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ADDENDUM TO THE DRAFT SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT PROBLEM FORMULATION STEP 1 AND EXPOSURE ESTIMATE SOLID WASTE MANAGEMENT UNIT 45 NAVAL ACTIVITY PUERTO RICO

5/22/2003

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Addendum to the Draft

Screening-Level Ecological Risk Assessment Problem Formulation (Step 1) and Exposure Estimate SWMU 45

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

May 22, 2003

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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
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
FIR	Food Ingestion Rate
GRO	Gasoline Range Organics
ICM	Interim Corrective Measure
IRP	Installation Restoration Program
K_d	Adsorption coefficient
kg	Kilograms
kg/day	Kilograms per day
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient

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
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
RAC	Remedial Action Contractor
RAGS	Risk Assessment Guidelines
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI	Remedial Investigation
SC_x	Concentration of Chemical in Soil/Sediment
SERA	Screening-level Ecological Risk Assessment
SQUIRT	Screening Quick Reference Table
SSI	Supplemental Site Investigation
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
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
UST	Underground Storage Tank
VOC	Volatile Organic Compound

1.0 INTRODUCTION

Methodology for conducting a screening-level ecological risk assessment (ERA) for Solid Waste Management Unit (SWMU) 45 was previously submitted as part of the Environmental Protection Agency (EPA)-approved document entitled Revised Final II Corrective Measures Study Work Plan, SWMU 45 - Areas Outside of Building 38, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 2001). 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 SWMU 45 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 analytical data for SWMU 45 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 SWMU 45, indicated that chemicals detected in sediment collected from a small cove of Puerca Bay 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 the Puerca Bay cove 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 SWMU 45 also included methodology for conducting Step 3a of the Navy ERA process.

The Revised Final II CMS Work Plan for SWMU 45 acknowledged that insufficient data exist to adequately characterize potential risks to ecological receptor species/communities at SWMU 45. Specific data deficiencies that have been identified are as follows:

- Lack of surface water analytical data for a surface water body downgradient from SWMU 45 (a small cove of Puerca Bay).

- Lack of background surface water and sediment data from an open water marine environment similar to the Puerca Bay cove.

- Lack of sediment quality characteristics for Puerca Bay cove sediment that can be used in Step 3a to assess the bioavailability preliminary ecological COPCs identified by the screening-level risk calculation.

In addition to the above deficiencies, the existing sediment analytical data for the Puerca Bay cove indicate that the extent of potential polychlorinated biphenyl (PCB) contamination has not been adequately characterized. As discussed in the Revised Final II CMS Work Plan, analytical data gaps and uncertainties 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 SWMU 45 will be completed following the sampling and analytical program. This will eliminate the need to reevaluate risks once the data gaps 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 SWMU 45. If methodology differs from the methodology presented in the work plan, justification with supporting documentation will be included with the risk assessment document.

Although the Revised Final II CMS Work Plan for SWMU 45 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 SWMU 45 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 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 SWMU 45.

- Summarize existing analytical data and identify and discuss analytical data gaps.

- Present a preliminary conceptual model for SWMU 45 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 receptors.

- 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 45 habitats and biota.

- **Section 3.0 - Available Analytical Data and Data Gaps**. Describes existing analytical data for SWMU 45 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 are also identified and discussed.

- **Section 4.0 - Screening-Level Problem Formulation.** Presents the preliminary conceptual model for SWMU 45, 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 NSRR. This information is supplemented by observations recorded during a habitat characterization conducted at SWMU 45 in May 2000 (terrestrial habitats) and June 2000 (marine habitats). 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 45 is comprised of the areas outside Building 38 (former power plant). Building 38 is located along an access road south of Forrestal Drive opposite Camp Moscrip and north of SWMU 3 - Base Landfill (see Figure 2-1). The former power plant contained a 60-megawatt steam turbine facility that operated from the early 1940s through 1949 (NEESA, 1984). The facility used Bunker C fuel, which was stored in two 50,000-gallon reinforced underground concrete tanks located directly northeast of the building (NEESA, 1984). Associated with Building 38 are two underground tunnels used to transfer cooling water to and from the building. A cooling water intake tunnel extends from Building 38 out into a small cove of Puerca Bay east-northeast of the building. The cooling water discharge tunnel originates from the building's east wall and parallels the access road to the landfill (SWMU 3). Apparently, the discharge tunnel terminates somewhere in Ensenada Honda (to the south), however the exact location of the outflow has not been determined. The underground storage tanks (USTs), cooling water intake and discharge tunnel, and the Puerca Bay cove are included as part of SWMU 45.

SWMU 45 was initially addressed under the Navy's Installation Restoration Program (IRP), which followed a CERCLA pattern. Under the IRP, a Remedial Investigation (RI) was performed. PCB contamination was found in soils immediately outside Building 38. An Interim

Corrective Measure (ICM) was designed for the affected soils, which included excavation of the contaminated soils, shipment off island for appropriate disposal, and sampling the surrounding area to ensure that cleanup was achieved. The soil removal took place in 1994. A report entitled <u>Final Closeout Report for Interim Remedial Action of PCB Contaminated Soils, Sites 15 and 16 at Naval Station Roosevelt Roads, Puerto Rico</u> was submitted to the EPA in May 1995 (OHM, 1995). [It is noted that the "Site 16" referenced in the report title is the IRP designation for what is now SWMU 45.]

NSRR submitted a RCRA Part B Permit application for the storage of hazardous waste on the base. Recognizing that Corrective Action would apply to unpermitted waste management units, the Navy performed a Supplemental Site Investigation (SSI) at a variety of units (including SWMU 45) to provide additional site characterization information to the EPA to assist in their permitting decisions. Included in the investigation were the sediments of the Puerca Bay cove and the cooling water tunnel interior. The investigations were reported in the report entitled <u>Draft Supplemental Investigation, Installation Restoration Program Activities, Naval Station Roosevelt Roads, Ceiba, Puerto Rico</u> (Baker 1993).

The Resource Conservation and Recovery Act (RCRA) corrective action portion of the facility's permit (issued in October 1994) contained specific requirements for investigation and, potentially, remediation at the site. To accomplish the goals of the permit, a RCRA Facility Investigation (RFI) work plan was submitted to, and subsequently approved by the EPA. The work plan provided the framework for site characterization activities; its scope was guided by the results of the SSI.

An RFI at SWMU 45 was performed in 1996 in accordance with the work plan. The findings of the RFI confirmed those of the SSI and indicated that USTs and cooling water tunnel represented a possible source of continuing release. On the basis of this finding, the Navy decided to perform an ICM to eliminate the potential for further release. The plans for the ICM, which were submitted to the EPA and approved, called for the cleaning and abandonment in place of the USTs and tunnel. Inflow of groundwater to the tunnel necessitated a field design change (approved by the EPA) which provided for the filling of the USTs and tunnel with low density concrete. This approach entombed and effectively immobilized any residual contamination.

During the ICM on the tunnel, an excavation was made at a point along the outside of the tunnel in an attempt to ascertain how groundwater was entering the tunnel. Soils contaminated with petroleum were observed. A work plan to investigate the outside of the tunnel was submitted to and subsequently approved by the EPA. The work was performed and the results were presented in the EPA-approved Revised Draft RCRA Facility Investigation Report for Operable Unit 3/5 (Baker 1999). This report (and/or its precursor the initial "draft" report) recommended a CMS for the Puerca Bay sediments and the soils immediately adjacent to the cooling water tunnel.

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.

The majority of the terrestrial vegetative community at SWMU 45 is dominated by shrubs (*Leucaena leucocephala*). However, maintained grasses dominated the road corridors. A fringe of black mangroves (*Stachytarpeta jamaicensis* and *Heliotropium curassavicum*) is present along the small cove within Puerca Bay. *Stahlia monosperma*, a federally-designated threatened tree, is known to occur in coastal forests of southeastern Puerto Rico (Little and Wadsworth 1964). However, this species was not observed as occurring at SWMU 45 (Geo-Marine, Inc. 2000).

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 (*Trichechas manatus*). The green sea turtle is a federally threatened species, while the West Indian manatee is a federally endangered species. Both species have been reported in the marine environment surrounding NSRR.

A reconnaissance survey of the Puerca Bay cove was conducted on June 19, 2000 as part of the habitat characterization at SWMU 45. Marine habitats observed during the reconnaissance survey included a rocky subtidal zone comprised of rip rap, shallow subtidal shelf characterized as a seagrass/algae bed dominated by turtle grass (*Thalassia testudium*), shelf slope devoid of seagrass and dominated by marine algae, and level sandy bottom. Seagrass cover within the shallow subtidal shelf habitat ranged from 50 to 75 percent. The sandy bottom habitat is unvegetated and is comprised of a sand to silty-sand bottom. The concrete side walls of the cooling tunnel intake structure also serves as habitat, supporting a hardbottom community dominated by soft corals, marine algae, and sponges.

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 small Puerca Bay cove. As such, this cove represents potential feeding habitat for the West Indian manatee. It is noted that this marine mammal was not observed during the marine reconnaissance survey.

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 monaqchus*). Of the 239 species native to Puerto Rico, 12 are endemic to the island (Raffaele 1989).

Numerous native and migratory bird species have been reported at NSRR (Geo-Marine, Inc. 1998). A list of bird species 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 melanoleauca*), black-bellied plover (*Squatarola squatarola*), clapper rail (*Rallus longirostris*), Royal tern (*Thalasseus maximus*), sandwich tern (*Thalasseus sandvicensis*), least tern (*Stema albifrons*), yellow warbler (*Dendroica petechia*), palm warbler (*Dendroica palmarum*), prairie warbler (*Dendroica discolar*), magnolia warbler (*Dendrocia magnolia*), mourning dove (*Zenaida macroura*), red-legged thrush (*Mimocichla plumbea*), common nighthawk (*Chordeiles minor*), and red-tailed hawk (*Buteo jamaicensis*).

Endemic species reported from NSRR include the Puerto Rican lizard cuckoo (*Saurothera vieilloti*), Puerto Rican flycatcher (*Myiarchus antillarum*), Puerto Rican woodpecker (*Malanerpes portoricensis*), Puerto Rican emerald (*Chlorostilbon maugaeus*), and yellow-shouldered blackbird (*Agelaius xanthomus*). 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-designated 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. SWMU 45 is outside of the critical habitat designation for the yellow shouldered blackbird, although potential feeding habitat (shrubland) for the Yellow-shouldered blackbird was present at the site (Geo-Marine, Inc, 2000). It is noted that the last reported nesting pair of yellow-shouldered blackbirds at NSRR was in 1986 (USFWS 1996). Other federally-designated 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).

Several bird species typically associated with coastal forests and shores were observed at SWMU 45 during the habitat characterization (see Appendix A). The specific species observed were the killdeer (*Charadrius vociferous*), common ground dove (*Columbina passerina*), yellow warbler, magnificent frigatebird (*Fregata magnificens*), pearly-eyed thrasher (*margarops fuscatus*), northern mockingbird (*Mimus polyglottos*), greater antillean grackle (*Quiscalus niger*), cave swallow (*Pterochelidon fulva*), gray kingbird (*Tyrannus dominicensis*), white-winged dove (*Zenaida asiatica*), and zenaida dove (*Zenaida aurita*). There were no federally protected bird species or critical/preferred habitat for protected bird species observed at SWMU 45. As discussed in the preceding paragraph, SWMU 45 is outside the area of critical habitat designation for the yellow shouldered blackbird.

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.

A single lizard species (*Anolis cristateluus*) was observed at SWMU 45 during the habitat characterization. Intact coastal forest habitat, preferred habitat for the Puerto Rican boa (*Epicrates inornatus*), is not present (Geo-marine, Inc, 2000). Therefore, it is unlikely that this species is present in the vicinity of SWMU 45. Marine reptiles were not observed within the Puerca Bay cove during the marine reconnaissance survey. However, given the presence of sea grass, the cove may represent 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.

Marine invertebrates observed within the Puerca Bay cove during the marine reconnaissance survey included sea urchins (*Echinometra lucunter* and *E. viridis*), encrusting fire coral (*Millipora alcicornus*), common sea fan (*Gorgonia ventalina*), starlet coral (*Siderastrea radians*), pincushion starfish (*Oreaster reticulatus*), and corkscrew anemone (*Bartholomea annulatta)*, as well as two species of sea cucumbers (*Actinopyga agassizii* and *Holothuria mexicana*). In addition to invertebrates, sixteen fish were observed within the Puerca Bay Cove. The specific species encountered included the sergeant major (*Abudefduf saxatillis*), dusky dameselfish (*Stegastes fuscus*), tomtate (*Haemulon aurolineatum*), gray snapper (*Lutjanus griseus*), squirrelfish (*Holocentrus* species), yellow fin mojarra (*Gerres cinereus*), and silver jenny (*Eucinostomus gula*). A complete list of invertebrate and fish species encountered within each Puerca Bay cove habitat unit is included within the habitat characterization report (see Appendix A).

3.0 AVAILABLE ANALYTICAL DATA

Sampling activities at SWMU 45 have previously been conducted under two RFI field investigations (1996 and 1997). Environmental media collected during the RFI field investigations included surface soil, subsurface soil, groundwater, and sediment (see Table 3-1). This analytical data was previously presented and discussed in the EPA-approved Revised Draft RFI for OU 3/5 (Baker, 1999). Surface soil, subsurface soil, groundwater, and sediment sampling locations are depicted on Figure 3-1.

The subsurface soil and groundwater analytical data collected during the 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 sediment data for the Puerca Bay cove and by future surface water and sediment samples collected from this surface water body (see Section 3.1).

3.1 Identification of Data Gaps

Based on the review of existing analytical data for SWMU 45, the following data gaps 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 Puerca Bay cove is not available for use in media-specific screening and the estimation of tissue concentrations in the prey of avian piscivores.

- Background surface water and sediment data from an open water marine environment similar to SWMU 45 is not available for use in Step 3a of the Navy ERA process.

- Total organic carbon data for Puerca Bay cove sediment is not available for use in Step 3a of the Navy ERA process (i.e., assessment of bioavailability).

In addition to the above data gaps, there is uncertainty associated with the characterization of the Puerca Bay cove sediment. Specifically, the extent of PCB contamination in Puerca Bay cove sediment has not been adequately characterized. A field sampling and analytical program will be conducted to address the data gaps and the uncertainties 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

Figure 4-1 shows a preliminary conceptual model for SWMU 45. 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 model (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 Figure 4-1, the primary mechanisms for contaminant transport from potential source areas at SWMU 45 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.

- Discharge of chemicals through the cooling water intake tunnel to Puerca Bay cove surface water and sediment.

- Uptake by biota from surface soil, surface water, and sediment, and trophic transfer to upper trophic levels.

The discharge of chemicals through the cooling water intake tunnel represents a historical transport pathway. This pathway was eliminated by the ICM conducted in 1996, which involved the filling of the tunnel with low density concrete (see Section 2.1).

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 Figure 4-1, SWMU 45 has 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 this screening-level ERA 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 Puerca Bay cove is an open water marine environment, salinity levels are assumed to be well above the 15 ppt threshold value. Additionally, there are no freshwater drinking water sources within or contiguous to SWMU 45. As such, 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 SWMU 45, dermal exposures for upper trophic level receptor avian 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 receptors (e.g., terrestrial invertebrates, fish, and benthic invertebrates). In addition to dermal contact, inhalation exposures were not 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 heron 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 are presented in Table 4-1. 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 (survival, growth, and reproduction) 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 (K_{ow}) indicates whether a compound is hydrophilic or hydrophobic. The 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). Table 4-2 presents K_{ow} values for Appendix IX VOCs, SVOCs, PCBs, A log K_{ow} of three equates to an aquatic species BCF of about 100, using the equation (Lyman et al. 1990):

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

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 (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 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 used as screening values (toxicological thresholds) for chemicals analyzed in surface soil, surface water, and sediment. 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 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 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. 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 using appropriate conversion factors (EPA 2002). For those chemicals lacking a saltwater NAWQC, 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 6.3.2.

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 ecological receptor species/groups selected to represent the assessment endpoints at SWMU 45.

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).

- For surface water screening, total (unfiltered) concentrations will be used. However, dissolved (filtered) 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 results of the habitat characterization (Geo-Marine Inc. 2000).

Terrestrial species:

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

Aquatic species:

- West Indian manatee (*Trichechus manatus*) (mammalian herbivore)
- Double-crested cormorant (*Phalacrocorax auritus*) (avian piscivore)
- Belted kingfisher (*Ceryle alcyon*) (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 SWMU 45. The mourning dove was included as an ecological receptor species for the following reasons:

- This species is known to occur at NSRR (see Table 2-1).

- Similar species were observed within terrestrial habitat at SWMU 45 during the habitat characterization (see Section 2.3 and Appendix A).

The double-crested cormorant was added to the list of ecological receptor species as a replacement for the great blue heron. This change is based on the available habitat within the Puerca Bay cove (see Appendix A). Although the double-brested cormerant 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.

6.3 Exposure Estimation

Chemical concentrations in surface soil will be used to estimate potential chemical exposures for the terrestrial receptor groups selected as assessment endpoints (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 selected as assessment endpoints (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 were modeled included 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/wetland 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 exposure 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):

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

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 shown in Table 6-2.

For 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:

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

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:

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

where C_{sed} is the maximum sediment is the maximum sediment concentration (mg/kg, BAF_{sed} is the sediment-to-fish BAF (unitless), and C_{xf}, BAF_{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 BAFs shown for mercury and selenium are based on organometalic (methylated) forms. The surface water-to-fish BAFs shown in Table 6-4 are limited to BAFs for inorganic chemicals. BAFs for bioaccumulative organic chemicals detected in surface water collected from the Puerca Bay cove 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).

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

where:

DI_x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR	=	Food ingestion rate (kg/day, dry-weight)
FC_{xi}	=	Concentration of chemical x in food item i (mg/kg, dry weight)
PDFi	=	Proportion of diet composed of food item i (mg/kg, dry weight basis)
SC_x	=	Concentration of chemical x in soil/sediment (mg/kg, dry weight)
PDS	=	Proportion of diet composed of soil/sediment (dry weight basis)
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.

Although not evaluated for food web exposures, Table 6-6 contains a dietary composition for a small mammal omnivore. As evidenced by Table 6-6, 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 items 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 SWMU 45). 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 (LD_{50}) is used. An uncertainty factor of 100 is used to convert the acute LD_{50} to a chronic NOAEL (i.e., the LD_{50} was multiplied by 0.01 to obtain the chronic NOAEL).

- An uncertainty factor of 10 is used to convert a reported LOAEL to a NOAEL (EPA 1997).

