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Final

Steps 3b and 4 of the Baseline Ecological Risk Assessment
SWMU 45
Naval Activity Puerto Rico
RCRA/HSWA Permit No. PR21700027203
Ceiba, Puerto Rico

Prepared for

Department of the Navy

Atlantic Division

Naval Facilities Engineering Command
Norfolk, Virginia
Under the
LANTDIV CLEAN Program

Contract No. N62470-02-D-3052
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July 26, 2006

Prepared by

CH2M HILL
Federal Group, Inc.

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

FINAL

STEPS 3b AND 4 OF THE BASELINE ECOLOGICAL RISK ASSESSMENT SWMU 45

NAVAL ACTIVITY PUERTO RICO
RCRA/HSWA PERMIT NO. PR2170027203
CEIBA, PUERTO RICO

CONTRACT TASK ORDER 108

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DEPARTMENT OF THE NAVY
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Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

CH2M Hill
Herndon, Virginia

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
ARAR	Applicable, Relevant, and Appropriate Regulations
As	Arsenic
AUF	Area Use Factor
AVS	Acid Volatile Sulfide
Baker	Baker Environmental, Inc.
bgs	below ground surface
BRAC PMO SE	Base Realignment and Closure Program Management office South East
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Cd	Cadmium
CLP	Contract Laboratory Program
cm	Centimeter
CMS	Corrective Measures Study
CNO	Chief of Naval Operations
CS	Confirmation Study
CTO	Contract Task Order
DCQAP	Data Collection Quality Assurance Plan
DMP	Data Management Plan
DoN	Department of the Navy
DQO	Data Quality Objective
DRMO	Defense Reutilization and Marketing Office
EA	Environmental Assessment
Eh	Oxidation-Reduction Potential
EP	Extraction Procedure
ERA	Ecological Risk Assessment
EqP	Equilibrium Partitioning
ER-L	Effects Range-Low
ER-M	Effects Range-Median
FS	Feasibility Study
FSAP	Field Sampling and Analysis Plan
GIS	Geographical Information System
GPS	Global Positioning System
HASP	Health and Safety Plan
Hg	Mercury
HQ	Hazard Quotient
HSWA	Hazardous and Solid Waste Amendments
IDW	Investigative Derived Waste
ICM	Interim Corrective Measure
IR	Installation Restoration

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

km	kilometer
K_{ow}	Octanol-Water Partition Coefficient
LEL	Lowest Effects Level
LOAEL	Lowest Observed Adverse Effects Level
m	meter
MeHg	Methlymercury
MeSe	Methylselenium
mg/kg	
mg/kg-bw/day	milligram per kilogram body weight per day
mg/L	
MHW	Mean High Water
MLW	Mean Low Water
MSL	Mean Sea Level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAPR	Naval Activity Puerto Rico
NEESA	Naval Energy and Environmental Support Activity
NFESC	Naval Facilities Engineering Service Command
NSRR	Naval Station Roosevelt Roads
NAVFAC	Naval Facilities Engineering Command
NOAEL	No Observed Adverse Effects Level
NOEC	No Observed Effect Concentration
OBIS	Ocean Biogeographic Information System
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PEL	Probable Effects Level
PMP	Project Management Plan
PPE	Personal Protective Equipment
ppm	parts per million
ppt	parts per thousand
PRDNR	Puerto Rico Department of Natural Resources
PRG	Preliminary Remediation Goal
QA/QC	Quality Assurance/Quality Control
RAC	Remedial Action Contractor
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

SCL	Standard Carapace Length
Se	Selenium
SOP	Standard Operating Procedure
SSI	Supplemental Site Investigation
SWMU	Solid Waste Management Unit
TEL	Threshold Effects Level
TNRCC	Texas Natural Resource Conservation Commission
TOC	Total Organic Carbon
UCL	Upper Confidence Limit
ug/kg	micrograms per kilogram
ug/g	micrograms per gram
USC	United States Code
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank

1.0 INTRODUCTION

This document presents Step 3b (baseline risk assessment problem formulation) and Step 4 (baseline risk assessment study design/data quality objectives) of the Navy ecological risk assessment (ERA) process (Chief of Naval Operations [CNO], 1999) for Solid Waste Management Unit (SWMU) 45 – Area Outside Building 38 (Former Power Plant), located at Naval Activity Puerto Rico (NAPR), Ceiba, Puerto Rico. Steps 1 though 3a of the ERA process for SWMU 45 have been finalized and are presented in the document entitled *Final Additional Data Collection Report and Screening Level Ecological Risk Assessment and Step 3a of the Baseline Ecological Risk Assessment* (Baker, 2006). This report has been prepared under the Corrective Action provisions of the NAPR's Resource Conservation and Recovery Act (RCRA) Permit No. PR2170027203. This document is based upon previous investigations and has been prepared by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division, Naval Facilities Engineering Command (NAVFAC Atlantic), Contract Number N62470-02-D-3052, Contract Task Order (CTO) 0108.

This Work Plan is to be used in conjunction with the Master Project Management Plan (PMP), Master Data Collection Quality Assurance Plan (DCQAP), Data Management Plan (DMP), and Master Health and Safety Plan (HASP) for NAPR, submitted under separate cover (Baker, 1995). Together, these plans provide all details regarding field investigation techniques, laboratory analysis, data validation, and data evaluation required to fulfill the requirements of the RCRA Facility Investigation (RFI) program. These plans provide the details for sampling and analysis protocols to be followed and general activities to be accomplished for the SWMU 45 baseline ERA. Addendums to the DCQAP and HASP have been prepared to address specific issues related to this investigation (see Appendix A and Appendix B, respectively). This document will supplement the Master Plans with site-specific information for the SWMU 45 baseline ERA.

1.1 Investigation Objectives

The primary purpose of the investigation at SWMU 45 is to provide additional data with which to refine previous risk estimates for ecological receptors from potential exposures to the polychlorinated biphenyl (PBC) Aroclor-1260 and the metals arsenic, cadmium, mercury, and selenium in sediment. These chemicals were identified as potential ecological risk drivers by the screening-level ERA (Steps 1 and 2) and Step 3a of the baseline ERA (Baker, 2006), which is summarized in Section 3.1. Once the data outlined in this document are collected (Steps 5 and 6 of the ERA process), they will be evaluated, along with previously collected data, in order to develop refined ecological risk estimates (Step 7). If unacceptable risks are indicated following Step 7, these data also will be used to develop ecologically-based Preliminary Remediation Goals (PRGs) for sediment to aid the risk management decision-making process.

The components of the Step 4 studies, as outlined in this document, will provide multiple lines of evidence on which to evaluate potential ecological risks or existing ecological impacts. These lines of evidence are site-specific, direct measures of potential ecological effects and are thus preferable to the comparison of chemical concentrations in environmental media to conservative, non-site-specific screening values, and other overly conservative assumptions associated with food web exposures, which form the basis for screening-level risk estimates. The use of multiple lines of evidence also reduces the dependence on any one type of data and thus reduces the uncertainty of the analysis, allowing more confident decisions to be made about the need for, and extent of, remedial actions.

The specific objectives of the baseline ERA at SWMU 45 are:

- Provide site-specific data (e.g., bulk-sediment toxicity test data and tissue concentrations in aquatic food items [seagrass]) with which to refine previous ecological risk estimates.

- Proved an examination of sea turtle life history information and a summary of available sea turtle habitat in the area of SWMU 45 to determine their potential for exposure to chemicals detected in embayment sediment.

- Provide the necessary data with which to develop ecologically-based PRGs for sediment to aid the risk-management decision-making process should unacceptable ecological risks be identified in Step 7 of the baseline ERA.

1.2 Report Organization

These project plans are organized as follows:

Section 1.0	Introduction
Section 2.0	Environmental Setting
Section 3.0	Baseline Risk Assessment Problem Formulation
Section 4.0	Study Design/Data Quality Objectives
Section 5.0	Field Sampling and Analysis Plan
Section 6.0	Project Schedule
Section 7.0	References

2.0 ENVIRONMENTAL SETTING

The sections that follow provide a brief description of the facility and SWMU 45. The habitats occurring within and contiguous to SWMU 45 are also described, as well as the biota that may be present. The description of habitats and biota relies primarily on literature-based information for Puerto Rico and NAPR. This information is supplemented by observations recorded during a habitat characterization conducted at SWMU 45 in May 2000 (upland habitats) and June 2000 (marine habitats). The habitat characterization report, prepared by Geo-Marine, Inc. (Plano, Texas), is included as Appendix C.

2.1 Facility Description

NAPR occupies over 8,600 acres on the northern side of the east coast of Puerto Rico, along Vieques Passage with Vieques Island lying to the east about 10 miles off the harbor entrance. The north entrance to NAPR is about 35 miles east along the coast road (Route 3) from San Juan. The closest large town is Fajardo (population approximately 37,000), which is located approximately 10 miles north of NAPR off Route 3. Ceiba (population approximately 17,000) adjoins the west boundary of NAPR (see Figure 2-1).

NAPR was commissioned in 1943 as a Naval Operations Base, and was redesignated a Naval Station in 1957 (Naval Station Roosevelt Roads [NSRR]). In March 2003, NSRR was disestablished and the base was designated as Naval Activity Puerto Rico. Currently NAPR is in caretaker status to preserve the present resources.

2.2 SWMU 45 Description

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 2-2). The former power plant contained a 60-megawatt steam turbine facility that operated from the early 1940s through 1949 (Naval Energy and Environmental Support Activity [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 over one hundred feet 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). The discharge tunnel terminates somewhere in the 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.

2.2.1 Regulatory Framework and Site History

In 1943, NAPR was commissioned as a Naval Operations Base. NAPR continued in this status until 1957 when it was redesignated as NSRR with the mission of providing full support for Atlantic Fleet weapons training and development activities. Until 1993, all environmental operations, with the exception of USTs, were conducted under the Department of the Navy's (DoN) Installation Restoration (IR) Program, which followed a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) pattern. Under the IR Program, 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, and a report entitled *Final Closeout Report for Interim Remedial Action of PCB Contaminated Soils, Sites 15 and 16 at Naval Station Roosevelt Roads, Puerto Rico* was submitted to the United States Environmental Protection Agency (USEPA) in May 1995 (OHM, 1995). [It is noted that the "Site 16" referenced in the report title is the IR Program designation for what is now SWMU 45.]

NAPR submitted a RCRA Part B Permit application for the storage of hazardous waste on the Base. RCRA regulations provide a procedure to investigate and remediate areas that may have been affected by a release of hazardous wastes. The first steps for investigating a site are the RCRA Facility Assessment (RFA) and the RFI. These assessments and investigations are studies on a property to determine if there has been a release of hazardous waste, and to quantify any releases that have occurred. If these studies determine that a release has occurred, a Corrective Measures Study (CMS) is performed to identify the most appropriate corrective measure for a given site. 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 USEPA 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 *Draft Supplemental Investigation, Installation Restoration Program Activities, Naval Station Roosevelt Roads, Ceiba, Puerto Rico* (Baker 1993).

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

On October 20, 1994, a Final RCRA Part B permit was issued by the USEPA Region II to the Defense Reutilization and Marketing Office (DRMO) of NSRR as RCRA/Hazardous and Solid Waste Amendments (HSWA) Permit No. PR2170027203. The corrective action provisions of the permit contained specific requirements for investigation, and potentially, remediation at SWMU 45, as well as required RFI activities at 25 SWMUs and 3 AOCs. Two additional SWMUs (53 and 54) were identified during May of 2000, bringing the total to 27 SWMUs and 3 AOCs.

The RCRA Part B permit required a full RFI for SWMU 45. RFI Work Plans (Baker, 1995) were developed for NAPR that included SWMU 45. The work plan provided the framework for site characterization activities; its scope was guided by the results of the SSI. The field investigation for SWMU 45 proposed in this work plan was conducted during November 1996 and September/October 1997. The Draft RFI Report for Operable Unit (OU) 3/5 (including SWMU 45) was submitted in March 1998 (Baker, 1999). The report confirmed the findings of the SSI, in 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 USEPA 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 USEPA) that provided for the filling of the USTs and sealing the tunnel with low density concrete. This approach entombed and effectively immobilized any residual contamination (OHM, 1997).

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 USEPA. The work was performed and the results were presented in the *Revised Draft RCRA Facility Investigation Report for Operable Unit 3/5* (Baker 1999), which was approved by the

EPA on September 28, 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.

Based on the recommendations presented in the Revised Draft RFI Report for OU 3/5 (Baker, 1999), a Revised Final II CMS Work Plan was submitted on July 14, 2000 and approved by the USEPA on May 4, 2001. A *Draft Screening-Level Ecological Risk Assessment Problem Formulation (Step 1) and Exposure Estimate* (Baker, 2001b), as well as the *Draft Additional Data Collection Work Plan in Support of Ecological Risk Assessment for SWMU 45* (Baker, 2001a) were submitted on August 10, 2001. The USEPA approved the above documents in their letter dated October 4, 2001. The Navy submitted a letter to the USEPA stating the lack of funding to perform the work associated with SWMU 45. The Navy submitted a response to USEPA's comment letter dated October 4, 2001, as well as an *Addendum to the Draft Screening Level ERA Problem Formulation (Step 1) and Exposure Assessment for SWMU 45* on May 22, 2003 (Baker, 2003). The USEPA approved the above addendum on June 10, 2003. The field investigation associated with the USEPA-approved Additional Data Collection Work Plan was initiated and completed in August 2003. A screening-level ERA and Step 3a of the baseline ERA, which utilized the results from the August 2003 additional data collection field investigation was finalized in January 2006 (Baker, 2006). The objectives of the current document are based on the conclusions and recommendations of the screening-level ERA and Step 3a report, as described below.

2.2.2 Previous Investigations

The 1988 Confirmation Study (CS) conducted by Environmental Science and Engineering, Inc. included the collection of 38 soil samples from the site (9 samples in Round 1 and 29 samples in Round 2). The analytical results indicated the presence of PCB and lead contamination at the site. Lead concentrations were less than the extraction procedure (EP) toxicity standard. Based on USEPA Region II review, the quality of the data obtained during the CS is questionable due to the unknown level of laboratory data quality objectives and the apparent lack of independent, third party data validation. Therefore, no conclusions regarding conditions at the site were drawn on the basis of this information.

A Remedial Investigation/Feasibility Study (RI/FS) conducted by Versar in 1992 determined that concrete surfaces, sediments, and soil surrounding Building 38 were contaminated with PCBs at levels exceeding applicable, relevant, and appropriate regulations (ARARs). Additionally, surface water and wipe samples collected from the cooling water tunnel and underground storage tank manways were contaminated and required further investigation as separate operable units (designated IR Site 16). Contamination was reported to a depth of at least one foot; however, the presence of coral prevented deeper sampling. The RI/FS focused on the soil/sediment operable unit.

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

During the Supplemental Investigation (Baker, 1993), seven surface water and six sediment samples were collected. Organic contaminants including toxaphene, endosulfan II, and Aroclor-1260 were detected in both media.

An ICM was performed for SWMU 45 to address the reported discharges of product from the cooling water tunnels. These actions included the breaching and sealing of the intake and discharge cooling

water tunnels with cast-in-place concrete, removal of liquids and sludge from the underground storage tanks and tunnels, backfilling the storage tanks with concrete, and the sealing of manway entrances to the storage tanks and cooling water tunnels. Remediation at the site was performed by the Remedial Action Contractor (RAC) OHM, Inc. Work began in May 1996 and was completed in November 1996.

In 1996 and again in 1997, a RFI field investigation was conducted at SWMU 45. Environmental media collected during these field investigations at SWMU 45 included surface soil, subsurface soil, groundwater, and sediment. The field investigations and associated analytical data for SWMU 45 were presented and discussed in the USEPA-approved Revised Draft RFI for OU 3/5 (Baker, 1999). The reader is referred to this document for a detailed description of sampling activities and analytical data. The additional data collection field investigation performed in August 2003 was designed to address the surface water and sediment data gaps in the Open Water Marine Environment as presented in the *Draft Screening Level ERA Problem Formulation (Step 1) and Exposure Estimate for SWMU 45* (Baker, 2001b). In addition to the nine surface water samples and the fourteen sediment samples collected as part of this effort, nine base background open water surface water and sediment samples were also collected. This data supported the screening-Level ERA and Step 3a refinement, which was finalized in 2006 (Baker, 2006) and is discussed in detail in Section 3.1.

2.2.3 Terrestrial and Marine Habitats

A description of terrestrial habitats within and contiguous to SWMU 45, as well as a description of the marine habitats occurring within the small cove of Puerca Bay is provided in the sections that follow. As discussed in Section 4.1, the description of habitats relies primarily on literature-based information for Puerto Rico and NAPR, and is supplemented by site-specific observations recorded during the habitat characterization conducted at SWMU 45 in May 2000 (upland habitats) and June 2000 (marine habitats).

2.2.3.1 Terrestrial Habitats

The upland habitat bounded by NAPR 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, 1998). After acquisition by the Navy, a secondary growth of thick scrub, dominated by lead tree (*Leucaena spp.*), Christmas tree (*Randia aculeate*), sweet acacia (*Acacia famesiana*), and Australian corkwood (*Sesbania grandiflora*) grew in the previously grazed sections (Geo-Marine, 1998). Secondary growth communities (upland coastal forest communities and coastal scrub forest communities) exist today throughout the station's undeveloped upland. The upland vegetative community within and contiguous to SWMU 45 is classified as a coastal scrub forest community (see Figure 2-3). Shrubs, including wild tamarind (*Leucaena leucocephala*), dwarf poinciana (*Caesalpinia pulcherrima*), bottle wiss (*Capparis flexusa*), and prickly mampoo (*Pisonia aculeate*) dominate the community. Maintained grasses, including *Bothriochloa ischaemum*, *Chloris barbata*, and *Digitaria sp.*, dominate areas immediately adjacent to road corridors. The fringe of the cove has near 100 percent shrub cover with little herbaceous vegetation. The community is dominated by seaside mahoe (*Thespesia populnea*), with sparse coverage by black mangroves (*Stachytarpeta jamaicensis*) and sea pusley (*Hellotropium curassavicum*).

