
2.1 Background Sampling and Analysis	2-1
2.2 Sampling and Analysis - SWMUs 1 and 2	2-4
3.0 REPORTING	3-1
4.0 SCHEDULE	4-1
5.0 REFERENCES	5-1

LIST OF TABLES

2-1	Sampling Laboratory Analysis Methods
-----	--------------------------------------

LIST OF FIGURES

1-1	SWMU/AOC Location Map
2-1	Estuarine Wetland System Background Sampling Locations
2-2	Open Water Marine Environment Background Sampling Locations
2-3	The Cowardin Wetland Classification System
2-4	SWMU 1 Sampling Locations
2-5	SWMU 2 Sampling Locations
4-1	Schedule

APPENDIX

Appendix A	Sample Matrix
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LIST OF ACRONYMS AND ABBREVIATIONS

Baker	Baker Environmental, Inc.
CMS	Corrective Measures Study
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
GPS	Global Positioning Satellite
HESI	Heartland Environmental Services, Inc.
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NSRR	Naval Station Roosevelt Roads
PAHs	Polyaromatic hydrocarbons
PCBs	Polychlorinated Biphenyls
pH	Minus the Log of the Hydrogen Ion Concentration
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TOC	Total Organic Carbon
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound

1.0 INTRODUCTION

This work plan presents the technical approach for locating, collecting, and analyzing field samples to address data gaps identified in Step 1 of the Screening Level Ecological Risk Assessment (ERA) for Solid Waste Management Unit (SWMU) 1 (Army Cremator Disposal Site) and SWMU 2 (Langley Drive Disposal Site) located at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico (see Figure 1-1). Additional details with respect to sampling methodologies, the Health and Safety Plan etc. are located in the EPA approved Final RCRA Facility Investigation September 13, 1995 (Baker 1995). This work plan has been prepared under contract to the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), Contract Number N62470-95-D-6007.

1.1 Basis for the Work Plan

A Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was performed at SWMUs 1 and 2. The results of the investigations and subsequent baseline human health risk assessment indicated that there were levels of inorganic and organic constituents present that posed potential risks to future residents and on-site construction workers. Based on the results of the risk assessment, a Corrective Measures Study (CMS) for the sites is under development.

As part of the CMS for SWMUs 1 and 2, an ERA is also under development. Step 1 of the Screening Level ERA identifies data gaps that need to be addressed prior to completion of the ERA.

1.2 Objectives

The objective of this work plan is to address the data gaps presented in the Draft Screening Level Ecological Risk Assessment Problem formulation (Step 1) and Exposure Estimate SWMUs 1 and 2 (Baker, 2001).

1.3 Site Status Summary

The RCRA Corrective Action portion of Naval Station Roosevelt Roads permit contained specific requirements for investigations at SWMUs 1 and 2. The RFI was performed in 1997 and 1998. Results of the RFI are provided in the document entitled Revised Draft RCRA Facility Investigation Report for Operable Unit 3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker, April 1999)

which was submitted on April 1, 1999. This document was approved by the United States Environmental Protection Agency (EPA) on September 28, 1999.

1.4 Organization of the CMS Work Plan

This CMS Work Plan is organized into five sections. The first section, the Introduction, is designed to introduce the reader to the basis for the work plan and a summary of the site status. The additional investigations to be performed are discussed in Section 2.0. Section 3.0 identifies the report that will discuss field activities and findings from the work plan. The project schedule is provided in Section 4.0. References cited in the work plan are provided in Section 5.0.

2.0 SCOPE OF THE INVESTIGATIONS

The scope of the investigation will consist of collecting and analyzing data from two distinct ecological environments, open water marine environment and estuarine wetland environment, in support of the ERA. First, a baseline of each environment will be established by collecting and analyzing samples from an area not impacted by base activities. Second, a representative sampling from each environment, if present, will be conducted at SWMUs 1 and 2. Finally, analysis of the samples will include listed field parameters for surface water samples, total organic carbon (TOC) for sediment samples, and selected RCRA Appendix IX parameters. A sample matrix for this investigation is provided as Appendix A.

Quality assurance/quality control (QA/QC) samples should also be collected for analysis. Six duplicate samples, three field blanks, and three matrix spike/matrix spike duplicates (MS/MSD) will be collected for analysis by the laboratory. In addition, one trip blank will be placed in each cooler that requires volatile organic compound (VOC) analysis. One equipment rinsate sample will be collected to verify proper decontamination procedures.

2.1 Background Sampling and Analysis

Background sampling is to be conducted from two distinct ecological environments, open water marine environment and estuarine wetland environment similar to SWMUs 1 and 2. Both of these environments have been identified at NSRR from areas unlikely to have been impacted by base operations. The background sampling to be conducted in these two environments are discussed in greater detail in the follow subsections.

Estuarine Wetland System Environment

Previous investigations have identified an area suitable for background sampling. The area sampled lies within the Los Machos National Forrest. Draft Corrective Measures Study Investigation Report for SWMU 9, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker, July 2, 2001) describes sampling and analytical results from the estuarine wetland environment of SWMU 9 and the base-wide estuarine wetland system background. The previous field sampling was performed on sediment and surface water. Previous analysis was limited to RCRA Appendix IX VOCs, semivolatile organic

compounds (SVOCs), metals, and polychlorinated biphenyls (PCBs). Since this area has not been impacted by base operations, it is ideally suited for further background sampling.

This work plan will use the existing background data collected during the CMS investigation at SWMU 9 to build a more definitive base-wide background database. Building upon the previous efforts to provide background for SWMU 9, additional analysis will be performed on samples collected from the same sample locations. Using a mobile Global Positioning System (GPS) unit to determine sample locations, sediment and surface water samples from the base-wide background estuarine wetland environment will be collected from the previously sampled locations as identified in Figure 2-1. Samples will be collected near high tide to assure surface water is available for sampling.

A stainless steel spoon will be used to collect the sediment from the top six inches of sediment. A new spoon will be used for each sample location to minimize the need to decontaminate between sample locations. Surface water samples will also be collected from the same locations using the direct dip method with the sample jar. A dedicated glass sample container will be utilized to collect and pour the surface water into the laboratory preserved sample containers. Samples will be labeled by the sample location first (i.e., BGEWSSD05). The location identifier will be “BGEWS” for background estuarine wetland system sample. Sample media designators include “SW” for surface water and “SD” for sediment. The sample numbering for all “BG” samples will coincide with previous background sampling done for SWMU 9. Therefore the “BG” samples will be labeled BGEWSSD05, BGEWSSD08, BGEWSSD09, BGEWSSD10, BGEWSSD11, and BGEWSSD12 for sediment samples. Surface water samples will be similar except the “SD” will be replaced with “SW”. All sediment and surface water samples will be analyzed for the following parameters.

- RCRA Appendix IX - PCBs
- RCRA Appendix IX - Cyanides
- RCRA Appendix IX - Chlorinated Herbicides
- RCRA Appendix IX - Pesticides (Organo Chlorine Pesticides only)
- Dioxins/Furans (Total - sediment and surface water, dissolved - surface water)
- TOC (Sediment samples only)
- Field Parameters (Surface water samples only) [pH, Dissolved Oxygen (DO), Temperature, and Salinity]

Open Water Marine Environment

The open water marine environment sediment and surface water background samples will be collected just off-shore of the Los Machos National Forrest (Figure 2-2). Two parallel rows of samples will be collected along the mangrove/ocean interface. The first row of samples will be located along the ocean side of the mangrove/ocean interface. A total of five samples will be collected in this first row. The second row of samples will be collected about 15 to 20 feet out into the ocean from the mangrove/ocean interface. Four samples will be collected from the second row of samples. The samples will be staggered so that they are between the first row of five samples. The total number of samples collected from the two parallel rows is nine. Access to this site will be along the shoreline from Gate 1 at NSRR. Chest waders will be used to access the sampling locations along the shoreline. Surface water samples will be collected just above the sediment samples (1 to 2 feet) via the direct dip method. A dedicated glass sample container will be utilized to collect and transfer the surface water sample into the laboratory preserved sample containers. All sampling locations will be surveyed using a portable GPS unit. Surface water samples will be analyzed for the following parameters.

- RCRA Appendix IX - VOCs
- RCRA Appendix IX - SVOCs
- RCRA Appendix IX - Metals (Total and Dissolved)
- RCRA Appendix IX - PCBs
- RCRA Appendix IX - Cyanides
- RCRA Appendix IX - Chlorinated Herbicides
- RCRA Appendix IX - Pesticides (Organo Chlorine Pesticides only)
- Dioxins/Furans (Total and Dissolved)
- Field Parameters (pH, DO, Temperature, and Salinity)

Sediment samples will be collected using sediment core liners since the depth of water is estimated to be no greater than two feet in this area. Sediment samples will be analyzed for the following parameters.

- RCRA Appendix IX - VOCs
- RCRA Appendix IX - SVOCs
- RCRA Appendix IX - Metals

- RCRA Appendix IX - PCBs
- RCRA Appendix IX - Cyanides
- RCRA Appendix IX - Chlorinated Herbicides
- RCRA Appendix IX - Pesticides (Organo Chlorine Pesticides only)
- Dioxins/Furans
- TOC

Samples will be packed in ice and shipped next day air to the fixed base laboratory. Because of previously encountered delays associated with sample shipments from Puerto Rico to the United States, additional insurance to cover re-sampling costs should be claimed on the bill of lading. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt.

Surface water and sediment samples will be analyzed in the laboratory using the methods identified in Table 2-1. The laboratory will use low level detection methods to report the analysis for polyaromatic hydrocarbons (PAHs) on sediment and surface water samples. The dissolved RCRA Appendix IX inorganic samples from surface water will be filtered in the field.

STL Savannah in Savannah, Georgia will perform the laboratory analysis. Data validation will be performed by Heartland Environmental Services, Inc. (HESI) in St. Charles, Missouri. These firms are being utilized to provide consistency for the project, since they performed the previous analytical and data validation work for these SWMUs.

2.2 Sampling and Analysis - SWMUs 1 and 2

Sample collection from the estuarine wetland and open water marine environment from SWMUs 1 and 2 will be similar. Both sites are located at the western end of the Ensenada Honda and are separated by an asphalt road as shown on Figure 1-1.

Estuarine Wetland System Environment

Nine sediment and surface water samples will be collected from the estuarine wetland environment from SWMUs 1 and 2 as identified on Figures 2-4 and 2-5 respectively. The first row of five samples will be collected on the estuarine wetland side of the upland/estuarine wetland interface. Identifiable drainage patterns will be preferentially sampled, however most of the site is covered in thick overgrowth and detection of drainage patterns may be difficult if not impossible to identify with certainty. The second row of four samples will be located 15 to 20 feet down gradient from the first row of samples. The second row will be staggered between the first row of samples in order to maximize coverage. The total number of samples collected from the two parallel rows is nine.

Surface water samples will be collected immediately above the sediment sample location prior to sediment sampling. The direct dip method will be employed to collect surface water samples. A dedicated glass sample container will be utilized to collect and transfer the surface water sample into the laboratory preserved sample containers.

All sampling locations will be surveyed using a portable GPS unit. Samples will be labeled as indicated:

- 01EWSSD01D Sample ID
- 01EWSSD01D SWMU Identifier (SWMU "01" or "02")
- 01EWSSD01D Environment Designator (Estuarine Wetland System "EWS" or Open Water Marine "OW")
- 01EWSSD01D Type of Sample (SW = Surface Water, SD = Sediment)
- 01EWSSD01D Sample Number (01 through 09)
- 01EWSSD01D QA/QC Identifier ("D" = Duplicate, "MS/MSD" = Matrix Spike/Matrix Spike Duplicate)

The surface water samples for SWMUs 1 and 2 will be analyzed for the following parameters.

- RCRA Appendix IX - VOCs
- RCRA Appendix IX - SVOCs
- RCRA Appendix IX - Metals (Total and Dissolved)

- RCRA Appendix IX - PCBs
- RCRA Appendix IX - Cyanides
- RCRA Appendix IX - Chlorinated Herbicides
- RCRA Appendix IX - Pesticides (Organo Chlorine Pesticides only)
- Dioxins/Furans (Total and Dissolved)
- Field Parameters (pH, DO, Temperature, and Salinity)

Sediment samples will be collected from the top six inches of sediment using stainless steel spoons since the depth of surface water is only a few inches deep. To minimize decontamination of sampling equipment, a new spoon will be used for each sampling location. Sediment samples will be analyzed for the following parameters.

- RCRA Appendix IX - VOCs
- RCRA Appendix IX - SVOCs
- RCRA Appendix IX - Metals
- RCRA Appendix IX - PCBs
- RCRA Appendix IX - Cyanides
- RCRA Appendix IX - Chlorinated Herbicides
- RCRA Appendix IX - Pesticides (Organo Chlorine Pesticides only)
- Dioxins/Furans
- TOC

Samples will be packed in ice and shipped next day air to the fixed base laboratory. Because of previously encountered delays associated with sample shipments from Puerto Rico to the United States, additional insurance to cover re-sampling costs should be claimed on the bill of lading. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt.

Surface water and sediment samples will be analyzed in the laboratory using the methods identified in Table 2-1. The laboratory will use low level detection methods to report the analysis for PAHs on

sediment and surface water samples. The dissolved RCRA Appendix IX inorganic samples from surface water will be filtered in the field.

STL Savannah in Savannah, Georgia will perform the laboratory analysis. Data validation will be performed by Heartland Environmental Services, Inc. (HESI) in St. Charles, Missouri.

Open Water Marine Environment

The open water marine environment sediment and surface water samples for SWMUs 1 and 2 will be collected just off shore in the Ensenada Honda. The area to be sampled is relatively shallow (one to two feet) and extends over one hundred feet from the mangrove/ocean interface into the Ensenada Honda. Since the mangroves along the shoreline are thick and the water near the mangroves is relatively shallow, access to the open water marine sampling locations will be obtained by boat. Both surface water and sediment samples will be collected from SWMUs 1 and 2 as depicted in Figures 2-4 and 2-5. Conditions at the time of sampling will mandate whether or not the sampling will be conducted from the boat or in the water with chest waders.

Two parallel rows of samples will be collected along the mangrove/ocean interface. The first row of samples will be located along the ocean side of the mangrove/ocean interface. A total of five samples will be collected in this first row for both SWMUs 1 and 2. The second row of samples will be collected about 15 to 20 feet out into the ocean from the mangrove/ocean interface. Four samples will be collected from the second row of samples. The samples will be staggered so that they are between the first row of five samples. The total number of samples collected from the two parallel rows is nine for both SWMUs. Surface water samples will be collected just above the sediment samples (1 to 2 feet) via the direct dip method. A dedicated glass sample container will be utilized to collect and transfer the surface water sample into the laboratory preserved sample containers. All sampling locations will be surveyed using a portable GPS unit. Surface water samples will be analyzed for the following parameters.

- RCRA Appendix IX - VOCs
- RCRA Appendix IX - SVOCs
- RCRA Appendix IX - Metals (Total and Dissolved)
- RCRA Appendix IX - PCBs
- RCRA Appendix IX - Cyanides

- RCRA Appendix IX - Chlorinated Herbicides
- RCRA Appendix IX - Pesticides (Organo Chlorine Pesticides only)
- Dioxins/Furans (Total and Dissolved)
- Field Parameters (pH, Dissolved Oxygen, Temperature, and Salinity)

Sediment samples will be collected using sediment core liners since the depth of water is estimated to be no greater than two feet in this area. Sediment samples will be analyzed for the following parameters.

- RCRA Appendix IX - VOCs
- RCRA Appendix IX - SVOCs
- RCRA Appendix IX - Metals
- RCRA Appendix IX - PCBs
- RCRA Appendix IX - Cyanides
- RCRA Appendix IX - Chlorinated Herbicides
- RCRA Appendix IX - Pesticides (Organo Chlorine Pesticides only)
- Dioxins/Furans
- TOC

Samples will be packed in ice and shipped next day air to the fixed base laboratory. Because of previously encountered delays associated with sample shipments from Puerto Rico to the United States, additional insurance to cover re-sampling costs should be claimed on the bill of lading. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt.

Surface water and sediment samples will be analyzed in the laboratory using the methods identified in Table 2-1. The laboratory will use low level detection methods to report the analysis for PAHs on sediment and surface water samples. The dissolved RCRA Appendix IX inorganic samples from surface water will be filtered in the field.

STL Savannah in Savannah, Georgia will perform the laboratory analysis. Data validation will be performed by HESI in St. Charles, Missouri.

3.0 REPORTING

A full report on the investigations described herein will be prepared and will be included as part of the Screening Level Ecological Risk Assessment, Steps 2 and 3a. Included in the report will be a description of the field activities, all screening and laboratory analytical results, and an interpretation of the information obtained.

4.0 SCHEDULE

A schedule for the implementation of this work plan is provided as Figure 4-1. The schedule is heavily dependent on EPA review times. The potential for modifications to the schedule exists if the EPA review times and approval vary from those listed in the schedule. Other factors that may extend the schedule include the following: re-sampling if further re-characterization is required, weather delays in the field, funding is delayed by the Navy, consensus cannot be reached on how the EPA's comments are incorporated. The schedule of events included in this Work Plan is presented on Figure 4-1.

5.0 REFERENCES

Baker Environmental, Inc. (Baker) (September 1995). Final RCRA Facility Investigation, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. Coraopolis, Pennsylvania. September 13, 1995.

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Baker (July 2001). Draft Corrective Measures Study Investigation Report SWMU 9, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. Coraopolis, Pennsylvania. July 2, 2001.

Baker (August 2001). Draft Screening Level Ecological Risk Assessment Problem Formulation (Step 1) and Exposure Estimates SWMUs 1 and 2. Coraopolis, Pennsylvania. August 10, 2001.