Ingestion screening values for birds and mammals are summarized in Tables 6-7 and 6-8, respectively. It is noted that the ingestion-based screening values summarized in Table 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 are not adjusted 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
SMWU 45 –AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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 45 -AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample Media	Phase	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
Surface Soil	I	45MW01-00	0.0-1.0	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45MW02-00	0.0-1.0	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45MW03-00	0.0-1.0	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45MW04-00	0.0-1.0	11/22/96	VOC, SVOC, PCB, RCRA Metals
Subsurface Soil	I	45MW01-02	4.0-6.0	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45MW01-03	6.0-8.0	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45MW02-01	2.0-4.0	11/21/96	VOC, SVOC, PCB, RCRA Metals
		45MW02-02	4.0-6.0	11/21/96	VOC, SVOC, PCB, RCRA Metals
		45MW03-03	6.0-8.0	11/21/96	VOC, SVOC, PCB, RCRA Metals
		45MW03-04	8.0-10.0	11/21/96	VOC, SVOC, PCB, RCRA Metals
		45MW04-01	2.0-4.0	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45MW04-02	4.0-6.0	11/22/96	VOC, SVOC, PCB, RCRA Metals
	II	11-SB01-02	2.0-8.0	9/17/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB04-01	2.0-4.0	9/24/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB05-02	2.0-8.0	9/17/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB06-02	2.0-8.0	9/18/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB07-02	2.0-8.0	9/18/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB08-02	2.0-8.0	9/18/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB09-02	2.0-8.0	9/19/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB11-02	2.0-8.0	9/19/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB14-01	2.0-4.0	9/19/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB15-02	2.0-4.0	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB16-04	4.0-8.0	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB18-02	2.0-6.0	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB19-04	6.0-10.0	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB22-04	7.5-9.5	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB22-06	11.5-13.5	9/22/97	PCB
		11-SB23-03	4.0-6.0	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB26-01	0.0-2.0	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SB27-04	6.0-10.0	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO

Notes:

VOC = Volatile Organic Compounds
SVOC = Semivolatile Organic Compounds
PCB = Polychlorinated Biphenyls
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
TOC = Total Organic Carbon
Shading indicates that the sample will be evaluated in the ecological risk assessment.

TABLE 3-1 (continued)
SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 45 -AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample Media	Phase	Sample Designation	Sample Depth (ft bgs)	Sample Date	Analytical Parameters
Groundwater	I	45MW01	- -	11/25/96	VOC, SVOC, PCB, RCRA Metals
		45MW02	- -	11/25/96	VOC, SVOC, PCB, RCRA Metals
		45MW03	- -	11/25/96	VOC, SVOC, PCB, RCRA Metals
		45MW04	- -	11/25/96	VOC, SVOC, PCB, RCRA Metals
		45HP01	- -	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45HP02	- -	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45HP03	- -	11/22/96	VOC, SVOC, PCB, RCRA Metals
		45HP04	- -	11/22/96	VOC, SVOC, PCB, RCRA Metals
	II	11GW01	- -	9/18/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW02	- -	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW05	- -	9/19/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW07	- -	9/19/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW08	- -	9/19/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW10	- -	9/20/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW11	- -	9/20/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW12	- -	9/20/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW13	- -	9/20/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW16	- -	9/20/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW18	- -	9/21/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW19	- -	9/21/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW24	- -	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
		11GW25	- -	9/22/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO, TOC
Sediment	II	11-SD01	0.0-0.25	9/19/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SD02	0.0-0.25	10/2/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SD03	0.0-0.25	10/2/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SD04	0.0-0.25	10/2/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SD05	0.0-0.25	10/2/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SD06	0.0-0.25	10/2/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SD07	0.0-0.25	10/2/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SD08	0.0-0.25	10/2/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO
		11-SD09	0.0-0.25	10/2/97	VOC, SVOC, PCB, App IX Metals, GRO, DRO

Notes:

VOC = Volatile Organic Compounds
SVOC = Semivolatile Organic Compounds
PCB = Polychlorinated Biphenyls
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
TOC = Total Organic Carbon

Shading indicates that the sample will be evaluated in the ecological risk assessment.

TABLE 4-1
PRELIMINARY ASSESSMENT ENDPOIINTS, RISK HYPOTHESES, AND MEASUREMENT ENDPOIINTS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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-retated 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 ENDPOIINTS, RISK HYPOTHESES, AND MEASUREMENT ENDPOIINTS
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 carnivorous omnivores.	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.	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 marine mammiliam herbivores.	Are site-related chemical concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to marine mammilian 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 surface water and sediment.

TABLE 4-2
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log Kow 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
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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log Kow Range	Recommended Log K_{ow}	Reference	K_{oc} [(1)] (L/Kg)	Bioaccumulative Chemical [(2)]
Volatile Organics (cont.):					
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
2,4-Dinitrotoluene	1.98 to 2.01	2.01	EPA 1995a	94.6	No
2,6-Dichlorophenol	Not Reported	2.75	SRC 1998	505	No
2,6-Dinitrotoluene	1.72 to 2.03	1.87	EPA 1995a	68.9	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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log Kow Range	Recommended Log K_{ow}	Reference	K_{oc} (1) (L/Kg)	Bioaccumulative Chemical (2)
Semi-Volatile Organics (cont.):					
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
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

TABLE 4-2 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log Kow Range	Recommended Log K_{ow}	Reference	K_{oc} [1] (L/Kg)	Bioaccumulative Chemical [2]
Semi-Volatile Organics (cont.):					
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
Nitrobenzene	1.70 to 2.93	1.84	EPA 1995a	64.4	No
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

Notes:

K_{ow} = Ocatnol-Water Partitian Coefficient K_{oc} = Organic Carbon Partition Coefficient

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

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

TABLE 5-1
SURFACE SOIL SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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-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 microbial processes
Benzene	105 (2)	MHSPE 1994	---
Bromodichloromethane	NA	---	---
Bromoform	NA	---	---
Bromomethane	NA	---	---
Carbon disulfide	NA	---	---
Carbon tetrachloride	1,000,000	Efroymson et. al. 1997a	Toicological 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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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	---	---
cis-1,2-Dichloroethene	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	NA	---	---
Methyl methacrylate	NA	---	---
Pentachloroethane	NA	---	---
Propionitrile (Ethyl cynaide)	NA	---	---
Styrene	10,010 (2)	MHSPE 1994	Toxicological threshold for plants
Tetrachloroethene	401 (2)	MHSPE 1994	---
Toluene	13,005 (2)	MHSPE 1994	Toxicological threshold for plants
trans-1,2-Dichloroethene	NA	---	---
trans-1,3-Dichloropropene	NA	---	---
trans-1,4-Dichloro-2-butene	1,000,000	Efroymson 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	---
o-Xylene	2,505 (2)	MHSPE 1994	Total xylene value
m-Xylene	2,505 (2)	MHSPE 1994	Total xylene value
p-Xylene	2,505 (2)	MHSPE 1994	Total xylene value

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg):			
1,2,4,5-Tetrachlorobenzene	NA	---	---
1,2,4-Trichlorobenzene	20,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
1,2-Dichlorobenzene	3,001 (1)	MHSPE 1994	Value for total chlorobenzenes (3)
1,2-Diphenylhydrazine	NA	---	---
1,3-Dichlorobenzene	3,001 (1)	MHSPE 1994	Value for total chlorobenzenes (3)
1,3-Dinitrobenzene (m-Dinitrobenzene)			
1,4-Dichlorobenzene	20,000	Efroymson 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	Efroymson et. al. 1997b	Toxicological threshold for plants
2,4,6-Trichlorophenol	10,000	Efroymson 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	Efroymson et. al. 1997b	Toxicological threshold for plants
2,4-Dinitrotoluene	NA	---	---
2,6-Dichlorophenol	1,001 (1)	MHSPE 1994	Value for total chlorophenols (4)
2,6-Dinitrotoluene	NA	---	---
2-Acetylaminofluorene	NA	---	---
2-Chloronaphthalene	NA	---	---
2-Chlorophenol	1,001 (1)	MHSPE 1994	---
2-Methylnaphthalene	1,200	---	Value for benzo(a)pyrene used as a surrogate
2-Methylphenol (o-Cresol)	NA	---	---
2-Naphthalamine	NA	---	---
2-Nitroaniline	NA	---	---
2-Nitrophenol	NA	---	---

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg)(cont.):			
2-Picoline	NA	---	---
2-sec-butyl-4,6-Dinitrophenol	NA	---	---
3,3'-Dichlorobenzidine	NA	---	---
3,3'-Dimethylbenzidine	NA	---	---
3-Methylcholanthrene	NA	---	---
3-Methylphenol (m-Cresol)	NA	---	---
3-Nitroaniline	NA	---	---
4,6-Dinitro-2-methylphenol	NA	---	---
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	NA	---	---
4-Chloro-3-methylphenol	NA	---	---
4-Chloroaniline	NA	---	---
4-Chlorophenyl phenyl ether	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	---	---
A, A-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

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg)(cont.):			
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	---	---
Dibenzofuran	NA	---	---
Diethylphthalate	100,000	Efroymson et. al. 1997b	Toxicological threshold for plants
Dimethylphthalate	200,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Di-n-butylphthalate	200,000	Efroymson 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	---	Screening value for Total PAHs (2)
Fluorene	30,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Hexachlorobenzene	1,000,000	Efroymson et. al. 1997a	Toicological 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

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg)(cont.):			
Isophorone	NA	---	---
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Naphthalene	1,200	---	Value for benzo(a)pyrene used as a surrogate
Nitrobenzene	40,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
n-Nitrosodiethylamine	20,000	---	Value for n-Nitrosophenylamine used as a surrogate
n-Nitrosodimethylamine	20,000	---	Value for n-Nitrosophenylamine used as a surrogate
n-Nitroso-di-n-butylamine	20,000	---	Value for n-Nitrosophenylamine used as a surrogate
n-Nitroso-di-n-propylamine	20,000	---	Value for n-Nitrosophenylamine used as a surrogate
n-Nitrosodiphenylamine	20,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
n-Nitrosomethylethylamine	20,000	---	Value for n-Nitrosophenylamine 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
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	Efroymson 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	---	---

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
PCBs (ug/kg):			
Aroclor-1016	2,510	EPA 1999	Toxicological threshold for earthworms
Aroclor-1221	2,510	Efroymson et. al. 1997b	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1232	2,510	Efroymson et. al. 1997b	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1242	2,510	Efroymson et. al. 1997b	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1248	2,510	Efroymson et. al. 1997b	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	Efroymson et. al. 1997b	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
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

Notes:

NA = Not Available
MHSPE = Ministry of Housing, Spatial Planning and Environment

TABLE 5-1 (continued)
SURFACE SOIL SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Notes (continued):

(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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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)	Sute 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 isobutyl ketone)	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
cis-1,3-Dichloropropene	7.9	EPA 2001	EPA Region 4 chronic screening value (cis and trans)

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value (1)	Reference	Comment
Volatile Organics (ug/L) (cont.):			
cis-1,2-Dichloroethene	22,400	Buchman 1999	Acute LOEL (summation of all 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
1,2-Diphenylhydrazine	12 (2)	EPA 2000	Minimum acute value (LC_{50}) with a safety factor of 100

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value (1)	Reference	Comment
Semi-Volatile Organics (ug/L) (cont.):			
1,3-Dichlorobenzene	28.5	EPA 2001	EPA Region 4 chronic screening value
1,3-Dinitrobenzene (m-Dintrobenzene)	500 (2)	EPA 2000	Minimum chronic value (NOEC based on growth and reproduction)
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
2,4-Dinitrotoluene	370	Buchman 1999	Chronic LOEL
2,6-Dichlorophenol	54	EPA 2000	Minimum acute value (LC_{50}) with a safety factor of 100
2,6-Dinitrotoluene	60 (2)	EPA 2000	Minimum chronic value (NOEC based on reproduction)
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 facto 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	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 facto 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

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment
Semi-Volatile Organics (ug/L) (cont.):			
3-Nitroaniline	9.8 [2]	EPA 2000	Minimum acute value (EC_{50}) with a safety factor of 100
4,6-Dinitro-2-methylphenol	183 [2]	EPA 2000	Minimum chronic value 9NOEC 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 vallue (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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value (1)	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
Nitrobenzene	66.8	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

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value (1)	Reference	Comment
Semi-Volatile Organics (ug/L) (cont.):			
n-Nitroso-di-n-butylamine	330,000	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
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	---	---
sym-Trinitrobenzne	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
Inorganics (ug/L):			
Antimony	500	Buchman 1999	Proposed CCC
Arsenic	36	EPA 2002	Total recoverable CCC for trivalent arsenic

TABLE 5-2 (continued)
MARINE SURFACE WATER SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment
Inorganics (ug/L) (cont.):			
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
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 rcoverable CCC

Notes:

NA = Not Available
CCC = Criteria Continuous Concentration
LOEL = Lowest Observed Effect Level
MATC = Maximum Acceptable Toxicant Concentration
NOEC = No Observed Effect Concentration
EC_{50} = Median Effective Concentration
LC_{50} = 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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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 cynaide)	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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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
1,3-Dinitrobenzene (m-Dintrobenzene)	149	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
2,4-Dinitrotoluene	350	EPA 1993a	EqP-based screening value
2,6-Dichlorophenol	273	EPA 1993a	EqP-based screening value
2,6-Dinitrotoluene	41.4	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

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment [1]
Semi-Volatile Organics (ug/kg) (cont.):			
3-Methylcholanthrene	NA	---	---
3-Methylphenol (m-Cresol)	259	EPA 1993a	EqP-based screening value
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	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	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

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment [(1)]
Semi-Volatile Organics (ug/kg) (cont.):			
Bis(2-chloroethoxy)methane	350	EPA 1993a	EqP-based screening value
Bis(2-chloroethyl)ether	141	EPA 1993a	EqP-based screening value
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	---	---
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

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment [1]
Semi-Volatile Organics (ug/kg) (cont.):			
Nitrobenzene	21.0	Buchman 1999	AET
n-Nitrosodiethylamine	9,787	EPA 1993a	EqP-based screening value
n-Nitrosodimethylamine	74.4	EPA 1993a	EqP-based screening value
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

TABLE 5-3 (continued)
MARINE SEDIMENT SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment [1]
PCBs (ug/kg) (cont.):			
Aroclor-1254	21.6	MacDonald 1994	TEL
Aroclor-1260	21.6	MacDonald 1994	TEL
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 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_{sed} 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 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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	1.169	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	0.1138	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	Assumed
3,3'-Dichlorobenzidine	0.3624	Travis and Arms 1988	1	Assumed
3,3'-Dimethylbenzidine	1.0938	Travis and Arms 1988	1	Assumed

TABLE 6-1 (continued)
CONSERVATIVE SOIL BIOACCUMULATION FACTORS FOR TERRESTRIAL PLANTS AND INVERTEBRATES
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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-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	0.0057	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	0.1138	Travis and Arms 1988	1	Assumed
Chrysene	0.0197	Travis and Arms 1988	0.44	Beyer and Stafford 1993
Diallate	0.0984	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
Hexachlorobutadiene	0.0642	Travis and Arms 1988	1	Assumed

TABLE 6-1 (continued)
CONSERVATIVE SOIL BIOACCUMULATION FACTORS FOR TERRESTRIAL PLANTS AND INVERTEBRATES
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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.):				
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
Inorganics:				
Antimony	0.2	Baes et al. 1984	1	--
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	--
Cadmium	3.25	Bechtel Jacobs 1998a	40.69	Sample et al. 1998a
Chromium	0.0075	Baes et al. 1984	3.162	Sample et al. 1998a

TABLE 6-1 (continued)
CONSERVATIVE SOIL BIOACCUMULATION FACTORS FOR TERRESTRIAL PLANTS AND INVERTEBRATES
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Inorganics (cont.):				
Cobalt	0.02	Baes et al. 1984	1	--
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	--
Thallium	0.004	Baes et al. 1984	1	--
Tin	0.03	Baes et al. 1984	1	--
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 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Soil-Small Mammal Omnivore BAF (dry weight)	
Chemical	**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 (continued)
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Small Mammal Omnivore BAF (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:		
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
Inorganics:		
Antimony	---	see text
Arsenic	0.014	Sample et al. 1998b
Barium	0.069	Sample et al. 1998b

TABLE 6-2 (continued)
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Small Mammal Omnivore BAF (dry weight)	
	Value	**Reference**
Inorganics (cont.):		
Beryllium	---	see text
Cadmium	0.462	Sample et al. 1998b
Chromium	0.349	Sample et al. 1998b
Cobalt	0.025	Sample et al. 1998b
Copper	0.554	Sample et al. 1998b
Lead	0.286	Sample et al. 1998b
Mercury	0.13	Sample et al. 1998b
Nickel	0.589	Sample et al. 1998b
Selenium	1.263	Sample et al. 1998b
Silver	---	see text
Thallium	0.1227	Sample et al. 1998b
Tin	---	see text
Vanadium	---	see text
Zinc	2.7822	Sample et al. 1998b

Notes:

BAF = Bioaccumulation Factor

TABLE 6-3
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS USED FOR AQUATIC INVERTEBRATES AND FISH
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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
3,3'-Dimethylbenzidine	1	Assumed	1	Assumed

TABLE 6-3 (continued)
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS USED FOR AQUATIC INVERTEBRATES AND FISH
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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-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
Hexachlorobutadiene	1	Assumed	1	Assumed

TABLE 6-3 (continued)
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS USED FOR AQUATIC INVERTEBRATES AND FISH
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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.):				
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
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	0.186	Bechtel Jacobs 1998b	0.038	Krantzberg and Boyd 1992

TABLE 6-3 (continued)
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS USED FOR AQUATIC INVERTEBRATES AND FISH
SWMU 45 - AREAS OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Inorganics (cont.):				
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
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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
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
Belted kingfisher	Aquatic	0.125	Dunning 1993	0.02666	EPA 1993b	1.0
Double-crested cormorant	Aquatic	1.825	Glahn and McCoy 1995	0.0925	Bivings et al. 1989	1.0
Mammals:						
West Indian Manatee	Aquatic					1.0

TABLE 6-6
DIETARY COMPOSITION FOR UPPER TROPHIC LEVEL RECEPTORS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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
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
Belted kingfisher	0	0	0	92.6	0	4.9	EPA 1993b	2.5	Beyer et al. 1994
Doouble-crested Cormorant	0	0	0	100	0	0	Bivings et al. 1989	0	Assumed
Mammals:									
West Indian Manatee	0	0	0	0		0			
Small mammal omnivore (prey item)	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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWERHOUSE)
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-dintrophenol	---	---	---	---	---	---	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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWERHOUSE)
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
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	---	---	---	---	---	---	---	---	---	---

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INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWERHOUSE)
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
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
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

TABLE 6-7
INGESTION-BASED SCREENING VALUES FOR BIRDS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWERHOUSE)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference	Ecological Receptors
Inorganics (cont.):										
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 hero	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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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	McCollister et al. 1961	West Indian manatee
2,4,6-Trichlorophenol	Rat	0.35	98 days	Oral in diet	Hepatic/renal	Not Applicable	800	80	McCollister 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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
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
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
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_2O_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 $K2Cr_2O_4$	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 (CH3HgCl)	0.025	0.015	Sample et al. 1996	West Indian manatee
	Rat	0.35	3 generations	Oral in diet	Reproduction	Methyl Mercury Chloride (CH_3HgCl)	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

RPM Input and Risk Management Consideration[3]

Step 8: Risk Management

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

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

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

Proceed to Exit Criteria for SRA

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

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

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

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

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

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

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

Step 5: Verification of Field Sampling Design (SMDP)

Step 6: Site Investigation and Data Analysis [SMDP]

Step 7: Risk Characterization

Proceed to Exit Criteria for BERA

Exit Criteria Step 3a Refinement

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

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

Exit Criteria Baseline Risk Assessment

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

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

Tier 3. Evaluation of Remedial Alternative (RAGs C)

a. Develop site specific risk based cleanup values.