Cobana negra (*Stahlia monosperma*), a federally threatened tree species, is known to occur 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). A single individual has been reported at NAPR. Although the location of the sighting was not documented, NAPR personnel believe the tree is located within the coastal forest community behind the former

Navy Exchange store, northwest of SWMUs 1 and Langley drive. Cobana negra were not observed at SWMU 45 during the May 15 to May 19, 2000 habitat characterization.

2.2.3.2 Marine Habitats

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

The nearest open water habitat downgradient from SWMU 45 is the Puerca Bay cove. As described above, a cooling water intake tunnel extends from Building 38 out into this cove. A reconnaissance survey of the cove, conducted on June 19, 2000 as part of the habitat characterization at SWMU 45, identified the following distinct habitats: (1) rocky subtidal zone comprised of riprap extending from above Mean High Water (MHW) to approximately 3 feet below Mean Low Water (MLW); (2) shallow subtidal shelf (3 to 10 feet below Mean Sea Level [MSL]) characterized as a seagrass/algae bed dominated by turtle grass; (3) shelf slope (10 to 15 feet below MSL) devoid of seagrass and dominated by marine algae; and (4) unvegetated sand to silty-sand bottom (15 to 20 feet below MSL) located within the interior of the cove from its mouth with Puerca Bay to and around the cooling water intake structure. The concrete sidewalls of the cooling tunnel intake structure also serves as habitat, supporting a hardbottom community dominated by soft corals, marine algae, and sponges.

A map showing the spatial relationship of SWMU 45 to the embayment is provided as Figure 2-4. Included on this figure are wetland units identified by the Cowardian Wetland Classification System (Cowardian et al., 1979 [see Figure 2-5]). The wetlands depicted on Figure 2-4 were delineated by Geo-Marine, in December 1999 from 1993 color infrared and 1998 true color aerial photography. Twenty percent of the wetlands delineated by aerial photography were field checked to verify the accuracy of the delineations. Field verification was based on the 1987 Corps of Engineers wetland delineation manual (United States Army Corps of Engineers [USACE], 1987). As evidenced by Figures 2-4 and 2-5, there are no freshwater or marine wetland units within or contiguous to SWMU 45.

2.2.3.3 Biota

A description of the biota occurring within Puerto Rico and the landmass encompassed by NAPR is provided in the sections that follow. This description is supplemented by information contained within the habitat characterization report included as Appendix C.

2.2.3.3.1 Mammals

A total of 22 terrestrial mammal species are known historically from Puerto Rico; however, all mammals except bats (13 species) have been extirpated (United States Geological Survey [USGS], 1999). None of the bats found on Puerto Rico are exclusive to the island. The West Indian manatee is known to occur in the marine environment surrounding NAPR. As depicted on Figure 2-3 and discussed in Section 2.2.3.2, seagrass (i.e., turtle grass) occurs within the small cove of Puerca Bay.

The location of the seagrass (shallow subtidal shelf 3 to 10 feet below MSL) represents potential feeding habitat for this marine mammal.

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

2.2.3.3.2 Birds

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 NAPR (Geo-Marine, 1998). A list compiled from literature-based information pre-dating 1990 (see Table 2-1) 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 NAPR include the Puerto Rican lizard cuckoo (*Saurothera vieilloti*), Puerto Rican flycatcher (*Myiarchus antillarum*), Puerto Rican woodpecker (*Malanerpes portoricensis*), Puerto Rican emerald (*Chlorostilbon maugaeus*), and yellow-shouldered blackbird (*Agelaius xanthomus*).

The yellow-shouldered blackbird is a federally endangered species. One of the principal reasons for the status of this species is attributed to parasitism by the nonindigenous shiny cowbird, which lays its eggs in blackbird nests and sometimes punctures the host's eggs (USFWS, 1983). Other factors contributing to the status of this species include nest predation by the introduced black rat, Norway rat, and mongoose, as well as habitat modification and destruction (USFWS 1996). The entire land area of NAPR was declared critical habitat for the yellow-shouldered blackbird in 1976; however, a 1980 agreement with the USFWS exempted certain areas from this categorization (Geo-Marine, 1998). A study conducted by the Naval Facilities Engineering Service Command (NFESC, 1996) reported that the mangrove forests surrounding NAPR should be considered the most important nesting habitats for the yellow-shouldered blackbird. SWMU 45 is outside the critical habitat designation for the yellow-shouldered blackbird; however, potential feeding habitat (shrubland) is present at the site (Geo-Marine, 2000). A survey conducted by the Puerto Rico Department of Natural Resources (PRDNR, 2002) reported fifteen yellow-shouldered blackbirds (including five juveniles) at NAPR. At the time of the survey, the birds were using structures at the NAPR airport for resting cover. Although nesting pairs were not observed (the survey was not conducted during the breeding season), the airport structures contained several inactive nests. The inactive nests and juvenile birds indicate that a small breeding population is present at NAPR. However, yellow-shouldered blackbirds were not observed within the coastal scrub forest community contiguous to SWMU 45 (Geo-Marine, 2000). Other federally listed bird species that have been reported at NAPR 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, 1998). Given their habitat preferences for feeding (open water), the brown pelican and roseate tern have the potential to use the small cove as a food source.

Several bird species typically associated with coastal forests were observed at SWMU 45 during the habitat characterization (see Appendix C). Specific species observed were the killdeer (*Charadrius vociferous*), common ground dove (*Columbina passerina*), frigatebird (*Fregata magnificens*), pearly-eyed thrasher (*Margarops fascatus*), northern mockingbird (*Mimus polygottos*), greater antillen grackle (*Quiscalus niger*), cave swallow (*Pterochelidon fulva*), gray kingbird (*Tyrannus dominicensis*), white-winged dove (*Zenaida asiatica*), zenaida dove (*Zenaida aurita*), and yellow warbler.

2.2.3.3.3 Reptiles and Amphibians

A total of 23 amphibians and 47 reptiles are known from Puerto Rico and the adjacent waters (USGS, 1999). Fifteen of the amphibians and 29 of the reptiles are endemic, while four amphibian species and three reptilian species have been introduced (USGS, 1999). Puerto Rico's native amphibian species include 16 species of tiny frogs commonly called coquis. On the coastal lowlands, almost all coqui species are arboreal. The only amphibians listed under provisions of the Endangered Species Act of 1973 are the Puerto Rican ridge-headed toad (*Peltophryene lemur*) and the golden coqui (*Eleutherodactylus jasperi*). Both species are listed as threatened. Distribution of the golden coqui is restricted to areas of dense bromeliad growth. All specimens to date have been collected from a small semicircular area of a 6-mile radius south of Cayeye (approximately 30 miles southwest of NAPR), generally at elevations above 700 meters (USFWS, 1984). The Puerto Rican ridge-headed toad occurs at low elevations (below 200 meters) where there is exposed limestone or porous, well drained soil offering an abundance of fissures and cavities (USFWS, 1987). A single large population is known to exist from the southwest coast in Guánica Commonwealth Forest, and a small population is believed to survive on the north coast near Quebradillas, Arecibo, Barceloneta, Vega Baja, and Bayamón (USFWS, 1987). It has also been collected on the southeastern coastal plain near Coamo (USFWS, 1987). Given the habitat preferences and locations of known occurrences, these two species are not expected to occur at NAPR.

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, as well as the leatherback sea turtle (*Caretta caretta*) and the Puerto Rican boa (*Epicrates inornatus*) represent the reptilian species listed under the provisions of the Endangered Species Act of 1973 (USGS, 1999). Given the presence of seagrass within the small cove of Puerca Bay, this surface water body represents potential feeding habitat for the listed sea turtles.

The Puerto Rican boa uses a variety of habitats but is most commonly found in karst forest habitats. Given the absence of karst forest habitat and the absence of any known occurrence of this species at or contiguous to Building 38 (Geo-Marine, 1998 and 2000), there is a low probability of occurrence for this species at SWMU 45. The only reptile species observed with the upland habitat at SWMU 45 during the May 2000 habitat characterization (Geo-Marine, 2000) was a lizard (crested anole [*Anolis cristatellus*]).

2.2.3.3.4 Fish and Aquatic Invertebrates

A diverse fish and invertebrate community can be found in the marine environment surrounding NAPR. This can be attributed to the varied habitats that include marine and estuarine open water habitat, mud flats, sea grass beds, and mangrove forests. The fish community is represented by stingrays, herrings, groupers, needlefish, mullets, barracudas, jacks, snappers, grunts, snooks,

lizardfishes, parrotfishes, gobies, filefishes, wrasses, damselfishes, and butterflyfish (Geo-Marine, 1998). The benthic invertebrate community includes sponges, corals, anemones, sea cucumbers, sea stars, urchins, and crabs.

Marine invertebrates observed within the small cove of Puerca Bay during the marine reconnaissance survey included sea urchins (*Echinometra lucunter* and *Echinometra viridis*), encrusting fire coral (*Millipora alcicormus*), common sea fan (*Gorgonia venalina*), starlet coral (*Siderastrea ammulatta*), pincushin starfish (*Oreaster reticulate*s), and corkscrew anemone (*Bartholomea annulatta*), as well as two species of sea cucumbers (*Actinopyga agassizii* and *Holothuria mexicana*). In addition to invertebrates, sixteen fish species were observed with in the cove. The specific species encountered included the sergeant major (*Abudefduf saxatillis*), dusky damselfish (*Stegates fuscus*), tomtate (*Haemulon aurolineatum*), gray snapper (*Lutjanus griseus*), squirrelfish (*Holocentrus sp.*), yellow fin mojarra (*Gerres cinereus*), and silver jenny (*Eucinostomus gula*). A complete list of the benthic invertebrate and fish species encountered within each of the cove's habitats is included within the habitat characterization report included as Appendix C.

3.0 BASELINE RISK ASSESSMENT PROBLEM FORMULATION

The baseline ERA problem formulation (Step 3b of the Navy ERA process) is focused on defining the issues associated with the potential ecological risk drivers identified in Step 3a of the baseline ERA (i.e. Aroclor-1260, arsenic, cadmium, mercury, and selenium). This revised problem formulation consists of an evaluation of the fate and transport and potential toxicity of these chemicals and presents a refined conceptual model. The conceptual model includes a discussion of exposure pathways, assessment endpoints, and risk hypotheses specific to contaminant-receptor combinations requiring further evaluation, as identified in the Step 3a evaluation, and summarized below.

3.1 Screening-Level Ecological Risk Assessment and Step 3a Summary

The Navy ERA process consists of eight steps organized into three tiers and represents a clarification and interpretation of the eight-step ERA process outlined in the USEPA ERA guidance for the Superfund program (USEPA, 1997). Tier 1 of the Navy ERA process represents the screening-level ERA:

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

Under Navy policy, if the results of Step 1 and Step 2 (Tier 1 screening-level ERA) indicate that, based on a set of conservative exposure assumptions, there are chemicals present in environmental media that may present a risk to receptor species/communities, the ERA process proceeds to the baseline ERA. According to Superfund guidance (USEPA, 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 preliminary conceptual model. The evaluation of risks in Step 3a may also include consideration of background data, chemical bioavailability, and the frequency of detection. If the re-evaluation of the conservative exposure assumptions does not support an acceptable risk determination, the site continues in the baseline ERA process (Step 3b baseline ERA problem formulation).

In conjunction with the RFI at SWMU 45, a screening-level ERA and Step 3a of the baseline ERA were conducted (Baker, 2006). The screening-level ERA and Step 3a included an evaluation of the terrestrial habitat and aquatic habitat associated with the site. A summary of this evaluation is provided below.

No ecological risk drivers were identified for terrestrial lower and upper trophic level receptors exposed to soils and to aquatic lower trophic level receptors exposed to surface water and no further evaluation was recommended. Based on statistical comparisons, on the lack of observed exceedances of a reference hazard quotient (HQ) of 1.0 for detected chemicals, and on confirmation that there is no "dilution" of maximum concentrations requiring further investigation, the conclusion of the screening-level ERA was that the levels of chemicals in soil and surface water do not pose an unacceptable potential for risk to ecological receptor populations.

Based on the evaluation of chemicals detected in sediments, Aroclor-1260 has the potential to impact aquatic receptor communities (i.e., benthic macroinvertebrates) within the embayment downgradient from SWMU 45. Aroclor-1260 was detected in nineteen of twenty-three sediment samples, at concentrations ranging from 12J to 150 micrograms per kilogram (ug/kg) (Table 3-1 and Figure 3-1).

The detected concentration in seventeen samples exceeded the sediment screening value of 21.6 ug/kg (MacDonald, 1994), which represents a Threshold Effects Level (TEL). The TEL represents the upper limit of the range of sediment concentrations dominated by "no effects" data. Within this range, concentrations are not considered to represent significant hazards to sediment-associated biota. Historical activities conducted at Building 38 (storage and maintenance of PCB transformers) and the evaluation of potential transport pathways presented indicate that Aroclor-1260 may have migrated to the embayment via the cooling water intake tunnel. Based on a mean HQ greater than 1.0 (2.03) and the frequency of detections exceeding the sediment screening value (17/23), it was recommended that Aroclor-1260 be carried on to Step 3b of the baseline ERA (baseline ERA problem formulation). Table 3-2 presents the results of the screening-level risk calculation for aquatic lower trophic level receptor exposure to Aroclor-1260 in sediments.

Although the preliminary conceptual model for SWMU 45 did not indicate that arsenic, cadmium, mercury, and selenium are related to historical site activities, they were identified as potential ecological risk drivers for West Indian manatee aquatic food web exposures based on maximum HQ values greater than 1.0 (HQs = 38.77, 6.15, 21.35, and 2.33, respectively; Table 3-3) and the Federal status of the West Indian manatee in Puerto Rico (endangered). Arsenic, cadmium, mercury, and selenium were detected in 18 of 18, 11 of 18, 9 of 18, and 10 of 18 sediment samples, respectively (Table 3-1). Detected concentrations ranged from 3.2 to 12 mg/kg for arsenic, 0.08J to 1.3 mg/kg for cadmium, 0.015J to 0.42 mg/kg for mercury, and 0.21J to 0.78J milligrams per kilogram (mg/kg) for selenium (Table 3-1 and Figure 3-2). The uncertainty associated with the recommendation of further evaluation for these four metals was discussed in the screening-level ERA and Step 3a report. Specifically, two outfalls (Outfall 015 and Outfall NR-020) discharge to the embayment downgradient from SWMU 45 (Baker, 2006). Both outfalls discharge storm water runoff from roadways and parking lots, as well as runoff from building associated with administrative, industrial, and material storage areas activities unrelated to SWMU 45. Based on the presence of these two storm water outfalls, the elevated metal concentrations detected in embayment sediment are not likely associated with a release from SWMU 45. This is supported by the preliminary conceptual model for SWMU 45 and the evaluation of upgradient analytical data for surface soil, subsurface soil, and groundwater. As such, the evaluation of these metals as potential risk drivers related to SWMU 45 historic activities is considered a particularly conservative measure.

Potentially complete exposure pathways were identified for aquatic reptiles (i.e., sea turtles). However, based on the paucity of data concerning the toxicological effects of chemicals for reptiles, a quantitative evaluation could not be performed. Given the Federal status of sea turtles in Puerto Rico, additional evaluation was recommended in Step 3b of the baseline ERA.

In summary, Aroclor-1260 in sediment was identified as a potential risk driver for aquatic invertebrate populations and communities. Arsenic, cadmium, mercury, and selenium were identified as potential risk drivers for the West Indian manatee as a conservative measure, based on the federally endangered status of the species. The potential for risk from sediment contaminants to aquatic reptiles (i.e., sea turtles) could not be quantitatively addressed based on the lack of toxicological data. Additional evaluation of chemical concentrations in sediment was recommended for this receptor group in Step 3b of an aquatic baseline ERA. No risk drivers were identified for terrestrial receptors or for aquatic receptors exposed to surface water and further investigation was not recommended. No significant data gaps were identified requiring further investigation or evaluation prior to proceeding to a baseline risk assessment for SWMU 45.

3.2 Refined Conceptual Model

Information on the habitat features of the site and the fate and transport of Aroclor-1260, arsenic, cadmium, mercury and selenium are used to build the conceptual model. The conceptual model addresses complete exposure pathways, receptors, assessment endpoints, measurement endpoints, and risk hypotheses/questions. Figure 3-3 presents a graphical representation of the conceptual model for the aquatic habitats at SWMU 45. This figure illustrates the primary functional components of the aquatic ecosystem and highlights those components indicated to be at potential risk. The model has been revised to reflect the results of the screening-level ERA and Step 3a of the baseline ERA, focusing on the contaminant-receptor combinations where the potential for unacceptable impacts has been identified. The components of the SWMU 45 conceptual model are described in the following sections.

3.2.1 Contaminant Fate and Transport and Toxicity Evaluation

The following sections include an evaluation of the fate and transport and a toxicity evaluation of the chemicals identified as potential ecological risk drivers in the screening-level ERA and Step 3a evaluation: Aroclor-1260, arsenic, cadmium, mercury, and selenium. The toxicity evaluations are focused on the receptor-chemical combinations that have the potential for unacceptable impacts, as identified in the screening-level and Step 3a evaluation (i.e., Arclor-1260: benthic invertebrates, metals: West Indian manatee).

3.2.1.1 Aroclor-1260

Aroclor-1260 is one of many PCB compounds, which are complex mixtures of chlorinated hydrocarbons. PCBs are manufactured organic compounds, which were widely used from the late 1920s to the late 1970s in many applications that benefited from their high insulation capacity and nonflammable properties. They are typically viscous, oily liquids that are pale or clear colored. Aroclor-1260 is a mixture of over 100 individual compounds (congeners) comprised of 60 percent chlorine (by weight). Aroclor-1260 has very low water solubility, low vapor pressure, high octanol-water partition coefficient (K_{ow} = 6.08), low degradation rates, and the tendency to strongly adsorb to sediment, especially to fine-grained sediments and in the presence of organic carbon (ATSDR, 2000 and MacDonald, 1994). Sedimentary burial and immobilization of Aroclor-1260 for long time periods is possible, depending on the physical processes within the environment, the tendency to strongly partition to sediment, and the persistence of PCBs in general. Degradation and transformation of PCBs in the environment is dependent upon the degree of chlorination of the biphenyl molecule. PCBs with higher chlorine contents (including Aroclor-1260) are not readily oxidized, for example, though photodegradation over time can impact chlorine content and decrease resistance to other processes. Once mobilized by physical or biological processes (erosion, flocculation, microbial degradation, bioturbation), suspended sediment dynamics are important in the transport and fate of Aroclor-1260. In the dissolved state, volatilization of Aroclor-1260 can be an important process (USEPA, 1999).