TABLES

TABLE 2-1

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

Volatiles	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
Acetone	50	50	8260
Acetonitrile	200	200	8260
Acrolein	100	100	8260
Acrylonitrile	100	100	8260
Benzene	5.0	5.0	8260
Bromodichloromethane	5.0	5.0	8260
Bromoform	5.0	5.0	8260
Bromomethane	10	10	8260
Carbon Disulfide	5.0	5.0	8260
Carbon Tetrachloride	5.0	5.0	8260
Chlorobenzene	5.0	5.0	8260
Chloroethane	10	10	8260
Chloroform	5.0	5.0	8260
Chloromethane	10	10	8260
Chloroprene	5.0	3.0	8260
3-Chloro-1-propene	5.0	5.0	8260
1,2-Dibromo-3-chloropropane	5.0	10	8260
Dibromochloromethane	5.0	5.0	8260
1,2-Dibromoethane	5.0	5.0	8260
Dibromomethane	5.0	5.0	8260
trans-1,4-Dichloro-2-butene	10	10	8260
Dichlorodifluoromethane	10	5.0	8260
Dibromomethane	5.0	5.0	8260
1,1-Dichloroethane	5.0	5.0	8260
1,2-Dichloroethane	5.0	5.0	8260
trans-1,2-dichloroethene	5.0	5.0	8260
1,1-Dichloroethene	5.0	5.0	8260
Methylene Chloride	5.0	5.0	8260
1,2-Dichloropropane	5.0	5.0	8260
cis-1,3-Dichloropropene	5.0	5.0	8260
trans-1,3-Dichloropropene	5.0	5.0	8260
Ethyl benzene	5.0	5.0	8260
Ethyl methacrylate	5.0	5.0	8260
2-Hexanone	25	25	8260
Iodomethane	5.0	5.0	8260
Isobutanol	200	200	8260
Methacrylonitrile	100	100	8260
2-Butanone	25	25	8260
Methyl methacrylate	5.0	5.0	8260
4-Methyl-2-pentanone	25	25	8260

TABLE 2-1

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

Volatiles	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
Pentachloroethane	25	25	8260
Propionitrile	100	100	8260
Stryene	5.0	5.0	8260
1,1,1,2-Tetrachloroethane	5.0	5.0	8260
1,1,2,2-Tetrachloroethane	5.0	5.0	8260
Tetrachloroethene	5.0	5.0	8260
Toluene	5.0	5.0	8260
1,1,1-Trichloroethane	5.0	5.0	8260
1,1,2-Trichloroethane	5.0	5.0	8260
Trichloroethene	5.0	5.0	8260
Trichlorofluoromethane	5.0	5.0	8260
1,2,3-Trichloropropane	5.0	5.0	8260
Vinyl Acetate	10	10	8260
Vinyl Chloride	10	10	8260
Xylene	10	10	8260

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

TABLE 2-1

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

Semivolatiles	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
Acenaphthene	10	330	8270
Acenaphthylene	10	330	8270
Acetophenone	10	330	8270
2-Acetylaminofluorene	10	330	8270
4-Aminobiphenyl	20	330	8270
Aniline	20	330	8270
Anthracene	10	330	8270
Aramite	10	330	8270
Benzo(a)anthracene	10	330	8270
Benzo(b)fluoranthene	10	330	8270
Benzo(k)fluoranthene	10	330	8270
Benzo(g,h,i)perylene	10	330	8270
Benzo(a)pyrene	10	330	8270
Benzyl alcohol	10	330	8270
Bis(2-chloroethoxyl)methane	10	330	8270
Bis(2-chloroethyl)ether	10	330	8270
Bis(2-ethylhexyl)phthalate	10	330	8270
4-Bromophenyl phenyl ether	10	330	8270
Butylbenzylphthalate	10	330	8270
4-Chloroaniline	20	660	8270
4-Chloro-3-methylphenol	10	330	8270
2-Chloronaphthalene	10	330	8270
2-Chlorophenol	10	330	8270
4-Chlorophenyl phenyl ether	10	330	8270
Chrysene	10	330	8270
3&4 Methylphenol	10	330	8270
2-Methylphenol	10	330	8270
Diallate	10	330	8270
Dibenzofuran	10	330	8270
Di-n-butyl phthalate	10	330	8270
Dibenzo(a,h)anthracene	10	330	8270
o-Dichlorobenzene	10	330	8270
m-Dichlorobenzene	10	330	8270
p-Dichlorobenzene	10	330	8270
3,3'-Dichlorobenzidine	20	660	8270
2,4-Dichlorophenol	10	330	8270
2,6-Dichlorophenol	10	330	8270
Diethylphthalate	10	330	8270
p-(Dimethylamino)azobenzene	10	330	8270
7,12-Dimethyl benz(a)anthracene	10	330	8270

TABLE 2-1

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

Semivolatiles	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
3,3-Dimethyl benzidine	20	1,700	8270
2,4-Dimethylphenol	10	330	8270
alpha, alpha-Dimethylphenethylamine	2,000	67,000	8270
Dimethyl phthalate	10	330	8270
m-Dinitrobenzene	10	330	8270
4,6-Dinitro-2-methylphenol	50	1,700	8270
2,4-Dinitrophenol	50	1,700	8270
2,4-Dinitrotoluene	10	330	8270
2,6-Dinitrotoluene	10	330	8270
Di-n-octylphthalate	10	330	8270
1,4-Dioxane	10	330	8270
Dinoseb	10	330	8270
Ethylmethanesulfonate	10	330	8270
Fluoranthene	10	330	8270
Fluorene	10	330	8270
Hexachlorobenzene	10	330	8270
Hexachlorobutadiene	10	330	8270
Hexachlorocyclopentadiene	10	330	8270
Hexachloroethane	10	330	8270
Hexachlorophene	5,000	170,000	8270
Hexachloropropene	10	330	8270
Indeno(1,2,3-cd)pyrene	10	330	8270
Isophorone	10	330	8270
Isosafrole	10	330	8270
Methapyrilene	2,000	67,000	8270
3-Methylcholanthrene	10	330	8270
Methyl methanesulfonate	10	330	8270
2-Methylnaphthalene	10	330	8270
Naphthalene	10	330	8270
1,4-Naphthoquinone	10	330	8270
1-Naphthylamine	10	330	8270
2-Naphthylamine	10	330	8270
2-Nitroaniline	50	1,700	8270
3-Nitroaniline	50	1,700	8270
4-Nitroaniline	50	1,700	8270
Nitrobenzene	10	330	8270
2-Nitrophenol	10	330	8270
4-Nitrophenol	50	1,700	8270
4-Nitroquinoline-1-oxide	20	3,300	8270
n-Nitrosodi-n-butylamine	10	330	8270

TABLE 2-1

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

Semivolatiles	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
n-Nitrosodiethylamine	10	330	8270
n-Nitrosodimethylamine	10	330	8270
n-Nitrosodiphenylamine	NA	330	8270
n-Nitrosodi-n-propylamine	10	330	8270
n-Nitrosomethylethylamine	10	330	8270
n-Nitrosomorpholine	10	330	8270
n-Nitrosopiperidine	10	330	8270
n-Nitrosopyrrolidine	10	330	8270
5-Nitro-o-toluidine	10	330	8270
bis-(2-chloroisopropyl)ether	10	330	8270
Pentachlorobenzene	10	330	8270
Pentachloronitrobenzene	10	330	8270
Pentachlorophenol	50	1,700	8270
Phenacetin	10	330	8270
Phenanthrene	10	330	8270
Phenol	10	330	8270
1,4-Phenylenediamine	2,000	1,700	8270
2-Picolin	10	330	8270
Pronamide	10	330	8270
Pyrene	10	330	8270
Pyridine	50	330	8270
Safrole	10	330	8270
1,2,4,5-Tetrachlorobenzene	10	330	8270
2,3,4,6-Tetrachlorophenol	10	330	8270
o-Toluidine	10	330	8270
1,2,4-Trichlorobenzene	10	330	8270
2,4,5-Trichlorophenol	10	330	8270
2,4,6-Trichlorophenol	10	330	8270
1,3,5-Trinitrobenzene	10	330	8270

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

NA = Not Available

TABLE 2-1

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

Pesticides/PCBs	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
Aldrin	0.05	1.7	8081
Alpha-BHC	0.05	1.7	8081
beta-BHC	0.05	1.7	8081
delta-BHC	0.05	1.7	8081
gamma-BHC	0.05	1.7	8081
Chlordane	0.5	17	8081
Chlorobenzilate	0.5	17	8081
4,4'-DDT	0.1	3.3	8081
4,4'-DDE	0.1	3.3	8081
4,4'-DDD	0.1	3.3	8081
Dieldrin	0.1	3.3	8081
Endosulfan I	0.05	1.7	8081
Endosulfan II	0.1	3.3	8081
Endosulfan sulfate	0.1	3.3	8081
Endrin	0.1	3.3	8081
Isodrin	0.05	3.3	8081
Kepone	1.0	170	8081
Toxaphene	5.0	170	8081
Endrin Aldehyde	0.1	3.3	8081
Heptachlor	0.05	1.7	8081
Heptachlor epoxide	0.05	1.7	8081
Methoxychlor	0.5	17	8081
Aroclor-1016	1.0	33	8082
Aroclor-1221	2.0	67	8082
Aroclor-1232	1.0	33	8082
Aroclor-1242	1.0	33	8082
Aroclor-1248	1.0	33	8082
Aroclor-1254	1.0	33	8082
Aroclor-1260	1.0	33	8082

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

TABLE 2-1

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

Dioxins/Furans (SW-846 Method 8280)	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
2,3,7,8-TCDD	0.005	0.50	8280
2,3,7,8-PCDF	0.005	0.50	8280
2,3,7,8-PCDD	0.005	0.50	8280
2,3,7,8-HCDF	0.005	0.50	8280
2,3,7,8-HCDD	0.005	0.50	8280
2,3,7,8-TCDF	0.005	0.50	8280

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

TABLE 2-1

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

Chlorinated Herbicides	Quantitation Limits*		Method Number
	Water (mg/L)	Low Soil (mg/kg)	
2,4-D	0.50	8.3	8151
2,4,5-T	0.50	8.3	8151
2,4,5-TP	0.50	8.3	8151

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

Field Reading Parameters	Quantitation Limits	Method Number
	Water (mg/L)	
Dissolved Oxygen (DO)	50	Chemets (Field)
Salinity	parts per trillion	Salinity Meter (Field)
Conductivity	μohms	Conductivity Meter (Field)
pH	unitless	Conductivity Meter (Field)
Temperature	degrees F	Conductivity Meter (Field)

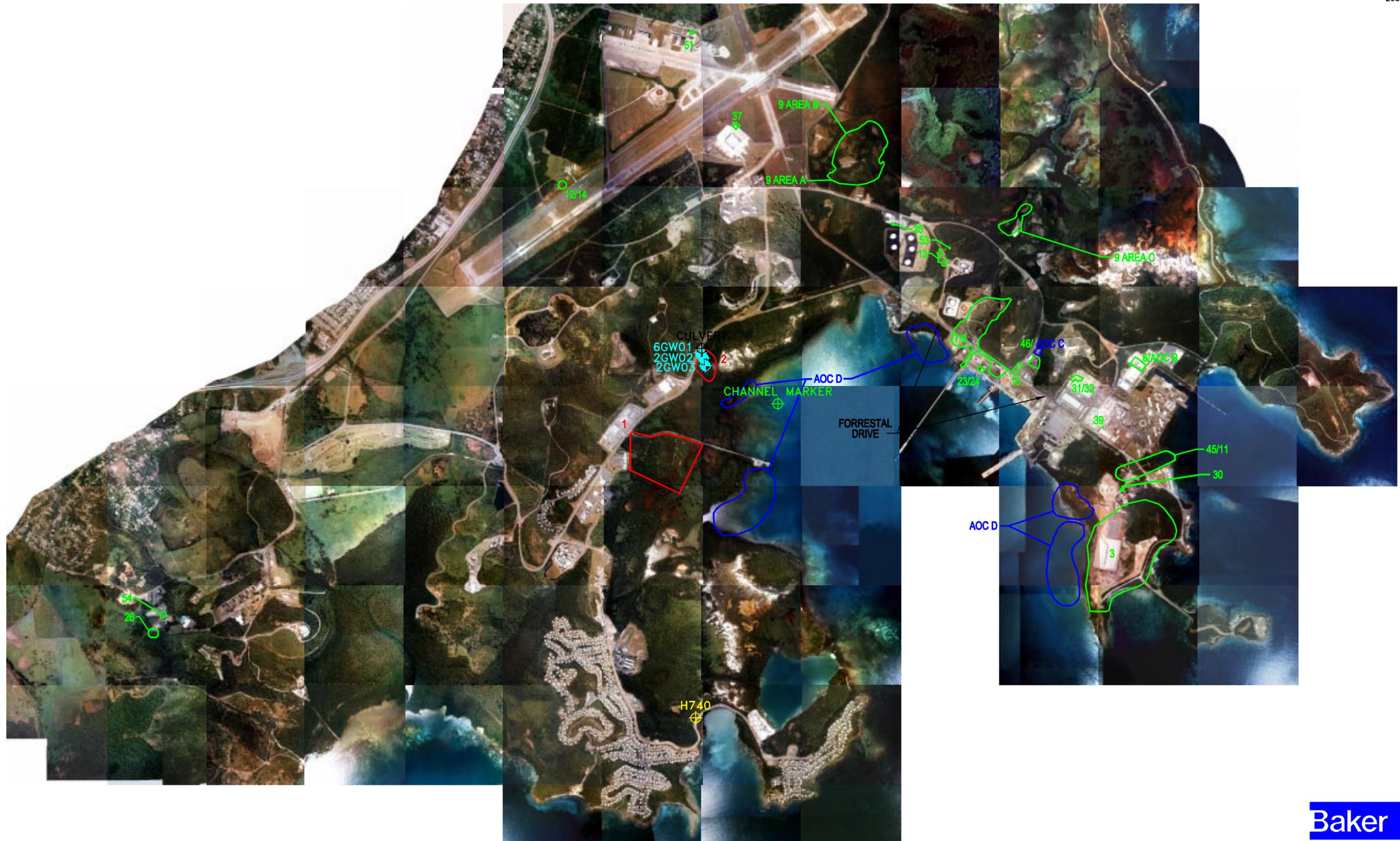
TABLE 2-1

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

Inorganics	Method Number	Quantitation Limits*		Method Description
		Water (mg/L)	Low Soil (mg/kg)	
Antimony	6010	20	2.0	Inductively Coupled Plasma
Arsenic	6010	10	1.0	Inductively Coupled Plasma
Barium	6010	10	1.0	Inductively Coupled Plasma
Beryllium	6010	4.0	0.4	Inductively Coupled Plasma
Cadmium	6010	5.0	0.5	Inductively Coupled Plasma
Chromium	6010	10	1.0	Inductively Coupled Plasma
Cobalt	6010	10	1.0	Inductively Coupled Plasma
Copper	6010	20	2.0	Inductively Coupled Plasma
Lead	6010	5.0	0.5	Inductively Coupled Plasma
Mercury	7470/7471	0.2	0.02	Cold Vapor AA
Nickel	6010	40	4.0	Inductively Coupled Plasma
Selenium	6010	10	1.0	Inductively Coupled Plasma
Silver	6010	10	1.0	Inductively Coupled Plasma
Thallium	6010	10	1.0	Inductively Coupled Plasma
Tin	6010	10	5.0	Inductively Coupled Plasma
Vanadium	6010	10	1.0	Inductively Coupled Plasma
Cyanide	9012	0.010	1.0	Colorimetric
Sulfide	9030	1.0	25	Titrimetric, Iodine
Zinc	6010	20	2.0	Inductively Coupled Plasma

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

FIGURES



LEGEND

- 9 - SWMUs
- AOC D - AOCs
- 1 - AREA OF WHICH THIS INVESTIGATION PERTAINS TO

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

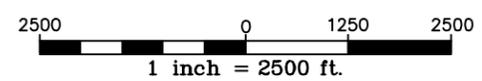
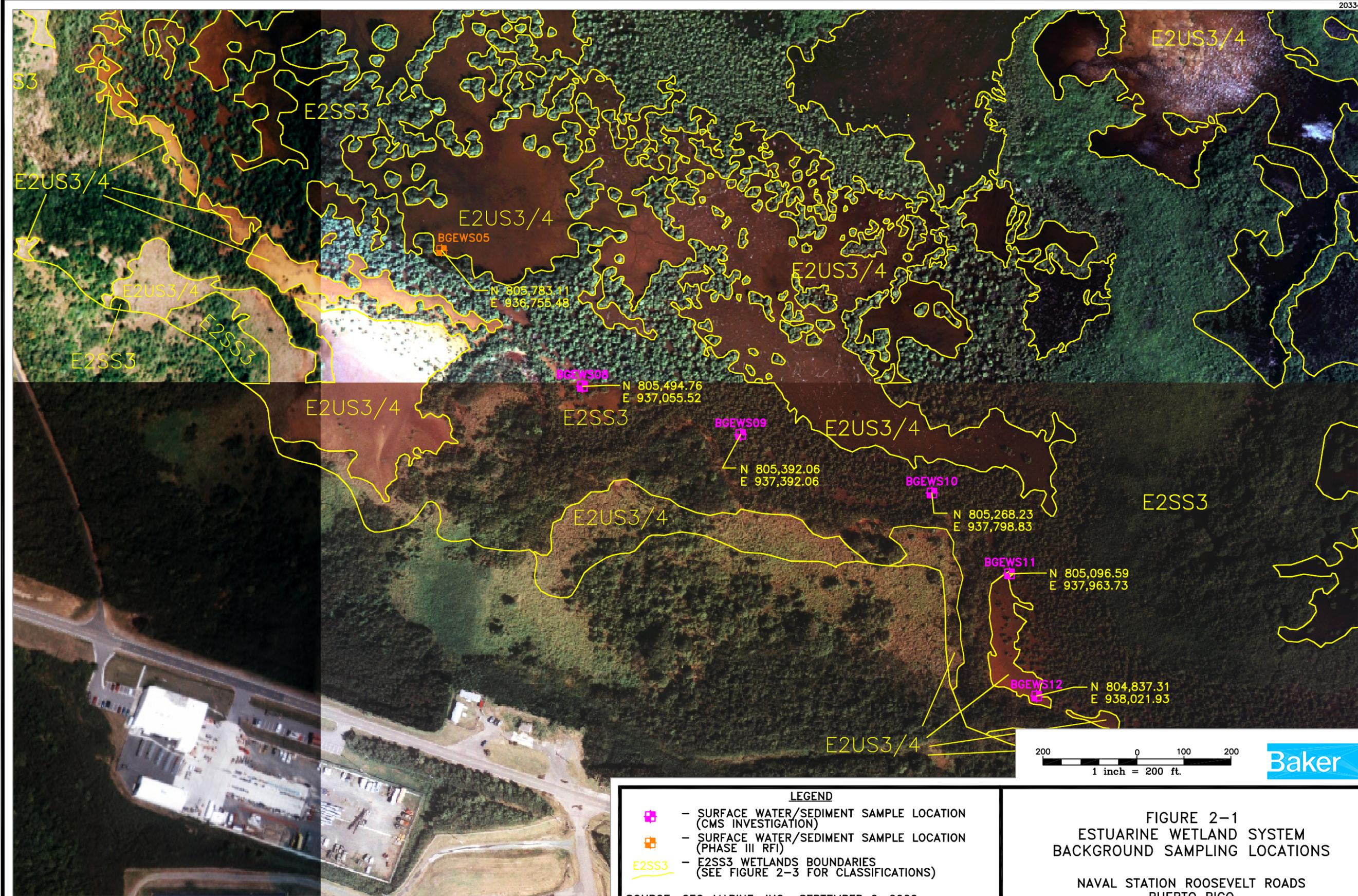