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

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

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

3) Risk Management is incorporated throughout the tiered approach.

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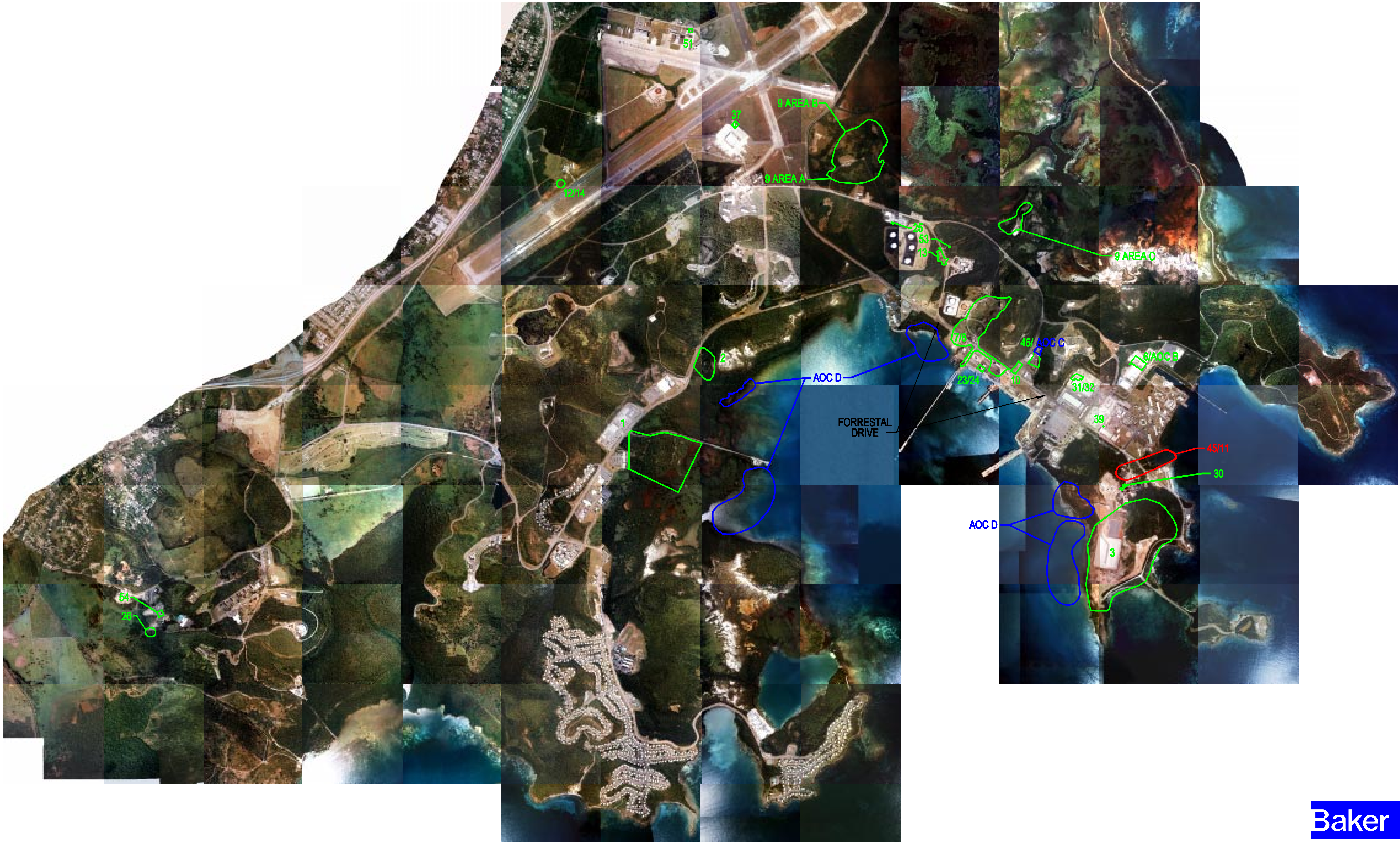

LEGEND

1 – SWMUs

45/11 – AREA OF WHICH THIS INVESTIGATION PERTAINS TO

AOC D – AOCs

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

2500 0 1250 2500

1 inch = 2500 ft.

FIGURE 2-1
SWMU/AOC LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

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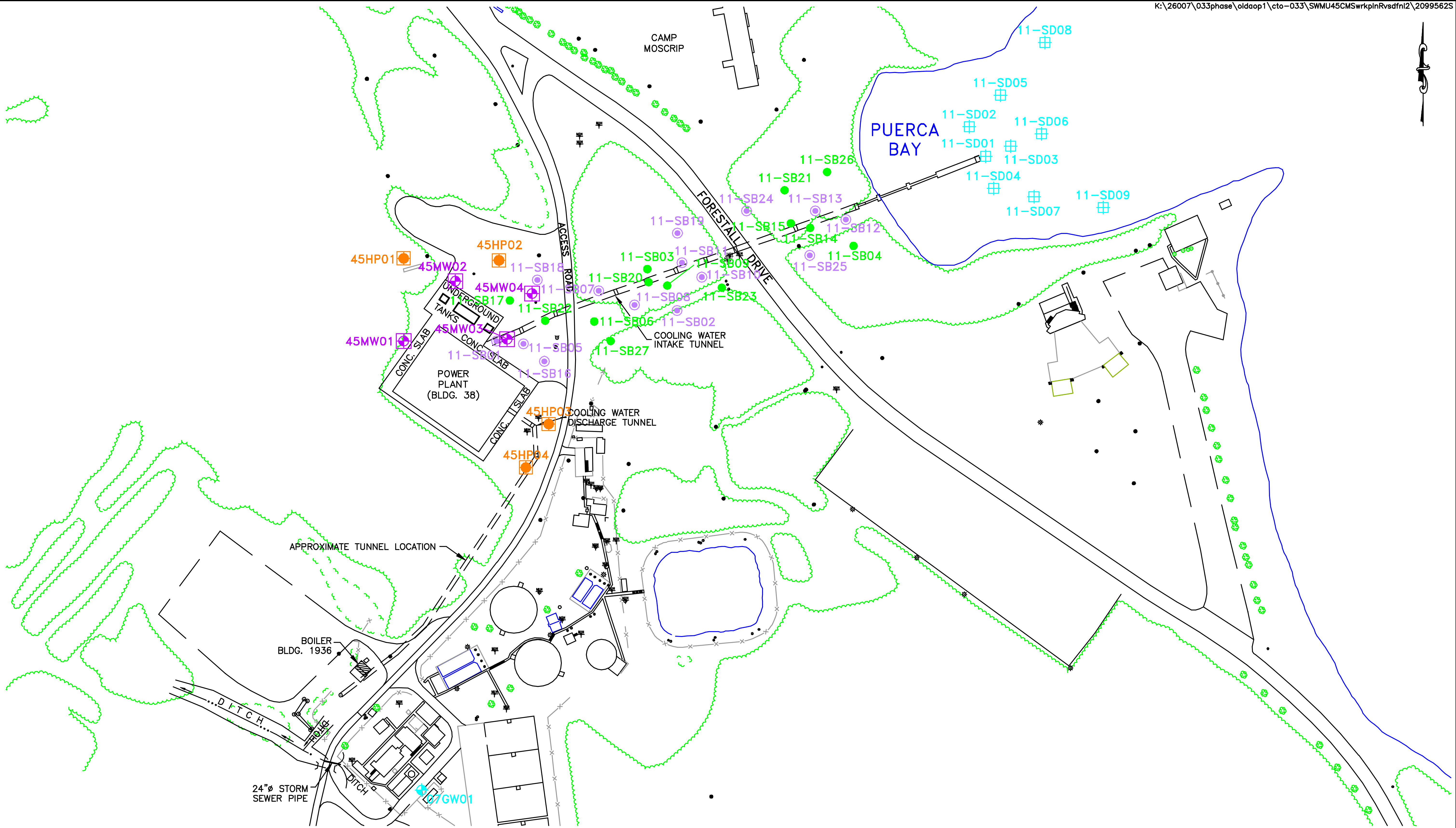


LEGEND

- – DIRECT PUSH SOIL SAMPLE LOCATION (1997 RFI)
- – SEDIMENT SAMPLE LOCATION (1997 RFI)
- – DIRECT PUSH SOIL AND GROUNDWATER SAMPLE LOCATION (1997 RFI)
- – HYDROPUNCH LOCATION (1996 RFI)
- – MONITORING WELL LOCATION (1996 RFI)
- – EXISTING GROUNDWATER SAMPLE LOCATION

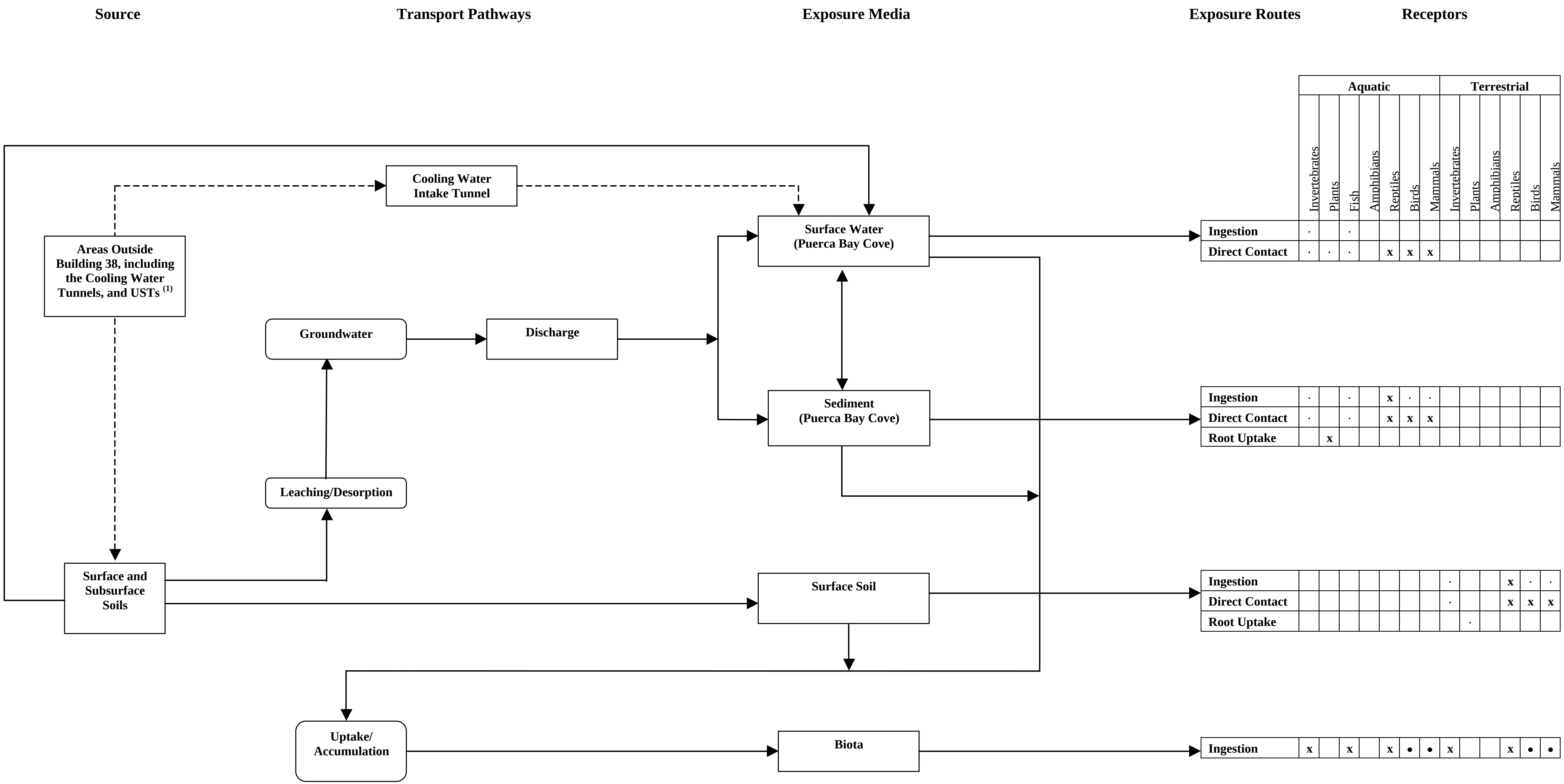
150 0 75 150
1 inch = 150 ft.

Baker

FIGURE 3-1
SWMU 45 SAMPLING LOCATIONS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Revised: 5/22/03



Exposure Media	Exposure Route	Aquatic Invertebrates	Aquatic Plants	Aquatic Fish	Aquatic Amphibians	Aquatic Reptiles	Aquatic Birds	Aquatic Mammals	Terrestrial Invertebrates	Terrestrial Plants	Terrestrial Amphibians	Terrestrial Reptiles	Terrestrial Birds	Terrestrial Mammals
Surface Water (Puerca Bay Cove)	Ingestion	·		·										
	Direct Contact	·	·	·		x	x	x						
Sediment (Puerca Bay Cove)	Ingestion	·		·		x	·	·						
	Direct Contact	·		·		x	x	x						
	Root Uptake		x											
Surface Soil	Ingestion								·			x	·	·
	Direct Contact								·			x	x	x
	Root Uptake									·				
Biota	Ingestion	x		x		x	•	•	x			x	•	•

FIGURE 4-1
PRELIMINARY CONCEPTUAL MODEL
SWMU 45 – AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

→ Potentially complete and significant pathway
- - → Historical pathway

• - Receptor/pathway to be evaluated quantitatively
x - Receptor/pathway will not be evaluated quantitatively
(1) Cooling water intake tunnel and USTs have been filled with low density concrete. As such, they no longer represent a source of continuing release.

APPENDICES

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

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October 11, 2000

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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.

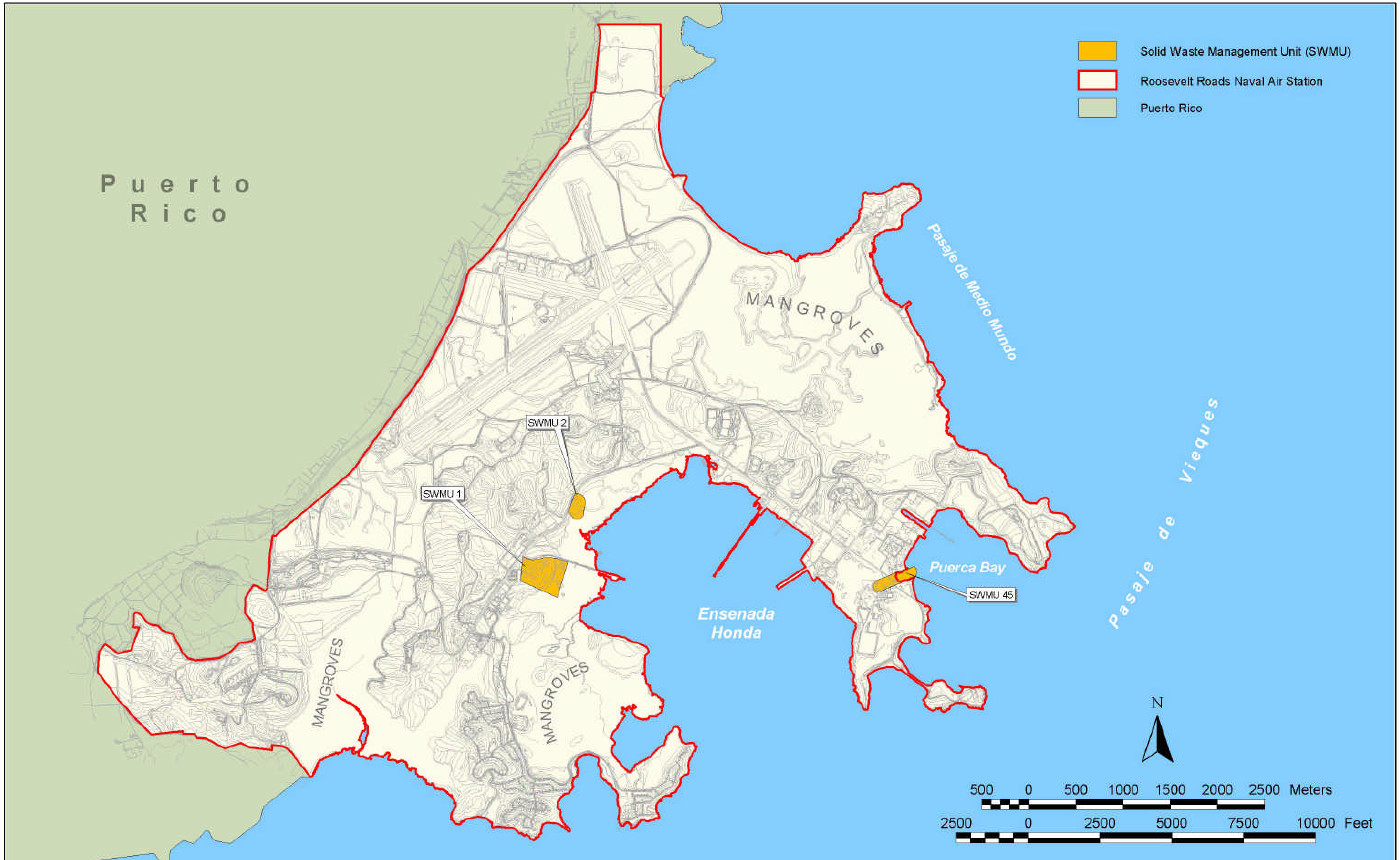

Figure 2. Location of SWMU 1,2 and 45, Roosevelt Roads, Puerto Rico.