The toxicity of PCBs in general is dependent on the particular congener mixture, the chemical structure of the compound, and environmental variables that impact bioavailability. For example, microbial dechlorination of PCBs has been found to reduce toxicity, though this process can mobilize a PCB compound, make it more soluble, and increase its bioavailability (Bushart et al., 1998). Reduced bioavailability is demonstrated in organic sedimentary environments, where PCBs are strongly sorbed to sediment particles (MacDonald, 1994 and USEPA, 1993). Aroclor-1260 is recognized as a bioaccumulative chemical, mobilization out of the sediments and into upper trophic level receptors via dietary exposures is an important transfer pathway (DiPinto and Coull, 1997). Trophic transfer factors, biota-sediment accumulation factors, and bioconcentration factors indicate that dietary uptate and

accumulation of PCBs in general are trophically dependent (Gerwurtz et al., 2000 and Maruya and Lee, 1998). Aroclor-1260 also has the potential to biomagnify in the food chain due to its high log $K_{ow,}$ slow metabolism and elimination, and tendency to partition to the lipid phase within organisms.

The toxicity of PCBs to invertebrates have been found to impact development and cellular physiology in sea urchins (Schweitzer et al., 1997) and hormonal and immune system impacts in fish (Barron et al., 2000) via direct contact exposures. However, PCBs are not considered to be highly toxic based on this exposure route (MacDonald, 1994). Impacts to higher trophic levels (included birds and mammals) are generally more significant, and include developmental abnormalities, behavioral and reproductive effects, and death (Fernie et al., 2001 and Barron et al., 2000). Based on the screening-level ERA and Step 3a investigation, Aroclor-1260 has the potential to impact aquatic invertebrates via direct contact exposures to sediment. Available Aroclor-1260 sediment benchmarks for benthic invertebrate species, in order of increasing concentration, include the following:

- 5 ug/kg: Freshwater sediment Lowest Effects Level (LEL) (Persaud et al., 1993)
- 5 ug/kg: USEPA Region VI freshwater sediment screening benchmark (Texas Natural Resource Conservation Commission [NRCC], 2001)
- 21.6 ug/kg: Marine TEL for total PCBs (MacDonald, 1994)
- 22.7 ug/kg: Effect Range-Low (ER-L) value for total PCBs (Long et al., 1995)
- 59.8 ug/kg: Consensus-Based Freshwater TEL for total PCBs (MacDonald et al., 2000)
- 180 ug/kg: Effect Range-Median (ER-M) value for total PCBs (Long et al., 1995)
- 189 ug/kg: Marine Probable Effects Level (PEL) for total PCBs (MacDonald, 1994)
- 676 ug/kg: Consensus-based freshwater PEL for total PCBs (MacDonald et al., 2000)
- 4,500,000 ug/kg: Equilibrium Partitioning (EqP) benchmark for freshwater sediments based on 1% total organic carbon (TOC) (Jones and Suter II, 1997)

Only one study (Murdoch et al., 1997) was identified from the literature which investigated the toxic effect of PCBs in marine or estuarine sediments to invertebrates. No Observed Effects Concentrations (NOECs) reported include:

- 27,700 ug/kg: Reproductive endpoint for marine polychaete exposed to total PCBs in spiked sediment (value normalized to organic carbon)
- 1,070 ug/kg: Reproductive endpoint for marine polychaete exposed to total PCBs in field-collected sediment (value normalized to organic carbon)

3.2.1.2 Arsenic

Arsenic is a naturally occurring element which exists mainly in rock or soil and cycles biogeochemically via oxidation and reduction (Eisler, 1988). Arsenate (pentavalent, As^{+5}) is the predominant inorganic form in oxygenated water (where it will be chemically bound to soil or sediment particles) and arsenite (trivalent, As^{+3}) is the predominant arsenic form under anaerobic conditions

(USEPA, 1981). Arsenite is water soluble and therefore more mobile and is considered to be the more toxic form (USEPA, 1999). Arsenic is readily adsorbed onto sediments with high organic matter and those with high clay content, sulphur, manganese, iron oxides and aluminum hydroxides (USEPA, 1999 and MacDonald, 1994). Adsorption and release also depend on the arsenic concentration, pH, oxidation-reduction potential (Eh), temperature, salinity, and the ionic concentration of other compounds (ATSDR, 2005 and Eisler, 1988). Transportation within the aquatic environment for bound arsenic, therefore, is largely a function of suspended sediment dynamics or larger-scale erosive events. Changes in the oxidative state and/or biological interactions can release arsenic back into the water column.

In soils, arsenic uptake is dependent upon the form of arsenic available and the physical and chemical properties of the soil, including organic carbon and clay content. Higher organic material and clay content favor binding within the soil to immobile forms, and thus less potential for uptake (USEPA, 1999). Arsenic is generally not bioavailable to aquatic organisms under aerobic conditions (MacDonald, 1994). Arsenic may be bioaccumulated by lower trophic level organisms; however, data does not indicate that significant biomagnification occurs (USEPA, 1999), especially in aquatic food chains. Once within the mammalian body, arsenic readily moves through the body and does not preferentially accumulate in any organs (USEPA, 1999). Arsenic is metabolized (methylated) readily in the liver of mammals to less toxic forms and is subsequently rapidly eliminated (USEPA, 1999). As such, the potential for bioaccumulation in mammalian tissues is minimal. Identified impacts to aquatic organisms include growth, reproduction, behavioral, mutagenic, and carcinogenic effects (MacDonald, 1994).

Based on the screening-level ERA and Step 3a investigation, arsenic in SWMU 45 sediment has the potential to impact the West Indian manatee via dietary (food web) exposures. The manatee is an herbivorous species, which feeds primarily on seagrasses. Uptake and adsorption of metals in general by submerged aquatic vegetation is influenced by salinity gradients along an individual plant (roots to stems), photosynthetic rates, and temporal periodicity, including growing season (Wasserman and Wasserman, 2002). A study comparing metals concentrations in aquatic plant material at the US Navy bombing range at Vieques and a neighboring reference location in Puerto Rico found arsenic concentrations of 0.61 micrograms per gram (ug/g) dry weight in manatee grass (*Syringodium filiforme*) within the bombing range and 1.04 ug/g in the reference area (Massol-Deyá et al., 2005). A literature search was conducted on the toxicological effects of arsenic ingestion to mammals as part of the screening-level ERA and Step 3a report (Baker, 2006). A 3-generation study on the reproductive effects of arsenite in mice determined a lowest observed effect level (LOAEL) of 1.26 mg/kg/day (Schroeder and Mitchner 1971, as summarized in Sample et al., 1996). At this dose, mice displayed declining litter sizes. A chronic no observed adverse effects level (NOAEL) of 0.126 mg/kg/day was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. This study forms the basis of the NOAEL and LOAEL values developed for the manatee, as discussed in Section 4.4.

3.2.1.3 Cadmium

Cadmium is a naturally occurring element found in phosphate rock. It is used in many industrial applications, including alloy manufacturing, batteries, plastics, paints, fuels, and agricultural products including fertilizers. It exhibits low vapor pressure and is found in two valence states: Cd^{+0} or Cd^{+2}. Cadmium is persistent in the environment and is generally stable in soil (ATSDR, 1999a). Terrestrial transformation processes include precipitation, complexation, ion exchange, and dissolution (USEPA, 1999). In the aquatic environment, cadmium is found as a component of organic compounds and as inorganic sulfides, oxides, and halides. Photodegradation and biological degradation are generally not important. Cadmium sorbs to sedimentary particles and precipitates with aluminum, manganese, and iron oxides (MacDonald, 1994 and ATSDR, 1999a). The bioavailability of cadmium is dependent on

the chemical and physical properties of the aquatic environment, including redox potential, water hardness, and pH (MacDonald, 1994). The presence of acid volatile sulfide (AVS) in sediment (a complexing agent, found under reducing conditions) has been identified as an important factor governing the bioavailability of cadmium (Di Toro et al., 1991).

Freshwater aquatic species are generally more sensitive to the toxic effects of cadmium than marine species; toxicity in freshwater environments is inversely proportional to the water hardness (USEPA, 1999). Survival, growth, reproduction, and behavioral impacts have been noted for marine invertebrates (MacDonald, 1994). Diatoms and aquatic plants also show impaired growth and development. Cadmium can cross the placental barrier in mammals and is a reproductive toxin in fish and other aquatic life. Other adverse effects in upper trophic level aquatic organisms include interference with the kinetics of other metals, decreased oxygen utilization, and bone marrow, heart, kidney, and vascular impacts (USEPA, 1999). Though elimination from the body does occur, cadmium can concentrate in tissues and thus can accumulate in food chains. An inverse relationship between cadmium uptake via dietary exposures and uptake of iron and calcium has been noted (USEPA, 1999). Vertebrates tend to accumulate cadmium in the kidney and liver (Eisler, 1985).

Based on the screening-level and Step 3a investigation, cadmium in SWMU 45 sediment has the potential to impact the West Indian manatee via dietary (food web) exposures. The manatee is an herbivorous species, which feeds primarily on seagrasses. A study comparing metals concentrations in aquatic plant material at the US Navy bombing range at Vieques and a neighboring reference location in Puerto Rico found cadmium concentrations of 0.28 ug/g dry weight in manatee grass within the bombing range while it was active, 0.15 ug/g following the cessation of bombing activities, and 0.28 ug/g in the reference area (Massol-Deyá et al., 2005). A literature search was conducted on the toxicological effects of cadmium ingestion to mammals as part of the screening-level ERA and Step 3a report (Baker, 2006). 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. This study forms the basis of the NOAEL and LOAEL values developed for the manatee, as discussed in Section 4.4.

3.2.1.4 Mercury

Mercury is a naturally occurring element found in cinnabar, a sulfide mineral. Industrial applications and uses include paint manufacturing, paper industry, electrical equipment, batteries, thermometers, and at one time, pesticides (MacDonald, 1994). Transport pathways to the aquatic environment include waste dumping and incineration, mining, smelting, and coal combustion. It is persistent in the environment and is found in three states naturally, Hg^0 (metallic/elemental), Hg^{+1} (mercurous), and Hg^{+2} (mercuric [Hg(II)]). Elemental mercury is unique among metals in being liquid at ambient temperature and being quite volatile. It partitions strongly to air in the environment and is not found in nature as a pure, confined liquid. Of the two ionic forms of mercury (mercurous and mercuric mercury), the mercuric form is more environmentally stable, and therefore predominates. Mercuric mercury is the dominant form in surface water (ATSDR, 1999b). In sediment, mercury is generally found adsorbed to particulate matter. Sorption to particulates immobilizes mercury and is dependent on the presence of organic matter, complexing agents (sulfides) and clay fractions. Bacterial metabolism and chemical reduction can mobilize sorbed mercury from particulate matter to more volatile forms. Ionic mercury (i.e., mercuric mercury) can be transformed to methylmercury (MeHg) by anaerobic, sulfur-reducing bacteria, which produce MeHg as a byproduct of their natural sulfur chemistry (Gilmour and Henry, 1991, Gilmour et al., 1992, and Zillioux et al., 1993). The major site of methylation in aquatic systems is the sediment, but methylation also occurs in the water column (Wright and Hamilton, 1992, Parks et al., 1989, and Gilmour and Henry, 1991). Once MeHg is

produced, it can either be demethylated via biotic and abiotic mechanisms (Sellers et al., 1996) or enter into the food web. The rate of mercury methylation is influenced by a number of environmental factors that affect both the availability of mercuric ions for methylation and the growth of the methylating microbial populations:

- Bacterial methylation rates appear to increase under anaerobic conditions (oxygen-poor environments exhibit a reducing electrochemical potential that favors sulfur metabolism by sulfur-reducing bacteria).

- Sulfate stimulates formation of methylmercury (sulfate is used by sulfur-reducing bacteria in their metabolic process).

- Increasing water temperature enhances bacterial activity, thereby increasing the formation of methylmercury.

- The presence of organic matter can stimulate growth of microbial populations (and reduce oxygen levels), thereby increasing the formation of MeHg.

- Increasing hydrogen ion concentrations increase the formation of MeHg (Xun et al., 1987 and Winfrey and Rudd, 1990) by enhancing mercury uptake by bacteria (Kelly et al., 2003).

- Sulfide inhibits MeHg formation by binding with inorganic mercury ions and forming an insoluble mercury-sulfide complex, thereby limiting the bioavailability of inorganic mercury to sulfur-reducing bacteria.

MeHg is the most bioavailable and toxic form of mercury. Based on the relationship between MeHg production and total mercury concentration, the proportion of mercury as MeHg in sediment and associated organisms has been found to be proportional to the distance from the mercury source (Hill et al., 1996). In addition, organisms at lower trophic levels usually contain the lowest proportion of total mercury as MeHg (May et al., 1987 and Watras and Bloom, 1992), while organisms higher in the food chain (i.e., piscivorous fish, birds, mammals) contain a higher proportion of total mercury as MeHg (generally over 90 percent of the total mercury [Huckabee et al., 1979, Watras and Bloom, 1992, Bloom, 1990, and Grieb et al., 1990]). Several studies have been identified which investigated total mercury and MeHg concentrations in seagrass species. Season variations in both total mercury and MeHg concentrations have been identified and concentrations are generally greater in the older plant material and in the root mat (Ferrat et al., 2002, Capiomont et al., 2000, and Pannhorst and Weber, 1999). Partitioning of MeHg as a function of total mercury does not appear to be a factor between above ground (shots, leaves, stems) and below ground (roots and rhizomes) portions of the plants (6.9% MeHg in above ground eelgrass tissue, 6.4% MeHg in below ground tissue [Pannhorst and Weber, 1999]).

A variety of adverse biological effects have been attributed to mercury. Enzymatic impacts have been noted in aquatic plants (Ferrat et al., 2002). Mercury is a known teratogen, mutagen, and carcinogen. The reproduction, growth, metabolism, blood chemistry, and oxygen exchange of marine and freshwater organisms is adversely affected by mercury. Mercury readily bioaccumulates and elimination from mammalian systems is slow (USEPA, 1999). Retention times appear to be longer for MeHg than for inorganic forms. Biological half-lives of 2 to 3 years in fish have been reported (USEPA, 1999).

Based on the screening-level ERA and Step 3a investigation, mercury in SWMU 45 sediment has the potential to impact the West Indian manatee via dietary (food web) exposures. A literature search was

conducted on the toxicological effects of mercury ingestion to mammals as part of the screening-level ERA and Step 3a report (Baker, 2006). 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 (Sample et al., 1996). No adverse effects were observed at 1.1 parts per million (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). This study forms the basis of the NOAEL and LOAEL values developed for the manatee, as discussed in Section 4.4.

3.2.1.5 Selenium

Selenium is a naturally occurring non-metal element commonly found in rocks and soil. Four stable valence states of selenium are found naturally, elemental (Se^{0}), selenides (Se^{-2}), alkali selenites (Se^{+4}), and selenates (Se^{+6}). Elemental selenium and selenides are insoluble, while the selenites and selenates are water soluble (ATSDR, 2003). Commercial and industrial uses include use as a nutritional supplement, in the glass industry, and as a component of paints, inks, rubber, pigments, pharmaceuticals, pesticides, and fungicides. In the environment, selenium is not often found in the pure form. Important factors regulating the form of selenium include pH, redox potential, and the presence of metal oxides. Much of the selenium in rocks is combined with sulfide minerals or with silver, copper, lead, and nickel minerals (Irwin et al., 1998). Selenium will readily combine with these and other metals directly or in solution and reacts with oxygen to form stable selenium dioxide. Within surface waters, the salts of selenic and selenious acids are prevalent. Depending on the pH of the surface water body, selenium compounds can be highly soluble and do not adsorb to sedimentary particles. Within sediments, organic selenides and selenium oxide are the dominant forms found. Natural transport properties include weathering of rock material, volatilization by plants and animals, and volcanic activity. The principle release mechanism of selenium to the environment, however, is coal combustion. Though generally stable in soils, soluble selenium compounds in agricultural fields can be transported from the field in irrigation and drainage waters. Oxidation state, which is dependent upon pH, redox potential, and biological activity, is the principal factor governing the behavior of selenium in the environment. Bacterial and fungal action produces methylselenium (MeSe) and other volatile, organic selenium compounds. In sediments, especially in acidic, reducing, organic-rich environments, selenium forms strong metal selenides complexes which sorb to sediment particles and are relatively immobile and stable (Irwin et al., 1998). Selenium, like mercury, interacts readily with sulphur. Synergistic and antagonistic interactions with mercury have been noted for selenium (Irwin et al., 1998).

Inorganic selenites and selenates, which are more commonly found in alkaline and oxidizing environments, are more bioavailable as they are water soluble (Purkerson et al., 2003). They are readily taken up by plants and converted to various organic compounds (ATSDR, 2003). This uptake is regulated by soil type, pH, organic material, redox potential, and total selenium concentrations. Selenites have been shown to be more concentrated in algae and benthic invertebrates, while equal proportions of the two forms have been measured in fish (ATSDR, 2003). Selenium is identified as a weakly bioaccumulative chemical; accumulation and sensitivity, however, are independent on trophic levels as well as species and complex biogeochemical cycling (Purkerson et al., 2003). However, as selenium is also an essential nutrient, it is metabolized by animal species, prevents tissue damage from oxygen, and is readily eliminated (Maher et al., 2004). The relative toxicity of selenium compounds has been identified as hydrogen selenides ~ dietary selenomethionine > selenites ~ water selenomethionine > selenate > elemental selenium > metal selenides ~ methylated selenium compounds (Irwin et al., 1998). Chatterjee et al. (2001) investigated selenium concentrations in seagrass species in India. Seasonal variations were noted and total selenium concentrations were found to be greater in roots (0.21 ug/kg dry weight) than in stems (0.17 ug/kg) and leaves (0.11 ug/kg).