FIGURE 1-1
 SWMU/AOC LOCATION MAP
 NAVAL STATION ROOSEVELT ROADS
 PUERTO RICO

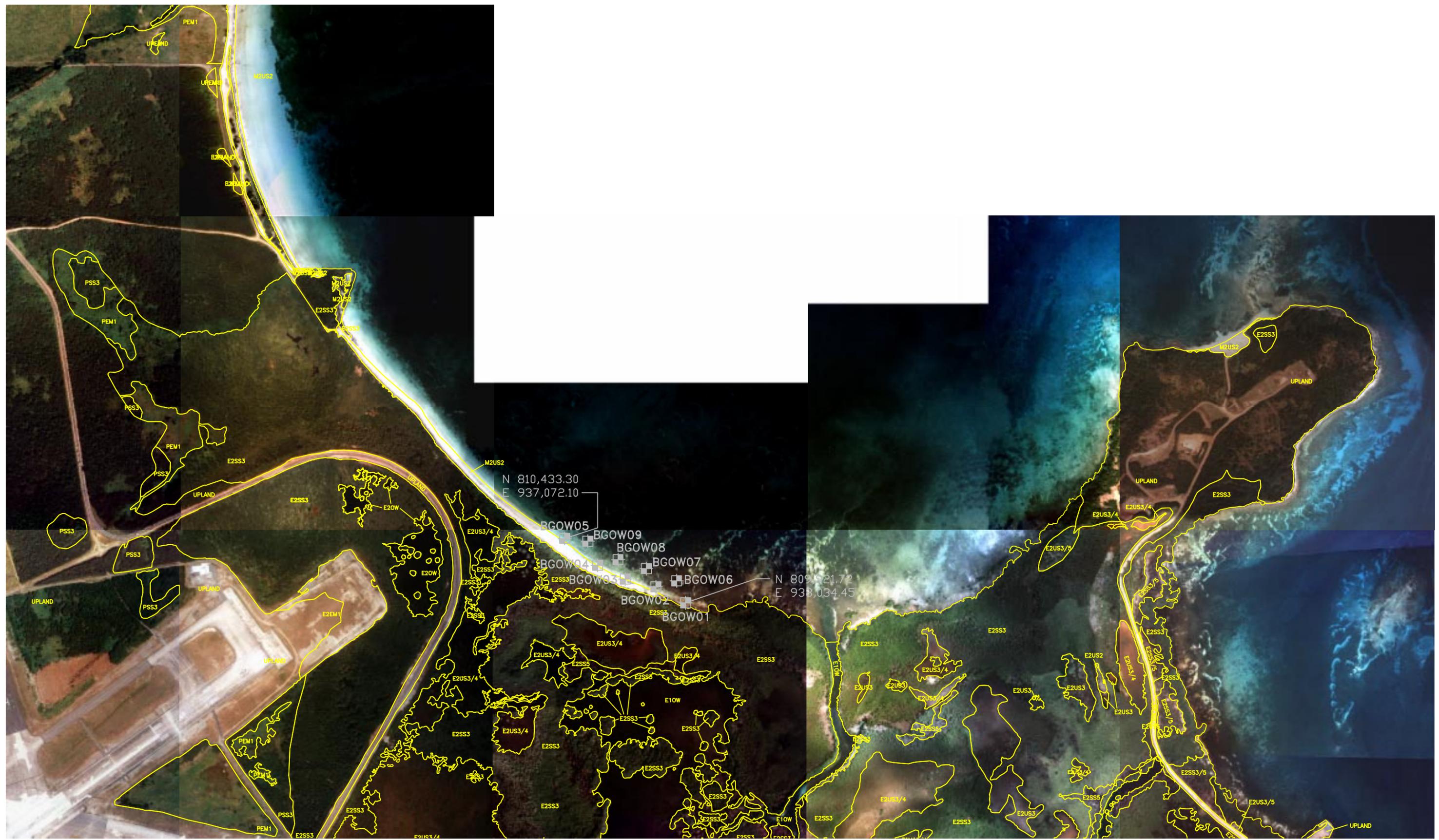


LEGEND

■	- SURFACE WATER/SEDIMENT SAMPLE LOCATION (CMS INVESTIGATION)
■	- SURFACE WATER/SEDIMENT SAMPLE LOCATION (PHASE III RFI)
E2SS3	- E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 2-3 FOR CLASSIFICATIONS)

FIGURE 2-1
ESTUARINE WETLAND SYSTEM
BACKGROUND SAMPLING LOCATIONS
 NAVAL STATION ROOSEVELT ROADS
 PUERTO RICO

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



LEGEND

- OPEN WATER MARINE
- PROPOSED SURFACE WATER/ SEDIMENT SAMPLE LOCATION
- E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 2-3 FOR CLASSIFICATIONS)

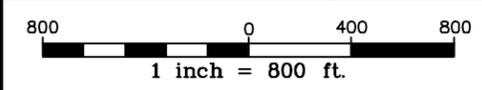


FIGURE 2-2
OPEN WATER MARINE ENVIRONMENT
BACKGROUND SAMPLING LOCATIONS
 NAVAL STATION ROOSEVELT ROADS
 PUERTO RICO

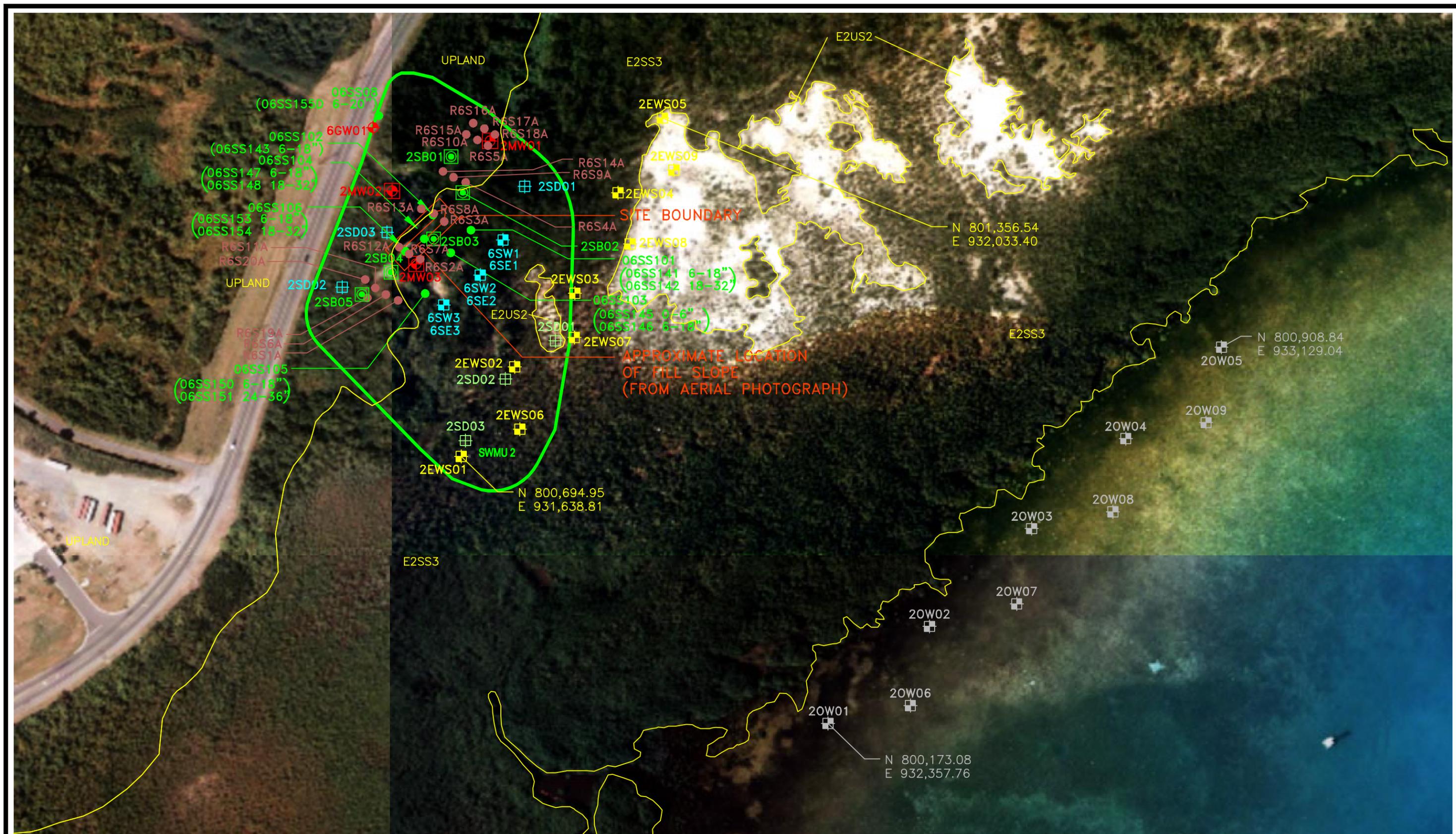
**FIGURE 2-3
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
SWMUs 1 and 2
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO**

SYSTEM	M - MARINE										E - ESTUARINE											
	1 - SUBTIDAL					2 - INTERTIDAL					1 - SUBTIDAL					2 - INTERTIDAL						
SUBSYSTEM	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	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
CLASS	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Rooted Vasc 3 Rooted Vasc 5 Unknown	1 Coral 3 Worm		1 Algal 2 Rooted Vasc 3 Rooted Vasc 5 Unknown	1 Coral 3 Worm	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Rooted Vasc 3 Rooted Vasc 4 Floating Vasc 5 Unknown Submerg. 6 Unknown Surface	2 Mollusk 3 Worm		1 Algal 2 Rooted Vasc 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	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
SUBCLASS																						

SYSTEM	R - RIVERINE								L - LACUSTRINE											
	1 - TIDAL	2 - LOWER PERENNIAL	3 - UPPER PERENNIAL	4 INTERMITTENT	5 - UNKNOWN PERENNIAL	1 - LIMNETIC	2 - LITTORAL													
SUBSYSTEM	RB - Rock Bottom	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	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)	
CLASS	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 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	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	2 Nonpersistent	
SUBCLASS																				

SYSTEM	P - PALUSTRINE									MODIFIERS									
	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)	WATER REGIME		WATER CHEMISTRY			SOIL	SPECIAL			
SUBSYSTEM	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		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	Tidal H Permanently Flooded I Intermittently Flooded J Artificially Flooded 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.	Coastal Salinity 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	g Organic n Mineral	b Beaver d partially drained/ditched f Farmed h Diked/Impounded r Artificial Substrate s Spoil x Excavated	
SUBCLASS																			

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



LEGEND

- SWMU
- E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 2-3 FOR CLASSIFICATIONS)
- SEDIMENT SAMPLE LOCATION (1996 RFI)
- SEDIMENT SAMPLE LOCATION (RELATIVE RISK RANKING)
- SURFACE WATER/SEDIMENT SAMPLE LOCATION (CONFIRMATION STUDY)
- SOIL SAMPLE LOCATION (APPROXIMATE) (SUPPLEMENTAL INVESTIGATION)
- SOIL BORING LOCATION (1996 RFI)
- SOIL SAMPLE LOCATION (APPROXIMATE) (CONFIRMATION STUDY)
- MONITOR WELL LOCATION (1996 RFI)
- EXISTING MONITOR WELL LOCATION (CONFIRMATION STUDY)
- ESTUARINE WETLAND SYSTEM**
- PROPOSED SURFACE WATER/SEDIMENT SAMPLE LOCATION
- OPEN WATER MARINE**
- PROPOSED SURFACE WATER/SEDIMENT SAMPLE LOCATION

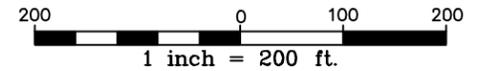
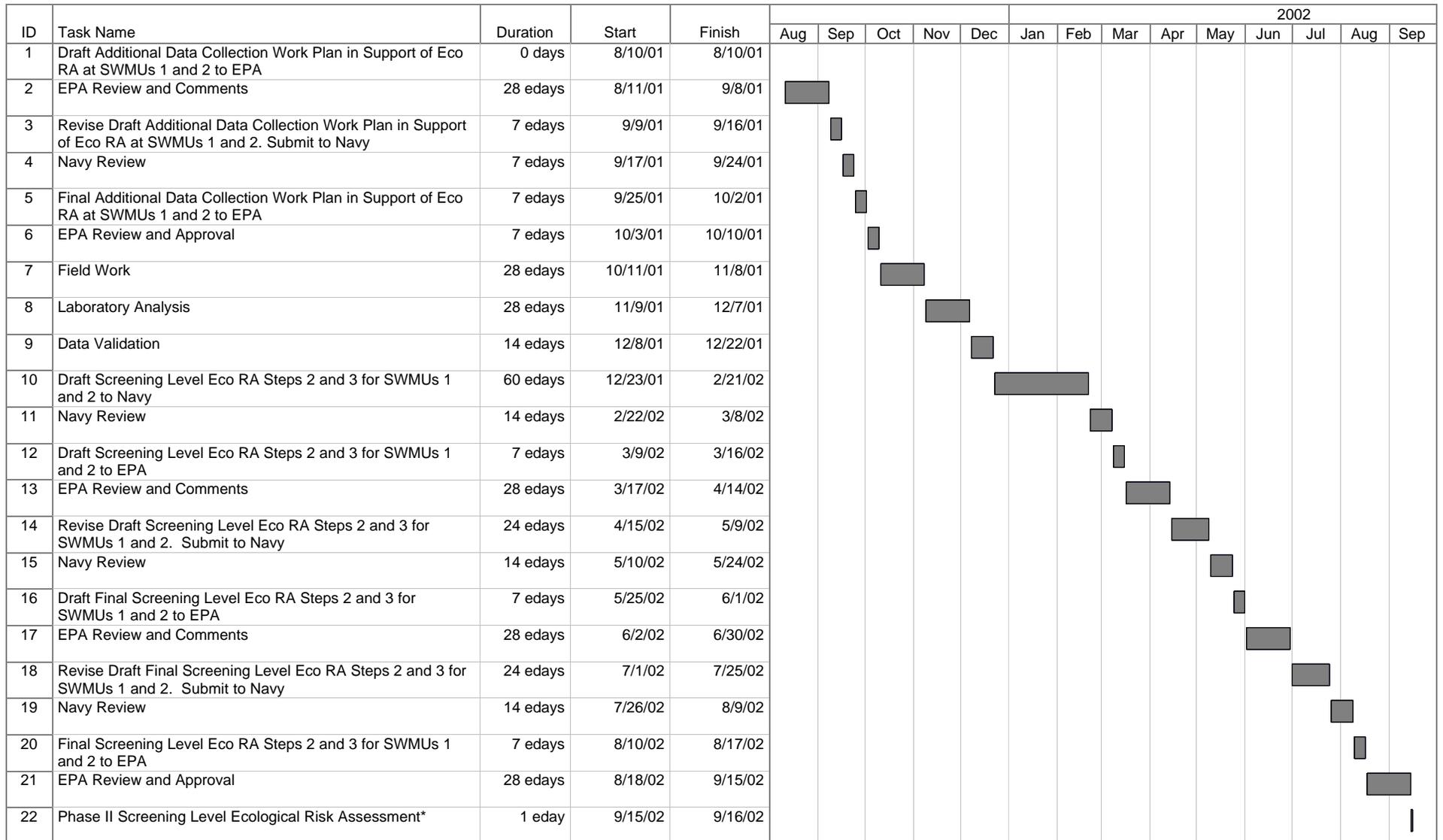


FIGURE 2-5
SWMU 2 SAMPLING LOCATIONS
 NAVAL STATION ROOSEVELT ROADS
 PUERTO RICO

Figure 4-1
Proposed Schedule
Additional Data Collection in Support of Ecological Risk Assessment at SWMUs 1 and 2
Naval Station Roosevelt Roads, Puerto Rico



Project: SWMUs1and2
Date: 8/1/01

* Remaining Schedule follows the schedule outlined in the Revised Final II Corrective Measures Study Work Plan SWMUs 1 & 2 (Baker 2000)