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	
Stahlia monosperma (Cobana negra)	Threatened
Reptiles and Amphibians	
Caretta caretta (Loggerhead sea turtle)	Threatened
Chelonia mydas (Green sea turtle)	Threatened
Dermochelys coriacea (Leatherback sea turtle)	Endangered
Eretmochelys imbricata (Hawksbill sea turtle)	Endangered
Epicrates inornatus (Puerto Rican Boa)	Endangered
Birds	
Agelaius xanthomus (Yellow-shouldered blackbird)	Endangered
*Falco peregrinus tundrius (*Arctic peregrine)	Threatened
*Pelecanus occidentalis occidentalis (*Brown pelican)	Endangered
Sterna dougalli dougalli (Roseate tern)	Endangered
Mammals	
*Trichechas manatus (*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 stratums (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 stratums, 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.

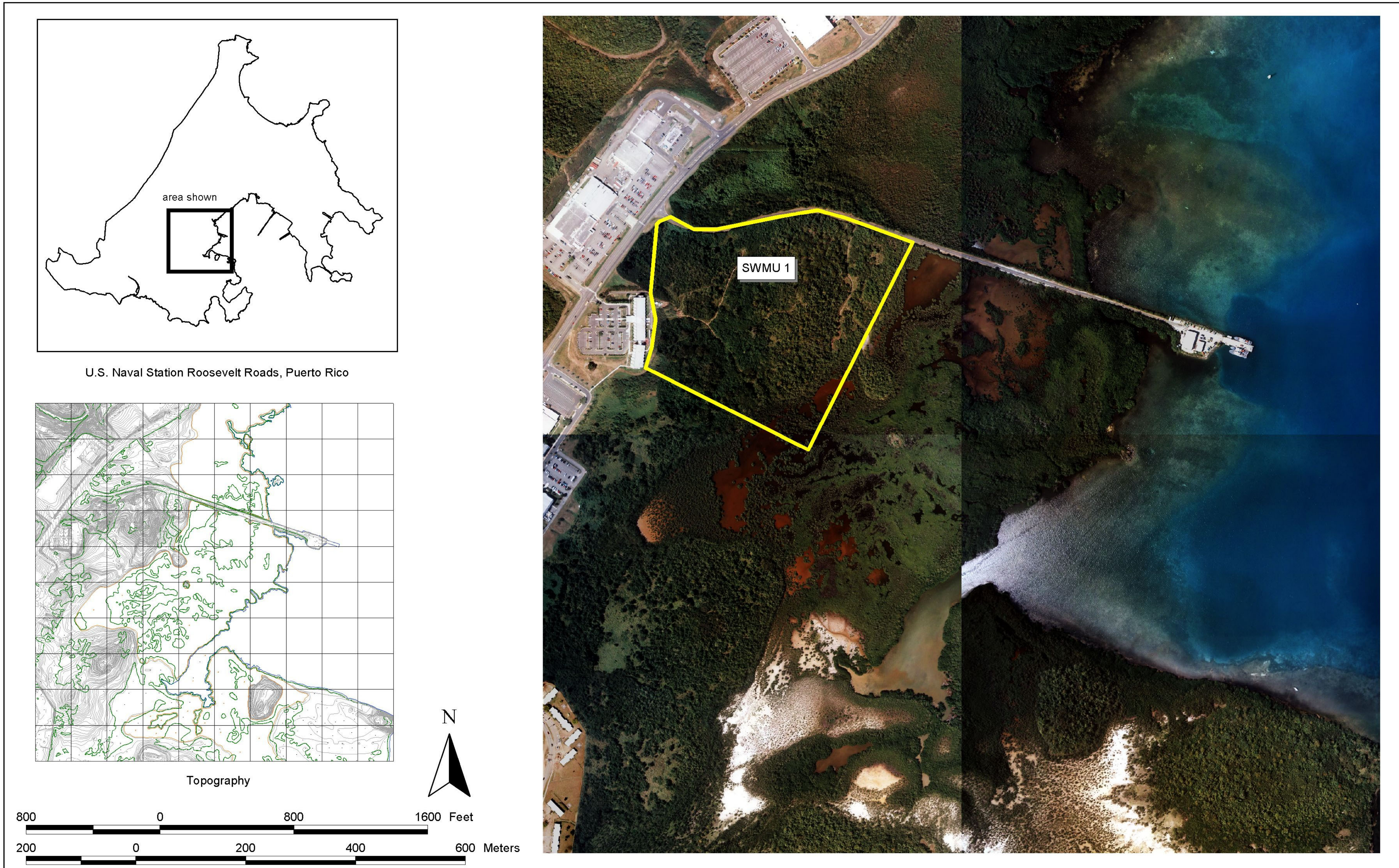

Figure 3. Location of SWMU 1, Roosevelt Roads, Puerto Rico

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	*Avicenia germinans*	S
salt plant, saltwort	*Batis maritima*	H
white mangrove	*Laguncularia racemosa*	S
verdolaga rosada, pink purslane	*Sesuvium portulacastrum*	H
None	*Sporobolus virginicus*	H
Red Mangrove		
red mangrove	*Rhizophora mangle*	S
Upland Coastal Forest		
crab's eye, jumbie bead, rosary bead	*Abrus precatorius*	S
none	*Acacia westiana*	S
none	*Bothriochloa ichaemum*	H
Ucar, oxhorn bucida	*Bucida buceras*	T
almácigo	*Bursera simaruba*	S/T
bottle wiss	*Capparis flexusa*	S
French grass	*Commelina erect*	H
Bermuda grass	*Cynodon dactylon*	H
none	*Ipomea* spp.	V
none	*Lasiacis divaricata*	H
none	*Leptochloa ichaemum*	H
tan tan, tanty, wild tamarind, lead tree	*Leucaena leucocephala*	S
none	*Panicum maximum*	H
guayaba, common guayaba	*Psidium guajava*	T
Christmas tree, tintillo	*Randia aculeata*	S
none	*Sporobolus indicus*	H
none	*Tragia volubilis*	H
basket wiss	*Trichostigma octandrum*	S/T
marsh-mallow	*Waltheria indica*	H
Coastal scrub forest		
none	*Asystasia gangetica*	H
almácigo	*Bursera simaruba*	S
bottle wiss	*Capparis flexusa*	S
none	*Cissus obovata*	V
palma de coco	*Cocos nucifera*	S
rattle box, yellow lupine	*Crotalaria retusa*	H
flamboyant tree, Poinciana	*Delonix regia*	S
brazilette	*Erythroxylum brevipes*	S
none	*Forestiera eggersiana*	S
black mampoo, wild mampoo	*Guapira fragans*	S
none	*Ipomea* spp.	H
tan tan, tanty, wild tamarind, lead tree	*Leucaena leucocephala*	S
cat claw, cat paw, monkey earing	*Macfadyena unguis-cati*	S
none	*Panicum maximum*	H
none	*Pinzona coriacea*	H
Christmas tree, tintillo	*Randia aculeata*	S
royal palm	*Roystonea borinquena*	S
basket wiss, white root, black or white wist	*Serjania polyphylla*	V
basket wiss	*Trichostigma octandrum*	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	*Anthracothorax viridis*	Zumbador Verde de P.R.
Red-tailed Hawk	*Buteo jamaicensis*	Guaraguao de Cola Roja
Wilson's Plover	*Charadrius wilsonia*	Playero Marítimo
Yellow Warbler	*Dendroica petechia*	Canario de Mangle
Common Moorhen	*Gallinula chloropus*	Gallareta Común
Ruddy Quail-Dove	*Geotrygon montana*	Perdiz Pequeña
Puerto Rico Woodpecker	*Melanerpes portoricensis*	Carpintero de Puerto Rico
Northern Mockingbird	*Mimus polyglottos*	Ruiseñor
Cave Swallow	*Pterochelidon fulva*	Golondrina de Cuevas
Greater Antillean Grackle	*Quiscalus niger*	Mozambique (Chango)
Louisiana Waterthrush	*Seiurus motacilla*	Pizpita de Rio
Loggerhead Kingbird	*Tyrannus caudifasciatus*	Clérigo
Gray Kingbird	*Tyrannus dominicensis*	Pitirre
Upland Coastal Forest		
Reptiles and Amphibians		
Crested Anole	*Anolis cristatellus*	not known
Birds		
Red-tailed Hawk	*Buteo jamaicensis*	Guaraguao de Cola Roja
Bananaquit	*Coereba flaveola*	Reinita Común
Yellow Warbler	*Dendroica petechia*	Canario de Mangle
Ruddy Quail-Dove	*Geotrygon montana*	Perdiz Pequeña
Pearly-eyed Thrasher	*Margarops fuscatus*	Zorzal Pardo
Northern Mockingbird	*Mimus polyglottos*	Ruiseñor
Greater Antillean Grackle	*Quiscalus niger*	Mozambique (Chango)
Coastal Scrub Forest		
Reptiles and Amphibians		
Brown Lizard	*Anolis cristatellus*	not known
Lizard	*Anolis stratulus*	not known
Birds		
Bananaquit	*Coereba flaveola*	Reinita Común
Ruddy Quail-Dove	*Geotrygon montana*	Perdiz Pequeña
Grackle	*Quiscalus niger*	Mozambique (Chango)
Loggerhead Kingbird	*Tyrannus caudifasciatus*	Clérigo
Gray Kingbird	*Tyrannus dominicensis*	Pitirre
Black-Whiskered Vireo	*Vireo altiloquus*	Bien-te-veo
Zenaida Dove	*Zenaida aurita*	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 (*Trichechas 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 dougallii*) 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 contaminates 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.

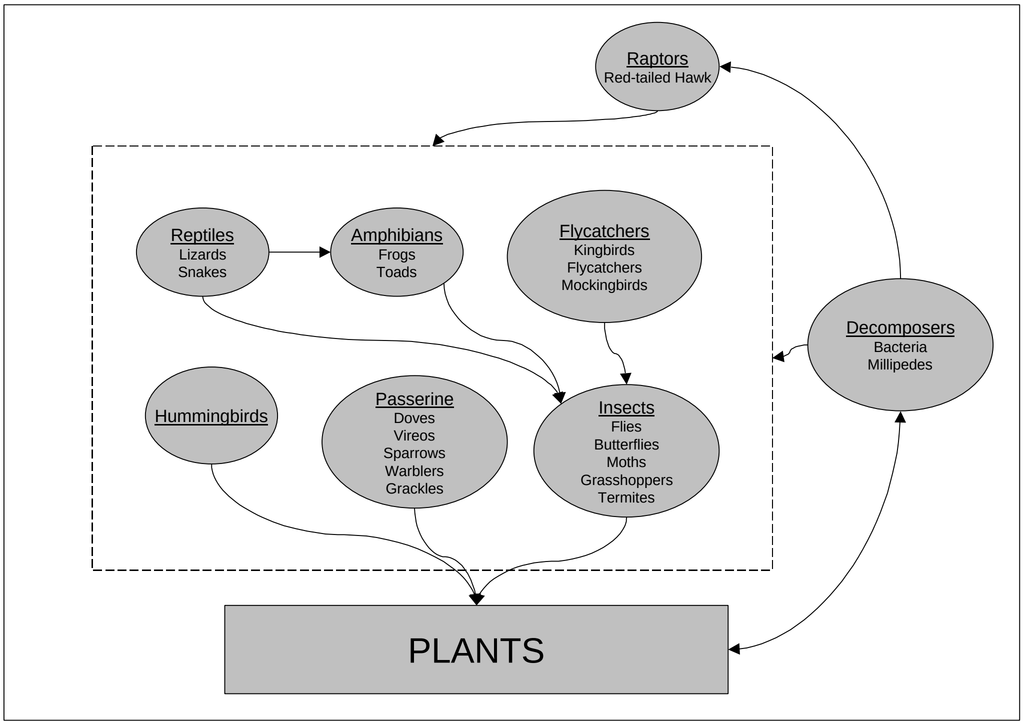

Figure 6. Generalized Food Web for the Upland Coastal Forest and Coastal Scrub Forest Communities at NAVSTA Roosevelt Roads.

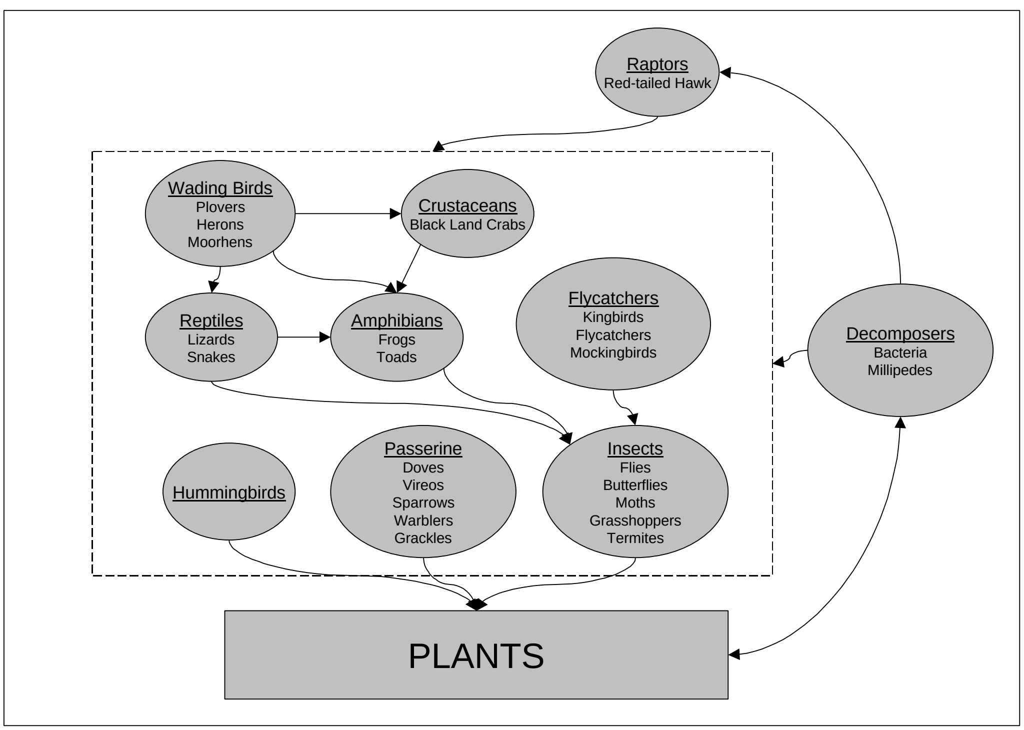

Figure 7. Generalized Food Web for Mangrove Communities at NAVSTA Roosevelt Roads.

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 indi*ca. 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	*Acacia farnensiana*	S
none	*Bothriochloa ichaemum*	H
bottle wiss	*Capparis flexusa*	S
none	*Cissus obovata*	V
none	*Ipomea spp.*	V
tan tan, tanty, wild tamarind, zarcilla	*Leucaena leucocephala*	S
none	*Macfadyena unguis-cati*	S
none	*Panicum maximum*	H
cattle tongue, sweet scent	*Pluchea carolinensis*	H
none	*Sporobolus indicus*	H
yerba socialista, socialist herb	*Vernonia cinerea*	H
marsh mallow	*Waltheria indica*	H
Black mangrove		
black mangrove	*Avicenia germinans*	S/T
almácigo, turpentine-tree	*Bursera simaruba*	S/T
bottle wiss	*Capparis flexuosa*	S
Black willie, Jamaican caper	*Capparis cynophallophora*	S/T
brazilette	*Erythroxylum brevipes*	S
none	*Foresteria eggersiana*	S
black mampoo, wild mampoo	*Guapira fragans*	S
none	*Lasiacis divaricata*	H
tan tan, tanty, wild tamarind, lead tree	*Leucaena leucocephala*	S
none	*Panicum maximum*	H
Christmas tree, tintillo	*Randia aculeata*	S
none	*Sporobolus indicus*	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	*Anolis cristatellus*	not known
Lizard	*Anolis pulchellus*	not known
Frog	*Eleutherodactylus sp.*	not known
Frog	*Leptodactylus albilabris*	not known
Birds		
Red-tailed Hawk	*Buteo jamaicensis*	Guaraguao de Cola Roja
Yellow Warbler	*Dendroica petechia*	Canario de Mangle
Pearly-eyed Thrasher	*Margarops fuscatus*	Zorzal Pardo
Puerto Rico Woodpecker	*Melanerpes portoricensis*	Carpintero de Puerto Rico
Northern Mockingbird	*Mimus polyglottos*	Ruiseñor
Greater Antillean Grackle	*Quiscalus niger*	Mozambique (Chango)
Gray Kingbird	*Tyrannus dominicensis*	Pitirre
Black-Whiskered Vireo	*Vireo altiloquus*	Bien-te-veo
Zenaida Dove	*Zenaida aurita*	Tórtola Cardosantera
Mangrove		
Crustacean		
Land Crab	*Ucar sp.*	Ucar
Birds		
Bananaquit	*Coereba flaveola*	Reinita Común
Loggerhead Kingbird	*Tyrannus caudifasciatus*	Clérigo
Black-Whiskered Vireo	*Vireo altiloquus*	Bien-te-veo
Zenaida Dove	*Zenaida aurita*	Tórtola Cardosantera

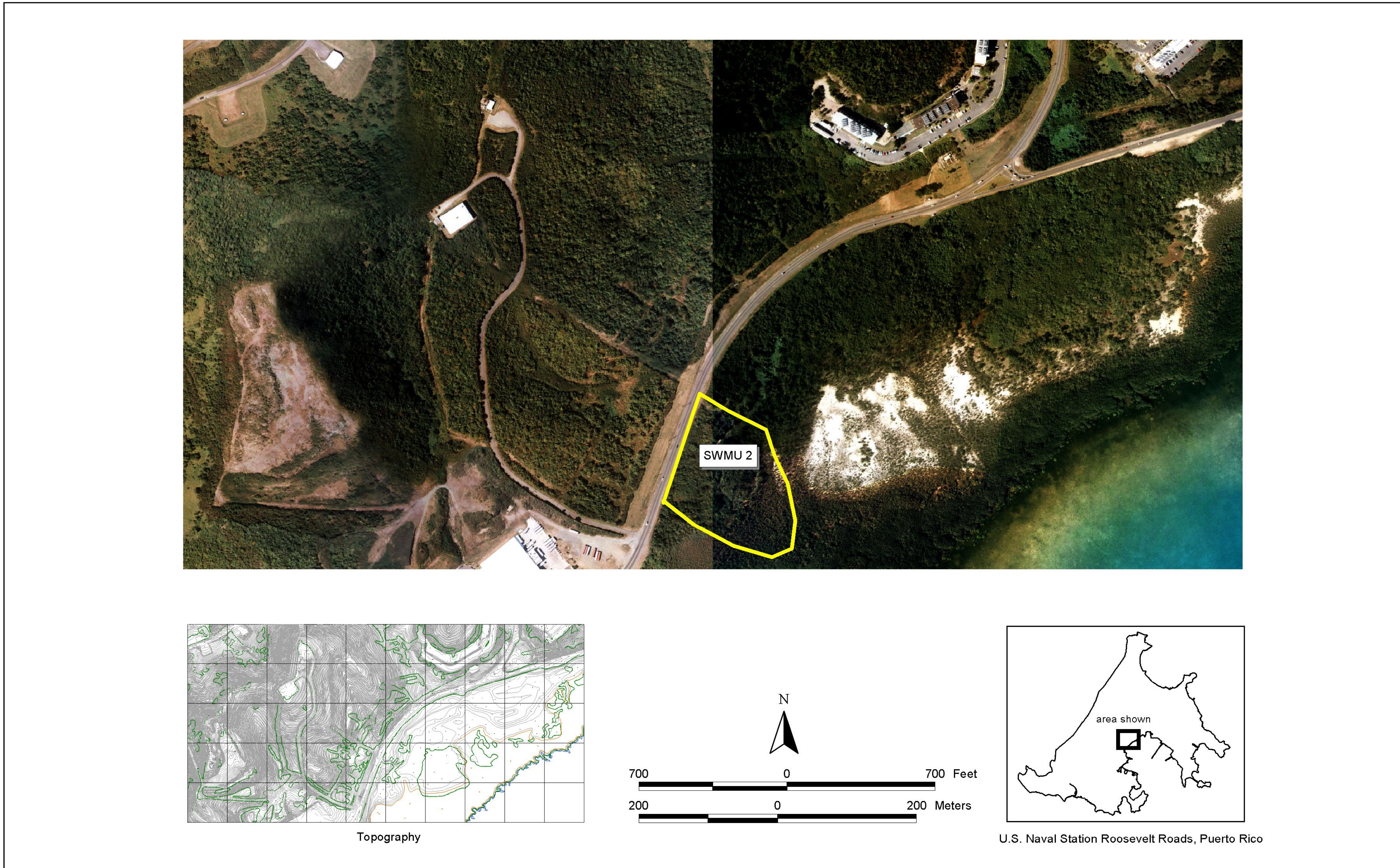

Figure 8. Location of SWMU 2, Roosevelt Roads, Puerto Rico

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, *Stachytarpeta 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.