As mentioned, selenium sensitivity is dependent upon species, lifestage, nutritional status, and health of individual organisms (Irwin et al., 1998). Younger animals and those consuming low-protein diets appear to be impacted more. Very high amounts of selenium can result in reproductive and survivorship effects in invertebrates, birds, and mammals. Exposure to high levels of selenium compounds caused malformations in birds, but selenium has not been shown to cause birth defects in mammals (ATSDR, 2003). Reproductive impacts have been identified concurrently with no impact on adult survivorship in fish (Irwin et al., 1998). Seed germination and growth inhibition has been noted in plants, yet selenium-deficient soils have also been identified.

Based on the screening-level ERA and Step 3a investigation, selenium in SWMU 45 sediment has the potential to impact the West Indian manatee via dietary (food web) exposures. A literature search was conducted on the toxicological effects of arsenic ingestion to mammals as part of the screening-level ERA and Step 3a report (Baker, 2006). A one-year study on the effects of potassium selenate on the reproduction of rats indicated a chronic oral toxic dose of 1.5 milligrams per liter (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. This study forms the basis of the NOAEL and LOAEL values developed for the West Indian manatee, as discussed in Section 4.4.

3.2.2 Transport and Exposure Pathways

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media. An exposure pathway links a source of contamination with one or more receptors through exposure to one or more media. Exposure, and thus potential risk, can only occur if each of the following conditions is present (USEPA, 1998):

- A source of contamination must be present.
- Release and transport mechanisms must be available to move the contaminants from the source to an exposure point.
- An exposure point must exist where ecological receptors could contact the affected media.
- An exposure route must exist whereby the contaminant can be taken up by ecological receptors.

3.2.2.1 Sources and Transport Mechanisms

The source of contamination at SWMU 45 are the USTs and associated piping for Bunker C fuel and the historical storage and maintenance of PCB transformers. The USTs and associated piping have historically represented source areas for the release of Bunker C fuel to subsurface soil and groundwater. Transformer storage and maintenance areas within Building 38, as well as historically contaminated soil adjacent to Building 38 and the contaminated sediment within the cooling water intake tunnel have represented historical source areas for the release of chemicals (i.e., PCBs and Bunker C fuel) to surface water and sediment within the embayment. The source areas at SWMU 45 have been eliminated by the ICMs conducted in 1994 and 1996.

The preliminary conceptual model for SWMU 45 did not indicate that arsenic, cadmium, mercury, or selenium concentrations in embayment sediment are not related to historical activities at SWMU 45.

These chemicals are not associated with transformers and are not components of Bunker C fuel (chemicals associated with Bunker C fuel include polycyclic aromatic hydrocarbons [PAHs] and oil soluble metals such as nickel and vanadium). An evaluation of upgradient analytical data also indicated that these metals are not associated with SWMU 45 surface soil, subsurface soil, and groundwater. A potential secondary source of metals contamination does exist, which is unrelated to SWMU 45. Potential input is possible from two storm water outfalls (Outfall 015 and Outfall NR-020) which discharge to the embayment downgradient from SWMU 45. Both outfalls discharge storm water runoff from roadways and parking lots, as well as runoff from buildings associated with administrative, industrial, and material storage areas activities unrelated to SWMU 45. Based on the presence of these two storm water outfalls, the elevated metal concentrations detected in embayment sediment are not likely associated with a release from SWMU 45. Because risk calculations indicated potentially unacceptable impacts to a federally threatened species from these metals (West Indian manatee), a recommendation for further evaluation was presented in the screening-level ERA and Step 3a report. The uncertainty associated with the source of these metals makes this evaluation a particularly conservative measure.

The primary mechanisms for contaminant transport from potential source areas to downgradient sediments at SWMU 45 are believed to include the following:

- Overland transport of chemicals with surface soil via surface runoff to downgradient surface soil. Given the nearly level upland terrain at SWMU 45, as well as the soil removal completed in 1996, this transport pathway was evaluated and concluded to be insignificant in the screening-level ERA and Step 3a report (Baker, 2006).

- The direct discharge of chemicals through the cooling water intake tunnel to embayment surface water and sediment. This historical transport pathway was eliminated during the 1996 ICM by sealing of the cooling water intake tunnel with cast-in-place concrete.

- Leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport to embayment surface water and sediment with groundwater.

- The direct discharge of non SWMU 45 related chemicals associated with stormwater through two outfalls, Outfalls 015 and NR-020, to embayment surface water and sediment.

- Uptake by biota from sediment and trophic transfer to upper trophic level receptors.

3.2.2.2 Exposure Points and Routes

Based upon the refined conceptual model and results of the Steps 3a and 3b evaluation, key exposure pathways include the following:

- Direct contact exposures by lower trophic level aquatic receptors (benthic invertebrates) to Aroclor-1260 in embayment sediment.

- Food web based exposures by upper trophic level aquatic mammalian receptors (West Indian manatee) to arsenic, cadmium, mercury, and selenium in embayment sediments.

A third exposure pathway that may require additional evaluation is exposures to aquatic upper trophic level reptilian receptors (sea turtles) to chemicals in embayment sediments. Based on the paucity of data concerning the toxicological effects of chemicals for reptiles, a quantitative evaluation of the

potential for risk to these species could not be performed in Steps 2 and 3a. Given the Federal status of sea turtles in Puerto Rico, a review of the available literature and additional evaluation was recommended for Step 3b of the baseline ERA. This evaluation, presented below, includes an examination of their life history information and a summary of available sea turtle habitat in the area of SWMU 45 to determine whether potential exposure points and routes exist whereby SWMU 45-associated contaminants may be encountered and subsequently taken up by aquatic reptiles. A thorough review of the scientific literature yielded no published studies that related food web exposures to toxicity in reptiles (i.e., no ingestion-based NOAELs were identified).

3.2.2.2.1 Sea Turtle Life History

Four species of sea turtle potentially inhabit or seasonally visit the coastal waters adjacent to NAPR: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), and loggerhead (*Caretta caretta)* (Geo-Marine, 2005). Each species is listed as a federally endangered species and is protected under the 1973 Endangered Species Act (16 United States Code [USC] 1531-1544). Except during the female's nesting activities, sea turtles spend their lives at sea. Males almost never return to the land following hatching. Three distinct life history stages are recognized for most sea turtles: 1) the hatchling phase, characterized by the early life-stage open ocean, pelagic lifestyle, when small turtles primarily float with the currents and major oceanic gyres, often congregating in *Sargassum* weed and convergence zones where food is plentiful, 2) the juvenile and/or subadult phase, when sexually immature turtles recruit back into shallow coastal areas to feed and develop, and 3) the adult phase, when reproductively active individuals migrate from feeding areas to mating and/or nesting areas, typically every few years. Due to their pelagic nature, little is known about the time turtles spend in each phase and estimates vary widely. The data available indicate that growth rates and reproductive maturity are dependent on environmental factors, including temperature and food availability. Sea turtle migration distances are impressive; some species have a circumglobal distribution and are encountered from the northern Atlantic and Canadian waters down to the southern tip of Africa. With the exception of the loggerhead, which often nests in the temperate zone, sea turtles generally nest on open subtropical beaches with neighboring deep water habitats, such as those present on NAPR. For many turtles, the nesting areas are often located on the female's natal beach and may be revisited year after year. Dietary preferences and trophic level status also vary by species, though with the exception of adult greens, sea turtles are generally carnivorous. Godley et al. (1988) investigated trophic status of European Atlantic and Mediterranean sea turtles using stable isotopes and found the following relationship: green < leatherback < loggerhead, with the loggerhead diet exhibiting the highest trophic level, on average 2 to 3 levels above greens. The following paragraphs present a summary of the life history and feeding ecology of each of the four species with the potential to inhabit NAPR.

Green Sea Turtle

Green turtles are named not for the color of their shells, but for the color of their body fat, which is thought to be due to their mainly herbivorous diet as adults. As hatchlings, the diet of the green is the same as it is for other turtles. Hatchling greens feed on the marine plants, mollusks, crustaceans, and jellyfish available in the open water convergence zones until they reach somewhere between 8 and 30 centimeters (cm) standard carapace length (SCL) (NatureServe, 2006 and Moreale and Standora, 1998), between 1 and 3 years (Barmes et al., 1993). As juveniles, greens reside in inshore locations, but travel widely (Barmes et al., 1993). During this developmental period their eating habits shift to the adult diet, which is unique among sea turtles and is selectively focused on seagrasses and to a lesser extent macroalgae. One study presented gut content analysis data of 78.9% turtle grass, 9.7% other grasses, 8.2% algae, 1.8% substrate, and 1.4% animal matter, including sponges, tunicates, soft corals, hydroids, gastropod eggs, and hydrozoans, which were thought to be incidental takes during grazing

(Mortimer, 1981). A stable isotope investigation agrees with this general dietary preference, which is not exclusively herbivorous (Godley et al., 1988). A review by Coyne (1994) demonstrated the high selectivity of this species, as the plant species with the highest concentrations in green turtle guts were often the rarest in the available foraging habitat. Mortimer (1981) and Coyne (1994) both identified red algae as an important dietary item for migrating individuals and noted that major dietary differences have been noted between colonies within a few kilometers of each other.

Green turtles travel daily, often over several miles, from shallow, low-energy feeding pastures to more protective reefs, coral shoals, and hard structures to rest at night (Diez et al., 2003b and Mortimer, 1981). Unless migrating, green turtle juveniles and adults mainly inhabit shallow waters within the tropical and subtropical regions (USFWS, 2006 and NatureServe, 2006), though juveniles are also commonly encountered in more temperate waters (NatureServe, 2006). They are present within the Caribbean region year-round (Barmes et al., 1993) and critical habitat associated with adult and juvenile feeding grounds has been identified for them in the waters surrounding Culebra Island and the Culebra Archipelago, Puerto Rico (50 Code of Federal Regulations [CFR] 226.208 and USFWS, 2006). Adults and juveniles generally inhabit the same areas, but may segregate within a habitat by age and size (Seminoff et al., 2002 and Coyne, 1994). The home range of the green, the area used during their normal, non-migratory daily activities, is assumed to be dependent on the suitability of available habitat and preferred diet. Estimates include 48 to 506 hectares in Florida and 22 to 311 hectares in the Gulf of Mexico for juveniles and 584 to 3,908 hectares in the Caribbean for adults (Godley et al., 2003 and Seminoff et al., 2002). Home ranges estimates indicate a generally smaller home range than that identified for the loggerhead but a larger home range than the hawksbill.

The age of sexual maturity of this species is not well documented, especially for males, but is likely linked to the availability of suitable habitat and diet. Estimates identified in the literature include 19 to 27 years (Godley et al., 1988) and 18 to 36 years (Barmes et al., 1993) in general to 18 to 26 years for populations in Texas and 27 to 33 years for populations in the U.S. Virgin Islands (Coyne, 1994). Age at maturity generally corresponds to a carapace length of approximately 60 to 88 cm SCL (Coyne, 1994). Once mature, adults do not reproduce every year. Mating periodicity is on the order of every two to three years. Males and females will migrate from widely spaced foraging grounds to more centralized subtropical and tropical mating and nesting areas. Migrations from feeding to nesting grounds up to 3,000 kilometers (km) have been reported (NatureServe, 2006, Avens and Lohmann, 2004, and Seminoff et al., 2002). Nesting generally takes place on small, isolated, high energy beaches with deep sand and flanking hard structures, such as coral or rock (NatureServe, 2006, and Barmes et al., 1993). Females will nest several times over a season, resting in neighboring foraging areas in between and then will migrate back to foraging grounds at the end of the season. Due to the difficulty finding and then tagging males, their migration patterns are less studied and the periodicity of their movement is not reported in the literature.

Hawksbill Sea Turtle

Hawksbill turtles are named for the shape of their hooked jaw and narrow head which allows them to feed as adults in the crevices characteristic of reef and hard bottom habitats. Hatchling hawksbills live the epipelagic lifestyle characteristic of all sea turtles, and omnivorously feed in the open water convergence zones until approximately 20-30 cm SCL (MarineBio, 2006 and Diez and van Dam, 2002), for an unknown length of time. Following the hatchling phase, juvenile hawksbills recruit to shallow (less than 65 feet deep) inshore coral reefs, hard bottoms, rocky areas and occasionally sea grass habitats in subtropical and tropical waters (USFWS, 2006, Diez et al., 2003a, and León and Bjorndal, 2002). Juvenile and adult hawksbills are generally omnivorous, feeding primarily on the sponges, crabs, sea urchins, shellfish, plant material and even fish (NatureServe, 2006) that are associated with reef habitat. Selective feeding, however, on rare sponges and anemone species by

hawksbills even when other forage is available has been documented and their local abundance is generally well correlated with reef distribution (Troëng et al., 2005 and León and Bjorndal, 2002). Juvenile occurrence in sea grass meadows seems to require a lagoon habitat or nearby reef breaker and is thought to be associated with the presence of chicken liver sponges (*Chondrilla nucula)*, which are common within sea grass beds (Diez et al., 2003a). This generalist diet places them on a higher trophic level than green turtles, likely on the same level as the loggerhead.

Hawksbill turtles have traditionally been identified as a relatively non-migratory species, when compared to other sea turtles that travel great distances during foraging and mating/nesting activities. Recent studies, however, have replaced this opinion. Though juveniles exhibit long-term residency in developmental habitats (Meylan, 1999a), and the species as a whole is considered subtropical to tropical in general (Troëng et al., 2005 and Diez and van Dam, 2002) individuals are encountered as far north as Massachusetts (MarineBio, 2006). Home range estimates are better defined for the hawksbill than for other sea turtles, though should be considered a lower limit based on the emerging evidence that they are more migratory. Home ranges (expressed as minimum distance traveled) of 110 to 1,936 km for adults and 46 to 900 km for juveniles were reported by Meylan (1999a) in the Caribbean region. Other estimates of home range include 7 to 21 hectares at Mona Island, Puerto Rico (van Dam and Diez, 1998) and 196 to 4,950 hectares in the West Indies (Horrocks et al., 2001). Like the green, hawksbills are present within the Caribbean region year-round (Barmes et al., 1993) and critical habitat has been identified for them in the beaches and surrounding waters of Culebra Island, Mona Island, Cayo Norte, and Culebrita Island, Puerto Rico for nesting (50 CFR 17.95 and USFWS, 2006) and the waters surrounding Mona and Monito Islands for juvenile and adult foraging grounds (50 CFR 226.209 and USFWS, 2006).

Growth rates of hawksbills are strongly linked to prey abundance and water temperature, and vary geographically (Diez and van Dam, 2002). Estimates of the age of sexual maturity include 20 to 30 years (Barmes et al., 1993) and 15 years on a good diet (Diez and van Dam, 2002). Age at maturity has been reported at a carapace length of 58 cm SCL on the lower limit, but averages 83 to 85 cm SCL in the Caribbean (Diez and van Dam, 2002). Like the green, hawksbills mate every two to three years. Preferred nesting sites are located on undisturbed deep sand beaches, in both low and high energy environments (NatureServe, 2006). Unique to the species, female hawksbills have been known to crawl over fringing rocks and reefs to nest (USFWS, 2006) and often prefer beaches with flanking hard structures (Barmes et al., 1993). Mona Island, Puerto Rico is an important nesting ground for Caribbean populations of hawksbills (NatureServe, 2006) and nest surveys have indicated one of the few areas in the Atlantic with increasing trends of nest numbers over time in recent years (Meylan, 1999b). Reproductively active males and females do not necessarily nest in areas close to their feeding grounds. Tagging studies indicate that migrating adults will cross paths with others between foraging and mating grounds (Meylan, 1999a), and that only 20% of the nesting females surveyed in Puerto Rico are from local waters (Troëng et al., 2005). Migration range estimates have noted post-nesting female movements of 200 to 435 km within 7 to 18 days (NatureServe, 2006). Female hawksbills nest several times within a season, foraging within 30 miles of the beach in the internesting period (approximately 17 days; Troëng et al., 2005). Males at Mona Island, Puerto Rico, have been observed using the reef areas up to 2 months to intercept females during the breeding season. Following the breeding season, males will move offshore to deeper waters within 100 km of Mona Island.

Leatherback Sea Turtle

The leatherback is the largest of the sea turtles and is named in credit of its distinctive, dark ridged, leathery shell. Virtually nothing is known about the hatchling phase of the leatherback lifestyle. Based on what is known about other turtles and the generally pelagic lifestyle of the leatherback, it is assumed that they spend the early years of their life like other sea turtles, generally moving with the currents and

feeding on floating prey. Unlike other sea turtles, which shift to a benthic lifestyle following the pelagic hatchling phase, leatherbacks largely remain open ocean creatures throughout their lives. Their diet is focused on soft organisms that they can shred with their delicate jaws; jellyfish are their preferred food (James, 2001). Other soft-bodied prey, characteristic of oceanic convergence zone habitats and routinely identified in leatherback guts, include siphonophores, tunicates, seaweed, squid, and small crustaceans and fish (MarineBio, 2006, USFWS, 2006, and James, 2001). A stable isotope investigation indicating a depleted carbon signature agrees with their pelagic lifestyle (Godley et al., 1988).

Due to their pelagic nature, leatherbacks are the most migratory and wide-ranging of all the sea turtles (USFWS, 2006). They rarely approach land, and are typically encountered along oceanic frontal systems and vertical gradients in water temperature, salinity, and/or water color where food is abundant (James, 2001). When working a coastal area, they can be found in shelf waters deeper than 20 to 40 meters (m) deep (NatureServe, 2006). They have been tracked diving to depths of 1,000 m and demonstrate a circumglobal distribution from Alaska to the southern tip of Africa (MarineBio, 2006). Individual males have been tracked traveling over 4,500 miles and 40 degrees of latitude within 5 months (Lutcavage et al., 2003 and James, 2001). Leatherbacks have the largest known geographical range of any reptile and are the only known reptile that can remain active in temperatures below 40 degrees Fahrenheit (James, 2001). They accomplish this via thermoregulatory abilities that are unique among reptiles. A review of world data on their distribution indicates that leatherbacks less than 100 cm SCL are restricted to subtropical and warmer waters less than 26 degrees latitude, indicating that their thermoregulatory behaviors are growth dependent (Eckert, 2002 and James, 2001). The spatial presence of both juveniles and adults in northern waters is dependent on temperature and the availability of food, and has been directly correlated with the relative abundance of jellyfish in an area (James and Herman, 2001). Adult leatherbacks are only seasonally present within the Caribbean region during nesting season (Barmes et al., 1993). Based on their pelagic lifestyle and wide-ranging geographical extent, no estimates on home range are available in the literature or would be meaningful in relation to foraging habitat.