APPENDIX A
SAMPLE MATRIX

APPENDIX A.1

**BACKGROUND SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMUs 1 AND 2
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Sample Media	Environment	Sample ID	Fixed Base Laboratory							Field Measurements					Comments	
			RCRA Appendix IX Parameters							pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets Field)	Temperature - (Conductivity Meter)	Salinity - (Salinity Meter)			
			VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Chlorinated Herbicides - (8151)	Pesticides ⁽¹⁾ - (8081)					Dioxins & Furans - (8280)		Total Organic Carbon - (9060)
Background Sediment	Estuarine Wetland System	BGEWSSD05				X	X	X	X	X	X					
		BGEWSSD08				X	X	X	X	X	X					
		BGEWSSD08D				X	X	X	X	X	X					Duplicate
		BGEWSSD09				X	X	X	X	X	X					
		BGEWSSD10				X	X	X	X	X	X					
		BGEWSSD11				X	X	X	X	X	X					
		BGEWSSD12				X	X	X	X	X	X					
	Open Water Marine	BGOWSD01	X	X	X	X	X	X	X	X	X					
		BGOWSD02	X	X	X	X	X	X	X	X	X					
		BGOWSD03	X	X	X	X	X	X	X	X	X					
		BGOWSD03D	X	X	X	X	X	X	X	X	X					Duplicate
		BGOWSD03MS/MSD	X	X	X	X	X	X	X	X	X					Matrix Spike/Matrix Spike Dup.
		BGOWSD04	X	X	X	X	X	X	X	X	X					
		BGOWSD05	X	X	X	X	X	X	X	X	X					
		BGOWSD06	X	X	X	X	X	X	X	X	X					
BGOWSD07		X	X	X	X	X	X	X	X	X						
BGOWSD08	X	X	X	X	X	X	X	X	X							
BGOWSD09	X	X	X	X	X	X	X	X	X							

Notes:

⁽¹⁾ Chlorinated Pesticides Only

APPENDIX A.1

**BACKGROUND SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMUs 1 AND 2
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Sample Media	Environment	Sample ID	Fixed Base Laboratory							Field Measurements					Comments	
			RCRA Appendix IX Parameters							Total Organic Carbon - (9060)	pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets Field)	Temperature - (Conductivity Meter)	Salinity - (Salinity Meter)		
			VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Chlorinated Herbicides - (8151)	Pesticides ⁽¹⁾ - (8081)							Dioxins & Furans - (8280)
Background Surface Water	Estuarine Wetland System	BGEWSSW05				X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGEWSSW08				X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGEWSSW08D				X	X	X	X	X ⁽²⁾		X	X	X	X	Duplicate
		BGEWSSW09				X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGEWSSW10				X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGEWSSW11				X	X	X	X	X ⁽²⁾		X	X	X	X	
	BGEWSSW12				X	X	X	X	X ⁽²⁾		X	X	X	X		
	Open Water Marine	BGOWSW01	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGOWSW02	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGOWSW03	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGOWSW03D	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Duplicate
		BGOWSW03MS	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Matrix Spike
		BGOWSW03MSD	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Matrix Spike Duplicate
		BGOWSW04	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGOWSW05	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGOWSW06	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGOWSW07	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGOWSW08	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		BGOWSW09	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	

Notes:

⁽¹⁾ Chlorinated Pesticides Only

⁽²⁾ Total and Dissolved

APPENDIX A.2

**SEDIMENT AND SURFACE WATER SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMU 1
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Sample Media	Environment	Sample ID	Fixed Base Laboratory								Field Measurements				Comments	
			RCRA Appendix IX Parameters								pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets Field)	Temperature - (Conductivity Meter)	Salinity - (Salinity Meter)		
			VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Chlorinated Herbicides - (8151)	Pesticides ⁽¹⁾ - (8081)	Dioxins & Furans - (8280)						Total Organic Carbon - (9060)
Sediment	Estuarine Wetland System	01EWSSD01	X	X	X	X	X	X	X	X	X					
		01EWSSD02	X	X	X	X	X	X	X	X	X					
		01EWSSD03	X	X	X	X	X	X	X	X	X					
		01EWSSD04	X	X	X	X	X	X	X	X	X					
		01EWSSD05	X	X	X	X	X	X	X	X	X					
		01EWSSD06	X	X	X	X	X	X	X	X	X					
		01EWSSD07	X	X	X	X	X	X	X	X	X					
		01EWSSD07D	X	X	X	X	X	X	X	X	X					Duplicate
		01EWSSD08	X	X	X	X	X	X	X	X	X					
01EWSSD09	X	X	X	X	X	X	X	X	X							
Sediment	Open Water Marine	01OWSD01	X	X	X	X	X	X	X	X						
		01OWSD02	X	X	X	X	X	X	X	X						
		01OWSD03	X	X	X	X	X	X	X	X						
		01OWSD04	X	X	X	X	X	X	X	X						
		01OWSD05	X	X	X	X	X	X	X	X						
		01OWSD05D	X	X	X	X	X	X	X	X					Duplicate	
		01OWSD05MS/MSD	X	X	X	X	X	X	X	X					Matrix Spike/Matrix Spike Dup.	
		01OWSD06	X	X	X	X	X	X	X	X						
		01OWSD07	X	X	X	X	X	X	X	X						
		01OWSD08	X	X	X	X	X	X	X	X						
01OWSD09	X	X	X	X	X	X	X	X								

Notes:

⁽¹⁾ Chlorinated Pesticides Only

APPENDIX A.2

**SEDIMENT AND SURFACE WATER SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMU 1
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Sample Media	Environment	Sample ID	Fixed Base Laboratory								Field Measurements				Comments	
			RCRA Appendix IX Parameters								Total Organic Carbon - (9060)	pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets Field)	Temperature - (Conductivity Meter)		Salinity - (Salinity Meter)
			VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Chlorinated Herbicides - (8151)	Pesticides ⁽¹⁾ - (8081)	Dioxins & Furans - (8280)						
Surface Water	Estuarine Wetland System	01EWSSW01	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01EWSSW02	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01EWSSW03	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01EWSSW04	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01EWSSW05	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01EWSSW06	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01EWSSW07	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01EWSSW07D	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Duplicate
		01EWSSW08	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01EWSSW09	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
Surface Water	Open Water Marine	01OWSW01	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01OWSW02	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01OWSW03	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01OWSW04	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01OWSW05	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01OWSW05D	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Duplicate
		01OWSW05MS	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Matrix Spike
		01OWSW05MSD	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Matrix Spike Duplicate
		01OWSW06	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01OWSW07	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		01OWSW08	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
01OWSW09	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X			

Notes:

⁽¹⁾ Chlorinated Pesticides Only

⁽²⁾ Total and Dissolved

APPENDIX A.3

**SEDIMENT AND SURFACE WATER SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMU 2
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Sample Media	Environment	Sample ID	Fixed Base Laboratory								Field Measurements				Comments	
			RCRA Appendix IX Parameters								pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets Field)	Temperature - (Conductivity Meter)	Salinity - (Salinity Meter)		
			VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Chlorinated Herbicides - (8151)	Pesticides ⁽¹⁾ - (8081)	Dioxins & Furans - (8280)						Total Organic Carbon - (9060)
Sediment	Estuarine Wetland System	02EWSSD01	X	X	X	X	X	X	X	X	X					
		02EWSSD02	X	X	X	X	X	X	X	X	X					
		02EWSSD03	X	X	X	X	X	X	X	X	X					
		02EWSSD04	X	X	X	X	X	X	X	X	X					
		02EWSSD05	X	X	X	X	X	X	X	X	X					
		02EWSSD06	X	X	X	X	X	X	X	X	X					
		02EWSSD07	X	X	X	X	X	X	X	X	X					
		02EWSSD07D	X	X	X	X	X	X	X	X	X					Duplicate
		02EWSSD08	X	X	X	X	X	X	X	X	X					
02EWSSD09	X	X	X	X	X	X	X	X	X							
Sediment	Open Water Marine	02OWSD01	X	X	X	X	X	X	X	X						
		02OWSD02	X	X	X	X	X	X	X	X						
		02OWSD03	X	X	X	X	X	X	X	X						
		02OWSD04	X	X	X	X	X	X	X	X						
		02OWSD05	X	X	X	X	X	X	X	X						
		02OWSD05D	X	X	X	X	X	X	X	X					Duplicate	
		02OWSD05MS/MSD	X	X	X	X	X	X	X	X					Matrix Spike/Matrix Spike Dup.	
		02OWSD06	X	X	X	X	X	X	X	X						
		02OWSD07	X	X	X	X	X	X	X	X						
		02OWSD08	X	X	X	X	X	X	X	X						
02OWSD09	X	X	X	X	X	X	X	X								

Notes:

⁽¹⁾ Chlorinated Pesticides Only

APPENDIX A.3

**SEDIMENT AND SURFACE WATER SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMU 2
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

Sample Media	Environment	Sample ID	Fixed Base Laboratory									Field Measurements				Comments
			RCRA Appendix IX Parameters									pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets Field)	Temperature - (Conductivity Meter)	Salinity - (Salinity Meter)	
			VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Chlorinated Herbicides - (8151)	Pesticides ⁽¹⁾ - (8081)	Dioxins & Furans - (8280)	Total Organic Carbon - (9060)					
Surface Water	Estuarine Wetland System	02EWSSW01	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02EWSSW02	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02EWSSW03	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02EWSSW04	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02EWSSW05	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02EWSSW06	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02EWSSW07	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02EWSSW07D	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Duplicate
		02EWSSW08	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02EWSSW09	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
Surface Water	Open Water Marine	02OWSW01	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02OWSW02	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02OWSW03	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02OWSW04	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02OWSW05	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02OWSW05D	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Duplicate
		02OWSW05MS	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Matrix Spike
		02OWSW05MSD	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	Matrix Spike Suplicate
		02OWSW06	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02OWSW07	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
		02OWSW08	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X	
02OWSW09	X	X	X ⁽²⁾	X	X	X	X	X ⁽²⁾		X	X	X	X			

Notes:

⁽¹⁾ Chlorinated Pesticides Only

⁽²⁾ Total and Dissolved

APPENDIX A.4

**TRIP BLANK, FIELD BLANK, EQUIPMENT RINSATE SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMUs 1 and 2
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO**

QA/QC Sample Type	Sample ID	Fixed Base Laboratory								Comments
		RCRA Appendix IX Parameters								
		VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Chlorinated Herbicides - (8151)	Pesticides ⁽¹⁾ - (8081)	Dioxins & Furans - (8280)	
Trip Blanks	1TB01 ⁽¹⁾	X								Lab Prepared
	1TB02 ⁽¹⁾	X								Lab Prepared
	2TB01 ⁽²⁾	X								Lab Prepared
	2TB02 ⁽²⁾	X								Lab Prepared
Field Blanks	2001FB01	X	X	X	X	X	X	X	X	Lab Grade DI Water
Equipment Rinsates	1ER01 ⁽¹⁾	X	X	X	X	X	X	X	X	Stainless Steel Spoon
	1ER02 ⁽¹⁾	X	X	X	X	X	X	X	X	Sediment Liner
	2ER01 ⁽²⁾	X	X	X	X	X	X	X	X	Stainless Steel Spoon
	2ER02 ⁽²⁾	X	X	X	X	X	X	X	X	Sediment Liner

Notes:

⁽¹⁾ - SWMU 1

⁽²⁾ - SWMU 2

APPENDIX C
CHEMICAL PROFILES

APPENDIX C – CHEMICAL PROFILES

INORGANICS

Antimony

Antimony is a silvery-white metal that is found in the earth's crust. Antimony ores are mined and then mixed with other metals to form antimony alloys or combined with oxygen to form antimony oxide. Antimony is released to the environment from natural sources and from industry. Most antimony ends up in soil, where it attaches strongly to particles that contain iron, manganese, or aluminum. Antimony is found at low levels in some rivers, lakes, and streams.

In short-term studies, animals that inhaled high levels of antimony had lung, heart, liver, and kidney damage and some died. In long-term studies, animals that inhaled low levels of antimony suffered eye irritation, hair loss, lung damage, and heart problems. Reproductive problems in rats have been caused by inhalation of high levels of antimony for a three-month period. Long-term animal studies have reported liver damage and blood changes when animals ingested antimony (ATSDR 1992).

A literature search was conducted on the toxicological effects of antimony ingestion to mammals. A one year study conducted on the effects of antimony on the growth, survival, and tissue levels in mice indicated a chronic oral toxicity dose of 5 ppm (Schroeder et al. 1968). This dose was converted to 1.25 mg/kg/day and considered a chronic LOAEL because median life span was reduced among female mice exposed to the 5 ppm dose level (Sample et al. 1996). A chronic NOAEL of 0.125 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A 6-week study with northern bobwhites, conducted during a critical life stage (reproduction), showed chronic oral toxicity at a dose of 47400 mg/kg/day (Opresko et al. 1993). This dose was considered a chronic LOAEL. A chronic NOAEL of 4740 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological profile for antimony*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Opresko, D.M., B.E. Sample, and G.W. Suter II. 1993. *Toxicological benchmarks for wildlife*. Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-86.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Schroeder, H.A., M. Mitchener, J.J. Balassa, M. Kanisawa, and A.P. Nason. 1968. Zirconium, niobium, antimony, and fluorine in mice: effects on growth, survival and tissue levels. *J. Nutr.* 95: 95-101.

Arsenic

Arsenic tends to be widespread in the environment (Woolson 1975) and is constantly being oxidized, reduced, or mobilized (Eisler 1988). Arsenic is readily adsorbed onto sediments with high organic matter. Adsorption depends on the arsenic concentration, sediment characteristics, pH, and the ionic concentration of other compounds (Eisler 1988). Arsenate (pentavalent, As+5) is the predominant arsenic form in oxygenated water and arsenite (trivalent, As+3) is the predominant arsenic form under anaerobic conditions (USEPA 1981).

Arsenic is not significantly concentrated in aquatic invertebrates. Arsenic may be bioaccumulated by lower trophic level organisms; however, data does not indicate that significant biomagnification occurs (USEPA 1985).

A literature search was conducted on the toxicological effects of arsenic ingestion to mammals. A 3-generation study on the reproductive effects of arsenite in mice determined a LOAEL of 1.26 mg/kg/day (Schroeder and Mitchner 1971). At this dose, mice displayed declining litter sizes. A chronic NOAEL of 0.126 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A literature search was conducted on the toxicological effects of arsenic ingestion to birds. In a 7-month study conducted by USFWS (1969) on male brown-headed cowbirds, four dietary dose levels were used. Doses of 675 and 225 ppm caused 100 percent mortality and doses of 75 (33.26 mg/kg) and 25 (11.09 mg/kg) ppm caused 20 percent and 0 percent mortality, respectively. The 75 and 25 ppm doses were considered the chronic LOAEL and NOAEL, respectively. A chronic NOAEL of 2.46 mg/kg/day and a LOAEL of 7.38 mg/kg/day were calculated from these data (Sample et al. 1996). Mallards exposed to arsenic in the diet for 128 days showed effects to survival at doses of 12.84 mg/kg/day (the estimated chronic LOAEL) with the NOAEL estimated at 5.14 mg/kg/day (Sample et al. 1996).

Eisler, R. 1988. *Arsenic hazards to fish, wildlife, and invertebrates: a synoptic review*. U.S. Fish and Wildlife Service Biological Report 85(1.12), Contaminant Hazard Reviews Report No. 12. 92 pp.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Schroeder, H.A. and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. *Arch. Environ. Health*. 23: 102-106.

United States Environmental Protection Agency (USEPA). 1981. *The carcinogen assessment group's final risk assessment on arsenic*. Office of Health and Environmental Assessment, Washington, D.C. PB 81-206013.

United States Environmental Protection Agency (USEPA). 1985. *Health advisory for arsenic*. Draft. Office of Drinking Water, Washington, D.C.

United States Fish and Wildlife Service (USFWS). 1969. Bureau of sport fisheries and wildlife. Publication 74:56-57.

Woolson, E.A. 1975. Arsenical pesticides. *ACS Ser* 7:1-176.

Barium

Barium occurs in nature combined with other chemicals such as sulfur, or carbon and oxygen. Some barium compounds dissolve easily in water and are found in lakes, rivers, and streams. Barium is found in most soils and foods at low levels. Fish and aquatic organisms accumulate barium in their tissues (ATSDR 1992). Studies on animals have shown that ingesting low levels of barium over the long term causes increased blood pressure and heart changes (ATSDR 1992).

A 16-month study conducted with barium administered orally in water to rats was used to derive a chronic NOAEL (endpoints were growth and hypertension) of 5.1 mg/kg/day, while a second study with rats (endpoint was mortality) was used to derive a chronic LOAEL of 19.8 mg/kg/day (Sample et al. 1996).

In a study conducted by Johnson (1960) over a 4-week period, chicks were exposed to eight barium dose levels in their diet. Exposures of up to 2000 ppm produced no mortality. Chicks in the 4000 to 32000 ppm groups experienced 5 to 100 percent mortality, respectively. The 2000 and 4000 ppm doses were considered the chronic NOAEL and LOAEL, respectively. These dietary concentrations were converted to a chronic NOAEL of 208 mg/kg/day and a chronic LOAEL of 417 mg/kg/day (Sample et al. 1996).

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological Profile for Barium*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Johnson, D., Jr., A.L. Mehring, Jr., and H.W. Titus. 1960. Tolerance of chickens for barium. *Proc. Soc. Exp. Biol. Med.* 104: 436-438.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Beryllium

In nature, beryllium can be found, in compounds with other elements, in mineral rocks, coal, soil, and volcanic dust. It can enter water from rocks, soil, and industrial waste. Most beryllium compounds do not dissolve in water and settle to the bottom as particles. Fish are not known to accumulate beryllium in their bodies from the surrounding water to any great extent (ATSDR 1993). Based on animal studies, beryllium compounds may be considered carcinogens (ATSDR 1993).

A literature search was conducted on the toxicological effects of beryllium ingestion to mammals. A study conducted on the effect to longevity and weight loss from beryllium given orally in water to rats (lifetime exposures) indicated a chronic no effect level of 5 ppm, the only dose tested (Schroeder and Mitchner 1975). Exposure to 5 ppm beryllium in water did not reduce longevity, but weight loss by male rats was observed in the second and sixth month. Because weight loss was not considered an adverse effect, the 5 ppm dose level was considered to be a chronic NOAEL. The 5 ppm dietary concentration was converted to a daily dose of 0.66 mg/kg/day (Sample et al. 1996), which was considered the chronic NOAEL. A chronic LOAEL of 6.6 mg/kg/day was estimated by multiplying the NOAEL by an uncertainty factor of 10.

No dietary information was found on the toxicological effects of beryllium to birds.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. *Toxicological profile for beryllium*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Schroeder, H.A. and M. Mitchener. 1975. Life-term studies in rats: effects of aluminum, barium, beryllium, and tungsten. *J. Nutr.* 105: 421-427.