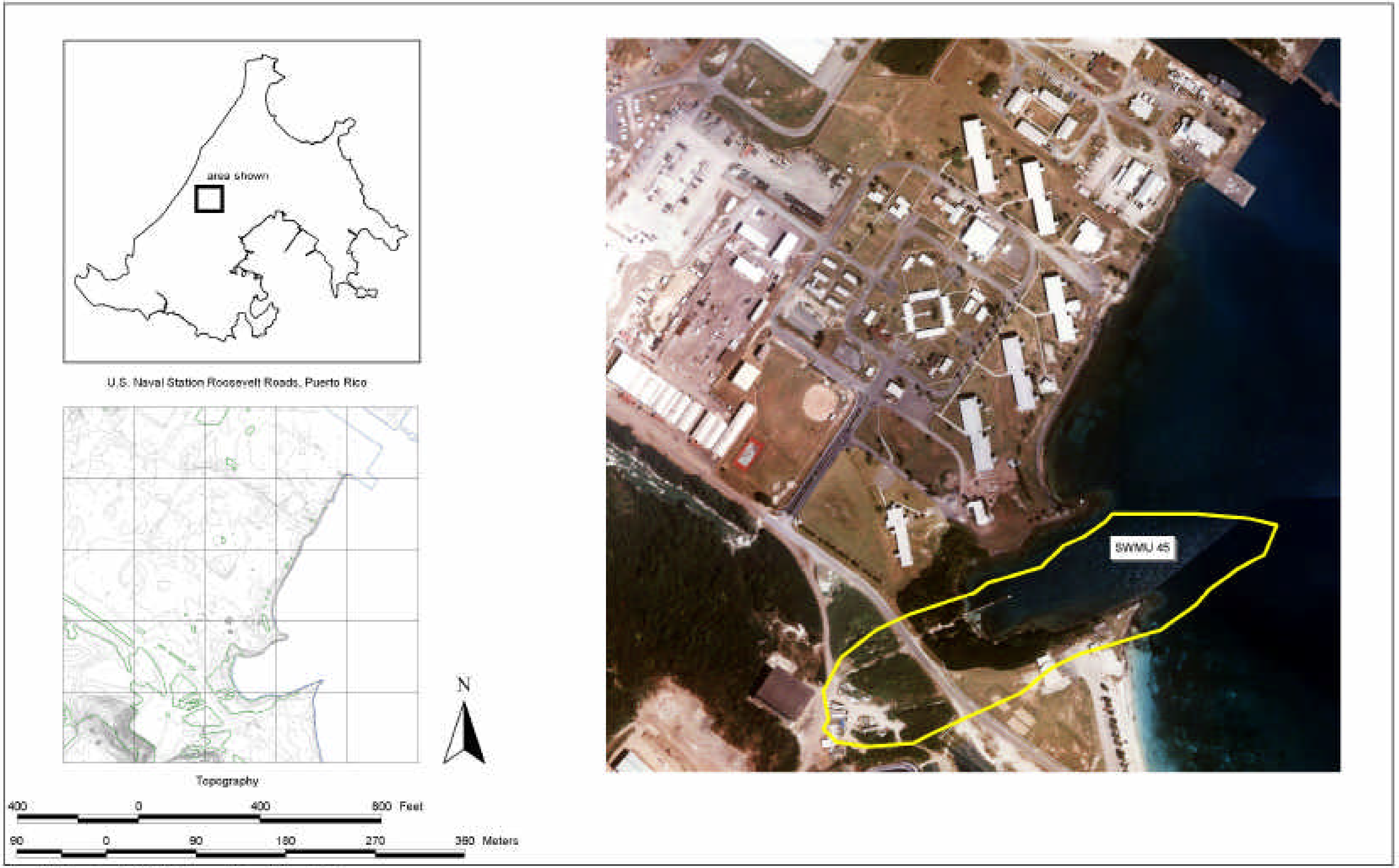

Figure 11. Location of SWMU 45, Roosevelt Roads, Puerto Rico

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	*Blutaparon vermiculare*	H
almácigo, turpentine-tree	*Bursera simaruba*	S/T
Barbados pride, dwarf poinciana	*Caesalpinia pulcherrima*	S
bottle wiss	*Capparis flexusa*	S
conchita de Virginia	*Centrosema virginianum*	V
none	*Chloris barbata*	H
péndula de sierra, fiddlewood	*Citharexylum caudafum*	S/T
copper	*Cordia alliodora*	S
none	*Dalbergia ecastaphyllum*	S
cotton	*Gossypium barbadense*	H
bay vine	*Ipomea pes-caprae*	V
willy vine	*Ipomea tiliacea*	V
tan tan, tanty, wild tamarind	*Leucaena leucocephala*	S
batatilla blanca	*Merremia quinquefolia*	V
Bellyache balsam, bitter bushplant	*Oncimum campechianum*	S
Prickly mampoo	*Pisonia aculeata*	S
guamá americano, guamuchil	*Pithcellobium dulce*	S
Christmas tree, tintillo	*Randia aculeata*	S
royal palm	*Roystonea borinquena*	S
bay flower, sea purslane, sea pusley	*Sesuvium portulacastrum*	H
None	*Sida rhombifolia*	S
Mangrove		
sea pusley	*Heliotropium curassavicum*	H
black mangrove	*Laguncularia racemosa*	S/T
None	*Stachytarpeta jamaicensis*	H/S
seaside mahoe, emajaguilla, portiatree	*Thespesia populnea*	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	*Anolis cristatellus*	Not known
Birds		
Killdeer	*Charadrius vociferous*	Playero Sabanero
Common-ground Dove	*Columbina passerina*	Rolita
Yellow Warbler	*Dendroica petechia*	Canario de Mangle
Magnificent Frigatebird	*Fregata magnificens*	Tijerilla (Rabijunco)
Pearly-eyed Thrasher	*Margarops fuscatus*	Zorzal Pardo
Northern Mockingbird	*Mimus polyglottos*	Ruiseñor
Cave Swallow	*Pterochelidon fulva*	Golondrina de Cuevas
Greater Antillean Grackle	*Quiscalus niger*	Mozambique (Chango)
Gray Kingbird	*Tyrannus dominicensis*	Pitirre
White-winged Dove	*Zenaida asiatica*	Tórtola Aliblanca
Zenaida Dove	*Zenaida aurita*	Tórtola Cardosantera

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

			Rocky Subtidal	Sandy Shelf	Shelf Slope	Outfall Structure
r	*Pomacantus paru*	French angelfish (juv)	x			
r	*Acanthurus coeruleus*	blue tang (juv)	x			
r	*Sphyraena barracuda*	great baracuda		x		
c	*Gerres cinereus*	yellowfin mojarra (juv)		x	x	
r	*Archosargus rhomboidalis*	sea bream				x
c	*Calamus penna*	sheepshead porgy (adult)		x		
c	*Eucinostomus gula*	silver jenny (juv)		x	x	
c	*Haemulon aurolineatum*	tomtate (juv)	x	x		
c	*Lutjanus griseus*	gray snapper (juv)	x			x
r	*Lutjanus aoidus*	schoolmaster snapper	x	x		
c	*Stegastes fuscus*	dusky damselfish (adult)	x			x
r	*Stegastes leucostictus*	Beaugregory	x			
ab	*Abudefduf saxatillis*	sergeant major	x			x
r	*Serranus tigrinus*	harlequin bass	x			
r	*Sparisoma aurofrenatum*	redband parrotfish (juv)	x	x		
r	*Halichoeres bivittatus*	slippery dick	x	x		
c	*Holocentrus sp.*	squirrelfish	x			
r	*Coryphopterus glaucofraenum*	bridled goby	x			
r	*Aulostomus maculatus*	trumpetfish	x			
r	*Sphoeroides spengleri*	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* s*p*, *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	
Thalassia testudinum	turtle grass
Condylactis gigantea	giant anemone
Echinometra viridis	reef urchin
Siderastrea radians	lesser starlet coral
Chaetodon ocellatus	spotfin butterflyfish
Stegastes fuscus	dusky damselfish

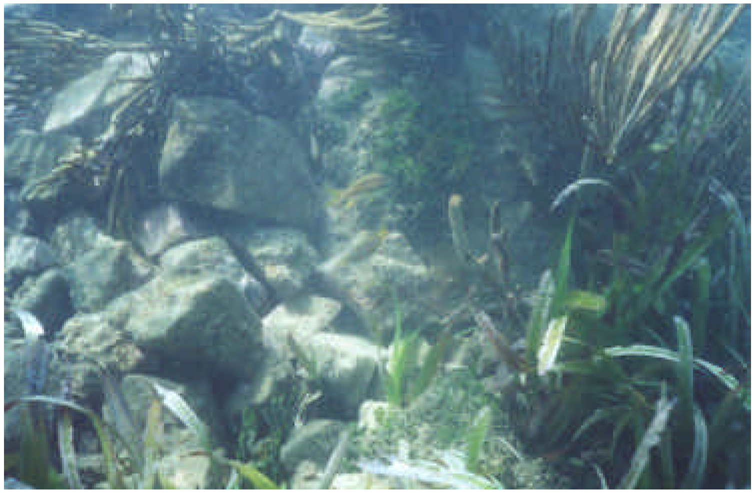
4.0 REFERENCES

Braun-Blanquet, J. 1965. Plant sociology: the study of plant communities. Hafner Publications, London. 439p.

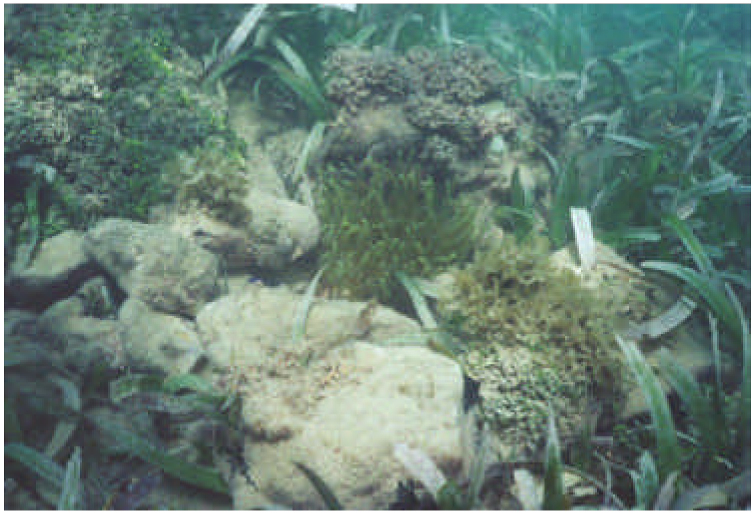
APPENDIX A

Photographs

Photogragh 1. Rocky subtidal habitat with squirrelfish (*Holocentrus adcensionis*).

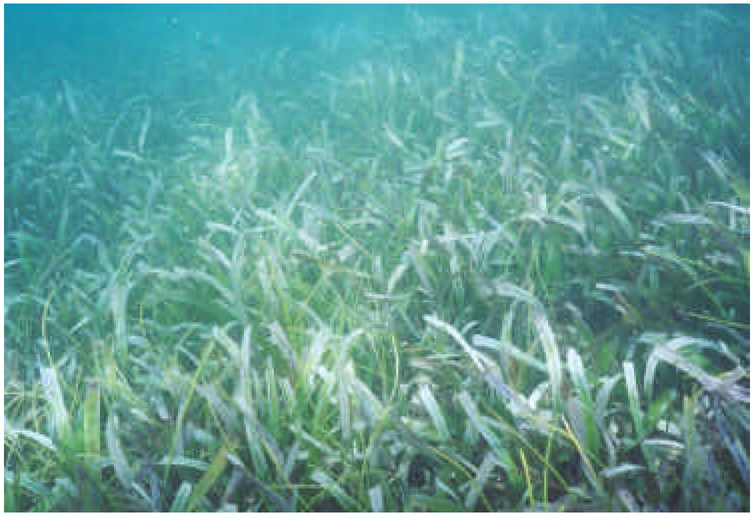


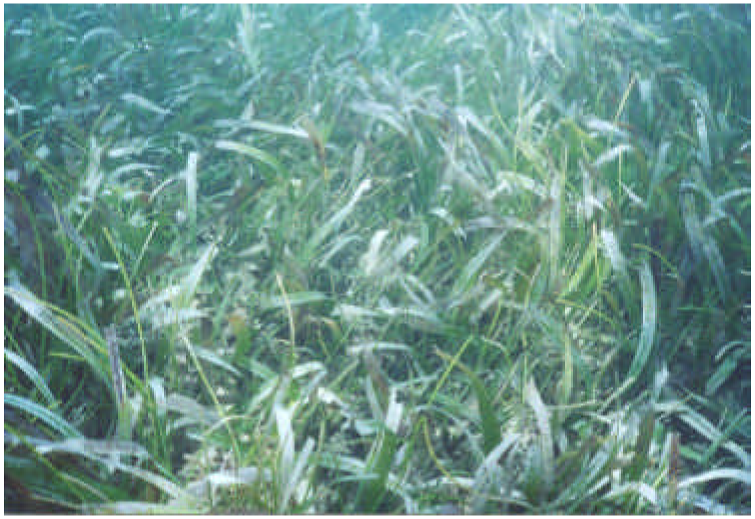
Photogragh 2. Rocky subtidal habitat and seagrass bed interface with calcareous green algae (*Halimeda incrassata)*, turtle grass (Thalassia testudinum) and porous sea rods (*Pseudoplexaura sp*.).



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

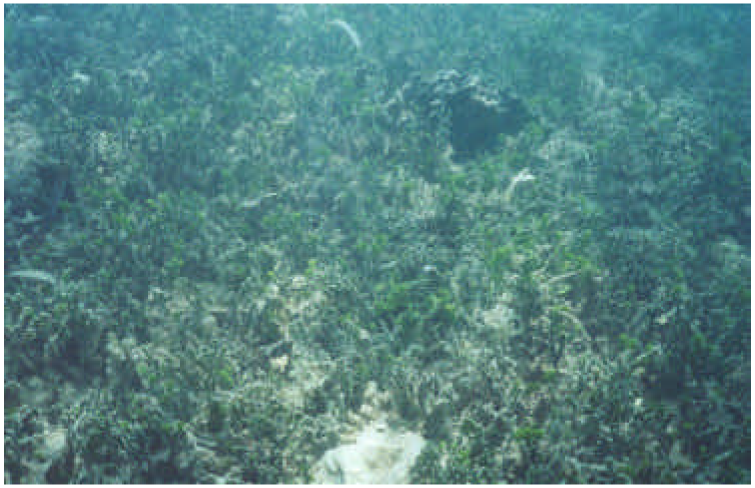
Photograph 4. Rocky subtidal habitat with red-boring sponge (*Cliona sp*.), porous sea rod (*Pseudoplexaura sp*.) and knobby brain coral (*Diploria clivosa*).





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 (H*alimeda 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 SWMU 45

Draft

Additional Data Collection Work Plan in Support of Ecological Risk Assessment at SWMU 45

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

CH2M HILL

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

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APPENDIX

Appendix A Sample Matrix

LIST OF ACRONYMS AND ABBREVIATIONS

Baker	Baker Environmental, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	Corrective Measure Study
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
EQB	Environmental Quality Board
ERA	Ecological Risk Assessment
GPS	Global Positioning System
HESI	Heartland Environmental Services, Inc.
ICM	Interim Corrective Measures
IRP	Installation Restoration Program
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
µg/mg	Micrograms per Milligram
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NSRR	Naval Station Roosevelt Roads
PAH	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
RI	Remedial Investigation
SSI	Supplemental Site Investigation
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TOC	Total Organic Carbon
USTs	Underground Storage Tanks
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) 45 (Former Power Plant) located at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico (see Figure 1-1). Additional details with respect to sampling methodologies, health and safety plan etc. are located in the EPA approved Final RCRA Facility Investigation September 13, 1995 (Baker, 1995a). 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

SWMU 45 is comprised of the areas outside Building 38 that is the former power plant. Included are two 50,000-gallon underground storage tanks (USTs) near the building and the cooling water tunnel that extends from the building out into Puerca Bay. Investigations conducted in Puerca Bay revealed that polychlorinated biphenyls (PCBs) and semivolatile organic compounds (SVOCs) were present in the sediments at levels which pose an unacceptable risk to sediment-associated biota. In addition, an area of oil contaminated soil is present in the subsurface around the cooling water tunnel. Based on these conditions, a Corrective Measures Study (CMS) for the site is under development.