The available data indicates that leatherbacks mature faster than other sea turtles and have a shorter life expectancy (18 years; James, 2001). Estimates of the age at sexual maturity include 5 to 6 years (noted as more likely 13 to 14 years; James, 2001), 6 to 10 years (MarineBio, 2006), 8 to 15 years (Ocean Biogeographic Information System [OBIS], 2006), and 9 to 14 years (Godley et al., 1988). Once mature, adults reproduce every two to three years (OBIS, 2006). Reproductively active adults migrate thousands of kilometers between their foraging grounds and nesting beaches; there are accounts of females tagged in Nova Scotia found nesting in Suriname and Costa Rica (NatureServe, 2006). Known nesting populations are small, estimated at 35 females/year in Florida, 50 to 100 females/year in the US Virgin Islands, and 30 to 90 females/year in Puerto Rico (OBIS, 2006 and Barmes et al., 1993) and are found as far north as the coast of the Carolinas. Unlike other sea turtles, female leatherbacks do not necessarily return to their natal beaches to nest and may nest on multiple island beaches within a region and nesting season (NatureServe, 2006). Females generally prefer open access, sloped beaches backed by vegetation that are near deep water and/or rough seas (James, 2001 and Barmes et al., 1993). Unlike other turtles, flanking hard structures such as reefs or rock are not preferred by leatherback females (NatureServe, 2006 and James, 2001). Females will nest approximately 6 times over a season, and will rest from 8 to 12 days between nesting periods in offshore waters (James, 2001). Following the nesting season, Caribbean nesters move immediately to northern waters along the temperate Atlantic coast. Like the green, the migration patterns between foraging and mating habitats for male leatherbacks remains to be studied. It has been suggested that mating takes place in temperate waters and that the males do not migrate to the subtropics for breeding purposes (James, 2001).

Loggerhead

Loggerhead turtles are named for their thick, large heads supporting their powerful jaws which sustain their carnivorous lifestyle. Hatchling leatherbacks exhibit the characteristic epipelagic lifestyle, omnivorously feeding in open waters convergence zones until approximately 40-50 cm SCL (Moreale and Standora, 1998). Estimates of the length of the hatchling phase vary, from 2 to 5 years (NatureServe, 2006 and Moreale and Standora, 1998) to 7 to 12 years (USFWS, 2006 and Avens and Lohmann, 2004). Juvenile loggerheads recruit to coastal waters and take up the adult, benthic lifestyle, feeding on mollusks, crustaceans, fish, sponges, echinoderms, horseshoe crabs, and slow-moving or dead fish in both rocky and sedimentary habitats (USFWS, 2006, Godley et al., 1998, and Godley et al., 1997). Loggerheads, especially juveniles, will also forage on jellyfish and other small prey concentrated on the water surface in convergence zones. Godley et al. (1988) noted that stable isotope analysis confirmed the high trophic status of the loggerhead.

Loggerheads are found in waters mainly associated with large sounds, bays, and estuaries and can be found hundreds of miles out to sea over the coastal shelf (Avens and Lohmann, 2004). Though not known to thermoregulate like the leatherback, they have a circumglobal range and can be found seasonally in Canadian waters (Jones, 2001 and Godley et al., 1997). They often frequent offshore reefs, rocky places, and ship wrecks (USFWS, 2006). Like the leatherbacks, loggerheads forage in more temperate areas and are seasonally present within the Caribbean region, mainly during nesting season (Barmes et al., 1993). Home ranges of 95,400 to 2,833,300 hectares have been calculated for loggerhead populations studied in the Gulf of Mexico (Renaud and Carpenter, 1994), reflecting their highly mobile lifestyle.

Loggerheads reach sexual maturity around 12 to 30 years (Barmes et al., 1993) and have a life expectancy of 30 to 50 years (MarineBio, 2006). Like other sea turtles, adults reproduce every two to three years (MarineBio, 2006). In general, loggerheads are more associated with the temperate and subtropical zones rather than the tropics. This is reflected in their preferred nesting habitat, primarily the southern coast of the U.S., from North Carolina to Florida (MarineBio, 2006). Nesting in tropical latitudes is rare (Barmes et al., 1993). Like the green and leatherback, loggerheads actively migrate long distances between their foraging grounds and nesting beaches. Females generally prefer high energy, steeply sloped beaches with gradual offshore approaches (NatureServe, 2006) and will nest approximately 2 to 5 times over a season (MarineBio, 2006). Information associated with the breeding migration patterns of male loggerheads was not identified in the literature.

3.2.2.2.2 Potential Habitat

An aerial survey of turtles was performed in 1984 and 1985 along the Puerto Rican Coast. This information was summarized by Geo-Marine (2005) in the NAPR Disposal Environmental Assessment (EA). Figures 3-4 and 3-5 (reproduced from Geo-Marine, 2005) present cumulative sea turtle sightings and potential turtle nesting sites on NAPR. Significant turtle observations were made within the Ensenada Honda, the northern shore of Pineros Island, Pelican Bay, and the Medio Mundo Passage with the frequency of turtle observations listed as green > hawksbill > loggerhead > leatherback.

Based on the life history information presented above as well as the SWMU 45 habitat assessment discussed in Section 2.2.3.2, potential green turtle foraging habitat within the SWMU 45 embayment is present on (1) the shallow subtidal shelf (3 to 10 feet below MSL), which supports a seagrass/algae bed (approximately 50 to 75 percent cover) dominated by turtle grass (*Thalassia testudinum*) and (2) the shelf slope (10 to 15 feet below MSL), dominated by marine algae. The level, unvegetated sand to silty-sand bottom (15 to 20 feet below MSL) located within the interior of the cove from its mouth with Puerca Bay to and around the cooling water intake structure is considered poor foraging territory,

however, due to the lack of potential prey species observed during the habitat assessment (Geo-Marine, 2000). The concrete sidewalls of the cooling tunnel intake structure may also serve as suitable foraging habitat for hawksbill and loggerhead turtles, as it supports hard bottom communities dominated by soft corals, marine algae, and sponges. In the neighboring environment, seagrass communities which likely support green turtles fringe the SWMU 45 embayment and the surrounding shallow water habitats of Puerca Bay and expansive beds traverse the seafloor between southeast coast of Puerto Rico and Vieques (Geo-Marine, 2005). No coral reefs, preferred habitat of the hawksbill, have been identified within the SWMU 45 study area or within Puerca Bay. The closest patch reef habitat can be found at headlands of Puerca Bay (approximately 1 mile from SWMU 45); more extensive reef habitats are found along north shore of Isla Pineros and Cabeza de Perro (Geo-Marine, 2005).

While several stretches of beach have been identified as suitable nesting habitat for hawksbill and leatherback turtles, the northern shore of Pineros Island has been noted as particularly high-quality nesting habitat. Beach nesting surveys performed by the Navy indicate that 73 and 16 nests were observed on 12 and 7 NAPR beaches in 2002 and 2004, respectively (Geo-Marine, 2005). The majority of the nests were created by hawksbill females and were observed at or near the mouth of the Ensenada Honda. As indicated on Figure 3-4 and 3-5, turtles have been sighted and potential nesting habitat has been identified on the Puerca Bay shoreline south of the SWMU 45 embayment. A reconnaissance survey of the SWMU 45 embayment conducted as part of the habitat characterization identified a distinct rocky subtidal zone comprised of riprap extending from above MHW to approximately 3 feet below MLW. With the exception of the hawksbill, which has been reported to climb over rocks to nest, the SWMU 45 cove would not be considered suitable nesting habitat for any of the sea turtle species potentially inhabiting the area due to the presence of this rip rap.

3.2.2.2.3 Potential for Exposure

As described in Section 3.2.2 exposure, and thus potential for risk, can only occur if exposure point and routes exist where ecological receptors could contact affected media and whereby the contaminant can be taken up by ecological receptors. The primary mechanism for contaminant transport from potential source areas at SWMU 45 to aquatic upper trophic level receptors is uptake by prey and/or forage biota from sediment and subsequent trophic transfer via dietary exposures. Based on the life history of sea turtles, juvenile and adults turtles have the potential to be exposed via dietary intake while foraging. Though the SWMU 45 area may provide marginal nesting habitat to hawksbill sea turtles as described above, hatchling turtles do not have the potential to be exposed to SWMU 45 sediments. The “race to the sea” of sea turtle hatchlings to avoid predation is well documented and as discussed, hatchling turtles feed pelagically and do not have diets associated with the sedimentary environment.

Based on the life history information for each turtle species discussed above, potentially complete exposure pathways are present in the SWMU 45 embayment for green, hawksbill, and loggerhead turtles via dietary exposures, but are likely incomplete for leatherback turtles. Exposure points are present within the habitat offered for the green, hawksbill, and loggerhead turtles based on the presence of available forage material (in the form of sea grasses and hardbottom corals and sponges). No exposure point is identified for leatherback sea turtles based on their very selective feeding strategies and habitat preferences. Leatherbacks rarely approach land outside of the nesting season and forage within open water environments for soft-bodied organisms, mainly jellyfish. The small size (approximately 2.04 hectares), shallow nature (0 to 20 feet below MSL deep), and presence of hard structure within the SWMU 45 embayment does not provide suitable open water foraging habitat for them. In addition, the presence of a distinct rocky subtidal zone comprised of riprap extending from above MHW to approximately 3 feet below MLW would deter nesting females from approaching the area. This deterrence would extent to the areas outside of the mouth of the SWMU 45 embayment, as leatherbacks do not favor nesting sites with flanking and/or neighboring hard structure.

Potentially complete exposure pathways have been identified for green, hawksbill, and loggerhead turtles based on the absolute presence of available forage material and/or nesting sites. Examination of the relative presence and quality of this habitat provides an indication of the magnitude and significance of this exposure pathway. As stated previously, the total area of the SWMU 45 embayment is 2.04 hectares. Approximately 3,900 square feet (ft^2) of this area (1,300 linear feet x 3 feet depth below MLW, approximately 2%) is covered in riprap and likely represents an excellent refuge zone from sea turtles predation rather than usable foraging habitat for them. The level, unvegetated sandy bottom (15 to 20 feet below MSL) located within the interior of the cove covers an area of approximately 1.16 acres (approximately 57% of the embayment). This area is also considered poor foraging territory, due to the lack of potential sea turtle prey and forage species. As such, approximately 41% of the SWMU 45 embayment offers potential foraging habitat for green, hawksbill, and loggerhead sea turtles. This 0.84 acres is approximately 3 to 15 feet deep and includes the shelf area dominated by turtle grass, the slope area dominated by brown and green algae, and the cooling tunnel intake structure itself, which supports a hard bottom habitat dominated by sea whips, gorgonians, green algae, boring sponges, and fire coral.

Assessment of the area of the SWMU 45 embayment which provides suitable habitat (0.84 acres = 0.34 hectares) in relation to the potential for exposure can be performed via an examination of an Area Use Factor (AUF), a variable within the dietary intake calculation used to evaluate exposures for upper trophic level receptor species (Section 4.4). An AUF of 1.0 assumes that a receptor spends 100 percent of its time on-site, an assumption that is valid for sessile or relatively immobile species, but is clearly not representative of sea turtles, which are highly mobile and migratory. The minimum (most conservative) home ranges identified from the literature in the Caribbean region for each of the three turtles are:

- Green sea turtles- 22 to 311 hectares in the Gulf of Mexico for juveniles and 584 to 3,908 hectares in the Caribbean for adults (Seminoff et al., 2002)

- Hawksbill sea turtles- 7 to 21 hectares at Mona Island, Puerto Rico (van Dam and Diez, 1998)

- Loggerhead sea turtles- 95,400 to 2,833,300 hectares in the Gulf of Mexico (Renaud and Carpenter, 1994)

These home ranges correspond to AUFs of 0.015 for juvenile green turtles, 0.00058 for adult green turtles, 0.049 for hawksbill turtles, and 0.0000036 for loggerheads, indicating that the potential for exposure is negligible. Calculated AUFs are less than 1% (= AUF of 0.1) even for hawksbills, which reside in the Caribbean year-round and are the least migratory of the species. This would indicate that any individual hawksbill's diet would not incorporate more than one half of one percent of the forage material from potentially contaminated embayment sediment. The AUF calculations (and thus the indication of potential for exposure) would be even lower if they were based on populations (vs. individuals) of turtles (where the integrated home range would be even larger) and/or more realistic assumptions (mean rather than minimum home ranges, factors considering the quality of each forage component available, seasonal considerations, etc.). This exposure assessment indicates that though a complete exposure pathway is potentially present from sediments to sea turtles, both the magnitude and the significance of the pathway are negligible. In summary, based on an examination of sea turtle life history information and an assessment of available turtle habitat in the area of SWMU 45, it is concluded that there is a minimal and insignificant potential for exposure of sea turtles to chemicals detected in embayment sediment. As a result, no further evaluation of sea turtles in the SWMU 45 area is required or recommended.

3.2.2.3 Summary of SWMU 45 Exposure Pathways

Figure 3-3 shows the critical exposure pathways for ecological receptors at SWMU 45. Based upon the refined conceptual model and results of the Step 3a and 3b evaluation, the key exposure pathways to be evaluated in the baseline ERA include the following:

- Direct contact exposures by lower trophic level aquatic receptors (benthic invertebrates) to Aroclor-1260 in embayment sediment.

- Ingestion-based exposures by upper trophic level herbivorous mammals to arsenic, cadmium, mercury, and selenium in embayment sediment.

3.3 Assessment Endpoints and Risk Questions

Assessment endpoints are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants. The assessment endpoints selected for SWMU 45 are:

- *Survival, growth, and reproduction of benthic invertebrate communities* - Benthic invertebrates serve as the prey base for many aquatic and semi-aquatic species. Many also are detritivores, playing an important role in the breakdown of organic matter and release of nutrients. The embayment will support fewer fish and birds if site-related chemical contamination is limiting the survival, growth, or reproduction of the benthic macroinvertebrate community.

- *Survival, growth, and reproduction of West Indian manatee communities* – Though herbivorous, manatees are susceptible to chemicals that may bioaccumulate within their diet of submerged aquatic vegetation. Food web impacts beyond the manatees are not of concern as manatees have no known predators due to a size refuge. Manatees are, however, listed as a federally endangered species.

Risk questions ask how the assessment endpoints could be affected by site-related conditions. Risk questions also clarify and articulate relationships that are possible through consideration of available data, information from the scientific literature, and the best professional judgment of risk assessors. Finally, they can form the basis for developing a study design for subsequent steps of the ERA process. The risk questions associated with the assessment endpoints identified above are listed below.

- Are Aroclor-1260 concentrations in sediment high enough to impair the survival, growth, and reproduction of aquatic invertebrate communities to the extent that the prey base to support aquatic predators is adversely affected?

- Are arsenic, cadmium, mercury, and selenium concentrations in sediment high enough to adversely effect the survival, growth, or reproduction of West Indian manatee populations?

4.0 STUDY DESIGN/DATA QUALITY OBJECTIVES

Step 4 of the ERA process (Study Design/Data Quality Objectives) establishes the measurement endpoints, the study design, data quality objectives, and data analysis methods for the additional site investigations necessary to complete the ecological risk assessment (USEPA, 1997). The proposed components of the Step 4 investigations will provide multiple lines of evidence on which to evaluate potential ecological risks or existing ecological impacts from exposures to contaminants in sediments from SWMU 45. These lines of evidence are site-specific, direct measures of potential ecological effects and are thus preferable to the comparison of chemical concentrations to conservative, non-site-specific screening values, and other conservative assumptions, which form the basis for screening-level ERAs. The use of multiple lines of evidence reduces the dependence on any one type of data and thus reduces the uncertainty of the analysis, allowing for more confident decisions to be made about the need for, and extent of, remedial actions.

4.1 Measurement Endpoints

The conceptual model for SWMU 45, begun in Step 3b (see Section 3.0), is completed in Step 4 with the development of measurement endpoints. Measurement endpoints are measures of biological effects (e.g., laboratory toxicity test results) that are related to each respective assessment endpoint (USEPA, 1997). The proposed measurement endpoints selected for the baseline ERA are listed below:

Survival, growth, and reproduction of benthic invertebrate communities:

- Comparison of Aroclor-1260 concentrations in sediment with sediment screening values and literature-based effect levels.

- Comparison of results of 28-day sediment laboratory toxicity tests (survival, growth, and reproduction) with the burrowing amphipod *Leptocheirus plumulosus*, using site and reference sediment.

- Existence of significant correlations between laboratory toxicity test results and concentrations of Aroclor-1260 or other chemical/physical characteristics of the tested sediment (e.g., ammonia, redox potential, pH, and grain size distributions).

Survival, growth, and reproduction of herbivorous West Indian manatee populations:

- Comparison of modeled dietary intakes of arsenic, cadmium, mercury, and selenium using field-collected seagrass tissue concentrations with literature-based ingestion screening values.

4.2 Baseline Risk Assessment Study Design

A detailed description of the proposed sampling and analytical program is presented in Section 5.0. Field activities conducted as part of the baseline ERA will include:

- Collection of sediment for laboratory-based analytical testing.

- Collection of sediment for laboratory-based toxicological testing using the amphipod *Leptocheirus plumulosus*. This species was selected as the test organism for the reasons listed below:

- *Leptocheirus plumulosus* is an infaunal amphipod intimately associated with sediment due to its burrowing habits and sediment ingesting nature (USEPA, 2001).

- *Leptocheirus plumulosus* is tolerant of a wide range of TOC, salinity, and grain size distributions (USEPA, 2001).

- *Leptocheirus plumulosus* has a high tolerance for ammonia, a naturally occurring compound in marine sediments that results from the degradation of organic debris (USEPA, 2001).

- A chronic test method has been developed by the USEPA (2001) using *Leptocheirus plumulosus* with two sublethal endpoints (i.e., growth and reproduction), allowing for population-level risk evaluations on benthic invertebrates.