Cadmium

Freshwater aquatic species are most sensitive to the toxic effects of cadmium, followed by marine organisms, birds, and mammals. Cadmium is a reproductive toxin in fish and other aquatic life. Adverse effects include carcinogenicity and teratogenicity. Other adverse effects in aquatic organisms include decreased oxygen utilization, bone marrow, heart, kidney, and vascular pressure. Diatoms and aquatic plants also show impaired growth and development at low concentrations of cadmium. Cadmium can concentrate in tissues and thus can accumulate in food chains. Vertebrates tend to accumulate cadmium in the kidney and liver (Eisler 1985).

A literature search was conducted on the toxicological effects of cadmium ingestion to mammals. A 6-week study conducted with rats indicated that oral doses of 1 mg/kg/day caused no reproductive impairment (Sample et al. 1996). This dose was considered a chronic NOAEL. Adverse reproductive (fetal) effects occurred at a dose of 10 mg/kg/day. This dose was considered a chronic LOAEL.

A similar study, conducted with dogs over a period of 3 months, indicated a NOAEL of 0.75 mg/kg/day because no adverse reproductive effects were observed (Loser and Lorke 1977). A chronic LOAEL was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10.

A 90-day study on the effects of cadmium administered orally in the diet on the reproduction of mallards indicated a chronic LOAEL of 20.03 mg/kg/day (White and Finley 1978). Ducks fed cadmium at this level were observed to produce significantly fewer eggs than those in lower dose groups. No adverse reproductive effects were observed at a dose of 1.45 mg/kg/day. This dose was considered to be a chronic NOAEL.

Eisler, R. 1985. *Cadmium hazards to fish, wildlife, and invertebrates: a synoptic review*. U.S. Fish and Wildlife Service Biological Report 85(1.2), Contaminant Hazard Reviews. Report No. 2. 46 pp.

Loser, E. and D. Lorke. 1977. Semichronic oral toxicity of cadmium. II. Studies on dogs. *Toxicology*. 7:225-232.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

White, D.H. and M.T. Finley. 1978. Uptake and retention of dietary cadmium in mallard ducks. *Environ. Res.* 17:53-59.

Chromium

Chromium is a naturally occurring element. Chromium compounds are used in the chemical industry for metal finishing, manufacture of pigments, leather tanning, and water treatment. Chromium has been widely studied and its effects are well known.

A 3-month study on the effects of chromium on survival in rats indicated adverse effects at a dose of 131.4 mg/kg/day. This dose was considered to be a chronic LOAEL (Sample et al. 1996). A chronic NOAEL of 13.14 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A literature search was conducted on the toxicological effects of chromium ingestion to birds. A study conducted with American black ducks indicated that dietary levels of 5.0 mg/kg/day of chromium caused reduced duckling survival. This dose was considered a chronic LOAEL (Sample et al. 1996). A dose of 1.0 mg/kg/day was considered a chronic NOAEL because no adverse reproductive effects were observed at this level.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Cobalt

Rats exposed to cobalt in the diet for 69 days showed impaired reproduction at 50 mg/kg/day; this dose is considered a chronic LOAEL. A chronic NOAEL of 5 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1 (ATSDR 1992). Chickens exposed to cobalt in the diet for 14 days showed impaired growth at 14.7 mg/kg/day; this dose is considered a chronic LOAEL (Diaz et al. 1994). A chronic NOAEL of 1.47 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological profile for cobalt*. July.

Diaz, G.J., R.J. Julian, and E.J. Squires. 1994. Lesions in broiler chickens following experimental intoxication with cobalt. *Avian Diseases*. 38:308-316.

Copper

Excess ingestion of copper leads to accumulation in tissues, mainly in the liver. When concentrations in the liver exceed a certain level, the metal is released into the blood causing hemolysis and jaundice. High levels of copper also inhibit essential metabolic enzymes (Demayo et al. 1982). Toxic symptoms appear when the liver accumulates 3 to 15 times the normal level of copper (Demayo et al. 1982).

Ruminants are the most sensitive mammalian species to the toxic effects of copper. Young animals retain more dietary copper than older animals and are more sensitive to copper toxicity (Venugopal and Luckey 1978). Copper is known to have adverse effects on aquatic organisms, but is dependent upon pH and hardness. Copper tends not to accumulate in most organisms or to biomagnify in food chains.

A 357-day study on the effects of copper on the reproduction of mink indicated increased mortality of mink kits at oral doses of 50, 100, and 200 ppm (Aulerich et al. 1982). The 50 ppm dose was converted to a chronic LOAEL of 15.14 mg/kg/day. A chronic NOAEL of 11.7 mg/kg/day was determined from the 25 ppm dietary concentration at which no adverse reproductive effects were observed.

A 10-week study on the effects of copper on the growth and mortality of day old chicks indicated reduced growth and increased mortality at a dietary concentration of 749 ppm (Mehring et al. 1960). This concentration, considered to be a chronic LOAEL, was converted to a daily dose of 61.7 mg/kg/day (Sample et al. 1996). No adverse effects were observed at a dietary concentration of 570 ppm. This concentration, considered to be a chronic NOAEL, was converted to a daily dose of 47 mg/kg/day.

Aulerich, R.J., R.K. Ringer, M.R. Bleavins et al. 1982. Effects of supplemental dietary copper on growth, reproduction performance and kit survival of standard dark mink and the acute toxicity of copper to mink. *J. Animal Sci.* 55:337-343.

DeMayo, A., M.C. Tylor and K.W. Taylor. 1982. Effects of copper on humans, laboratory and farm animals, terrestrial plants and aquatic life. *CRC Critical Reviews in Environmental Control*. 12(3):183-255.

Mehring, A.L. Jr., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus. 1960. The tolerance of growing chickens for dietary copper. *Poult. Sci.* 39:713-719.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Venugopal, B. and T.D. Luckey. 1978. *Metal toxicity in mammals, Volume 2*. Plenum Press, New York, N.Y.

Cyanide

Cyanide has a greater impact upon fish, in general, than upon invertebrates. Plants demonstrate a wide range of susceptibility. In general terms, plants will be protected at the same range considered safe for animals. Cyanide, which is readily metabolized by most organisms, does not bioaccumulate in food chains (Eisler 1991).

Eisler, R. 1991. *Cyanide hazards to fish, wildlife, and invertebrates: a synoptic review*. U.S. Fish and Wildlife Service Biological Report 85(1.23), Contaminant Hazard Reviews Report No. 23. 55 pp.

Lead

Organic forms of lead are more bioavailable than inorganic forms, but microorganisms in streams are capable of transforming inorganic lead into organic forms. Soluble lead is toxic to all aquatic plant phyla. In plants, lead inhibits growth by reducing photosynthetic activity, mitosis, and water absorption. In the terrestrial environment, lead has been demonstrated to be toxic to birds, mammals, reptiles, and amphibians. Lead poisoning in birds is particularly well documented, but most lead poisoning in wild birds results from ingestion of lead pellets. In contrast, lead poisoning of birds, such as raptors, from biologically incorporated lead is considered unlikely.

Lead is known to be toxic to mammalian species, but information on the effects on wild species is very limited. Toxic effects include mortality, reduced growth and reproduction, alterations of blood chemistry, lesions, and behavioral changes. Terrestrial vegetation also may be affected by elevated lead concentrations. Demonstrated effects include reduced photosynthesis, mitosis, and water absorption. Lead, however, appears to bind tightly to moist soil, and substantial amounts of lead typically need to accumulate before effects on plants are observed. Lead does not biomagnify to a great extent in food chains, although bioaccumulation in plants and animals has been extensively documented (Wixson and Davis 1993, Eisler 1988).

A study on three generations of rats fed lead acetate indicated a chronic NOAEL of 8 mg/kg/day (Azar et al. 1973). Rats fed this dose level were not observed to exhibit any adverse reproductive effects. Rats fed 80 mg/kg/day were observed to have reduced offspring weights and kidney damage in the young. This dose was considered to be a chronic LOAEL.

A 7-month study on the toxicological effects of lead ingestion in American kestrels found that an oral dose of 3.85 mg/kg/day did not cause any adverse reproductive effects (Sample et al. 1996); this dose was considered a chronic NOAEL. A chronic LOAEL of 38.5 mg/kg/day was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10. A 12-week study with Japanese quail found that oral exposures to lead acetate in the diet did not have any adverse reproductive effects at doses of 1.13 mg/kg/day (chronic NOAEL) although adverse effects were observed at a dose of 11.3 mg/kg/day (chronic LOAEL; Sample et al. 1996).

Azar, A., H.J. Trochimowicz, and M.E. Maxwell. 1973. Review of lead studies in animals carried out at Haskell Laboratory: two-year feeding study and response to hemorrhage study. Pages 199-210 IN Barth, D et al. (eds). *Environmental health aspects of lead: proceedings, international symposium*. Commission of European Communities.

Eisler, R. 1988. *Lead hazards to fish, wildlife, and invertebrates: a synoptic review*. U.S. Fish and Wildlife Service Biological Report 85(1.14), Contaminant Hazard Reviews Report No. 14. 134 pp.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Wixson, B.G. and B.E. Davis. 1993. *Lead in soil*. Lead in Soil Task Force, Science Reviews. Northwood. 132 pp.

Mercury

Mercury is persistent in the environment and may cause significant effects on ecological receptors. A variety of adverse biological effects have been attributed to mercury. Mercury is a known teratogen, mutagen, and carcinogen. Mercury has been documented to adversely effect reproduction, growth and development, behavior, blood and serum chemistry, motor coordination, vision, hearing, histology, and metabolism at relatively low concentrations in birds and mammals. The reproduction, growth, metabolism, blood chemistry, and oxygen exchange of marine and freshwater organisms also is adversely affected by relatively low concentrations of mercury. The form of mercury most readily assimilated by biota is methylmercury. Once incorporated in tissues, methylmercury is very slow to depurate. The rate of bioaccumulation of methylmercury is species- and site-specific.

A three-generation study on the effects of mercury (administered orally as methyl mercury chloride) on the reproduction of rats indicated a LOAEL of 0.16 mg/kg/day because reduced pup viability was observed (Verschuuren et al. 1976). A chronic NOAEL of 0.032 mg/kg/day was determined because no adverse reproductive effects were observed at this level.

A 93-day study conducted on mink indicated that a dose of 1.8 ppm (administered orally as methyl mercury chloride) caused mortality, weight loss, and behavioral abnormalities (Wobeser et al. 1976). No adverse effects were observed at 1.1 ppm so this dose was considered a chronic NOAEL. These values were converted to a daily dose of 0.25 mg/kg/day (chronic LOAEL) and 0.15 mg/kg/day (chronic NOAEL).

A literature search was conducted on the toxicological effects of mercury ingestion to birds. A one-year study conducted on Japanese quail indicated that an oral dose of 0.9 mg/kg/day (as mercuric chloride) caused reduced fertility and egg hatchability (Sample et al. 1996). This dose was considered a chronic LOAEL. No adverse reproductive effects were observed at a dose of 0.45 mg/kg/day. This dose was considered a chronic NOAEL.

Mallards fed methyl mercury during a 3-generation study showed significant reproductive effects (reduced egg and duckling production) at a daily dose 0.064 mg/kg/day (Sample et al. 1996).

This dose was considered a chronic LOAEL. A chronic NOAEL of 0.0064 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Verschuuren, R.G., R. Kroes, E.M. Den Tonkelaar, J.M. Berkvens, P.W. Helleman, A.G. Rauws, P.L. Schuller, and G.J. Van Esch. 1976. Toxicity of methyl mercury chloride in rats. II. Reproduction study. *Toxicol.* 6:97-106.

Wobeser, G., N.O. Nielson, and B. Schiefer. 1976. Mercury and mink. II. Experimental methyl mercury intoxication. *Can. J. Comp. Med.* 34-45.

Nickel

Nickel is a metal that is usually used in the formation of alloys such as stainless steel. It is found in the environment as oxides or sulfides. Nickel may be released to the environment through mining, oil- and coal- burning power plants, and incinerators. Nickel will attach to soil or sediment particles, especially those containing iron or manganese. Under acidic conditions, nickel can become more mobile and infiltrate groundwater. Nickel is present in water mostly as insoluble hydroxides at pH levels higher than 6.7. At pH levels below 6.5, most nickel compounds are soluble. Water-insoluble inorganic nickel is usually unavailable in water and soils. However, low pH can enable nickel to be mobilized and therefore more bioavailable for uptake by plants and animals. Therefore, the speciation and physiochemical state of nickel is important in evaluating its behavior in the environment and its availability to biota. Low nickel concentrations can cause acute toxicity to freshwater and marine organisms.

A 3-generation study on the effects of nickel on the reproduction of rats indicated a chronic LOAEL of 80 mg/kg/day due to reduced body weights in offspring (Ambrose et al. 1976). A dose of 40 mg/kg/day was considered a chronic NOAEL because it caused no adverse effects.

A literature search was conducted on the effects of nickel ingestion to birds. A study conducted on mallard ducklings indicated that a dose of 107 mg/kg/day of nickel over a 90-day period caused reduced growth and resulted in 70 percent mortality (Cain and Pafford 1981). This dose

was considered to be the chronic LOAEL. A dose of 77.4 mg/kg/day did not increase mortality or reduce growth and was therefore considered a chronic NOAEL.

Ambrose, A.M., P.S. Larson, and J.F. Borzelleca. 1976. Long-term toxicological assessment of nickel in rats and dogs. *J. Food. Sci. Technol.* 13:181-187.

Cain, B.W. and E.A. Pafford. 1981. Effects of dietary nickel on survival and growth of mallard ducklings. *Arch. Environm. Contam. Toxicol.* 10:737-745.

Selenium

Selenium is a metal commonly found in rocks and soil. In the environment, selenium is not often found in the pure form. Much of the selenium in rocks is combined with sulfide minerals or with silver, copper, lead, and nickel minerals. Selenium and oxygen combine to form several compounds. Small selenium particles in the air settle to the ground or are taken out of the air in rain. Soluble selenium compounds in agricultural fields can be transported from the field in irrigation drainage water. Selenium can accumulate in animals that live in water containing high levels of selenium. Very high amounts of selenium can result in reproductive effects in rats and monkeys. Exposure to high levels of selenium compounds caused malformations in birds, but selenium has not been shown to cause birth defects in other mammals (ATSDR 1996). Chronic exposure of mice and rats to selenium adversely affected fertility and reduced the viability of the offspring of the pairs of mice that were able to breed (Schroeder and Mitchener 1971).

A one-year study on the effects of potassium selenate on the reproduction of rats indicated a chronic oral toxic dose of 1.5 mg/L (Rosenfeld and Beath 1954). This dose was considered to be a chronic NOAEL because no adverse effects were observed. This dose was converted to a daily dose of 0.20 mg/kg/day. A chronic LOAEL of 2.5 mg/L was indicated due to a reduction in the number of second-generation young. This dose was converted to a daily dose of 0.33 mg/kg/day.

A 100-day study conducted on the effects of selenomethionine on reproduction in mallard ducks indicated a chronic NOAEL of 4 ppm in food because it produced no adverse effects on reproduction. This dose was converted to a daily dose of 0.4 mg/kg/day (Sample et al. 1996). A dose of 8 ppm was determined to be the chronic LOAEL because it resulted in reduced duckling survival and was converted to a daily dose of 0.8 mg/kg/day.

Reproduction in screech owls fed selenomethionine for 13.7 weeks was not adversely affected at a daily dose of 0.44 mg/kg/day (chronic NOAEL), although a daily dose of 1.5 mg/kg/day (chronic LOAEL) resulted in decreased egg production, egg hatchability, and nestling survival (Sample et al. 1996).

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. *Toxicological profile for selenium*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Rosenfeld, I. and O.A. Beath. 1954. Effect of selenium on reproduction in rats. *Proc. Soc. Exp. Biol. Med.* 87:295-297.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Schroeder, H.A. and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. *Arch. Environ. Health.* 23:102-106.

Silver

Silver adheres strongly to clay particles found suspended in water and in sediments. The impact of silver is most likely to occur in the soil/water interface. It is acutely toxic to scuds at <6 µg/L and midges at <5 µg/L. Aquatic plants are less sensitive to silver exposure.

A literature search was conducted on the toxicological effects of silver ingestion to mammals and birds. Ingestion-based studies were not available for birds. A study conducted on rats indicated that a dose of 18.1 mg/kg/day did not result in increased mortality. This dose was considered a chronic NOAEL (ASTDR 1990). A chronic LOAEL was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological profile for silver*. TO-90/24.

Thallium

Thallium enters the environment primarily from coal-burning and smelting, in which it is a trace contaminant of the raw materials. Thallium is absorbed by plants and enters the food chain. It builds up in fish and shellfish. Studies in rats exposed to high levels of thallium, showed adverse developmental effects (ATSDR 1992). Rats ingesting thallium for several weeks had some adverse reproductive effects (ATSDR 1992). Data also suggest that the male animal reproductive system may be susceptible to damage by low levels of thallium.

A literature search was conducted on the toxicological effects of thallium ingestion to mammals and birds. Ingestion-based studies were not available for birds. A study conducted on the reproductive (male testicular function) effects of thallium in rats indicated that a dose of 0.74 mg/kg/day caused reduced sperm motility (Formigli et al. 1986). This dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1 to obtain a daily dose 0.074 mg/kg/day.

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological profile for thallium*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Formigli, L., R. Scelsi, P. Poggi, C. Gregotti, A. DiNucci, E. Sabbioni, L. Gottardi, and L. Manzo. 1986. Thallium-induced testicular toxicity in the rat. *Environ. Res.* 40:531-539.

Vanadium

Vanadium enters the environment primarily from natural sources and from the burning of fuel oils. It is an essential element in certain animals, but may induce toxic effects in sufficient quantities. Young rats fed 92 and 194 ppm vanadium lost body weight and exhibited gross pathological symptoms, and 56 percent of those fed 368 ppm vanadium died (Daniel and Lillie 1938). In a study with mallard ducks, vanadium accumulated in the bone, kidney, and liver. Hens fed 100 ppm accumulated vanadium in the bone to about five times the levels in drakes (White and Dieter 1978). Several studies have shown contradictory effects of vanadium on lipid metabolism in birds and mammals. Responses were dependent on species, age, and diet composition. The alterations in lipid metabolism caused by vanadium were considered

biologically significant because they were demonstrable in ducks that had absorbed and accumulated only minute tissue concentrations of the metal (White and Dieter 1978).