As part of the CMS for SWMU 45, an ERA is also under development. Step 1 of the 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 SWMU 45 (Baker, 2001)

1.3 Site Status Summary

SWMU 45 was initially addressed under the Navy's Installation Restoration Program (IRP) which followed a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) pattern. Under the IRP, a Remedial Investigation (RI) was performed. PCB contamination was found in the soils immediately outside Building 38. An Interim Corrective Measure (ICM) was designed for the affected soils which included excavation of the contaminated soils, shipment off-island for appropriate disposal, and sampling the surrounding area to ensure that the cleanup goals were achieved. The soil removal took place in 1994. A report entitled Final Closeout Report for Interim Remedial Action of PCB Contaminated Soils, Site 15 and 16 at the Naval Station Roosevelt Roads, Puerto Rico (Baker, 1995b) was submitted in May 1995. [It should be noted that the "Site 16" referenced in the report title is the IRP designation for what is now SWMU 45.]

NSRR submitted a Resource Conservation and Recovery Act (RCRA) Part B Permit application for the storage of hazardous waste on the base. Recognizing that Corrective Action would apply to unpermitted waste management units, the Navy performed a Supplemental Site Investigation (SSI) at a variety of units (including SWMU 45) to provide additional site characterization information to the United States Environmental Protection Agency (EPA) to assist in their permitting decisions. Included in the investigations were the sediments of Puerca Bay and the cooling water tunnel interior. The investigations were reported in the report entitled Draft, Supplemental Investigations, Installation Restoration Program Activities, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker, 1993).

The RCRA corrective action portion of the facility's permit (issued in October 1994) contained specific requirements for investigation and, potentially, remediation at the site. To accomplish the goals of the permit, a RCRA Facility Investigation (RFI) work plan (Baker, 1995) was submitted to, and subsequently approved by, the EPA. The work plan provided the framework for site characterization activities; its scope was guided by the results of the SSI.

An RFI at SWMU 45 was performed in 1996 in accordance with the work plan. The findings of the RFI (Baker, 1996) confirmed those of the SSI, and indicated that the USTs and cooling water tunnel represented a possible source of continuing release. On the basis of this finding, the Navy decided to perform an ICM to eliminate the potential for further release. The plans for the ICM, which were submitted to the EPA and approved, called for the cleaning and abandonment in place of the USTs and tunnel. Inflow of groundwater to the tunnel necessitated a field design change (approved by the Puerto Rico Environmental Quality Board [EQB]) which provided for the filling of the USTs and tunnel with low density concrete. This approach entombed and effectively immobilized any residual contamination.

During the ICM on the tunnel, an excavation was made at a point along the outside of the tunnel in an attempt to ascertain how groundwater was entering the tunnel. Soils contaminated with petroleum were observed. A work plan to investigate the outside of the tunnel was submitted to, and subsequently approved by, the EPA. The work was performed and the results were presented in the EPA approved document entitled Revised Draft, RCRA Facility Investigation Report, Operable Unit 3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker, 1999). This report (and/or its precursor the initial "draft" report) recommended a CMS for the Puerca Bay sediment and the soils immediately adjacent to the cooling water tunnel.

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 one distinct ecological environment, the open water marine environment, in support of the ERA. First, a baseline of this environment will be established by collecting and analyzing samples from an area not impacted by base activities. Second, a representative sampling from this environment, will be conducted at SWMU 45. 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.

In addition to the collection of ERA parameters, additional sampling and analysis of PCBs near the cooling water tunnel at SWMU 45 will be performed. Sediment and surface water will be collected at selected locations to further delineate the extent of PCB impacts to Puerca Bay. 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 <u>Background Sampling and Analysis</u>

Open water marine environment sediment and surface water background samples will be collected just off-shore of the Los Machos National Forrest (Figure 2-1). 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 pre-preserved sample containers. All sampling locations will be surveyed using a portable Global Positioning Satellite (GPS) unit. Surface water samples will be analyzed for the following parameters. It should be noted that these samples are to be utilized for all sites for NSRR and, therefore, will contain additional parameters then those necessary for SWMU 45. The parameter associated with the work for SWMU 45 are identified in Appendix A and the following list.

- 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)

* = Data to be utilized for the report on this investigation

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 laden. 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 and dioxin/furan 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 - SWMU 45

Previous investigations, Revised Draft RCRA Facility Investigation Report for OU 3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker, 1999) identified PCBs in Puerca Bay sediment near the cooling water tunnel. As a result of this investigation, further delineation of the PCBs in Puerca Bay is warranted. Using the information already obtained from the previous investigation, additional sediment sampling for PCBs will be collected in Puerca Bay.

SWMU 45 does not have an estuarine wetland system environment, so no surface water or sediment sampling for this environment will be performed. However, SWMU 45 does have an open water marine environment, so surface water and sediment sampling for this environment will be performed.

The cooling water tunnel for the former power plant extends over one hundred feet into Puerca Bay. Previous investigations focused sampling efforts near the end of the cooling water tunnel and continued sampling into the bay. Therefore, two additional sediment and surface water samples on either side of the cooling water tunnel (Figure 2-3) will be collected. To further delineate the possible extent of the PCBs in the bay, two samples will be collected approximately 100 feet past 11SD06 and 11SD09. Three additional samples will then be collected across the mouth of the bay, as shown on Figure 2-3. A total of nine surface water and sediment samples will be collected. If the field screening analysis of samples indicates the presence of PCBs, then additional sampling further into the bay will be performed and analyzed for PCBs only.

Depth of water in Puerca Bay is such that a boat must be used to access these sample locations. Sediment samples will be obtained using an Eckman or petite ponar dredge and surface water samples will be collected using a Wildco Beta Plus horizontal water bottle. The surface water will be collected at one to two feet above the sediment. Sampling locations will be surveyed using a portable GPS unit.

Field analysis for PCBs in sediment will be determined using a PCB Ensys® 12T Soil Test System kit. The detection limits for the Ensys kits will be 100 micrograms/milligram (μg/mg). As previously stated, if samples show elevated levels of PCBs as determined by the Ensys kits, then additional sampling and field screen analysis will be performed. Since the first nine samples will be going to the laboratory for analysis for RCRA Appendix IX PCBs, no laboratory confirmation for the first nine samples will be required. However, any additional positive detection PCB samples, as determined by the Ensys kit, collected beyond the first nine samples will be shipped to the laboratory for confirmatory analysis.

Samples will be labeled as shown below:

11OWSD11D Sample I.D.
11OWSD11D SWMU Identifier (i.e. SWMU 11)
11OWSD11D Environment Designator ("OW" Open Water)
11OWSD11D Type of Sample ("SD" - Sediment, "SW" - Surface Water)
11OWSD11D Sample Number (Start at 10, 11, etc. . . .)
11OWSD11D QA/QC Identifier ("D" - Duplicate, "MS" - Matrix Spike)

The first nine sediment and surface water samples as identified in Figure 2-3 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

- TOC (Sediment samples only)
- Field Parameters (Surface water samples only) (pH, DO, Temperature, and Salinity)

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 laden. 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 VOCs and SVOCs 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

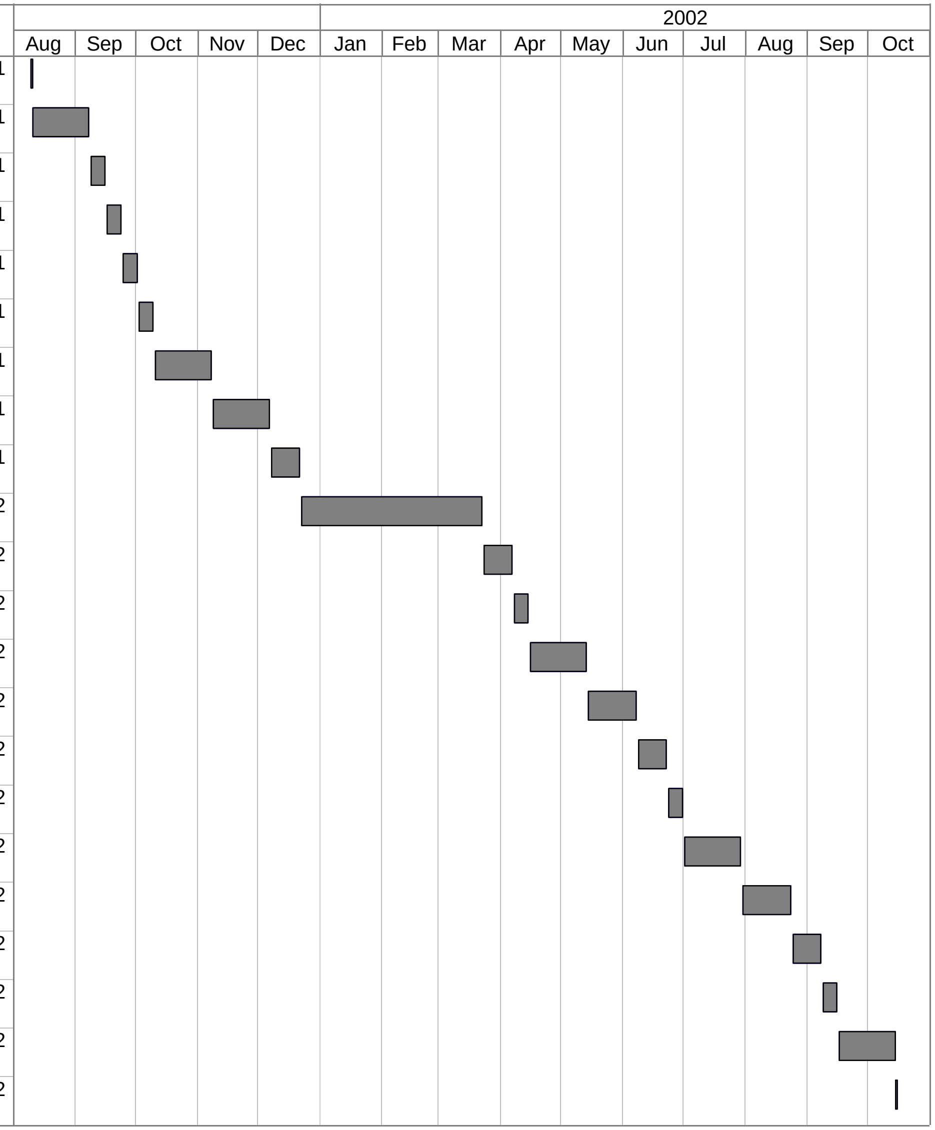
A full report on the investigations described herein will be prepared and will be included as part of the Screening Level Ecological Risk Assessment, Steps 2 and 3a. Included in the report will be a description of the field activities, all screening and laboratory analytical results, and an interpretation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

Figure 4-1
Proposed Schedule
Additional Data Collection in Support of Ecological Risk Assessment at SWMU 45
Naval Station Roosevelt Roads, Puerto Rico

ID	Task Name	Duration	Start	Finish
1	Draft Additional Data Collection Work Plan in Support of Eco RA at SWMU 45 to EPA	1 day	8/10/01	8/10/01
2	EPA Review and Comments	28 edays	8/11/01	9/8/01
3	Revise Draft Additional Data Collection Work Plan in Support of Eco RA at SWMU 45. Submit to Navy	7 edays	9/9/01	9/16/01
4	Navy Review	7 edays	9/17/01	9/24/01
5	Final Additional Data Collection Work Plan in Support of Eco RA at SWMU 45 to EPA	7 edays	9/25/01	10/2/01
6	EPA Review and Approval	7 edays	10/3/01	10/10/01
7	Field Work	28 edays	10/11/01	11/8/01
8	Laboratory Analysis	28 edays	11/9/01	12/7/01
9	Data Validation	14 edays	12/8/01	12/22/01
10	Draft Screening Level Eco RA Steps 2 and 3 for SWMU 45 to Navy	90 edays	12/23/01	3/23/02
11	Navy Review	14 edays	3/24/02	4/7/02
12	Draft Screening Level Eco RA Steps 2 and 3 for SWMU 45 to EPA	7 edays	4/8/02	4/15/02
13	EPA Review and Comments	28 edays	4/16/02	5/14/02
14	Revise Draft Screening Level Eco RA Steps 2 and 3 for SWMU 45. Submit to Navy	24 edays	5/15/02	6/8/02
15	Navy Review	14 edays	6/9/02	6/23/02
16	Draft Final Screening Level Eco RA Steps 2 and 3 for SWMU 45 to EPA	7 edays	6/24/02	7/1/02
17	EPA Review and Comments	28 edays	7/2/02	7/30/02
18	Revise Draft Final Screening Level Eco RA Steps 2 and 3 for SWMU 45. Submit to Navy	24 edays	7/31/02	8/24/02
19	Navy Review	14 edays	8/25/02	9/8/02
20	Final Screening Level Eco RA Steps 2 and 3 for SWMU 45 to EPA	7 edays	9/9/02	9/16/02
21	EPA Review and Approval	28 edays	9/17/02	10/15/02
22	Phase II Screening Level Ecological Risk Assessment*	1 eday	10/15/02	10/16/02



Project: SWMU45
Date: 8/1/01

* Remaining Schedule follows the schedule outlines in the Revised Final II Corrective Measures Study Work Plan SWMU 45 (Baker 2000)

5.0 REFERENCES

Baker Environmental, Inc., (Baker). (1993). Draft, Supplemental Investigations, Installation Restoration Program Activities, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. Coraopolis, Pennsylvania. June 1993.

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

Baker. (1995b). Final Closeout Report for Interim Remedial Action of PCB Contaminated Soils, Site 15 and 16 at the Naval Station Roosevelt Roads, Puerto Rico. Coraopolis, Pennsylvania. May 1995.

Baker. (1998). Draft RCRA Facility Investigation Report for Operable Unit 3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. Coraopolis, Pennsylvania. March 1998.

Baker. (1999). Revised Draft RCRA Facility Investigation Report for Operable Unit 3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. Coraopolis, Pennsylvania. April 1999.

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

	Quantitation Limits*		
Volatiles	**Water (mg/L)**	**Low Soil (mg/kg)**	**Method Number**
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 (µg/L)	Low Soil (µg/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)

	Quantitation Limits*		
Semivolatiles	**Water (mg/L)**	**Low Soil (mg/kg)**	**Method Number**
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* Water (μg/L)	Quantitation Limits* Low Soil (μg/kg)	Method Number
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
Methyoxychlor	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 Water (mg/L)	Method Number
Dissolved Oxygen (DO)	50	Chemets (Field)
Salinity	parts per trillion	Salinity Meter (Field)
pH	unitless	Conductivity Meter (Field)
Temperature	degrees F	Conductivity Meter (Field)

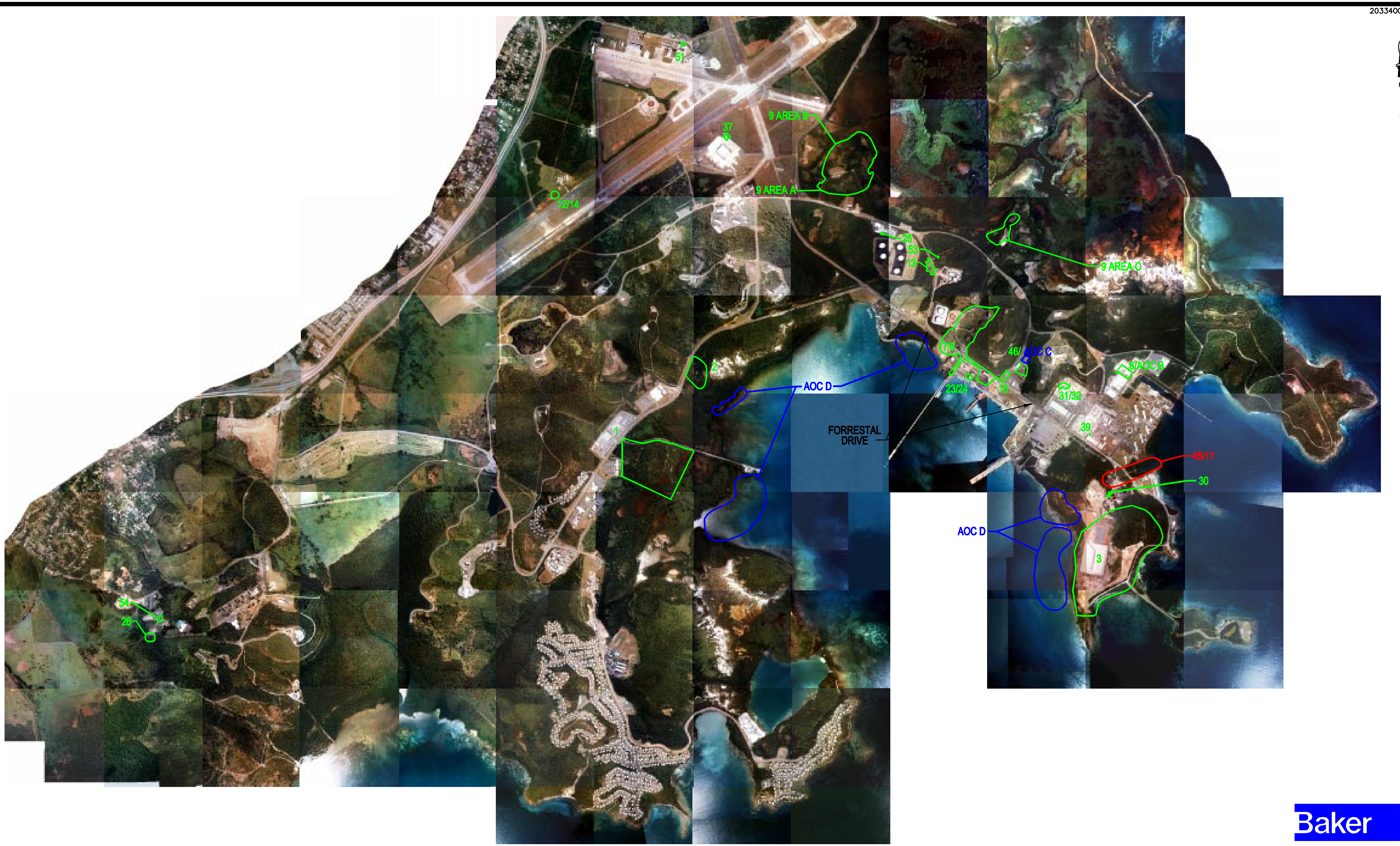
TABLE 2-1

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

		Quantitation Limits*		
Inorganics	**Method Number**	**Water (μg/L)**	**Low Soil (μg/kg)**	**Method Description**
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