- Collection of above ground and whole plant turtle grass tissue samples for laboratory-based analytical testing of arsenic, cadmium, mercury, and selenium. This species was selected to evaluate West Indian manatee food web exposures for the reasons listed below:

  - Observations made during previous site visits and investigations indicate that turtle grass represents the dominant submerged aquatic vegetation species in Puerto Rican coastal waters in general and in the SWMU 45 embayment specifically (Appendix C).

  - Though manatees will forage on manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), and green algae (*Ulva lactuca*), they preferentially feed on turtle grass, even when it is not the dominant species. This preference is the same, across age classes and genders (Mignucci-Giannoni and Beck, 1998).

  - Foraging studies demonstrate that manatees in NAPR waters feed via two primary strategies, depending on substrate firmness: (1 selective grazing of above ground shoots and stems only or (2 rooting behavior and subsequent feeding on the entire plant, including roots and rhizomes (Geo-Marine, 2005, Reid et al., 2001, and Mignucci-Giannoni and Beck, 1998). Selective above ground feeding behavior is characteristic of manatees observed in firm bottom habitats, where encrusting algae, coarser sediments, and/or more cohesive sediments are present (Reid et al., 2001).

- Collection of sediment samples co-located with the above ground and whole plant turtle grass tissue samples for laboratory-based analytical testing of arsenic, cadmium, mercury, and selenium. This data will be utilized to relate plant tissue concentrations to sediment concentration and verify that the collected turtle grass samples are from areas that are representative of the sediment concentrations observed in the embayment down gradient of the site.

- Identification of suitable reference areas, and the collection of sediment and turtle grass tissue samples at these locations for laboratory-based analytical and toxicological testing.

4.3 Data Quality Objectives

The USEPA defines the Data Quality Objectives (DQO) process as a "*strategic approach based on the scientific method that is used to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to*

collect samples, where to collect samples, the tolerance level of decision errors for the study, and how many samples to collect" (Barnthouse and Suter, 1996).

The purpose of the DQO process is to ensure that the type, quantity, and quality of data used in the decision-making process will be appropriate for estimating potential ecological risks. By employing the DQO process, data requirements and error levels acceptable to the investigation can be defined prior to the collection of data. The DQO process is composed of seven steps (USEPA, 2000a and

2000b). These seven steps, as well as the general DQO process that will be applied to the baseline ERA for SWMU 45 are outlined below:

- Step 1 - State the problem: Define the degree and spatial extent of any ecological risks from exposure to site-related chemicals in sediments within SWMU 45 embayment of Puerca Bay.

- Step 2 - Identify the decision: Is there evidence of unacceptable risk to ecological receptors? Are there sufficient data on which to base this decision?

- Step 3 - Identify the inputs: Analytical chemistry data from relevant media (sediment and vegetation), physical/chemical characteristics of exposure media, and toxicological testing.

- Step 4 - Define the boundaries of the study: SWMU 45: sediment and vegetation within the embayment to its confluence with Puerca Bay.

- Step 5 - Develop a decision rule: Based upon the results of multiple lines of evidence for which data will be available, including (1) comparison of measured media concentrations to applicable risk-based screening values; (2) refined food web modeling using measured tissue concentrations; and (3) toxicological testing.

- Step 6 - Specify tolerable limits on decision errors: Acceptable data requirements and error levels associated with the field and analytical portions of this investigation are presented in the Master Plans (Baker, 1995). Acceptable data requirements and error levels associated with the laboratory-based toxicity tests (i.e., test conditions, data, and data interpretation) have been established by the USEPA (2001). Note that specific data requirements and error levels specified by the USEPA may vary from those identified by the procured laboratory's standard operating procedures (SOPs). Once a laboratory is procured, SOPs for the 28-day *Leptocheirus plumulosus* survival, growth, and reproduction test, will be provided to NAPR, Navy Base Realignment and Closure Program Management Office Southeast (BRAC PMO SE), and the USEPA prior to implementation of the Field Sampling and Analysis Plan (FSAP) presented in Section 5.0.

- Step 7 - Optimize the design for obtaining data: Compile and evaluate information and data to focus sampling efforts. Inherently optimized through the iterative nature of the 8-step ERA process.

4.4 Data Evaluation and Interpretation

The specific lines of evidence that will be employed in this investigation and methods of evaluation are identified and discussed below.

- *Comparison of the spatial and statistical distributions of Arolcor-1260 concentrations in sediment to appropriate literature-based toxicological thresholds* – The maximum, mean, and 95 percent upper confidence limit (UCL) of sediment Aroclor-1260 concentrations will be calculated from the data generated as part of the baseline ERA field investigation (see Section 5.0). The spatial pattern of detections and exceedances of relevant criteria will be evaluated along with these statistical parameters.

  The Aroclor-1260 sediment screening value used in the comparison will be a TEL of 21.6 ug/kg developed by MacDonald (1994). The TEL represents the upper limit of the range of

sediment concentrations dominated by "no effects" data. Within this range, concentrations are not considered to represent significant hazards to sediment-associated biota. Discussions of site concentrations relative to alternative toxicity values obtained from the literature may also be provided.

- *Comparison of Leptocheirus plumulosus survival, growth, and reproduction data in site sediment to that in reference sediment* - Statistical comparisons between site samples and their assigned reference sample will be conducted for survival, growth, and reproduction of *Leptocheirus plumulosus*. The tests (specified by the toxicity testing laboratory SOP [see Section 5.4]) will determine whether organism performance is significantly reduced (at α = 0.05) when exposed to sediment collected from the site relative to the reference area.

- *Existence of patterns in laboratory toxicity test results with chemical burdens and other chemical/physical characteristics of the site media* - The data will be reviewed to determine whether there are relationships between biological response in the toxicity tests and Aroclor-1260 content of sediment. This will be done with the use of multiple regressions or other appropriate statistical analyses. Other factors that may be considered in the analyses include ammonia, pH, TOC, redox potential, salinity of the overlying water column, and grain size distributions. Analysis of correlations between chemical concentrations and toxicity test results (considering the most sensitive of measured endpoints for each species) will be used to determine effects levels for Aroclor-1260 at the site.

- *Comparison of dietary intake for West Indian manatee to literature-based toxicity reference values.* Maximum arsenic, cadmium, mercury, and selenium total concentrations in turtle grass will be used in place of modeled values to estimate dietary intakes for mammalian herbivores (West Indian manatee). Inorganic dietary intakes for each upper trophic level receptor species will be estimated using the following formula modified from USEPA (1993):

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

where:

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

Receptor-specific exposure parameters for the West Indian manatee include the maximum food ingestion rate: 145.8 kg/day wet weight (Etheridge et al., 1985) and minimum body weight: 800 kg (USGS, 2000), as developed in the screening-level ERA and Step 3a report (Baker, 2006). As the manatee is a strictly herbivorous species, the exposure diet is assumed to be made up of 99% plant material (USFWS, 1986 and Odell, 1992) and 1% sediment (from incidental ingestion; USGS, 2000). Direct ingestion of drinking water is only considered if the salinity of a drinking water source is less than 15 parts per thousand (ppt), the approximate toxic threshold for wildlife receptors (Humphreys, 1988). As discussed in the screening-level

ERA and Step 3a document (Baker, 2006), no potential drinking water sources are available in the SWMU 45 embayment or the larger Puerca Bay. As such, ingestion of surface water is not a potential complete exposure pathway and will not be considered in risk calculations for dietary exposures. For the baseline ERA, an AUF of 1.0 will be assumed (i.e., each receptor is assumed to spend 100% of its time within SWMU 45, an overly conservative assumption).

Ingestion-based HQs will be calculated by dividing maximum dietary intakes by literature-based NOAEL and LOAEL values. The NOAEL and LOAEL values used in the derivation of inorganic HQ values will be:

- Arsenic: 0.009 milligrams per kilogram body weight per day (mg/kg-BW/day, NOAEL) and 0.093 mg/kg-BW/day (LOAEL), based on a laboratory study that exposed mice to arsenic as arsenite (As^{+3}) orally in water and incidentally in food over three generations (Sample et al., 1996).

- Cadmium: 0.019 mg/kg-BW/day (NOAEL) and 0.187 mg/kg-BW/day (LOAEL) from USEPA, 1999, based on a laboratory study that exposed mice to cadmium over 150 days, with a reproductive endpoint (USEPA, 1999).

- Mercury: 0.003 mg/kg-BW/day (NOAEL) and 0.004 mg/kg-BW/day (LOAEL) from Sample et al., 1996, based on a laboratory study that exposed mink to methylmercury chloride orally in the diet (Sample et al., 1996).

- Selenium: 0.027 mg/kg-BW/day (NOAEL) and 0.045 mg/kg-BW/day (LOAEL) from Sample et al., 1996, based on a laboratory study that exposed rat to selenium as potassium selenate (SeO_4) through 2 generations (Sample et al., 1996).

Table 4-1 summarizes the decision rules and criteria that will be used to outline potential recommendations and actions associated with these lines of evidence. In general, each of the lines of evidence will be weighted equally. However, the following considerations to weight will be given once analytical results are compiled and all statistical tests are completed:

- Exposure-Response - Data that demonstrates a clear, unconfounded dose-relationship between the response variable and Aroclor-1260, arsenic, cadmium, mercury, and selenium will be preferentially weighted at the decision point.

- Quality - Data sets that meet the acceptable data requirements and error levels outlined in the Master DCQAP (Baker, 1995) and the procured toxicity testing laboratory's SOPs will be preferentially weighted at the decision point.

- Power - Data sets of sufficient size and coverage to detect a statistical difference between groups of interest will be preferentially weighted at the decision point.

- Spatial coverage - Data sets that adequately characterized the concentration gradient of the identified risk drivers will be preferentially weighted at the decision point.

- Uncertainty - Data sets relating to the assessment endpoints with lower uncertainty will be preferentially weighted at the decision point.

If significant conflicts among the lines of evidence result in uncertain risk conclusions, the risk managers will need to decide if these uncertainties are too high. If so, additional data collection and evaluation beyond the proposed sampling might be required to resolve the uncertainties.

5.0 FIELD SAMPLING AND ANALYSIS PLAN

This section presents the proposed field and laboratory activities for the baseline ERA at SWMU 45. Activities will include fieldwork support (subcontractor procurement and mobilization/demobilization), field verification of the FSAP, field investigations, analytical testing and data validation, data evaluation, and report preparation. The primary purpose of the FSAP is to provide guidance for all the project field activities by describing in detail the methods and procedures to be used to implement various field tasks for SWMU 45.

To simplify the process of developing site-specific project plans, Master Plans have been prepared for project management (PMP), DCQAP, DMP, and HASP (Baker, 1995). Together, these plans provide all details regarding field investigation techniques, laboratory analysis, data validation, and data evaluation required to fulfill the requirements of the RFI program. These plans provide the details for sampling and analysis protocols to be followed and general activities to be accomplished for the SWMU 45 baseline ERA. Addendums to the DCQAP and HSAP have been prepared to address specific issues related to this investigation (see Appendix A and Appendix B, respectively). This document will supplement the Master Plans with site-specific information for the SWMU 45 baseline ERA.

5.1 Field Work Support

Field work support includes subcontractor procurement and mobilization/demobilization. Subcontractors procured for the baseline ERA at SWMU 45 will consist of: (1) an analytical laboratory; (2) a third party, independent data validator; and (3) a toxicity testing laboratory. Mobilization/demobilization activities will include procurement of equipment and supplies necessary for the field sampling program, and shipping or transporting those items to and from the field.

5.2 Verification of the Field Sampling Design

Prior to implementation of the baseline ERA field investigation at SWMU 45, the sampling design will be verified in the field to ensure that the study design is appropriate and can be implemented at the site. The testable hypotheses, exposure pathway models, and measurement endpoints also will be evaluated for their appropriateness.

Toxicity tests require that samples from an area not known to be impacted by identified contaminant sources (i.e. SWMU 45), termed reference areas, be collected for comparison to potentially impacted areas. Suitability of the proposed reference area will be evaluated analytically via surface sediment sampling and qualitatively, via examination of the suitability of the habitat for manatee foraging.

Three potential reference areas have been identified based on the lack of potential contaminant influences and availability of seagrass habitat similar to that identified in the SWMU 45 embayment (Figure 5-1). Prior to sampling activities, a qualitative seagrass survey will be performed at each of the proposed reference areas. Species dominance and percent cover by seagrass will be determined. Following the vegetative characterization, six sediment samples will be collected from the SWMU 45 embayment and each of the proposed reference areas (for a total of 24 sediment samples, plus associated quality assurance/quality control samples [QA/QC], Table 5-1). Sediment samples will be collected from representative areas and will be analyzed for TOC and grain size. Sediment samples collected from the proposed reference areas also will be analyzed for Aroclor-1260, arsenic, cadmium, mercury, and selenium. To be considered an appropriate reference area, the following conditions must be met: (1) the concentration of each analyte in reference area sediment must not exceed their respective screening values, as developed in the conservative screening-level ERA and Step 3a report

(Aroclor-1260: 21.6 ug/kg, arsenic: 7.24 mg/kg, cadmium: 0.68 mg/kg, mercury: 0.13 mg/kg, and selenium: 1.0 mg/kg; Baker, 2006), (2) the physical and chemical properties of reference area media (e.g., TOC and grain size) must have a range similar to those traits in site media, and (3) the suitability as a foraging area must be similar to that offered within the SWMU 45 embayment (shallow subtidal shelf within SWMU 45 characterized as a seagrass/algal bed dominated by turtle grass, seagrass cover values from 50% to greater than 75%; Appendix C).

By verifying the field sampling design prior to conducting the field investigation, well-considered alterations to the study design can be made if necessary. If the field verification indicates that the study design cannot be met, or that significant deviations from this FSAP are necessary, discussion will be held with representatives from NAPR, Navy BRAC PMO SE, Baker, and USEPA to determine appropriate actions. If the requirements for contaminant concentrations and the physical/chemical/biological properties are not met at any of the proposed reference areas, an alternate reference area will be established within an unimpacted portion of the study area during the baseline ERA field investigation (as determined by analytical results for sediment). The alternate reference area will be considered acceptable if it meets the requirements noted above.

5.3 Baseline Ecological Risk Assessment Field Sampling Activities

Field sampling activities at SWMU 45 will involve the collection of surface sediment and seagrass tissue samples from SWMU 45 and an appropriate reference area. Field data collection activities will be recorded in a project logbook. Entries will be described at an appropriate level of detail so that the situation can be reconstructed without reliance on memory. A discussion of proposed sampling activities is presented in the sections that follow.

5.3.1 Sediment Sampling

Surface sediment samples will be collected within the SWMU 45 embayment and one or more of the reference areas to characterize the extent and magnitude of Aroclor-1260 concentrations in embayment sediments and to evaluate direct contact exposures to benthic macroinvertebrates. Table 5-1 presents a sample summary, described in detail below.

A maximum of 25 surface sediment samples (from approximately 0 to 6 inches below ground surface [bgs]) will be collected from the SWMU 45 embayment to characterize the current extent and magnitude of Aroclor-1260 concentrations in sediment. Sample locations will be identified using a stratified design by establishing a 90-foot by 90-foot sampling grid covering the SWMU 45 embayment (see Figure 5-2). Each grid will contain one sediment sample location. The location of each sampling point within a given grid will be determined in the field. A maximum of 6 surface sediment samples will also be collected from one or more of the identified reference areas (Figure 5-1), depending on the results of the field verification evaluations described in Section 5.2. The location of the reference area sediment samples will be determined based on their suitability for comparison to SWMU 45 sediment, as outlined in Section 5.2.

Sediment samples will be collected using dedicated stainless steel spoons, hand corers, and/or a petit ponar grab, depending on substrate type and depth of the overlying water column. Enough sediment from each location will be collected in aluminum pans in volumes sufficient for both analytical and toxicological testing (approximately 1 gallon of sediment). Samples will be homogenized, and a portion of each sample will be submitted to the analytical laboratory for quick-turn (24-hour) analysis of Aroclor-1260. Field QA/QC samples (i.e., field duplicates and matrix spike/matrix spike duplicates [MS/MSDs]) associated with these samples also will be collected and analyzed on a quick-turn basis. The remainder of each homogenized sediment sample will be held in a sealed storage container on ice

until analytical results are available. Upon receipt of the analytical results for surface sediment samples, a maximum of 7 site and 3 reference sediment samples will be selected and submitted to the toxicity laboratory for 28-day *Leptocheirus plumulosus* toxicity testing, described below. Samples for toxicity testing will be selected to span the range of Aroclor-1260 contamination (ranging from non-detects or levels less than the 21.6 ug/kg screening value to the maximum detected concentration collected during the baseline ERA field investigation). Reference samples selected for toxicity testing will meet the Aroclor-1260 concentration criteria specified above and will have a range of pH (field measured), TOC (apparent, based on professional judgment), and grain size distributions (apparent, based on professional judgment) similar to the range found in sediments collected from SWMU 45 embayment (based on the field verification dataset, described above). In addition to Aroclor-1260 analyses, each sediment sample submitted for toxicity testing will be analyzed for TOC, grainsize, ammonia, pH, arsenic, cadmium, copper, mercury, and tin. Arsenic, cadmium, copper, mercury, and tin represents the Appendix IX metals identified as preliminary ecological COPCs for embayment sediment in Step 2 of the ERA process. Although not identified as potential ecological risk drives in Step 3a (refinement of conservative exposure assumptions; see Baker, 2006), they are included in the analytical program as potential confounding factors that may contribute to any observed toxicity.

5.3.2 Seagrass Tissue Sampling with Co-located Sediment Sampling

As indicated on Table 5-1, a maximum of 3 above ground plant and 3 whole-body composite seagrass tissue samples will be collected from the SWMU 45 embayment and from the identified reference area(s), for a total of 12 composite tissue samples. Compositing of plant samples will be necessary to achieve the desired tissue mass (2 to 5 grams wet weight) for analysis. All samples will be collected from shallow (< 2 meters) shelf waters, as these habitats represent the prime foraging areas for West Indian manatees. Waters deeper than 2 meters are generally used more for resting and traveling than for foraging (Reid et al., 2001). Above ground seagrass tissue will be collected by shearing plants at the sediment water interface with a sharp blade. Whole-plant samples will be collected with a rake and/or shovel, depending on the depth of the water column and firmness of the sediment and rhizome layer. As discussed in Section 4.2, turtle grass will be targeted for tissue collection as it is the preferred manatee forage species and is the dominant species found in the SWMU 45 embayment. Plants used for tissue samples will be rinsed in distilled water, wrapped in aluminum foil, placed in freezer bags, frozen in a freezer prior to shipment to the analytical laboratory, and packed with ice to remain frozen during shipment. Each above ground and whole-body tissue composite sample will be analyzed for total arsenic, cadmium, mercury, and selenium.