A literature search was conducted on the toxicological effects of vanadium ingestion to mammals. A 60-day study was conducted on the reproductive effects of vanadium to rats. The rats were fed three dose levels of sodium metavanadate: 5, 10, and 20 mg/kg/day. Significant differences in reproductive parameters (e.g., number of dead young, litter size) were observed at all dose levels. Therefore, the lowest dose was considered to be a chronic LOAEL. The LOAEL of 5 mg/kg/day was converted to an elemental vanadium dosage of 2.1 mg/kg/day (Sample et al. 1996). A chronic NOAEL (0.21 mg/kg/day) was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A literature search was conducted on the toxicological effects of vanadium ingestion to birds. A study conducted on mortality, body weight, and blood chemistry effects of vanadium to mallards indicated a chronic NOAEL of 11.4 mg/kg/day (White and Dieter 1978). The mallards were fed three dose levels of vanadium in food over a 12-week period and no effects were observed at any dose level. The maximum dose was considered the chronic NOAEL. A chronic LOAEL (114 mg/kg/day) was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10.

Daniel, E.P. and R.D. Lillie. 1938. Experimental vanadium poisoning in the white rat. *U.S. Public Health Rep.* 53:765-777.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

White, D.H. and M.P. Dieter. 1978. Effects of dietary vanadium in mallard ducks. *J. Toxicol. Environ. Health.* 4:43-50.

Zinc

Zinc, like many other metals, is essential in cell growth and enzymatic formation. *Ceriodaphnia*, a genus of aquatic invertebrates, are the most sensitive of 35 genera tested, but some aquatic plants are three times as sensitive to zinc. Zinc toxicity can result in destruction of gill epithelium and tissue hypoxia in fish. In terrestrial species, chronic exposure to zinc can result in softening

of bone, anemia, enteropathy, and kidney damage. Zinc is not known to magnify in food chains because the body regulates it and excess zinc is eliminated.

A study conducted with rats indicated that a dose of 320 mg/kg/day of zinc caused adverse reproductive effects in pregnant rats (Sample et al. 1996). This dose was considered a chronic LOAEL. A chronic NOAEL of 160 mg/kg/day was determined since no adverse effects were observed at this dose. Mink exposed to zinc in the diet for 25 weeks did not exhibit any adverse reproductive effects at a daily dose of 20.8 mg/kg/day (ATSDR 1992).

Reproduction in chickens exposed to zinc in the diet for 44 weeks was not adversely affected at a daily dose of 14.5 mg/kg/day but was adversely affected at 131 mg/kg/day. These doses are considered chronic NOAEL and LOAEL values, respectively (Sample et al. 1996).

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological profile for zinc*. Draft.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

PESTICIDES

4, 4'-DDD, 4, 4'-DDE, and 4, 4'-DDT

DDT is a synthetic organochlorine compound which has been used extensively for insect control. DDD and DDE are metabolites of DDT. Both of these two breakdown products and DDT are often found together in the environment and are referred to collectively as total DDT. DDT was banned in the United States in 1972, primarily due to its environmental effects, but is very persistent in the environment and is still detected in many biochemical and geochemical surveys.

The USEPA's Aquatic Information Retrieval Toxicity database (AQUIRE) for DDT contains more than 40 acute toxicity values for various aquatic organisms. These range from 0.36 µg/L for *Daphnia pulex* to 1230 µg/L for the planarian *Polycelis felina* (USEPA 1984).

Historical studies of terrestrial invertebrates have found that earthworms are much more tolerant of organochlorine pesticides than arthropods (Davis 1971). The storage of total DDT in

earthworms can lead to harmful effects in higher trophic-level organisms including birds and mammals.

The toxicity and accumulation of DDT in fish are correlated with age, fat content, and body length. Signs of toxicity are similar to those exhibited by insects (Ellgaard et al. 1977). Exposure to lethal concentrations of DDT results in increasing levels of irritability or excitability followed by muscular spasms, complete loss of equilibrium, convulsions, and eventually death. Toxic effects on amphibians and reptiles include uncoordinated behavior, loss of equilibrium, restricted development, weight loss, and death (Russell et al. 1995).

The toxicity and accumulation of DDT and its metabolites are of primary concern in birds. These chemicals can accumulate in fat after even brief, low-level exposures. In general, birds that feed on fish or other birds have greater tissue residues than those that feed on vegetation or seeds, and DDE is more common than either DDT or DDD in bird tissues (Stickel 1973). Adverse effects resulting from DDT poisoning in birds include reproductive impairment, reduced fledging success, and eggshell thinning. DDE produced significant eggshell thinning in three major groups of birds: the orders Strigiformes (owls), Falconiformes (all other raptors), and Anseriformes (most common waterfowl).

Studies of DDT toxicity to mammals have been generally limited to laboratory mammals. Liver, neurological, developmental, reproductive, and carcinogenic effects after exposure to DDT have also been noted for mice, rats, shrews, hamsters, monkeys, dogs, and bats. Laboratory studies with wild mammals have indicated that big brown bats are much more sensitive to DDT than other mammals (Stickel 1973).

A literature search was conducted on the effects of 4, 4'-DDD, 4, 4'-DDE, 4, 4'-DDT ingestion to mammals and birds. A study conducted on the reproductive effects of DDT on rats indicated a chronic NOAEL of 0.8 mg/kg/day and a chronic LOAEL of 4 mg/kg/day (Fitzhugh 1948). The rats ingested three dose levels over a 2-year period. Consumption of 4 mg/kg/day caused a reduction in the number of young produced. No adverse effects were observed at the 0.8 mg/kg/day dose level.

Dogs fed DDT for two generations showed reproductive effects at an oral dose of 5 mg/kg/day but not at 1 mg/kg/day. These values are considered the chronic LOAEL and chronic NOAEL, respectively (ATSDR 1994).

A 2-year reproductive study with American kestrels resulted in estimated chronic NOAEL and LOAEL values of 0.05 and 0.5 mg/kg/day, respectively, for DDE. Chronic oral exposures of

mallards with DDT and DDD resulted in chronic NOAEL and LOAEL values (reproductive endpoints) of 0.104 and 1.04 mg/kg/day, respectively, for DDT, and 0.52 and 5.2 mg/kg/day, respectively for DDD (Stickel 1973). Brown pelicans exposed to DDE showed no chronic reproductive effects at 0.131 mg/kg/day (Beyer et al. 1996).

Agency for Toxic Substances and Disease Registry (ATSDR). 1994. *Toxicological profile for 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD*. May.

Beyer, W.N., G.H. Heinz, and A.W. Redmon-Norwood. 1996. *Environmental contaminants in wildlife: interpreting tissue concentrations*. Lewis Publishers, Boca Raton, FL. 494 pp.

Davis, B.N.K. 1971. Laboratory studies on the uptake of dieldrin and DDT by earthworms. *Soil Biol. Biochem.* 3:221-233.

Ellgaard, E.G., J.C. Ochsner, and J.K. Cox. 1977. Locomotor hyperactivity induced in the bluegill sunfish, *Lepomis macrochirus*, by sublethal concentrations of DDT. *Can. J. Zool.* 55:1077-1081.

Fitzhugh, O.G. 1948. Use of DDT insecticides on food products. *Ind. Eng. Chem.* 40:704-705.

McLane, M.A.R. and L.C. Hall. 1972. DDE thins screech owl eggshells. *Bulletin of Environmental Contamination and Toxicology.* 8:65-68.

Russell, R.W., S.J. Hecnar, and G.D. Haffner. 1995. Organochlorine pesticide residues in southern Ontario spring peepers. *Environ. Contam. Toxicol.* 14:815-817.

Stickel, L.F. 1973. Pesticide residues in birds and mammals. Pages 254-312 IN C.A. Edwards (ed). *Environmental pollution by pesticides*. Plenum Press, New York.

United States Environmental Protection Agency (USEPA). 1984. *AQUIRE: Aquatic information retrieval toxicity database*. EPA/600/8-84-021.

Aldrin and Dieldrin

Aldrin and dieldrin are insecticides that do not occur naturally in the environment. From 1950 to 1970, aldrin and dieldrin were popular pesticides for crops like corn and cotton. Because of

concerns about damage to the environment and the potential harm to human health, USEPA banned all uses of aldrin and dieldrin in 1974 except to control termites. In 1987, USEPA banned all uses (ATSDR 1993).

Aldrin is easily converted to dieldrin in the environment, and after being ingested and absorbed in animals. Aldrin is found in the blood only after very high doses. Dieldrin binds tightly to soil and slowly evaporates to the air. Dieldrin breaks down very slowly in the environment. Plants uptake and store dieldrin from the soil. In animals, dieldrin accumulates in fatty tissues and leaves the body very slowly. The major acute toxic effects are on the central nervous system. Studies in animals also indicate that dieldrin may reduce the body's ability to resist infection. Mice given high amounts of dieldrin developed liver cancers (ATSDR 1993).

A three-generation study on the effects of dieldrin on rat reproduction indicated that a chronic dose of 2.5 mg/kg (Treon and Cleveland 1955) caused a reduction in the number of pregnancies. This dose was considered a chronic LOAEL and converted to a daily dose of 0.2 mg/kg/day. A chronic NOAEL of 0.02 mg/kg/day was determined by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A two-year study of the effects of dieldrin on the reproduction of barn owls indicated a chronic NOAEL of 0.077 mg/kg/day (Mendenhall et al. 1983). A slight reduction in the eggshell thickness was observed, but no effects on the number of eggs laid per pair, number of eggs hatched per pair, percent of eggs broken, or embryo and nestling mortality were observed. A LOAEL of 0.77 mg/kg/day was estimated by multiplying the NOAEL by an uncertainty factor of 10.

Rats exposed to aldrin for three generations showed adverse reproductive effects at a daily dose of 1 mg/kg/day, but not at a dose of 0.2 mg/kg/day. These doses are considered the chronic LOAEL and NOAEL, respectively (Sample et al. 1996). Chronic NOAELs and LOAELs for mallards exposed to aldrin in the diet have been estimated at 0.5 and 5 mg/kg/day based on data from Tucker and Crabtree (1970).

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. *Toxicological profile for dieldrin*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Mendenhall, V.M., E.E. Klaas, and M.A.R. McLane. 1983. Breeding success of barn owls (*Tyto alba*) fed low levels of DDE and dieldrin. *Arch. Environ. Contam. Toxicol.* 12:235-240.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-86/R3.

Treon, J.F. and F.P. Cleveland. 1955. Toxicity of certain chlorinated hydrocarbon insecticides for laboratory animals, with special reference to aldrin and dieldrin. *Ag. Food Chem.* 3:402-408.

Tucker, R.K. and D.G. Crabtree. 1970. *Handbook of toxicity of pesticides to wildlife*. U.S. Fish and Wildlife Service Research Publication 84. 131 pp.

Alpha-, Beta-, and Delta-BHC

A literature search was conducted on the toxicological effects alpha-, beta-, and delta-BHC ingestion to animals. A 4-generation rat study with mixed BHC isomers indicated adverse reproductive effects at 3.2 mg/kg/day (chronic LOAEL) but not at 1.6 mg/kg/day (chronic NOAEL; Sample et al. 1996). Rats exposed to beta-BHC for 13 weeks exhibited growth and systemic effects at 20 mg/kg/day (chronic LOAEL) but not 4 mg/kg/day (chronic NOAEL; Sample et al. 1996). Japanese quail exposed to mixed BHC isomers BHC for 90 days exhibited reproductive effects at 2.25 mg/kg/day (chronic LOAEL) but not 0.56 mg/kg/day (chronic NOAEL; Sample et al. 1996).

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-86/R3.

Chlordane

Chlordane is a manufactured chemical that was used as a pesticide in the United States from 1948 to 1988. Chlordane is not a single chemical, but is actually a mixture of pure chlordane mixed with many related chemicals. It does not occur naturally in the environment. Chlordane adsorbs to soil particles and can remain in the soil for over 20 years. Most chlordane leaves soil by evaporation to the air. It breaks down very slowly and does not dissolve easily in water. It bioaccumulates in the tissues of fish, birds, and mammals (ATSDR 1994).

Chlordane affects the nervous system, the digestive system, and the liver in animals. Acute ingestion-based exposure of high levels of chlordane can cause mortality and convulsions in animals. Chronic exposure caused harmful effects in the liver of test animals. Animals exposed before birth or while nursing developed behavioral effects (ATSDR 1994).

A study on the effects of chlordane on the reproductive systems of six generations of mice indicated a chronic NOAEL of 4.58 mg/kg/day (WHO 1984) because no adverse effects were observed. The study indicated a chronic LOAEL of 9.16 mg/kg/day because of observations of decreased viability and reduced abundance of offspring in the test mice.

A ten-week study on the effects of chlordane on the mortality rates in red-winged blackbirds indicated a chronic NOAEL of 2.14 mg/kg/day because no adverse effects were observed at this dose level (Stickel et al. 1983). A chronic LOAEL of 10.7 mg/kg/day was determined based on a 26 percent mortality rate at this dose.

These chronic NOAEL and LOAEL values were used for both alpha- and gamma-chlordane.

Agency for Toxic Substances and Disease Registry (ATSDR). 1994. *Toxicological profile for chlordane*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Stickel, L.F., W.H. Stickel, R. A. Dyrlund, and D. L. Hughes. 1983. Oxychlordane, HCS-3260, and nanchlor in birds; lethal residues and loss rates. *J. Toxicol. Environ. Health*. 12:611-622.

World Health Organization (WHO). 1984. Chlordane. *Environ. Health Criteria* 34. 82 pp.

Endosulfan I, Endosulfan II, and Endosulfan Sulfate

Endosulfan occurs in two isomeric forms, endosulfan I and endosulfan II. The ratio of these two forms varies depending on the environmental media from which the samples are collected. Air tends to have the highest ratio of endosulfan I to endosulfan II. Air/water partitioning experiments were conducted with the technical mix of endosulfan and with the individual isomers. The partitioning in these experiments resulted in a ratio of endosulfan I to endosulfan II

similar to what was observed in the environment. The results of this experiment suggest that endosulfan II is being converted to endosulfan I as it transfers across the air/water interface. This has important implications to modeling the fate of these materials in the environment (ATSDR 1993). Endosulfan sulfate results from the oxidation of endosulfan in nature (Coleman and Dolinger 1982).

A literature search was conducted on the toxicological effects of endosulfan ingestion to mammals and birds. Form-specific information was not available therefore toxicity studies on total endosulfan were used for endosulfan I, endosulfan II, and endosulfan sulfate. A 30-day study conducted on male and female rats indicated that 1.5 mg/kg/day of endosulfan in the diet did not cause adverse reproductive effects (Dikshith et al. 1984). This dose was considered a chronic NOAEL. A chronic LOAEL of 15 mg/kg/d was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10.

A literature search was conducted on the toxicological effects of endosulfan ingestion to birds. A study conducted by Abiola (1992) on gray partridges indicated that 5, 25, and 125 ppm of endosulfan in the diet did not cause adverse reproductive effects. The maximum dose of 125 ppm (10 mg/kg/d) was considered a chronic NOAEL because exposure occurred during reproduction (Sample et al. 1996). A LOAEL of 100 mg/kg/d was estimated by multiplying the NOAEL by an uncertainty factor of 10.

Abiola, F.A. 1992. Ecotoxicity of organochloride insecticides: effects of endosulfan on birds' reproduction and evaluation of its induction effects in partridge, *Perdix perdix* L. *Rev.Vet. Med.* 143:443-450.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. *Toxicological profile for 1,4-endosulfan*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Coleman, P.F. and P.M. Dolinger. 1982. *Endosulfan monograph number four: environmental health evaluations of California restricted pesticides*. Prepared by Peter M. Dolinger Associates, Menlo Park, CA. Sacramento, CA: State of California Department of Food and Agriculture.

Dikshith, T.S.S., R.B. Raizada, M.K. Srivastava, and B.S. Kaphalia. 1984. Response of rats to repeated oral administration of endosulfan. *Ind. Health.* 22:295-304.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Endrin, Endrin Aldehyde, and Endrin Ketone

Endrin was used in the United States as a pesticide and rodenticide but the use of endrin was banned in 1984. Endrin does not easily dissolve in water and is more likely to be found in sediments. Endrin breaks down slowly in the environment (ATSDR 1989). Endrin can bioaccumulate in aquatic animals from 1450 to 10000 times the concentration in water (USEPA 1980).

Little information is known about the properties of endrin aldehyde. It is not commercially used but is found as an impurity and breakdown product of endrin. It is not known what happens to this substance once it is released to the environment (ATSDR 1989). Endrin ketone might be found in the environment as a breakdown product of endrin. Little information is known about the properties of endrin ketone (ATSDR 1996).

A dietary dose of 0.92 mg/kg/day of endrin over 120 days caused significant reproductive effects in mice including reduced parental survival, litter size, and number of young (Good and Ware 1969). This dose was considered a chronic LOAEL. A chronic NOAEL of 0.092 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A study conducted by Fleming et al. (1982) exposed screech owls to a dietary dose of 0.75 ppm (0.1 mg/kg/day) of endrin over 10 weeks to assess reproductive effects. Egg production and hatching success was reduced. This dose was considered a chronic LOAEL. A chronic NOAEL of 0.01 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. Mallards exposed to endrin in the diet for 200+ days showed no adverse reproductive effects at 0.3 mg/kg/day (the highest dose tested). This dose is considered a chronic NOAEL (Sample et al. 1996). A chronic LOAEL was estimated by multiplying the chronic NOAEL by and uncertainty factor of 10.

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. *Endrin ketone*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. *Toxicological profile for endrin/endrin aldehyde*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Fleming, W.J., M.A. Ross McLane, and E. Cromartie. 1982. Endrin decreases screech owl productivity. *J. Wildl. Manage.* 46:462-468.