1 – SWMUs

AOC D – AOCs

45/11 – AREA OF WHICH THIS INVESTIGATION PERTAINS TO

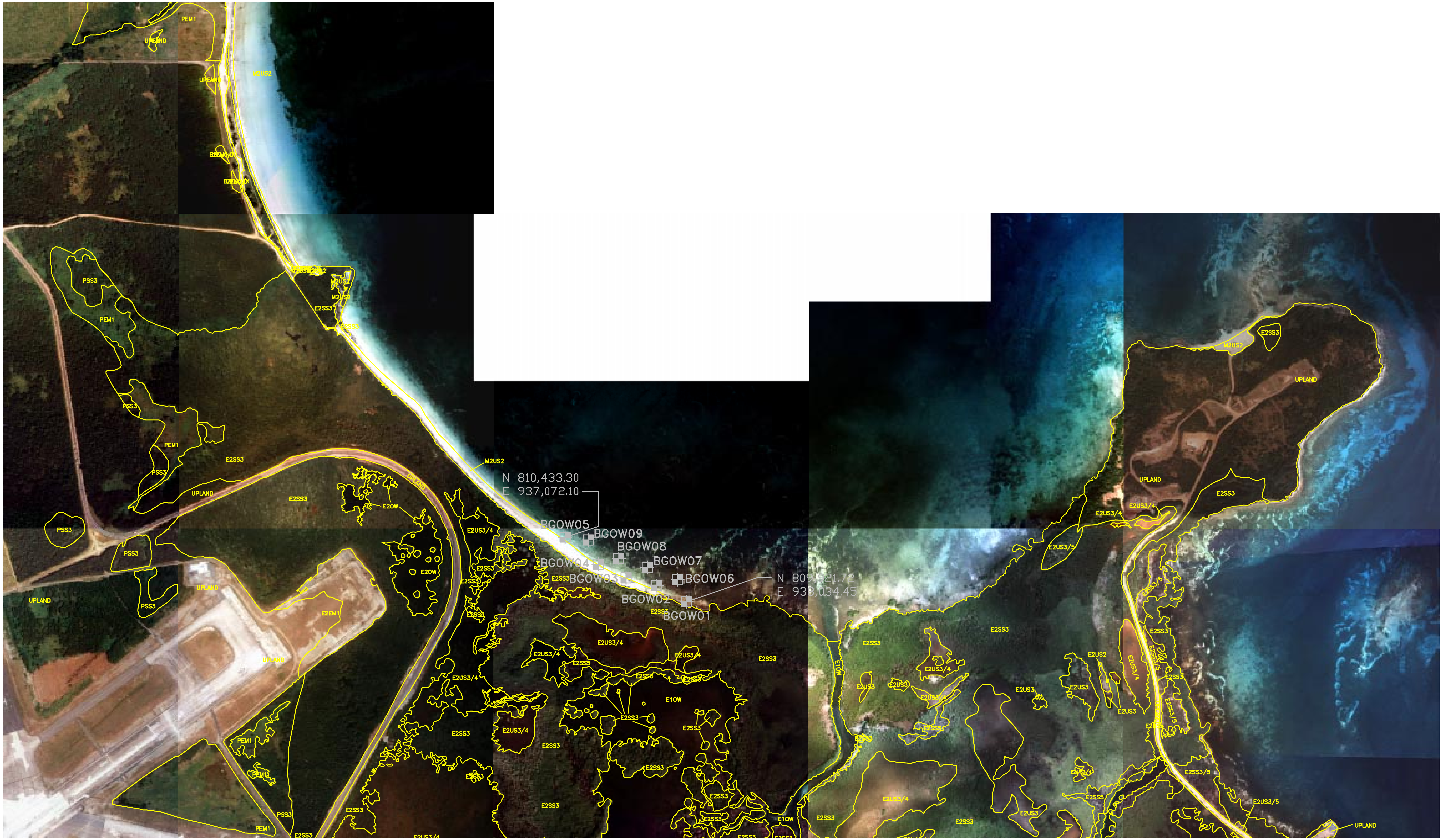
SOURCE: GEO-MARINE, INC., SEPTEMBER 6, 2000.

2500 0 1250 2500
1 inch = 2500 ft.

FIGURE 1-1
SWMU/AOC LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

2033407E



LEGEND

OPEN WATER MARINE

– PROPOSED SURFACE WATER/ SEDIMENT SAMPLE LOCATION

E2SS3 – E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 2-2 FOR CLASSIFICATIONS)

800 0 400 800

1 inch = 800 ft.

Baker

FIGURE 2-1
OPEN WATER MARINE ENVIRONMENT BACKGROUND SAMPLING LOCATIONS
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

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

FIGURE 2-2
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
SWMU 45
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

SYSTEM: M - MARINE

SUBSYSTEM: 1 - SUBTIDAL

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

SUBSYSTEM: 2 - INTERTIDAL

CLASS	Subclass
AB - Aquatic Bed	1 Algal; 3 Rooted Vasc; 5 Unknown
RF - Reef	1 Coral; 3 Worm
RS - Rocky Shore	1 Bedrock; 2 Rubble
US - Unconsolidated Shore	1 Cobble - Gravel; 2 Sand; 3 Mud; 4 Organic

SYSTEM: E - ESTUARINE

SUBSYSTEM: 1 - SUBTIDAL

CLASS	Subclass
RB - Rock Bottom	1 Bedrock; 2 Rubble
UB - Unconsolidated Bottom	1 Cobble - Gravel; 2 Sand; 3 Mud; 4 Organic
AB - Aquatic Bed	1 Algal; 3 Rooted Vasc; 4 Floating Vasc; 5 *Unknown Submerg.*; 6 *Unknown Surface*
RF - Reef	2 Mollusk; 3 Worm
OW - Open Water *(unknown bottom)*	

SUBSYSTEM: 2 - INTERTIDAL

CLASS	Subclass
AB - Aquatic Bed	1 Algal; 3 Rooted Vasc; 4 Floating Vasc; 5 *Unknown Submerg.*; 6 *Unknown Surface*
RF - Reef	2 Mollusk; 3 Worm
SB - Streambed	1 Cobble - Gravel; 2 Sand; 3 Mud; 4 Organic
RS - Rocky Shore	1 Bedrock; 2 Rubble
US - Unconsolidated Shore	1 Cobble - Gravel; 2 Sand; 3 Mud; 4 Organic; 5 Dead
EM - Emergent	1 Persistent; 2 Nonpersistent
SS - Scrub-Shrub	1 Broad-leaved Decid.; 2 Needle-leaved Decid.; 3 Broad-leaved Everg.; 4 Needle-leaved Everg.; 5 Dead; 6 *Deciduous*; 7 *Evergreen*
FO - Forested	1 Broad-leaved Decid.; 2 Needle-leaved Decid.; 3 Broad-leaved Everg.; 4 Needle-leaved Everg.; 5 Dead; 6 *Deciduous*; 7 *Evergreen*

SYSTEM: R - RIVERINE

SUBSYSTEM: 1 - TIDAL; 2 - LOWER PERENNIAL; 3 - UPPER PERENNIAL; 4 INTERMITTENT; 5 - UNKNOWN PERENNIAL

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

SYSTEM: L - LACUSTRINE

SUBSYSTEM: 1 - LIMNETIC

CLASS	Subclass
RB - Rock Bottom	1 Bedrock; 2 Rubble
UB - Unconsolidated Bottom	1 Cobble - Gravel; 2 Sand; 3 Mud; 4 Organic
AB - Aquatic Bed	1 Algal; 2 Aquatic Moss; 3 Rooted Vasc; 4 Floating Vasc; 5 *Unknown Submerg.*; 6 *Unknown Surface*
OW - Open Water *(unknown bottom)*	

SUBSYSTEM: 2 - LITTORAL

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

SYSTEM: P - PALUSTRINE

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

MODIFIERS

WATER REGIME

Non-Tidal			Tidal
A Temp. Flooded	H Permanently Flooded	K Artificially Flooded	*S Temporary-Tidal
B Saturated	J Intermittently Flooded	L Subtidal	*R Seasonal-Tidal
C Seasonally Flooded	K Artificially Flooded	M Irregularly Flooded	*T Semipermanent- Tidal
D Seasonally Flooded/ Well Drained	W Intermittently Flooded/ Temporary	N Regularly Flooded	*V Permanent-Tidal
E Seasonally Flooded/ Saturated	Y Saturated/Semipermanent/ Seasonal	P Irregularly Flooded	U Unknown
F Semipermanently Flooded	Z Intermittently Exposed Permanent		
G Intermittently Exposed	U Unknown		

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

WATER CHEMISTRY

Coastal Halinity	Inland Salinity	pH (fresh water)
1 Hyperhaline	7 Hypersaline	a Acid
2 Euhaline	8 Eusaline	t circumneutral
3 Mixohaline	9 Mixosaline	i Alkaline
4 Polyhaline	0 Fresh	
5 Mesohaline		
6 Oligohaline		
0 Fresh		

SOIL

- g Organic
- n Mineral

SPECIAL

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

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

2033405E

LEGEND

30 – SWMU

– HYDROPUNCH LOCATION (1996 RFI)

– MONITOR WELL LOCATION (1996 RFI)

– DIRECT PUSH SOIL SAMPLE LOCATION (1997 RFI)

– DIRECT PUSH SOIL AND GROUNDWATER SAMPLE LOCATION (1997 RFI)

OPEN WATER MARINE

– SEDIMENT SAMPLE LOCATION (1997 RFI)

– PROPOSED SURFACE WATER/SEDIMENT SAMPLE LOCATION

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

150 0 75 150

1 inch = 150 ft.

Baker

FIGURE 2-3
SWMU 45 SAMPLING LOCATIONS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

APPENDIX A
SAMPLE MATRIX

APPENDIX A.1

BACKROUND SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMU 45
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample Media	Environment	Sample ID	Sample Date	Fixed Base Laboratory									Field Measurements				Comments
				RCRA Appendix IX													
				VOCs* - (8260)	SVOCs* - (8270)	Metals* - (6010/7000)	PCBs* - (8082)	Cyanides* - (9012)	Chlorinated Herbicides - (8151)	Pesticides(1) - (8081)	Dioxins & Furans - (8280)	Total Organic Carbon* - (9060)	pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets)	Tempreature - (Conductivity Meter)	Salinity - (Salinity Meter)	
Background Sediment	Open Water Marine	BGOWSD13		X	X	X	X	X	X	X	X	X					
		BGOWSD14		X	X	X	X	X	X	X	X	X					
		BGOWSD15		X	X	X	X	X	X	X	X	X					
		BGOWSD15D		X	X	X	X	X	X	X	X	X					Duplicate
		BGOWSD15MS/MSD		X	X	X	X	X	X	X	X	X					Matrix Spike/Matrix Spike Dup.
		BGOWSD16		X	X	X	X	X	X	X	X	X					
		BGOWSD17		X	X	X	X	X	X	X	X	X					
		BGOWSD18		X	X	X	X	X	X	X	X	X					
		BGOWSD19		X	X	X	X	X	X	X	X	X					
		BGOWSD20		X	X	X	X	X	X	X	X	X					
		BGOWSD21		X	X	X	X	X	X	X	X	X					
Background Surface Water	Open Water Marine	BGOWSW13		X	X	X(1)	X	X	X	X	X		X	X	X	X	
		BGOWSW14		X	X	X(1)	X	X	X	X	X		X	X	X	X	
		BGOWSW15		X	X	X(1)	X	X	X	X	X		X	X	X	X	
		BGOWSW15D		X	X	X(1)	X	X	X	X	X		X	X	X	X	Duplicate
		BGOWSW15MS		X	X	X(1)	X	X	X	X	X		X	X	X	X	Matrix Spike
		BGOWSW15MSD		X	X	X(1)	X	X	X	X	X		X	X	X	X	Matrix Spike Duplicate
		BGOWSW16		X	X	X(1)	X	X	X	X	X		X	X	X	X	
		BGOWSW17		X	X	X(1)	X	X	X	X	X		X	X	X	X	
		BGOWSW18		X	X	X(1)	X	X	X	X	X		X	X	X	X	
		BGOWSW19		X	X	X(1)	X	X	X	X	X		X	X	X	X	
		BGOWSW20		X	X	X(1)	X	X	X	X	X		X	X	X	X	
		BGOWSW21		X	X	X(1)	X	X	X	X	X		X	X	X	X	

Notes:
Additional parameters are being collected for this data set which are not shown on this sample matrix since they are not related to this investigation. These additional parameters are provided in the Additional Data Collection Work Plan in Support of Ecological Risk Assessment at SWMU 45 (Baker, 2001).

* - Data to be utilized for the report on this investigation

(1) - Total and Dissolved

APPENDIX A.2

SEDIMENT AND SURFACE WATER SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMU 45
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

Sample Media	Environment	Sample ID	Fixed Base Laboratory						Field Measurements				Comments
			RCRA Appendix IX										
			VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Total Organic Carbon - (9060)	pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets)	Tempreature - (Conductivity Meter)	Salinity - (Salinity Meter)	
Sediment	Open Water Marine	11OWSD10	X	X	X	X	X	X					
		11OWSD11	X	X	X	X	X	X					
		11OWSD11D	X	X	X	X	X	X					Duplicate
		11OWSD12	X	X	X	X	X	X					
		11OWSD13	X	X	X	X	X	X					
		11OWSD14	X	X	X	X	X	X					
		11OWSD15	X	X	X	X	X	X					
		11OWSD16	X	X	X	X	X	X					
		11OWSD17	X	X	X	X	X	X					
		11OWSD18	X	X	X	X	X	X					
Surface Water	Open Water Marine	11OWSW10	X	X	X[(1)]	X	X		X	X	X	X	
		11OWSW11	X	X	X[(1)]	X	X		X	X	X	X	
		11OWSW11D	X	X	X[(1)]	X	X		X	X	X	X	Duplicate
		11OWSW12	X	X	X[(1)]	X	X		X	X	X	X	
		11OWSW13	X	X	X[(1)]	X	X		X	X	X	X	
		11OWSW14	X	X	X[(1)]	X	X		X	X	X	X	
		11OWSW15	X	X	X[(1)]	X	X		X	X	X	X	
		11OWSW16	X	X	X[(1)]	X	X		X	X	X	X	
		11OWSW17	X	X	X[(1)]	X	X		X	X	X	X	
		11OWSW18	X	X	X[(1)]	X	X		X	X	X	X	

Notes:

[(1)] - Total and Dissolved

APPENDIX A.3

TRIP BLANK, FIELD BLANK, EQUIPMENT RINSATE SAMPLE MATRIX
ADDITIONAL DATA COLLECTION - SWMU 45
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

QA/QC Sample Type	Sample ID	Fixed Base Laboratory: RCRA Appendix IX: VOCs - (8260)	SVOCs - (8270)	Metals - (6010/7000)	PCBs - (8082)	Cyanides - (9012)	Total Organic Carbon - (9060)	Field Measurements: pH - (Conductivity Meter)	Dissolved Oxygen - (Chemets)	Tempreature - (Conductivity Meter)	Salinity - (Salinity Meter)	Comments
Trip Blanks	45TB01	X										Lab Prepared
	45TB02	X										Lab Prepared
Field Blanks	2001FB01	X	X	X	X	X	X					Lab Grade DI Water
Equipment Rinsates	45ER01	X	X	X	X	X	X					Stainless Steel Spoon
	45ER02	X	X	X	X	X	X					Dredge

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 NOAEL 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. Tyalor 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.

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 selanomethionine 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 selanomethionine 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. 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. USEPA (1999) reports a chronic NOAEL for mallards of 178 mg/kg/day.

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

U.S. Environmental Protection Agency (USEPA). 1999. *Screening level ecological risk assessment protocol for hazardous waste combustion facilities.* Peer Review Draft. EPA/530/D-99/001.

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. 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. USEPA (1999) reports a chronic NOAEL of 0.35 mg/kg/day for the European starling. This value was based on a LD_{50} of 35 mg/kg/day and an uncertainty factor of 0.01.

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.

U.S. Environmental Protection Agency (USEPA). 1999. *Screening level ecological risk assessment protocol for hazardous waste combustion facilities.* Peer Review Draft. EPA/530/D-99/001.

Tin

Tin enters the environment by both natural and human activities such as mining, coal and oil combustion, and the production and use of tin products (ATSDR 1995). Inorganic and organic forms of tin as well as tin metal are found in air, water and soil near places where they are naturally present in the rocks, or where they are mined, manufactured, or used.

The organic form of tin, tributyltin, is known to accumulate in the tissues of plants, fish, and other organisms.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *ToxFAQs - Tin*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. www.atsdr.cdc.gov.

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.

POLYCHLORINATED BIPHENYLS (PCBs)

Aroclor 1016, 1221, 1232, 1242, 1248, 1254, and 1260

PCBs are a group of manufactured organic chemicals that were banned in the United States in 1977 because of their proven adverse environmental effects. PCBs occur in a variety of different formulations consisting of mixtures of individual compounds such as Aroclor 1016, 1248, 1254, and Aroclor 1260. The Aroclor formulations vary in the percent chlorine, and generally, the higher the chlorine content the greater the toxicity. PCBs elicit a variety of biologic and toxic effects including death, birth defects, reproductive failure, liver damage, tumors, and a wasting syndrome (Eisler 1986). Skin exposure to PCBs in animals resulted in liver, kidney, and skin damage (ATSDR 1996). They are known to bioaccumulate and to biomagnify within the food chain. PCBs in water accumulate in fish and marine mammals and can reach levels thousands of times higher than the levels in water (ATSDR 1996). Toxicity data for white-footed mice, oldfield mice, and mink show that their reproductive systems and developing embryos were adversely affected by both acute and chronic exposures (McCoy et al. 1995).

An 18-month study conducted on the effects of Aroclor 1016 on the reproduction of mink indicated that 25 ppm in the diet reduced kit growth (Aulerich and Ringer 1980). This dose was considered a chronic LOAEL and was converted to a daily dose of 3.43 mg/kg/day. The10 ppm dose was considered to be a chronic NOAEL because no adverse effects were observed at this dosage. The chronic NOAEL was converted to a daily dose of 1.37 mg/kg/day.

A seven-month study on the effects of Aroclor 1242 on the reproduction of mink indicated that doses of 5, 10, 20, and 40 ppm caused complete reproductive failure (Bleavins et al. 1980). The 5 ppm dose (chronic LOAEL) was converted to a daily dose of 0.69 mg/kg/day. A chronic NOAEL of 6.9 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A study conducted on the effects of Aroclor 1242 on the reproduction on two generations of screech owls indicated that a 3 ppm dose had no observed effects (McLane and Hughes 1980). This dose (chronic NOAEL) was converted to a daily dose of 0.41 mg/kg/day. A chronic LOAEL of 4.1 mg/kg/day was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10.