As indicated on Table 5-1, a maximum of 3 surface sediment samples (from approximately 0 to 6 inches below ground surface [bgs]) will be co-located with the seagrass tissue samples being collected from the SWMU 45 embayment and from the identified reference area(s), for a total of 6 samples.

Sediment samples will be collected using dedicated stainless steel spoons, hand corers, and/or a petit ponar grab, depending on substrate type and depth of the overlying water column. Enough sediment from each location will be collected in aluminum pans in volumes sufficient for analytical testing. Samples will be submitted to the analytical laboratory for analysis of total arsenic, cadmium, mercury, and selenium. Field QA/QC samples (i.e., field duplicates and matrix spike/matrix spike duplicates [MS/MSDs]) associated with these samples also will be collected and analyzed. In addition to total arsenic, cadmium, mercury, and selenium analyses, each sediment sample submitted will be analyzed for TOC, grainsize, ammonia, and pH.

5.4 Sediment Toxicity Tests

Direct toxicity to aquatic benthic invertebrates will be evaluated using 28-day *Leptocheirus plumulosus* survival, growth, and reproduction tests. General test endpoints for *Leptocheirus plumulosus* are survival, calculated as the percentage of neonates at test initiation that survive as adults at test termination; growth rate, calculated as the mean dry weight per adult amphipod at test termination; and reproduction; calculated as the number of offspring per surviving adult. Specific calculations for each measurement endpoint will be specified in laboratory toxicity test SOPs, which will be provided to NAPR, Navy BRAC PMO SE, and USEPA once a toxicity laboratory is procured (prior to implementation of the FSAP).

Sediment samples will be overlain with water specified by the procured laboratory with water quality characteristics (e.g., hardness) similar to the water quality characteristics of surface water at the site (field measurements of temperature, salinity, dissolved oxygen, conductivity, pH, and total suspended solids will be collected from representative locations during the collection of sediment samples). A negative control will be run to ensure that the populations of organisms used in the toxicity tests are healthy. The testing laboratory will determine the appropriate substrate for control testing. Good health is demonstrated when the organism's performance meets or exceeds the control performance acceptability criteria for survival, growth, and reproduction. The procured laboratory's SOPs will specify acceptable control performance criteria. If control performance falls below the acceptability criteria, the results of the toxicity tests will be considered invalid and the tests will be rerun at the expense of the toxicity laboratory.

General criteria for the *Leptocheirus plumulosus* toxicity tests are outlined in *Methods for Assessing the Chronic Toxicity of Marine and Estuarine Sediment-Associated Contaminants with the Amphipod Leptocheirus plumulosus* (USEPA, 2001). However, these criteria may vary from those specified by the procured laboratory's SOP. Once a laboratory is procured, the laboratory's SOP will be provided to NAPR, Navy BRAC PMO SE, and USEPA for approval prior to implementation of field activities.

The performance of organisms in site sediment will be statistically compared to that of organisms in the appropriate reference sediment to determine if endpoint measurements (e.g., survival, growth, and/or reproduction) differ significantly using statistical tests outlined in the toxicity testing laboratories SOPs.

As at any field site, there is local variability in sediment physical/chemical properties. Because these factors can influence toxicity test results, it is often difficult to discern the cause of biological responses in laboratory toxicity tests. To determine if these factors are influencing test results, sediment collected for toxicity testing will be analyzed for pH, TOC, and grain size distribution. These data will be reviewed to determine whether there are any correlations between their concentration/distribution in sediment and test organism response.

5.5 Quality Assurance/Quality Control Samples

The QA/QC requirements for samples collected during the baseline ERA field investigation are presented in the Master DCQAP (Baker, 1995). As presented on Table 5-1, the following QA/QC samples will be collected during field sampling activities to (1) ensure dedicated sampling equipment are not contaminated (equipment rinsate blanks); (2) establish field background conditions (field blanks); (3) evaluate field methodologies (duplicate samples); and (4) evaluate the laboratory process (MS/MSDs).

Equipment Rinsate Blanks - Equipment rinsate blanks are defined as samples that are obtained by running analyte-free water over/through sample collection equipment before its first use (new or dedicated sampling equipment). The following equipment rinsate blanks are anticipated. Note that the actual equipment rinsate blanks collected will depend on the specific equipment used to collect the sediment samples discussed in Sections 5.3.2 and 5.3.1, respectively:

- One equipment rinsate blank will be collected from a stainless steel spoon used to sample sediments during the field verification. The rinsate will be analyzed for Aroclor-1260, arsenic, cadmium, mercury, and selenium.

- One equipment rinsate blank will be collected from a hand corer used to sample sediments during the baseline ERA field investigation. The rinsate will be analyzed for Aroclor-1260.

- One equipment rinsate blank will be collected from the petit ponar grab used to sample sediments during the baseline ERA field investigation. The rinsate will be analyzed for Aroclor-1260.

- One equipment rinsate blank will be collected from an aluminum pan used to homogenize sediment samples collected for split analytical and toxicological testing during the baseline ERA field investigation. The rinsate will be analyzed for Aroclor-1260.

The results from the equipment rinsates will be used to evaluate the dedicated sampling equipment. This comparison is made during data validation and the rinsates are analyzed for the same parameters as the related samples.

Field Blanks - Field blanks are defined as samples that are obtained by pouring analyte-free water (e.g., laboratory distilled water) into appropriate sample containers at pre-designated field locations. This is done to determine if any contaminants present in the area may have an effect on sample integrity. Field blanks should not be collected in dusty environments and/or from areas where contamination is present in the atmosphere and originating from a source other than the source being sampled. One field blank will be collected during the field verification (analyzed for Aroclor-1260, arsenic, cadmium, mercury, and selenium) and one will be collected during the field investigation (analyzed for Aroclor-1260).

Field Duplicates - Field duplicates samples are collected concurrently with environmental samples. All samples are homogenized and split. Field duplicates will be collected at a frequency of 10 percent (1/10).

MS/MSDs - MS/MSD samples are collected to evaluate the matrix effect of the sample upon the analytical methodology and the laboratory process through a comparison of MS and MSD analytical results. MS/MSDs will be collected at a frequency of 5 percent (1/20).

5.6 Sample Designations

In order to identify and accurately track the sediment samples, all samples collected during this investigation, including QA/QC samples, will be designated with a unique number. The number will serve to identify the site, the sample media, sampling location, the investigation, and QA/QC qualifiers. The sample designation format is as follows:

[Site #]-[Investigation]-[Media][Station #][QA/QC]

An explanation of each of these identifiers is given below.

Site #: SWMU 45

Investigation: Samples collected during the baseline ERA sampling event will be indicated by "B".

Media: ER = Equipment Rinsate
FB = Field Blank
SD = Sediment Sample
VEG = Vegetative Tissue Sample

Station #: Each sample will be identified with a unique identification number (starting with 01). Sediment sampling stations will be distinct from seagrass sampling

locations. Seagrass tissue sample identification numbers also will include a "-AG" extension to indicate collection of the above ground portion of the plant or "-WB" extension to indicate collection of the whole body plant.

QA/QC: (D) = Duplicate Sample
(MS/MSD) = Matrix Spike/Matrix Spike Duplicate

Under this sample designation format the sample number 45B-SD01D refers to:

45B-SD01D	SWMU 45
45B-SD01D	Baseline ERA
45B-SD01D	Sediment sample
45B-SD01D	Sample Location 01
45B-SD01D	Duplicate (QA/QC) Sample

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

5.7 Investigation Derived Waste

Investigative Derived Waste (IDW) management will be conducted in accordance with guidance from USEPA's Guide to Management of Investigation-Derived Wastes (USEPA, 1992). The document states, *"most IDW (with the exception of non-indigenous IDW) generated during the course of the investigation are intrinsic elements of the site, and should be managed with other wastes from the site, consistent with final remedy."* IDW generated during the field investigation will only include miscellaneous items such as gloves and used personal protective equipment (PPE). No decontamination fluid IDW will be generated due to the use of dedicated sampling equipment. Sediment cuttings from the sampling activities will be returned to the areas sampled. Items of PPE that have come in contact with potentially contaminated materials, such as disposable gloves and Tyvek®, as well as dedicated sampling equipment, will be placed in garbage bags and disposed of in trash dump boxes.

As stated, the use of dedicated equipment or materials negates the requirement of decontamination of any equipment or materials. As such, no IDW sampling or analysis will be required.

5.8 Sample Analysis, Data Validation, and Data Evaluation

All analyses will be conducted at a contracted laboratory that fulfills all requirements of the Navy's QA/QC Program Manual and USEPA's Contract Laboratory Program (CLP). All contaminant analytical data (Aroclor-1260, arsenic, cadmium, mercury, and selenium) generated by this investigation will be subjected to independent, third party validation in accordance with the USEPA Region III Data Validation Operating Procedures. Analytical data related to physiochemical properties of sediment and laboratory toxicity test conditions (TOC, grainsize, pH, ammonia) will not be validated. The Master DCQAP establishes all the general QA requirements for the analyses that will occur during the investigation (Baker, 1995). The Master DCQAP presents the specific policies, organization, functions, and QA/QC activities associated with the analytical data, and in conjunction with data validation, is designed to ensure that acceptable data requirements and error levels are achieved. A summary of the samples collected as part of the preliminary and baseline ERA sediment sampling events is presented in Table 5-1. Analytical methods and analytical data quality levels are summarized in Table 5-2, while Table 5-3 presents method performance limits for each contaminant.

5.9 Data Management/Geographical Information System

Data management activities will include the establishment of sample tracking forms and activities from sample collection to independent, third party data validation. Activities include the systematic assignment of alphanumeric sample identifiers to each sample location for use in the relational database and the production of sample tracking spreadsheets. Coordination with field personnel during field sampling activities, the laboratory project manager, and the data validation subcontractor will also be included. This also includes management of laboratory data and conversion of the analytical data into tables that will be included in the individual reports.

Geographic coordinates of the SWMU 45 and reference area sample locations will be collected using a Global Positioning System (GPS) during the field event. Coordinates of some permanent or significant structures in the vicinity of each location may also be collected to identify approximate boundaries, if required. All GPS coordinate points will be correlated to the Puerto Rico State Plane Coordinate System.

Mapping data and analytical data will be compiled for use in a Geographical Information System (GIS) and other data management processes. When the field investigation and laboratory analysis are complete, Baker personnel will review all laboratory data and the results from the independent data validation subcontractor. Data and all appropriate validation qualifiers will be added to the database containing the laboratory data. Ultimately, these data will be exported to the GIS for mapping, presentation, and archival purposes.

5.10 Project Reporting

The analytical and toxicity test data will be evaluated and presented in the Step 7 draft baseline ERA report. The report will evaluate the potential risk to aquatic invertebrate exposures to Aroclor-1260 in embayment sediment and West Indian manatee food web exposures to arsenic, cadmium, mercury, and selenium from ingestion of seagrass using the following lines of evidence (see section 4.4):

- Comparison of Aroclor-1260 sediment concentrations to appropriate literature-based toxicological thresholds.

- Comparison of *Leptocheirus plumulosus* survival and growth data in SWMU 45 sediment to *Leptocheirus plumulosis* survival and growth in reference sediment.

- Existence of patterns in laboratory toxicity tests results with chemical burden and other chemical/physical characteristics of the sediments.

- Comparison of West Indian dietary intakes to NOAELs/LOAELs.

These lines of evidence will be evaluated in Step 7 using a weight-of-evidence approach (see Section 4.4). The methods, results, analyses, and risk characterization conclusions will be reported in a draft and final baseline ERA report. If significant conflicts among these lines of evidence result in uncertain risk conclusions, additional data collection and evaluation beyond the proposed Step 4 sampling (see Section 4.0) might be required to resolve the uncertainties. Chemical-specific PRGs, if needed, will be calculated to aid the risk-management decision-making process. The decision to calculate PRGs will be based upon the results of the Step 7 baseline ERA (i.e., conclusion of unacceptable risk). The rational, methods, and calculations will be documented in a Step 8 technical memorandum.

6.0 PROJECT SCHEDULE

The schedule of events included in this Work Plan is depicted on Figure 6-1. It should be noted that this schedule is dependent upon USEPA review time. Many other factors can also extend the schedule such as resampling if additional sampling is required, weather delays in the field, funding is delayed by the Navy, and consensus cannot be reached on how the USEPA's comments are incorporated.

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TABLES

TABLE 2-1

LIST OF BIRDS REPORTED FROM NAVAL ACTIVITY PUERTO RICO
SWMU 45 – AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT AND STEP 3A OF THE BASELINE ECOLOGICAL RISK ASSESSMENT
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

LIST OF BIRDS REPORTED FROM NAVAL ACTIVITY PUERTO RICO
SWMU 45 – AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT AND STEP 3A OF THE BASELINE ECOLOGICAL RISK ASSESSMENT
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 Activity Puerto Rico.

TABLE 3-1

AQUATIC RISK DRIVERS - ANALYTICAL DATA SUMMARY
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Sample ID	11-SD01	11-SD02	11-SD03	11-SD04	11-SD05	11-SD06	11-SD07	11-SD08	11-SD09	11OWSD10	11OWSD11	11OWSD12
Sample Date	09/19/97	10/02/97	10/02/97	10/02/97	10/02/97	10/02/97	10/02/97	10/02/97	10/02/97	08/05/03	08/06/03	08/06/03
Sample Depth (inches bgs)	0.00-3.00	0.00-3.00	0.00-3.00	0.00-3.00	0.00-3.00	0.00-3.00	0.00-3.00	0.00-3.00	0.00-3.00	0.00-6.00	0.00-6.00	0.00-6.00
PCBs (ug/kg)												
Aroclor-1260	34 J	42	46	53	42	62	51	33	130	18 J	150	35 J
Inorganics (mg/kg)												
Arsenic	12	3.3 J	5.4 J	3.7 J	5.8 J	5.6 J	4.8 J	7.8 J	5.4 J	5.9	7.3	6.6
Cadmium	0.66 J	0.07 U	0.08 J	0.07 U	0.07 U	0.08 U	0.06 U	0.06 U	0.06 U	0.13 J	0.21 J	0.13 J
Mercury	0.42	0.04 U	0.06 U	0.04 U	0.05 U	0.04 U	0.04 U	0.03 U	0.04 U	0.031 J	0.034 J	0.034 J
Selenium	0.78 J	0.37 U	0.44 U	0.36 U	0.41 U	0.42 U	0.35 U	0.32 U	0.35 U	0.25 J	0.4 J	0.38 J

Notes:

J = estimated value
NA = Not available
U = non-detected value

TABLE 3-1

AQUATIC RISK DRIVERS - ANALYTICAL DATA SUMMARY
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Sample ID	11OWSD13	11OWSD14	11OWSD15	11OWSD16	11OWSD17	11OWSD18	11OWSD20	11OWSD21	11OWSD22	11OWSD23	11OWSD24
Sample Date	08/06/03	08/06/03	08/05/03	08/05/03	08/05/03	08/05/03	08/06/03	08/06/03	08/06/03	08/06/03	08/06/03
Sample Depth (inches bgs)	0.00-6.00	0.00-6.00	0.00-6.00	0.00-6.00	0.00-6.00	0.00-6.00	0.00-6.00	0.00-6.00	0.00-6.00	0.00-6.00	0.00-6.00
PCBs (ug/kg)											
Aroclor-1260	22 J	77 U	35 J	25 J	26 J	38 J	24 J	12 J	63 U	60 U	58 U
Inorganics (mg/kg)											
Arsenic	6.8	5.3	4.1	3.6	3.2	4.7	NA	NA	NA	NA	NA
Cadmium	0.14 J	0.11 J	0.25 J	0.17 J	0.38 J	1.3	NA	NA	NA	NA	NA
Mercury	0.036 J	0.015 J	0.07 U	0.016 J	0.017 J	0.038 J	NA	NA	NA	NA	NA
Selenium	0.36 J	0.39 J	0.26 J	0.25 J	0.21 J	0.37 J	NA	NA	NA	NA	NA

Notes:
J = estimated value
NA = Not available
U = non-detected value

TABLE 3-1

AQUATIC RISK DRIVERS - ANALYTICAL DATA SUMMARY
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Sample ID Sample Date Sample Depth (inches bgs)	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Frequency of Detection	Arithmatic Mean Positive Detects	Arithmatic Mean Half Non-Detects	Standard Deviation	Upper 95% Confidence Level	Location of Maximum Detect
PCBs (ug/kg)										
Aroclor-1260	58 U	77 U	12 J	150	19/23	46.21	43.78	32.61	55.46	11OWSD11
Inorganics (mg/kg)										
Arsenic	---	---	3.2	12	18/18	5.63	5.63	2.08	6.48	11-SD01
Cadmium	0.06 U	0.08 U	0.08 J	1.3	11/18	0.32	0.21	0.31	0.34	11OWSD18
Mercury	0.03 U	0.07 U	0.015 J	0.42	9/18	0.07	0.05	0.09	0.09	11-SD01
Selenium	0.32 U	0.44 U	0.21 J	0.78 J	10/18	0.37	0.29	0.15	0.35	11-SD01

Notes:
J = estimated value
NA = Not available
U = non-detected value

TABLE 3-2
FREQUENCY AND RANGE OF AROCLOR-1260 SEDIMENT DATA COMPARED TO SEDIMENT SCREENING VALUES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND STEP 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Analyte	Contaminant Frequency/Range								Sediment Screening Value	Reference	Max. HQ	Mean HQ
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Positive Detections	Range of Non-Detects	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Step 2 Screen	Value used in Step 3a Screen				
PCBs (ug/kg)												
Aroclor-1260	19/23	12	12J - 150	58	58U - 77U	44	150	43.8	22	MacDonald, 1994	6.94	2.03

Notes:
HQ = Hazard Quotient
Max HQ = maximum detected value/screening value
Mean HQ = arithmetic mean (1/2 non-detects) value/screening value
J = Value is estimated
U = Not detected
ug/kg = microgram per kilogram
Shaded cells indicate the Hazard Quotient (HQ) is greater than 1.0.
MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Waters: Volume 1 – Development and Evaluation of Sediment Quality Assessment Guidelines. Florida Department of Environmental Protection, Tallahassee, Fl.