Good, E.E. and G.W. Ware. 1969. Effects of insecticides on reproduction in the laboratory mouse. IV. Endrin and dieldrin. *Toxicol. Appl. Pharmacol.* 14:201-203.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

United States Environmental Protection Agency (USEPA). 1980. *Ambient water quality criteria for endrin*. Washington, D.C. Office of Water Regulations and Standards. EPA-440/5-80-047. NTIS No. PB81-117582.

Heptachlor and Heptachlor Epoxide

Heptachlor is a manufactured chemical that does not occur naturally. Heptachlor does not dissolve easily in water, adheres strongly to soil particles, and evaporates slowly to air. Plants and animals can change heptachlor (C₁₀H₅Cl₇) to heptachlor epoxide (C₁₀H₅Cl₇O) by means of oxidation. Heptachlor epoxide can remain in the soil and water for many years. Plants can uptake heptachlor from the soil. Heptachlor and heptachlor epoxide have been shown to bioaccumulate in the tissues of fish, bivalves, and cattle (ATSDR 1993).

Most of what we know about the health effects of these pesticides comes from studies on mice and rats fed heptachlor and heptachlor epoxide. Acute studies using high levels of heptachlor damaged the livers of rats and the livers and adrenal glands of mice. Mice also had trouble walking and rats developed tremors. Animals that ingested heptachlor or heptachlor epoxide before and/or during pregnancy had smaller litters or were unable to reproduce. Some of the offspring had cataracts and others died shortly after birth (ATSDR 1993).

A literature search was conducted on the toxicological effects of heptachlor ingestion to mammals and birds. An 181-day study on the effects of heptachlor on the reproduction of mink indicated a chronic LOAEL of 6.25 ppm (Crum et al. 1993) which was converted to a daily dose of 1.0 mg/kg/day. Minks given this dose were observed to have reduced kit weights at 3 and 6 weeks as compared to controls. A chronic NOAEL of 0.1 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. Studies with quail (Hill et al. 1975) result in estimated chronic NOAELs and LOAELs of 0.405 and 4.05 mg/kg/day, respectively.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. *Toxicological profile for heptachlor*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Crum, J.A., S.J. Bursian, R.J. Aulerich, P.Polin, and W.E. Braselton. 1993. The reproductive effects of dietary heptachlor in mink (*Mustela vison*). *Arch. Environ. Contam. Toxicol.* 24:156-164.

Hill, E.F., R.G. Heath, J.W. Spann, and J.D. Williams. 1975. *Lethal dietary toxicities of environmental pollutants to birds*. U.S. Fish and Wildlife Service Special Scientific Report - Wildlife No. 191, Washington D.C.

Methoxychlor

Methoxychlor is a man made insecticide used to kill flies, cockroaches and mosquitoes. Methoxychlor is released to the environment from chemical plants that produce it and from hazardous waste sites. Methoxychlor remains in the atmosphere for under a month. Methoxychlor does not dissolve in water but instead binds to sediments where it is degraded. It bioaccumulates in some aquatic species but not in mammalian species due to high metabolism and elimination.

Methoxychlor is a structural analogue of the pesticide DDT. Renal nephrosis was observed in rats administered methoxychlor in their diets. In pigs fed methoxychlor, cystic tubular nephropathy and elevated blood urea nitrogen was observed (ATSDR 1992).

In an 11-month study on the effects of methoxychlor on the reproduction of rats, no significant effects were observed at doses of 50 ppm (Gray et al. 1988). This exposure level was considered to be a chronic NOAEL and was converted to a daily dose of 4 mg/kg/day. A dose of 100 ppm

caused significant reduction in the fertility and litter size of the rats. This dose (8 mg/kg/day) was considered a chronic LOAEL. Mortality studies with quail indicate estimated chronic LOAEL and NOAEL values of 4050 and 405 mg/kg/day, respectively (Hill and Camardese 1986).

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological profile for methoxychlor*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Gray L.E., J.S. Ostby, and J.M. Ferrell. 1988. Methoxychlor induces estrogen-like alterations of behavior and the reproductive tract in the female rat and hamster: Effects on sex behavior, running wheel activity, and uterine morphology. *Toxicol. Appl. Pharmacol.* 96:525-540.

Hill, E.F. and M.B. Camardese. 1986. *Lethal dietary toxicities of environmental contaminants and pesticides to Coturnix*. U.S. Fish and Wildlife Service Technical Report 2.

SEMI-VOLATILE ORGANICS

2-Methylnaphthalene

Mice exposed to 2-methylnaphthalene in the diet for 81 weeks showed systemic effects at a dose of 1437 mg/kg/day (the chronic LOAEL; ATSDR 1995). A chronic NOAEL was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. Information on the toxicity of 2-methylnaphthalene on birds was not available in the literature.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Toxicological profile for polycyclic aromatic hydrocarbons (PAHs)*. August.

2-Methylphenol and 4-Methylphenol

2-methylphenol and 4-methylphenol are also known as cresols. Cresols are manufactured and also occur naturally. These forms occur separately or as a mixture. 2-methylphenol is used to dissolve other chemicals, as a disinfectant and deodorizer, and to produce pesticides. It is found in many foods and in wood and tobacco smoke, crude oil, coal tar, and in brown mixtures such as

creosote and cresylic acids, which are wood preservatives. Microorganisms in soil and water produce cresols when they break down materials in the environment (ATSDR 1992).

2-methylphenol occurs widely in the environment at low levels, because it quickly breaks down. It does not evaporate quickly from water, but can be removed by bacteria. In soils, half the total amount of 2-methylphenol will break down in about a week. It does not appear to accumulate in fish or animal tissue (ATSDR 1992).

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological profile for cresols*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

2,4-Dinitrophenol

Dinitrophenols are a class of manmade chemicals of which 2,4-dinitrophenol is the most commercially important. 2,4-dinitrophenol is used for making dyes, wood preservatives, and other organic chemicals. 2,4-dinitrophenol is a yellow solid that dissolves slightly in water. It does not evaporate easily into air but instead settles to the ground in rain and snow. When it enters water it adheres to particles and accumulates in the sediment. It does not bioaccumulate in fish.

2,4-Dinitrotoluene and 2,6-Dinitrotoluene

2,4-dinitrotoluene and 2,6-dinitrotoluene are two of the six forms of dinitrotoluene. They are usually formed by mixing toluene with nitric acid. Dinitrotoluene is used in the production of foams for use in furniture, and in the productions of dyes and munitions. Dinitrotoluene is decomposed by sunlight and by bacteria and therefore does not persist in the environment. It can be transported by surface and groundwater due to its moderate water solubility. Bioaccumulation of 2,4-dinitrotoluene and 2,6-dinitrotoluene in animal tissues is not expected. Plants have been shown to readily uptake 2,4-dinitrotoluene and 2,6-dinitrotoluene.

4-Chloro-3-methylphenol

Information regarding 4-chloro-3-methylphenol was not available in the literature.

Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate (DEHP) is used in the production of polyvinyl chloride, where it is added to plastics to make them flexible. Acute animal tests, such as the LD₅₀ test in rats, have shown DEHP to have low acute toxicity from oral exposure (RTECS 1993). Oral exposure animal studies indicate that DEHP has adverse effects on the liver, kidney, weight gain and food consumption, and can cause liver tumors in rats and mice. Tests on rats and mice demonstrated that DEHP can cause developmental and reproductive toxicity, such as birth defects, decrease in testicular weights, and tubular atrophy (ATSDR 1993). Animal chronic, inhalation exposure studies have reported increased lung weights and liver weights (ATSDR 1993).

A literature search was conducted on the effects of bis(2-ethylhexyl)phthalate ingestion to mammals and birds. A 105-day study conducted on mice indicated that 1000 mg/kg of bis(2-ethylhexyl)phthalate in the diet caused significant reproductive effects (Lamb et al. 1987). The 1000 mg/kg dose was considered the chronic LOAEL. No adverse effects were observed among the 100 mg/kg dose group; this value was considered the chronic NOAEL. These dietary concentrations were converted to a daily doses of 183.3 mg/kg/day (LOAEL) and 18.3 mg/kg/day (NOAEL; Sample et al. 1996).

A 4-week study conducted on the reproductive effects of bis(2-ethylhexyl)phthalate to ringed doves indicated a chronic NOAEL of 10 ppm (Peakall 1974). No significant reproductive effects were observed among doves on diets containing 10 ppm of bis(2-ethylhexyl)phthalate. This dietary concentration was converted to daily dose (NOAEL) of 1.1 mg/kg/day (Sample et al. 1996). A chronic LOAEL was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. *Toxicological profile for bis(2-ethylhexyl)phthalate*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Lamb, J.C., IV, R.E. Chapin, J. Teaque, A.D. Lawton, and J.R. Real. 1987. Reproductive effects of four phthalic acid esters in a mouse. *Toxicol. Appl. Pharmacol.* 88:255-269.

Peakall, D.B. 1974. Effects of di-n-butylphthalate and di-2-ethylhexylphthalate on the eggs of ring doves. *Bull. Environ. Contam. Toxicol.* 12:698-702.

Registry of Toxic Effects of Chemical Substances (RTECS). 1993. Online database. U.S. Department of Health and Human Services. National Toxicology Information Program, National Library of Medicine. Bethesda, MD.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Risk Assessment Program, Health Sciences Research Division. Oak Ridge, Tennessee.

Di-n-butylphthalate

Di-n-butylphthalate is a man-made chemical that is used to make soft plastics, carpet backing, paints, glue, insect repellents, hairspray, nail polish, and rocket fuel. Di-n-butylphthalate does not evaporate easily, but small amounts do enter into the air as a gas and by attaching to dust particles. In the air, di-n-butylphthalate usually breaks down within a few days. Di-n-butylphthalate does not dissolve easily in water, but can be transported to water by adhering to soil/sediment particles. Bacteria break down di-n-butylphthalate in water and soil within a day or up to a month. The length of time it takes to break down di-n-butylphthalate in soil or water depends on the kind of bacteria present and the soil/water temperature (ATSDR 1990). Di-n-butylphthalate appears to have relatively low toxicity. The levels of di-n-butylphthalate which cause toxic effects in animals are about 10,000 times higher than the typical levels of di-n-butylphthalate found in air, food, or water (ATSDR 1990).

In animals, ingestion of high levels of di-n-butylphthalate can affect their ability to reproduce, cause death of unborn animals, and decrease sperm production. Sperm production seems to return to near normal levels when exposure to di-n-butylphthalate ceases.

A literature search was conducted on the toxicological effects of di-n-butylphthalate ingestion to mammals and birds. In a 105-day study on the effects of di-n-butylphthalate on reproduction of mice, reduced litters per pair and reduced live pups per pair were observed among mice who were fed a diet containing 1 percent di-n-butyl-phthalate (Lamb et al. 1987). This equates to a daily dose of 1833 mg/kg/day (chronic LOAEL). No adverse effects were observed among mice fed diets containing 0.03 or 0.3 percent d-n-butylphthalate. The 0.3 percent dose (550 mg/kg/day) was considered the chronic NOAEL.

A study on the effects of di-n-butylphthalate on the reproduction of ringed doves was conducted over a four-week period (Peakall 1974). Doves fed diets containing 10 ppm di-n-butylphthalate (1.1 mg/kg/day) were observed to have reduced eggshell thickness and water permeability of the shell. This dose was considered a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological profile for di-n-butylphthalate*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Lamb, J.C., IV, R.E. Chapin, J. Teaque, A.D. Lawton, and J.R. Real. 1987. Reproductive effects of four phthalic acid esters in a mouse. *Toxicol. Appl. Pharmacol.* 88:255-269.

Peakall, D.B. 1974. Effects of di-n-butylphthalate and di-2-ethylhexylphthalate on the eggs of ring doves. *Bull. Environ. Contam. Toxicol.* 12: 698-702.

Di-n-octylphthalate

Small amounts of di-n-octylphthalate can accumulate in animals that live in water, such as fish and oysters. Some rats and mice that were given very high doses of di-n-octylphthalate orally died. Mildly harmful effects have been seen in the livers of some rats and mice given very high doses of di-n-octylphthalate orally for short (14 days or less) or intermediate periods (15 to 365 days) of time, but lower doses given for short periods of time generally caused no harmful effects.

Acute toxic effects may include the death of animals, birds, or fish, and death or low growth rate in plants. Acute effects are seen two to four days after animals or plants come in contact with the chemical. Di-n-octylphthalate has moderate acute toxicity to aquatic life. Insufficient data are available to evaluate or predict the short- term effects of di-n-octylphthalate to plants, birds, or land animals. Chronic toxic effects may include shortened life span, reproductive problems, lower fertility, and changes in appearance or behavior. Chronic effects can be seen long after first exposure(s). Di-n-octylphthalate has moderate chronic toxicity to aquatic life. Insufficient data are available to evaluate or predict the long- term effects of di-n-octylphthalate to plants, birds, or land animals.

Estimated chronic LOAELs and NOAELs for mice exposed to di-n-hexylphthalate orally for 105 days were 550 and 55 mg/kg/day, respectively (Sample et al. 1996). These values are directly extrapolated to di-n-octylphthalate. Estimated chronic LOAELs and NOAELs for ring-necked pheasant are 500 and 50 mg/kg/day, respectively (TERRETOX 1998).

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-86/R3.

Terrestrial Toxicity Database (TERRETOX). 1998. Environmental Research Laboratory, U.S. Environmental Protection Agency, Duluth, MN.

Diethylphthalate

Diethylphthalate is a synthetic substance that is commonly used to make plastics more flexible. Products in which it is found include toothbrushes, automobile parts, tools, toys, and food packaging. Diethylphthalate can be released fairly easily from these products because it is not part of the chain of chemicals (polymers) that makes up the plastic. Diethylphthalate is also used in cosmetics, insecticides, and aspirin. Diethylphthalate has a moderate acute and chronic toxicity to aquatic organisms and can be mildly irritating when applied to the skin or eyes of animals.

A literature search was conducted on the toxicological effects of diethylphthalate ingestion to mammals and birds. Information was not available for birds. A 105-day study was conducted on the effects of diethylphthalate on reproduction of mice. Mice fed diets containing 2500, 12,500, and 25,000 mg/kg diethylphthalate did not exhibit any negative reproductive effects (Lamb et al. 1987). The dose of 25,000 mg/kg (chronic NOAEL) was converted to a daily dose of 4,583 mg/kg/day. A chronic LOAEL of 45,830 mg/kg/day was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10.

Lamb, J.C., IV, R.E. Chapin, J. Teaque, A.D. Lawton, and J.R. Real. 1987. Reproductive effects of four phthalic acid esters in a mouse. *Toxicol. Appl. Pharmacol.* 88:255-269.

Hexachlorobenzene

Rats exposed orally to hexachlorobenzene for two years demonstrated adverse effects to their reproduction at a dose of 16 mg/kg/day (ATSDR 1989). This dose was considered a chronic LOAEL. A chronic NOAEL (1.6 mg/kg/day) was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. Reproductive effects in birds from oral exposures occurred at a dose of 0.8 mg/kg/day (Coulston and Kolbye 1994). This dose was considered a chronic LOAEL. A chronic NOAEL (0.08 mg/kg/day) was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. *Toxicological profile for hexachlorobenzene*. Draft.

Coulston, F. and A.C. Kolbye, Jr. (eds). 1994. Interpretive review of the potential adverse effects of chlorinated organic chemicals on human health and the environment. *Regulatory Toxicology and Pharmacology*. 20:S1-S1056.

Polynuclear Aromatic Hydrocarbons (PAHs)

PAHs are virtually ubiquitous in nature, primarily as a result of natural processes such as forest fires, microbial synthesis, and volcanic activity. They have been detected in animal and plant tissues, sediments, soils, air, surface water, drinking water, and groundwater. Anthropogenic sources of PAHs in the environment include high temperature combustion of organic materials typical of processes used in the steel industry, heating and power generation, and petroleum refining.

Environmental concern has focused on PAHs, which range in molecular size from two-ring structures to seven-ring structures. The number of rings on the molecule strongly affects its biochemical interactions in the environment. Consequently, the fate, transport, and toxicity of PAHs correlate strongly with the size of the specific PAH molecule.

Relatively little information is known on the fate and transport of specific PAH compounds. Information on PAHs as a group is largely inferred from information on benzo(a)pyrene and mixtures of PAHs.

PAHs are moderately persistent in the environment and therefore may potentially cause significant effects to vegetation, wildlife and fish. The carcinogenicity of individual PAHs differs. Some lower weight compounds such as naphthalene, fluorene, phenanthrene, and anthracene exhibit acute toxicity and other adverse effects to some organisms, but are non-carcinogenic. In contrast, the higher molecular weight compounds are significantly less acutely toxic, but many are demonstrably carcinogenic, mutagenic, or teratogenic to a wide variety of organisms, including fish and other aquatic life, amphibians, birds, and mammals.

PAHs can be taken into the mammalian body by inhalation, ingestion or dermal contact. Acute and chronic exposure to carcinogenic PAHs have been shown to cause tumors in the stomach, lung, and skin. PAHs also have been associated with the destruction of hematopoietic and lymphoid tissues, ovotoxicity, adrenal necrosis, changes in intestinal and respiratory epithelia and immunosuppression.

The environmental effects of most non-carcinogenic PAHs are poorly understood. Available information suggests that these PAHs are not very potent teratogens or reproductive toxins. Effects include damage to the liver and kidney, and external effects of sebaceous gland ulceration.

Studies on PAH toxicity in birds indicated no mortality or visible signs of toxicity when fed 4,000 mg total PAH per kilogram of body weight for seven months. In another study, toxic and sub-lethal effects were noted at concentrations of between 0.036 and 0.18 µg PAH per egg following application of various PAHs (e.g., chrysene and benzo(a)pyrene) to the surface of mallard eggs. Another study reported acute oral effect levels for the red-winged blackbird and house sparrow and acenaphthene, phenanthrene and anthracene LD₅₀ values exceeded 100 mg/kg of body weight for these species.