A 5-week study on the effects of Aroclor 1248 on immune function in mice indicated a dose of 13 mg/kg/day to be a chronic LOAEL (ATSDR 1996). A chronic NOAEL of 1.3 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A year-long study conducted on oldfield mice indicated that 5 ppm of Aroclor 1254 in the diet reduced the number of litters, offspring weights, and offspring survival (McCoy et al. 1995). This dose was considered a chronic LOAEL and converted to a daily dose of 0.68 mg/kg/day (Sample et al. 1996). A chronic NOAEL of 0.068 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

A study conducted by Aulerich and Ringer (1977) exposed mink to 3 dose levels of Aroclor 1254 for a 4.5-month period. Exposure to 5 and 15 ppm in the diet reduced the number of offspring born alive. A dose of 1 ppm caused no adverse effects. The 5 ppm dose was considered to be a chronic LOAEL and was converted to a daily dose of 0.69 mg/kg/day (Sample et al. 1996). The 1 ppm dose was considered to be a chronic NOAEL and was converted to a daily dose of 0.14 mg/kg/day.

A study conducted on ring-necked pheasants indicated that a dose of 1.8 mg/kg/day in the diet for 17 weeks caused significantly reduced egg hatchability (Dahlgren et al. 1972). This dose was considered a chronic LOAEL. A chronic NOAEL of 0.18 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). 1996. *Toxicological profile for polychlorinated biphenyls (update)*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Aulerich, R.J. and R.K. Ringer. 1977. Current status of PCB toxicity, including reproduction in mink. *Arch. Environ. Contam. Toxicol*. 6:279-292.

Aulerich, R.J. and R.K. Ringer. 1980. *Toxicity of the polychlorinated biphenyl Aroclor 1016 to mink.* Environmental Research Laboratory, Office of Research and Development.

Bleavins, M.R., R.J. Aulerich, and R.K. Ringer. 1980. Polychlorinated biphenyls (Aroclors 1016 and 1242): Effects on survival and reproduction in mink and ferrets. *Arch. Environ. Contam. Toxicol.* 9:627-635.

Dahlgren, R.B., R.L. Linder, and C.W. Carlson. 1972. Polychlorinated biphenyls: their effects on penned pheasants. *Environ. Health Perspect*. 1:89-101.

Eisler, R. 1986. *Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: a synoptic review.* U.S. Fish and Wildlife Service, Contaminant Hazard Reviews, Report No. 7.

McCoy, G., M.F. Finlay, A. Rhone, K. James, and G.P. Cobb. 1995. Chronic polychlorinated biphenyls exposure on three generations of oldfield mice (*Permyscus polionotus*): effects on reproduction, growth, and body residues. *Arch. Environ. Contam. Toxicol*. 28:431-435.

McLane, M.A.R. and D.L. Hughes. 1980. Reproductive success of screech owls fed Aroclor 1248. *Archives of Environmental Contamination and Toxicology*. 9:661-665.

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.

SEMIVOLATILE ORGANICS

1,2,4,5-Tetrachlorobenzene

No information regarding 1,2,4,5-tetrachlorobenzene was available in the literature.

1,2,4-Trichlorobenzene

Three-generation rat studies with 1,2,4-trichlorobenzene indicate adverse effects on reproduction at oral doses of 106 mg/kg/day (Coulston and Kolbye 1994). This dose is considered a chronic LOAEL. No adverse reproductive effects were found at a dose of 53 mg/kg/day. This dose is considered the chronic NOAEL. No avian toxicological data were found for this chemical.

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.

1,2-Dichlorobenzene and 1,3-Dichlorobenzene

Chronic rat studies with 1,2-dichlorobenzene indicate adverse effects on the liver and kidney at oral doses of 857 mg/kg/day (Coulston and Kolbye 1994). This dose is considered a chronic LOAEL. A chronic NOAEL of 85.7 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. Avian data for 1,4-dichlorobenzene is applied to these two chemicals.

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.

1,4-Dichlorobenzene

1,4-dichlorobenzene is used mainly as a fumigant for the control of moths, molds, and mildews and as a space deodorant for toilets and refuse containers (ATSDR 1993). Tests involving acute exposure of animals, such as the LD_{50} test in rats and mice, have shown that 1,4-dichlorobenzene has moderate toxicity from oral exposure (RTECS 1993). Studies have reported effects on the blood, liver, and kidneys from acute, oral exposure. Chronic inhalation exposures can cause adverse effects on the respiratory system, liver, and kidneys. A study on pregnant rats reported adverse developmental effects in fetuses when administering the chemical by gavage (HSDB 1993).

An oral study on the effects of 1,4-dichlorobenzene on pregnant rats determined a NOAEL of 250 mg/kg/day (Coulston and Kolbye 1994). At this level, no adverse effects were seen for maternal and developmental toxicity. Effects were observed at 500 mg/kg/day (the chronic LOAEL).

Fourteen-day studies with northern bobwhites showed adverse effect on growth and survival from oral exposures of 2500 mg/kg/day (Grimes and Jaber 1989). 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). 1993. *Toxicological profile for 1,4-dichlorobenzene*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

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.

Grimes, J. and M. Jaber. 1989. *Para-dichlorobenzene: An acute oral toxicity study with the bobwhite, Final Report.* Prepared by Wildlife International Ltd. - Easton, MD under project No. 264-101 and submitted to Chemical Manufacturers Association, Washington, DC, report dated July 19, 1989.

Hazardous Substances Databank (HSDB). 1987. Record for 1,4-Dichlorobenzene. Computer Printout. National Library of Medicine.

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.

2,3,4,6-Tetrachlorophenol

Information regarding 2,3,4,6-tetrachlorophenol was not available in the literature.

2,4,5-Trichlorophenol

Information regarding 2,4,5-trichlorophenol was not available in the literature.

2,4,6-Trichlorophenol

Information regarding 2,4,6-trichlorophenol was not available in the literature.

2,4-Dichlorophenol

Information regarding 2,4,-dichlorophenol was not available in the literature.

2-Acetylaminofluorene

Information regarding 2-acetylaminofluorene was not available in the literature.

2-Chloronaphthalene

Information regarding 2-chloronaphthalene was not available in the literature.

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-sec-butyl-4,6-Dinitrophenol

Information regarding 2-sec-butyl-4,6-dinitrophenol was not available in the literature.

3,3'-Dichlorobenzidine

3,3'-dichlorobenzidine breaks down rapidly in water exposed to natural sunlight and in air, but is retained in soil for months. In air, it is estimated that half of the 3,3'-dichlorobenzidine can breakdown within 2 hours. In water exposed to natural sunlight, 3,3'-dichlorobenzidine is expected to break down rapidly with half being removed in approximately 90 seconds.

Death has occurred in experimental animals that have ingested high concentrations of 3,3'-dichlorobenzidine. In studies conducted on pregnant mice, exposure to 3,3'-dichlorobenzidine caused the kidneys of their offspring to develop improperly. Chronic dietary exposure of experimental animals to moderate levels of 3,3'-dichlorobenzidine caused mild injury to the liver (ATSDR 1989).

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. *Toxicological profile for 3,3'-dichlorobenzidine*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

3,3'-Dimethylbenzidine

Information regarding 3,3'-dimethylbenzidine was not available in the literature.

3-Methylcholanthrene

Information regarding 3-methylcholanthrene was not available in the literature.

4-Bromophenyl-phenylether

Information regarding 4-bromophenyl-phenylether was not available in the literature.

4-Chloro-3-methylphenol

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

4-Chlorophenyl-phenylether

Information regarding 4-chlorophenyl-phenylether was not available in the literature.

7,12-Dimethylbenz(a)anthracene

Information regarding 7,12-dimethylbenz(a)anthracene was not available in the literature.

Aramite

Information regarding aramite 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 LD_{50} 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.

Butylbenzylphthalate

Butylbenzylphthalate is used as a plasticizer. When it is released into the environment, butylbenzylphthalate tends to bind to soil and sediment. It does not persist in the environment when oxygen is present, with half-lives in air, water, and soil of only a few days. It is more persistent at low temperatures, and in an anaerobic environment.

A two-year study with rats indicated hepatic effects when this chemical was administered orally at a dose of 2400 mg/kg/day (NTP 1997). This value is considered the chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. No toxicological data were found for birds.

NTP (National Toxicology Program). 1997. *Effect of dietary restriction on toxicology and carcinogenesis studies of butyl benzyl phthalate (CAS No. 85-68-7) in F344/N rats and B6C3F1 mice (feed studies).* Technical Report Series No. 458, NTP TR458. Prepared by U.S. Department of Health and Human Services.

Carbozole

Information regarding carbozole was not available in the literature.

Chlorobenzilate

Information regarding chlorobenzilate was not available in the literature.

Diallate

Information regarding diallate was not available in the literature.

Dibenzofuran

Dibenzofuran is a polynuclear aromatic compound that may be found in coke dust, grate ash, fly ash, and flame soot. It has been listed as a pollutant of concern to USEPA's Great Waters Program due to its persistence in the environment, potential to bioaccumulate, and toxicity to the environment.

A literature search was conducted on the toxicological effects of dibenzofuran ingestion to mammals and birds. Studies measuring the toxicological effects of dietary dibenzofuran were not available.

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.

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-octylhthalate 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.

Diphenylamine

Information regarding diphenylamine was not available in the literature.

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.

Hexachlorobutadiene

Hexachlorobutadiene is a colorless, manmade liquid that is used in the production of rubber compounds, and lubricants. Hexachlorobutadiene in the water can be released to soil and air. It is expected to remain there for a long time because it attaches to organic matter in the soil. Hexachlorobutadiene can accumulate in fish and shellfish that live in contaminated waters, but it is not known if hexachlorobutadiene accumulates in plants. Under aerobic conditions in water, hexachlorobutadiene undergoes degradation. Degradation does not occur under anaerobic conditions.

Rats exposed orally to hexachlorobutadiene for 90 days demonstrated adverse effects to their reproduction at a dose of 20 mg/kg/day (IPCS 1994). This dose was considered a chronic LOAEL. A chronic NOAEL (2 mg/kg/day) was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. Reproductive effects in Japanese quail from oral exposures occurred at a dose of 8 mg/kg/day (Coulston and Kolbye 1994). This dose was considered a chronic LOAEL. The chronic NOAEL from this study was 2.5 mg/kg/day.

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.

International Programme on Chemical Safety (IPCS). 1994. *Environmental health criteria 156 - hexachlorobutadiene.* World Health Organization, Geneva.

Hexachlorocyclopentadiene

Rats exposed to hexachlorocyclopentadiene during pregnancy demonstrated adverse effects at a dose of 30 mg/kg/day but no adverse effects at 10 mg/kg/day (USEPA 1984). These doses were considered the chronic LOAEL and NOAEL, respectively. Information regarding the toxicological effects on avian species from exposure to hexachlorocyclopentadiene was not available in the literature.

U.S. Environmental Protection Agency (USEPA). 1984. *Health assessment document for hexachlorocyclopentadiene.* EPA/600/8-84/001F.

Hexachloroethane

Information regarding hexachloroethane was not available in the literature.

Hexachlorophene

Information regarding hexachlorophene was not available in the literature.

Hexachloropropene

Information regarding hexachloropropene was not available in the literature.

Isosafrole

Information regarding isosafrole was not available in the literature.

N-Nitrosodiphenylamine

N-nitrosodiphenylamine is an industrial compound that has been produced since 1945 in the manufacture of rubber products and other chemicals. Manufacturers have since replaced it with more efficient chemicals. It is not known whether it exists naturally in the environment; there is some evidence that microorganisms may produce it. Aquatic organisms can accumulate low levels of n-nitrosodiphenylamine in their bodies (ATSDR 1993). It is not known whether terrestrial animals and plants accumulate n-nitrosodiphenylamine. Animals exposed to n-nitrosodiphenylamine through long-term dietary intake developed swelling, cancer of the bladder, and changes in body weight (ATSDR 1993). Higher levels have caused death.

Systemic effects in rats fed n-nitrosodiphenylamine for 8 to 11 weeks were observed at a dose of 1500 mg/kg/day (ATSDR 1993). This dose was considered a chronic LOAEL. A chronic NOAEL of 150 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. No avian toxicological data were found.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. *Toxicological profile for n-nitrosodiphenylamine.*

p-Dimethylaminoazobenzene

Information regarding p-dimethylaminoazobenzene was not available in the literature.

Pentachlorobenzene

Information regarding pentachlorobenzene was not available in the literature.

Pentachloronitrobenzene

Information regarding pentachloronitrobenzene was not available in the literature.

Pentachlorophenol

Pentachlorophenol is a manufactured chemical not found naturally in the environment. Pentachlorophenol has been used as a biocide and wood preservative. It was one of the most heavily used pesticides in the United States. Now, only certified applicators can purchase and use pentachlorophenol (ATSDR 1992).

Pentachlorophenol adsorbs to soil particles, but is more likely to occur under acidic conditions than neutral or basic conditions. Microorganisms break it down into other compounds in soil and surface waters (ATSDR 1992).

Reproductive effects of pentachlorophenol on rats exposed to pentachlorphenol in the diet for up to 24 months occurred at a dose of 30 mg/kg/day while a dose of 3 mg/kg/day caused no adverse reproductive effects (Coulston and Kolbye 1994). These doses were considered chronic LOAELs and NOAELs, respectively. Chickens fed pentachlorophenol for 8 weeks showed adverse effects on growth at a dose of 200 mg/kg/day but not at 100 mg/kg/day (Eisler 1989). These doses are considered chronic LOAELs and NOAELs, respectively.

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

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.

Eisler, R. 1989. *Pentachlorophenol hazards to fish, wildlife, and invertebrates: a synoptic review*. U.S. Fish and Wildlife Service Biological Report 85(1.17), Contaminant Hazard Reviews Report No. 17. 72 pp.

Pronamide

Information regarding pronamide was not available in the literature.

Polycyclic 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 hematopoietci and lymphoid tissues, ovatoxicity, 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 LD_{50}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.

Acenaphthylene

Information regarding acenaphthylene was not available in the literature. For mammals, data for acenaphthene was applied to this chemical. For birds, data for benzo(a)pyrene was applied to this chemical.

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.

Carbazole

Information regarding carbazole was not available in the literature.

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.

Dibenz(a,h)anthracene

Information regarding dibenz(a,h)anthracene 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.

Naphthalene

Mice fed naphthalene orally for 13 weeks showed adverse reproductive effects at a dose of 1400 mg/kg/day (ATSDR 1995). This dose was considered a chronic LOAEL. A chronic NOAEL of 140 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1.

Mallards fed naphthalene 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.

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

1,1,1,2-Tetrachloroethane

No information regarding 1,1,1,2-tetrachloroethane was available in the literature.

Carbon Tetrachloride

Carbon tetrachloride is a clear liquid that was produced in large quantities to make refridgeration fluid and propellant for aerosol cans. Production of this chemical is being phased out due its harmful effects on the ozone layer. Carbon tetrachloride evaporates very easily and can remain in the air for several years. Carbon tetrachloride does not adhere to soil or sediment particles but instead will move to the groundwater where it will be broken down into other chemicals.

A two-year study on the effects of carbon tetrachloride on reproduction in rats indicated a chronic NOAEL of 16 mg/kg/day (Alumot et al. 1976). This was the highest dose administered and no adverse effects were observed. A chronic LOAEL of 160 mg/kg/day was estimated by multiplying the chronic NOAEL by an uncertainty factor of 10. No data were found on the toxicological effects to birds from ingestion exposures.

Alumot, E., E. Nachtomi, E. Mandel et al. 1976. Tolerance and acceptable daily intake of chlorinated fumigants in the rat diet. *Food Cosmet. Toxicol.* 14:105-110.

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.

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.

n-Butylbenzene

Information regarding n-butylbenzene was not available in the literature.

n-Propylbenzene

Information regarding n-propylbenzene was not available in the literature.

Pentachloroethane

Information regarding pentachloroethane was not available in the literature.

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.

Quast J.F., C.G. Humiston, and R.V. Kalnins. 1979. Results of a toxicity study of monomeric styrene administered to beagle dogs by oral intubation for 19 months. Report to manufacturing Chemists Association, Washington, D.C., by Health and Environmental Sciences, Dow Chemical USA, Midland, MI.

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.

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

Nawrot, P.S. and R.E. Staples. 1979. Embryofetal toxicity and teragenicity of benzene and toluene in the mouse. *Teratology.* 19: 41A.

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.

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.

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.

Xylenes

Xylene is primarily a man-made chemical that is produced from petroleum and coal. Xylene also occurs naturally in petroleum and coal tar, and is formed during forest fires. There are three forms or isomers of xylene including *meta*-xylene, *ortho*-xylene, and *para*-xylene.

Xylene evaporates and burns easily. Xylene does not mix well with water, however, it does mix with alcohol and with many other chemicals. Xylene is a liquid and it can leach into soil, surface water (creeks, streams, and rivers), and groundwater where it can remain for 6 months or longer before it is broken down into other chemicals. Because it evaporates readily, most xylene is transported to the air, where it lasts for several days and is broken down by sunlight into other kinds of chemicals.

Results of studies with animals indicate that large amounts of xylene can cause changes in the liver and adverse effects on the kidney, lung, heart, and nervous system. Short-term exposure to high concentrations of xylene causes death in some animals, as well as muscular spasms, incoordination, hearing loss, changes in behavior, changes in organ weights, and changes in enzyme activity. Long-term exposure to low concentrations of xylene has not been well studied in animals (ATSDR 1990).

A study on the effects of xylene on the reproduction in mice indicated a chronic LOAEL of 2.6 mg/kg/day (Marks et al. 1982). A dose of 2.6 mg/kg/day showed significantly reduced fetal weights and increased the incidence of fetal malformations. While the xylene exposure studies were of a short duration, they occurred during a critical lifestage. The highest dose that produced no adverse effects (2.1 mg/kg/day) was considered to be a chronic NOAEL.

Quail exposed to xylene in the diet showed chronic effects at an estimated dose of 405 mg/kg/day (Hill and Camardese 1986). A chronic NOAEL of 40.5 mg/kg/day was estimated by multiplying this chronic LOAEL by an uncertainty factor of 0.1.

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

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.

Marks, T.A., T.A. Ledoux, and J. A. Moore. 1982. Teratogenicity of a commercial xylene mixture in the mouse. *J. Toxicol. Environ. Health.* 9:97-105.

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:

$$C_s = (K_{oc})(f_{oc})(CPW) \quad \text{(Equation D-3)}$$

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):

$$Log\ K_{oc} = 0.00028 + (0.983)(Log\ K_{ow}) \quad \text{(Equation D-5)}$$

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.

References

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