Few ingestion-based studies have been conducted on mammals using PAHs. Neal and Rigdon (1967) conducted a study on mice for the development of forestomach tumors. Mice were fed between 0.13 mg/kg/day and 32.5 mg/kg/day of PAH for 110 days. The highest dose produced tumors in 90 percent of the mice. The NOAEL was calculated at 1.3 mg/kg/day and the LOAEL was 2.6 mg/kg/day (4 percent occurrence of tumors) (Charters et al. 1996). A study conducted on nestling European starlings indicated that a dose of 100 mg/kg/day of 7,12-dimethylbenz(a)anthracene caused an 11 percent reduction in mean body weight, a 16 percent reduction in mean hemoglobin concentrations, and a 90 percent reduction in lymphocyte

proliferation (Trust et al. 1993). A dose of 10 mg/kg/day caused no adverse effects to nestling birds. Adult starlings dosed as high as 300 mg/kg/day showed no adverse effects.

Charters, D.W., N.J. Finley, and M. Huston. 1996. *Draft report, preliminary ecological risk assessment, Avtex Fibers Site, Front Royal, Virginia*. U.S. Environmental Protection Agency, Environmental Response Team Center, Office of Emergency and Remedial Response.

Neal, J. and R.H. Rigdon. 1967. Gastric tumors in mice fed benzo(a)pyrene: a quantitative study. *Tex. Rep. Biol. Med.* 25:553-557.

Trust, K.A., A. Fairbrother, and M.J. Hooper. 1993. Effects of 7,12-dimethylbenz(a)anthracene on immune function and mixed-function oxygenase activity in the European starling. *Environ. Toxicol. and Chemistry.* 13:821-830.

Acenaphthene

Mice fed acenaphthene orally for 13 weeks showed adverse reproductive effects at a dose of 3500 mg/kg/day (ATSDR 1995). This dose was considered a chronic LOAEL. A chronic NOAEL of 350 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. For birds, data for benzo(a)pyrene was applied to this chemical.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Toxicological profile for polycyclic aromatic hydrocarbons (PAHs)*. August.

Anthracene

Mice fed anthracene orally for 13 weeks showed adverse reproductive effects at a dose of 10,000 mg/kg/day (ATSDR 1995). This dose was considered a chronic LOAEL. A chronic NOAEL of 1,000 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Mallards fed anthracene orally for 7 months showed adverse effects to the hepatic system at a dose of 228 mg/kg/day (Patton and Dieter 1980). This dose was considered a chronic LOAEL.

A chronic NOAEL of 22.8 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Toxicological profile for polycyclic aromatic hydrocarbons (PAHs)*. August.

Patton, J.F. and M.P. Dieter. 1980. Effects of petroleum hydrocarbons on hepatic function in the duck. *Comp. Biochem. Physiol.* 65C:33-36.

Benzo(a)anthracene

Information regarding benzo(a)anthracene was not available in the literature. Data for benzo(a)pyrene was applied to this chemical for both birds and mammals.

Benzo(a)pyrene

Female mice were fed benzo(a)pyrene during pregnancy. Adverse reproductive effects were found at a dose of 10 mg/kg/day (Sample et al. 1996). This dose was considered a chronic LOAEL. A chronic NOAEL of 1 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Mice fed benzo(a)pyrene orally for 19 to 29 days showed adverse reproductive effects at a dose of 1330 mg/kg/day (ATSDR 1995). This dose was considered a chronic LOAEL. A chronic NOAEL of 133 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Chickens were fed benzo(a)pyrene for 34 days. Adverse reproductive effects were found at a dose of 395 mg/kg/day (Rigdon and Neal 1963). This dose was considered a chronic LOAEL. A chronic NOAEL of 39.5 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Toxicological profile for polycyclic aromatic hydrocarbons (PAHs)*. August.

Rigdon, R.H. and J. Neal. 1963. *Fluorescence of chickens and eggs following the feeding of benzpyrene crystals*. Texas Reports on Biology and Medicine 21(4):558-566.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological benchmarks for wildlife: 1996 revision*. Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-86/R3.

Benzo(b)fluoranthene

Information regarding benzo(b)fluoranthene was not available in the literature. Data for benzo(a)pyrene was applied to this chemical for both birds and mammals.

Benzo(g,h,i)perylene

Information regarding benzo(g,h,i)perylene was not available in the literature. Data for benzo(a)pyrene was applied to this chemical for both birds and mammals.

Benzo(k)fluoranthene

Information regarding benzo(k)fluoranthene was not available in the literature. Data for benzo(a)pyrene was applied to this chemical for both birds and mammals.

Chrysene

Information regarding chrysene was not available in the literature. Data for benzo(a)pyrene was applied to this chemical for both birds and mammals.

Fluoranthene

Mice fed fluoranthene orally for 13 weeks showed adverse effects to the hepatic system at a dose of 1250 mg/kg/day (ATSDR 1995). This dose was considered a chronic LOAEL. A chronic NOAEL of 125 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. For birds, data for benzo(a)pyrene was applied to this chemical.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Toxicological profile for polycyclic aromatic hydrocarbons (PAHs)*. August.

Fluorene

Mice fed fluorene orally for 13 weeks showed adverse hematological effects at a dose of 1250 mg/kg/day (ATSDR 1995). This dose was considered a chronic LOAEL. A chronic NOAEL of 125 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. For birds, data for benzo(a)pyrene was applied to this chemical.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Toxicological profile for polycyclic aromatic hydrocarbons (PAHs)*. August.

Indeno(1,2,3-cd)pyrene

Information regarding indeno(1,2,3-cd)pyrene was not available in the literature. Data for benzo(a)pyrene was applied to this chemical for both birds and mammals.

Phenanthrene

Information regarding phenanthrene was not available in the literature. Data for benzo(a)pyrene was applied to this chemical for both birds and mammals.

Pyrene

Information regarding pyrene was not available in the literature. Data for benzo(a)pyrene was applied to this chemical for both birds and mammals.

VOLATILE ORGANICS

1,1-Dichloroethane

1,1-dichloroethane is a manmade liquid that is a vapor when released to the environment. It is used to make other chemicals, and to dissolve paints, varnishes, and grease. 1,1-dichloroethane does not dissolve easily in water but can evaporate easily to the air. 1,1-dichloroethane found in soils can evaporate to the air or can move to groundwater (ATSDR 1989). Brief exposures to high levels of 1,1-dichloroethane have caused death in animals. Longer exposures to 1,1-dichloroethane in the air have caused kidney disease in animals (ATSDR 1989).

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. *Toxicological profile for 1,1-dichloroethane*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

2-Butanone

2-butanone is a manufactured chemical but it is also present in the environment from natural sources. It is used in paints, glues, and as a cleaning agent. 2-butanone is also produced naturally by some trees and is found in some fruits and vegetables in small amounts (ATSDR 1992). It is also known as methyl ethyl ketone (MEK).

2-butanone enters the air during production, use and transport, and from hazardous waste sites. It dissolves in water and is broken down to a simpler chemical form in about 2 weeks. It does not adsorb to soil, therefore it is highly mobile and can infiltrate to the groundwater. It is not known to bioaccumulate in fish or animal tissues and does not biomagnify in the food chain (ATSDR 1992).

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological profile for 2-butanone*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Bromodichloromethane

Bromodichloromethane is a colorless, heavy liquid that is formed as a by-product when chlorine is added to drinking water. Bromodichloromethane is also used in the production of other chemicals. Bromodichloromethane evaporates quickly and most that is released evaporates into the air where it is slowly broken down. Animals that have been fed quantities of bromodichloromethane have developed cancer of the liver, kidney, and intestines (ATSDR 1989).

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. *Toxicological profile for bromodichloromethane*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Carbon Disulfide

The chief uses of carbon disulfide are for the manufacture of rayon and for regenerated cellulose film. Acute and chronic exposure to carbon disulfide affects the central nervous system.

Chlorobenzene

Chlorobenzene is a colorless liquid with an almond-like odor. This chemical does not widely occur naturally but is manufactured for use as a solvent and to produce other chemicals. Chlorobenzene can persist in soil for several months but will persist in air and water for only hours or a few days (ATSDR 1990).

A chronic study on the effects of chlorobenzene on dogs showed adverse effects to the liver at a dose of 273 mg/kg/day (IRIS 1998). This dose is considered a chronic LOAEL. A chronic NOAEL of 27.3 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. No data were found on the toxicological effects to birds from ingestion exposures.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological profile for chlorobenzene. Draft*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Integrated Risk Information System (IRIS). 1998. U.S. Environmental Protection Agency, Washington DC.

Chloroform

Chloroform is a colorless or water-white liquid. Most of what is produced in the United States is used to make fluorocarbon 22, which is a cooling fluid for air conditioners. A lesser amount is used in the production of pesticides and solvents. Most of the chloroform that is released to the environment is transported to the air (ATSDR 1988).

A literature search was conducted on the toxicological effects of chloroform ingestion to mammals and birds. Ingestion-based studies were not available for birds.

A 13-week study of the effects of chloroform on livers, kidneys, and gonad condition in rats indicated a chronic LOAEL of 410 mg/kg/day (Palmer et al. 1979). At this dosage, both female

and male rats developed gonadal atrophy. A dose of 150 mg/kg/day was determined to be the chronic NOAEL because no adverse effects were observed at this dosage.

Agency for Toxic Substances and Disease Registry (ATSDR). 1988. *Toxicological profile for chloroform*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Palmer, A.K., A.E. Street, F.J.C. Roe, A.N. Worden, and N.J. Van Abbe. 1979. Safety evaluation of toothpaste containing chloroform. II. Long term studies in rats. *J. Environ. Pathol. Toxicol.* 2:821-833.

Chloromethane

Chloromethane is a clear colorless gas that is produced naturally in the oceans and by microbial fermentation, and by industry to create other chemicals. Chloromethane evaporates into the air where it can remain for up to two years. If present in a landfill, it can leach through the soil and infiltrate groundwater.

Ethylbenzene

Ethylbenzene occurs naturally in coal tar and petroleum and is also found in many man-made products including paints, inks, and insecticides. Gasoline contains about 2 percent (by weight) ethylbenzene. Ethylbenzene is a colorless liquid that smells like gasoline. It evaporates at room temperature and burns easily. Ethylbenzene is most commonly found as a vapor because it evaporates easily into the air from water and soil. Once in the air, other chemicals help break down ethylbenzene into chemicals found in smog. This breakdown happens in about 3 days with the aid of sunlight. In surface water such as rivers and harbors, ethylbenzene breaks down by reacting with other compounds naturally present in water. In soil, bacteria break down ethylbenzene. It can also infiltrate groundwater since it does not readily bind to soil. Several studies indicate that ethylbenzene causes systemic effects in animals following inhalation exposure. The principal target organs appear to be the lungs, liver, and kidney, with transient toxic effects on the hematological system (ATSDR 1990).

A chronic study on the effects of ethylbenzene on rats showed adverse effects to the liver and kidney at a dose of 971 mg/kg/day (Wolf et al. 1956). This dose is considered a chronic LOAEL. A chronic NOAEL of 97.1 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. No data were found on the toxicological effects to birds from ingestion exposures.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological profile for ethylbenzene*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Wolf, M.A., V.K. Rowe, D.D. McCollister, R.L. Hollinsworth, and F. Oyen. 1956. Toxicological studies of certain alkylated benzenes and benzene. *Arch. Ind. Health*. 14:387-398.

Methylene Chloride

Methylene chloride is an organic solvent with a sweet smell that is used as an industrial solvent, a paint stripper, and in the manufacture of photographic film. Animals given large amounts of methylene chloride have developed cancer (ATSDR 1989).

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. *Toxicological profile for methylene chloride*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Styrene

Styrene is a colorless liquid used to make rubber and plastics. Billions of pounds of styrene are produced each year in the United States. It does not occur naturally in the environment. Styrene is quickly broken down in the air when ozone is present, but remains in the soil and water for several months (ATSDR 1991).

A 90-day study on the effects of ingestion of styrene on reproduction in rats indicated a chronic NOAEL of 35 mg/kg/day (Beliles et al. 1985). A chronic LOAEL of 350 mg/kg/day was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10.

In a 560-day study on the effects of styrene on the hepatic system of dogs indicated a chronic LOAEL of 400 mg/kg/day (Quast et al. 1979). Dogs given this dosage by gavage exhibited increased numbers of Heinz bodies, decreased packed cell values, and sporadic decreases in hemoglobin and erythrocyte counts. No adverse effects were observed a dose of 200 mg/kg/day. This was determined to be a chronic NOAEL.

No data on the toxicological effects of styrene on birds were found in the literature.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological profile for styrene*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Beliles, R.P., J.H. Butala, C.R. Stack et al. 1985. Chronic toxicity and three-generation reproduction study of styrene monomer in the drinking water of rats. *Fundam. Appl. Toxicol.* 5:855-868.

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Toluene

Toluene is produced as a by-product in the processing of gasoline and coke, and in the manufacture of styrene. Toluene readily degrades once it is released to the environment. It is readily broken down by microorganisms in the soil and evaporates quickly from the soil and surface water. Toluene can accumulate in aquatic organisms such as fish, shellfish, plants, and aquatic mammals. It is not known to biomagnify in food chains.

Studies on animals have shown that toluene can effect the central nervous system, liver, kidney and lungs. Studies using moderate to high concentrations of toluene indicate that toluene is a developmental toxicant, but not a reproductive toxicant (ATSDR 1994).

A literature search was conducted on the toxicological effects of toluene ingestion to mammals and birds. Ingestion-based studies were not available for birds.

A study on the effects of toluene on the reproduction of rats indicated a chronic LOAEL of 0.3 mL/kg/day (Nawrot and Staples 1979). Exposure to this dose via oral gavage during gestation significantly reduced fetal weights and significantly reduced embryo mortality. The chronic LOAEL was converted to a daily dose of 260 mg/kg/day (Sample et al. 1996). A chronic

NOAEL of 26 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

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Trichloroethene

A study on the effects of trichloroethene on rats showed adverse reproductive effects at a dose of 10,000 mg/kg/day (Coulston and Kolbye 1994). This dose is considered a chronic LOAEL. A chronic NOAEL of 1,000 mg/kg/day was calculated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. No data were found on the toxicological effects to birds from ingestion exposures.

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APPENDIX D
EQUILIBRIUM PARTIONING APPROACH

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EQUILIBRIUM PARTITIONING APPROACH

The EPA has chosen the EqP approach for developing sediment quality criteria (or sediment screening values in the case of this ERA) for nonionic organic chemical constituents (EPA 1993). This approach was used to derive sediment screening values for nonionic organic chemicals lacking literature-based, bulk sediment screening values.

There are three underlying assumptions to the derivation of sediment quality criteria (or, in the case of this document, sediment screening values). First, it is assumed that sediment toxicity correlates with the concentration of the chemical in the sediment pore water and not the bulk sediment concentration (i.e., the pore water concentration represents the bioavailable fraction). Secondly, partitioning between sediment pore water and bulk sediment is assumed to be dependent on the organic content of the sediment with little dependence upon other chemical or physical properties. Finally, the EqP approach assumes that equilibrium has been attained between the sediment pore water concentration and the bulk sediment concentration.

The relationship between the concentration of a nonionic organic chemical in sediment pore water and bulk sediment is described by the partitioning coefficient, K_p (EPA 1993):

$$K_p = (C_s)/(C_{pw}) \quad (\text{Equation D-1})$$

Where C_s is the concentration in bulk sediment and C_{pw} is the concentration in sediment pore water. For a given organic chemical, the partition coefficient can be derived by multiplying the fraction of organic carbon (f_{oc}) present in the sediment by the chemical's organic carbon partition coefficient (K_{oc}) (EPA 1993):

$$K_p = (f_{oc})(K_{oc}) \quad (\text{Equation D-2})$$

Combining Equations D-1 and D-2 yields the following:

$$C_s = (K_{oc})(f_{oc})(C_{pw}) \quad (\text{Equation D-3})$$

If the organic carbon content of the sediment is known, a site-specific sediment screening value (SSV) can be calculated for a given non-polar organic chemical by setting C_{pw} equivalent to a conservative surface water screening value for that chemical (SWSV):

$$SSV = (K_{oc})(f_{oc})(SWSV) \quad (\text{Equation D-4})$$

In this equation, SSV represents the concentration of the chemical in bulk sediment that, at equilibrium, will result in a sediment pore water concentration equal to the surface water screening value. Sediment concentrations less than SSV would be protective of sediment-associated biota. The use of surface water threshold screening values (i.e., criteria and toxicological benchmarks) in Equation D-4 assumes that the sensitivities of sediment-associated biota and the species typically tested to derive surface water screening values such as EPA NAWQC (predominantly water column species) are similar. Furthermore, it assumes that levels of protection afforded by the surface water screening values are appropriate for sediment-associated biota. It is noted that the EqP approach can only be used if the f_{oc} in sediment is greater than 0.02 (i.e., 2.0 percent). At f_{oc} values less than 0.02, other factors (e.g., particle size, sorption to nonorganic mineral fractions) become relatively more important (EPA 1993).

Although the EqP approach was developed by the EPA for nonionic organic chemicals, this method was also used to derive sediment threshold screening values for ionic organic chemicals lacking literature-based bulk sediment toxicological benchmarks. Application of the EqP approach to ionic organic chemicals likely overestimates their pore water concentrations since adsorption mechanisms other than hydrophobicity may significantly increase the fraction of the chemical sorbed to sediment particles (Jones et al. 1997). Therefore, the EqP-based threshold screening values developed for ionic chemicals may be overly conservative. Regardless, application of the EqP approach to the development of sediment screening values for ionic chemicals is documented in the literature (EPA 1996 and Jones et al. 1997).

The EqP-based sediment screening values summarized in Section 5.0, Table 5-3 are conservatively based on a default f_{oc} of 0.01 (one percent) (EPA 1996). The K_{oc} values applied to Equation E-4 were estimated from the following equation (EPA 1993 and 1996):

$$\text{Log } K_{oc} = 0.00028 + (0.983)(\text{Log } K_{ow}) \quad (\text{Equation D-5})$$

Where $\log K_{ow}$ is the log octanol-water partition coefficient. $\log K_{ow}$ and estimated K_{oc} values for organic chemicals evaluated by the Tier I screening-level ERA are listed in Section 4.0, Table 4-2. Surface water screening values used in the derivation of EqP-based sediment screening values were taken from Section 5.0, Table 5-2. It is noted that EqP-based sediment screening values could not be calculated for those organic chemicals lacking a surface water screening value.

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