TABLE 3-3
SUMMARY OF HAZARD QUOTIENTS FOR WEST INDIAN MANATEE INGESTION-BASED EXPOSURES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND STEP 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	West Indian Manatee		
	NOAEL	LOAEL	MATC
Inorganics:			
Arsenic	38.77	3.88	12.26
Cadmium	6.15	0.62	1.94
Mercury	21.35	12.81	16.54
Selenium	2.33	1.41	1.82

Notes:
LOAEL = Lowest Observed Adverse Effect Level
MATC = Maximum Acceptable Toxicant Concentration
NOAEL = No Observed Adverse Effect Level
Shaded cells indicate the Hazard Quotient (HQ) for the ecological receptor is greater than 1.0.

TABLE 4-1
DECISION RULES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND STEP 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Line of Evidence	Decision Based on	Uncertainties/ Limitations/ Factors to Consider	Decision Criteria	Decision Recommendations/Actions
Comparison of the spatial and statistical distributions of sediment Aroclor-1260 concentrations in sediment to appropriate literature-based toxicological thresholds	Do the maximum, mean, and 95% UCL Aroclor-1260 concentration exceed acceptable media-specific toxicological thresholds? What is the spatial pattern of exceedance of these criteria?	Literature-based toxicological thresholds are not site-specific (do not take into consideration site-specific factors than can influencew bioavailability)	HQ > 1.0	Indication of unacceptable risk
			HQ ≤ 1.0	Indication of acceptable/minimal risk
Comparisons of toxic response to reference areas	Is there a significant reduction ($\alpha = 0.05$) in the survival, growth, and/or reproduction of *Leptocheirus plumulosus* raised in SWMU 45 vs. reference sediments?	Low control or reference survival or reproduction - potential inability to make decision; Power of statistical test	$p<0.05$, significant difference	Unacceptable risk identified; Risk remediation considerations recommended
			$p\geq 0.05$, non significant difference	Indication of acceptable/minimal risk; No further action recommended
Demonstration of a dose-response relationship between Aroclor-1260 concentrations and endpoint response variables	Does a response relationship exists (indicated by multiple regression with a $p<0.05$ and $r^2>0.50$) between Aroclor-1220 and the most sensitive of the measured aquatic response variables (survival, growth, or reproduction)?	Confounding influences may include the use of inappropriate reference samples, inability of field effort to capture known concentration gradient of risk drivers, response variables outside of concentration ranges, and physical/chemical (grainsize, TOC, pH, etc.) parameters impacting the response variable.	$p<0.05$ and $r^2\geq 0.50$, significant difference, low variability in response	Unacceptable risk identified; Risk remediation considerations recommended
			$p<0.05$ and $r^2<0.50$ significant difference, high variability in response	Large variability in response variable caused by confounding variables; Investigation into variable impact and weight to arrive at decision point
			$p\geq 0.05$, non significant difference	Indication of acceptable/minimal risk only after investigation of the limits and uncertainties associated with the potential for confounding influences; No further action recommended

TABLE 4-1
DECISION RULES
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND STEP 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Line of Evidence	Decision Based on	Uncertainties/ Limitations/ Factors to Consider	Decision Criteria	Decision Recommendations/Actions
Comparison of dietary intake for West Indian manatee to literature based toxicity reference values for arsenic, cadmium, mercury, and selenium	Do dietary dose estimates using seagrass tissue data exceed literature-based NOAEL and LOAEL ingestion-based screening values?	Site-specific bioaccumulation	HQ > 1.0	Indication of unacceptable risk
			HQ ≤ 1.0	Indication of acceptable/minimal risk

Notes:

HQ = Hazard Quotient
TOC = Total Organic Carbon
NOAEL = No Observed Adverse Effect Concentration
LOAEL = Lowest Observed Adverse Effect Levels
UCL = Upper Confidence Limit

TABLE 5-1

Revised: July 26, 2006

SAMPLING SUMMARY
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND STEP 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Matrix	Laboratory Parameter	Samples (1)		Quality Assurance/Quality Control				Total Samples
		SWMU 45	Reference	Field Duplicates (2)	MS/MSD (3)	Field Blank	Equipment Rinsate Blank (4)	
Field Verification of Reference Area Appropriateness (5)								
Surface Sediment (0-6 inches bgs)	Aroclor-1260		18	2	1	1	1	23
	Arsenic, Cadmium, Mercury, Selenium		18	2	1	1	1	23
	TOC	6	18					24
	Grain Size	6	18					24
Baseline Ecological Risk Assessment Field Investigation								
Surface Sediment (0-6 inches bgs)	Aroclor-1260 (quick turn)	25	6	4	2	1	3	41
Surface Sediment Toxicity Test Samples	Toxicity Test (28-day) - *Leptocheirus plumulosus*	7	3					10
	Arsenic, Cadmium, Copper, Mercury, Tin	7	3	1	1	1	3	15
	TOC	7	3					10
	Grain Size	7	3					10
	pH	7	3					10
	Ammonia	7	3					10
Seagrass Tissue (6)	Aboveground plant material - Arsenic, Cadmium, Mercury, Selenium	3	3					6
	Whole plant - Arsenic, Cadmium, Mercury, Selenium	3	3					6
Surface Sediment (0-6 inches bgs) co-located with Seagrass Tissue	Arsenic, Cadmium, Mercury, Selenium	3	3	1	1			8
	TOC	3	3					6
	Grain Size	3	3					6

Notes:

MS/MSD = Matrix Spike/ Matrix Spike Duplicate

TOC = Total organic carbon

(1) The actual number of site and reference samples submitted for analysis may vary based on conditions encountered in the field.

(2) Field duplicates will be collected at a frequency of 10% (1/10 samples).

(3) MS/MSD samples will be collected at a frequency of 5% (1/20 samples).

(4) The actual number of equipment rinsate blanks collected will depend on the different types of field sampling equipment (stainless steel spoons, hand corers, and/or petite ponar) used to collect the sediment samples (minimum of one, maximum of three).

(5) Three potential reference areas will be evaluated for appropriateness (see Figure 5-1).

(6) Composites of the dominant species, turtle grass (*Thalassia testudium*), will be preferentially sampled.

TABLE 5-2 Revised: July 26, 2006

ANALYTICAL METHODS AND ANALYTICAL DATA LEVELS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND STEP 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Matrix	Analyte	Analytical Method	Analytical Data Levels	Turn Around Time
Field Verification of Reference Area Appropriateness				
Sediment	Aroclor-1260	SW-846 8082	USEPA Level IV	28 days
	Arsenic	SW-846 6020	USEPA Level IV	28 days
	Cadmium	SW-846 6020	USEPA Level IV	28 days
	Mercury	SW-846 7471A	USEPA Level IV	28 days
	Selenium	SW-846 6020	USEPA Level IV	28 days
	TOC	SW-846 9060	USEPA Level III	28 days
	Grain size (sieve)	ASTM D422	USEPA Level III	28 days
Aqueous [(1)]	Aroclor-1260	SW-846 8082	USEPA Level IV	28 days
	Arsenic	SW-846 6020	USEPA Level IV	28 days
	Cadmium	SW-846 6020	USEPA Level IV	28 days
	Mercury	SW-846 7471A	USEPA Level IV	28 days
	Selenium	SW-846 6020	USEPA Level IV	28 days
Baseline Ecological Risk Assessment Field Investigation				
Sediment	Aroclor-1260	SW-846 8082	USEPA Level IV	48 hours
	Arsenic	SW-846 6020	USEPA Level IV	48 hours
	Cadmium	SW-846 6020	USEPA Level IV	48 hours
	Copper	SW-846 6020	USEPA Level IV	48 hours
	Mercury	SW-846 7471A	USEPA Level IV	48 hours
	Selenium	SW-846 6020	USEPA Level IV	48 hours
	Tin	SW-846 6020	USEPA Level IV	48 hours
	TOC	SW-846 9060	USEPA Level III	28 days
	Grain size (sieve)	ASTM D422	USEPA Level III	28 days
	pH	SW-846 9045C	USEPA Level III	28 days
Seagrass Tissue	Arsenic	SW-846 6020	USEPA Level IV	28 days
	Cadmium	SW-846 6020	USEPA Level IV	28 days
	Mercury	SW-846 7471A	USEPA Level IV	28 days
	Selenium	SW-846 6020	USEPA Level IV	28 days
Aqueous [(1)]	Aroclor-1260	SW-846 8082	USEPA Level IV	28 days
	Arsenic	SW-846 6020	USEPA Level IV	28 days
	Cadmium	SW-846 6020	USEPA Level IV	28 days
	Copper	SW-846 6020	USEPA Level IV	48 hours
	Mercury	SW-846 7471A	USEPA Level IV	28 days
	Selenium	SW-846 6020	USEPA Level IV	28 days
	Tin	SW-846 6020	USEPA Level IV	48 hours

Notes:
ASTM = American Society for Testing and Materials
SW-846 = Test methods for evaluating solid wastes, physical/chemical methods
TOC = Total organic carbon
(1) Aqueous samples include equipment rinsate and field blanks.

TABLE 5-3

Revised: July 26, 2006

METHOD PERFORMANCE LIMITS
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND STEP 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Compound	Water MDL (µg/L)	Sediment MDL (mg/kg)	Tissue MDL (mg/kg)	Method
PCBs:				
Aroclor-1260	0.17	0.0064	NA	8082
Total Metals:				
Arsenic	0.6	0.12	0.098	6020 - ICP-MS
Cadmium	0.1	0.02	0.027	6020 - ICP-MS
Copper	0.39	0.038	0.038	6020 - ICP-MS
Mercury	0.08	0.004	0.0037	7471A - CVAA
Selenium	0.5	0.1	0.051	6020 - ICP-MS
Tin	1	5	5	6020 - ICP-MS

Notes:
CVAA = Cold Vapor Atomic Absorption
ICP-MS = Inductively Coupled Plasma - Mass Spec
MDL = Method Detection Limit
NA = Not applicable
mg/kg = milligrams per kilogram
ug/L = micrograms per liter

FIGURES

K\CH2M HILL CLEAN III\CTO108 (106547)\CAD\106547F00

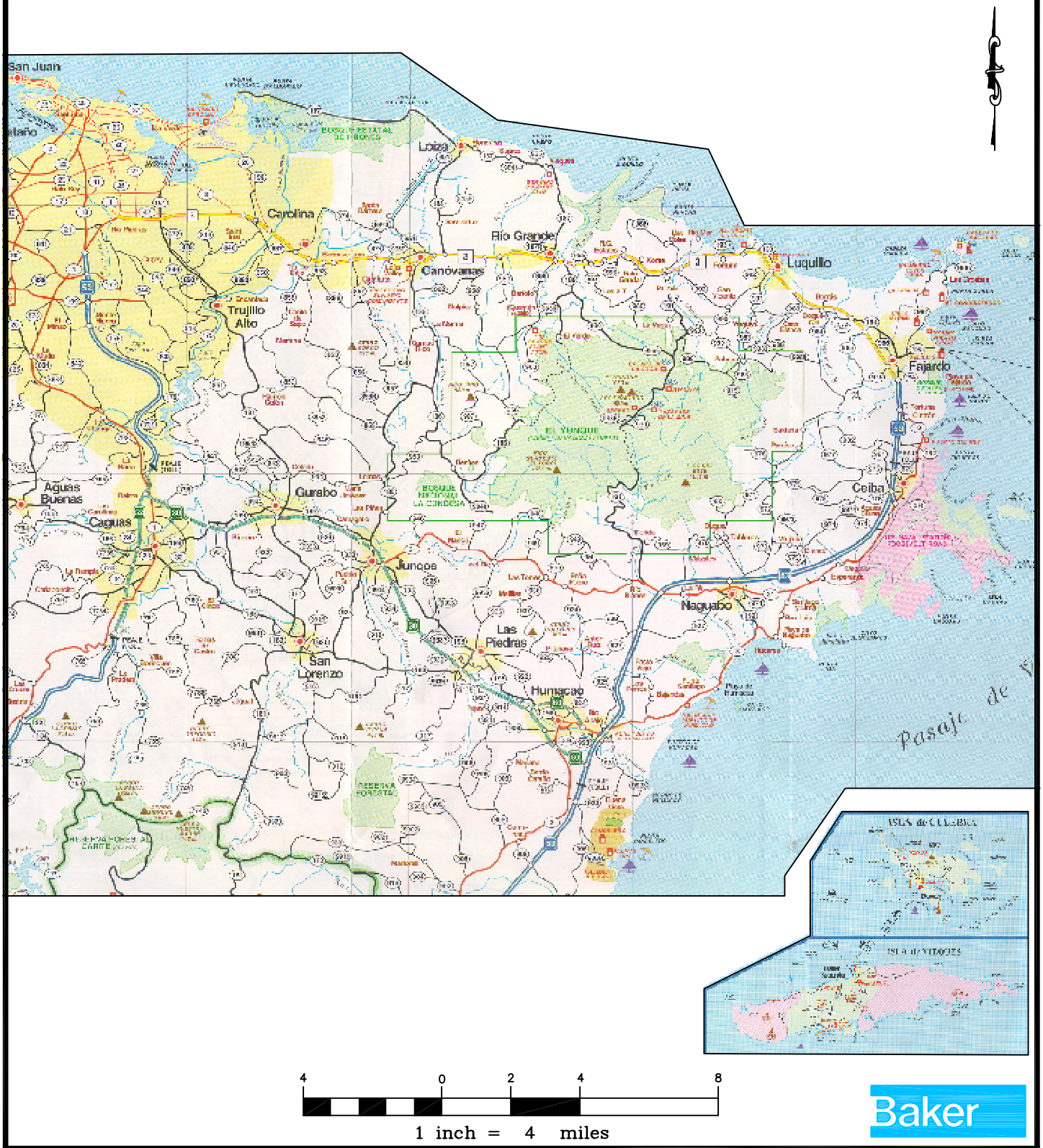
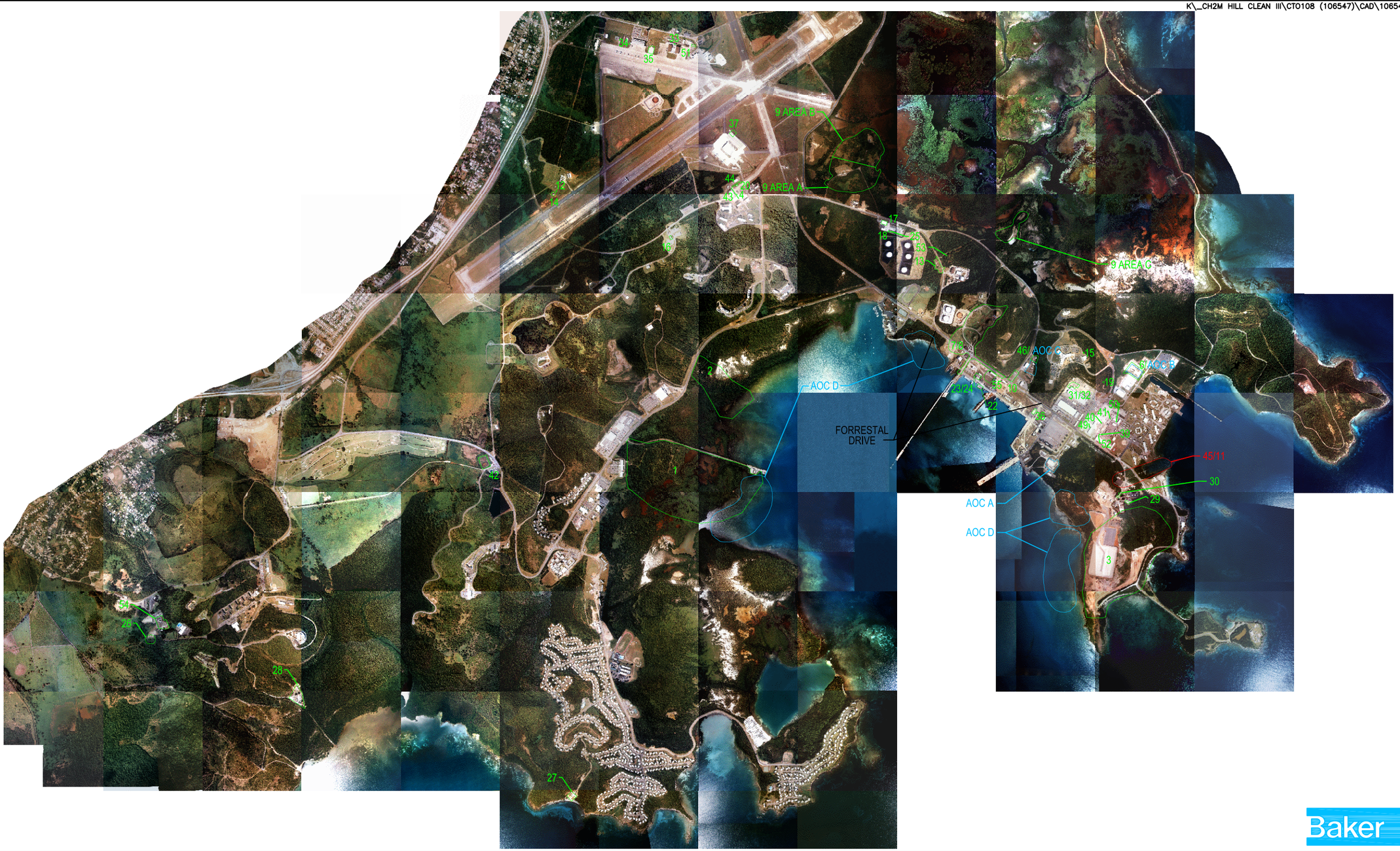


FIGURE 2–1
REGIONAL LOCATION MAP

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

SOURCE: METRODATA, INC., 1999.

K_CH2M HILL CLEAN III\CTO108 (106547)\CAD\106547F08



LEGEND

1 – SWMUs

45/11 – AREA OF WHICH THIS INVESTIGATION PERTAINS TO

AOC D – AOCs

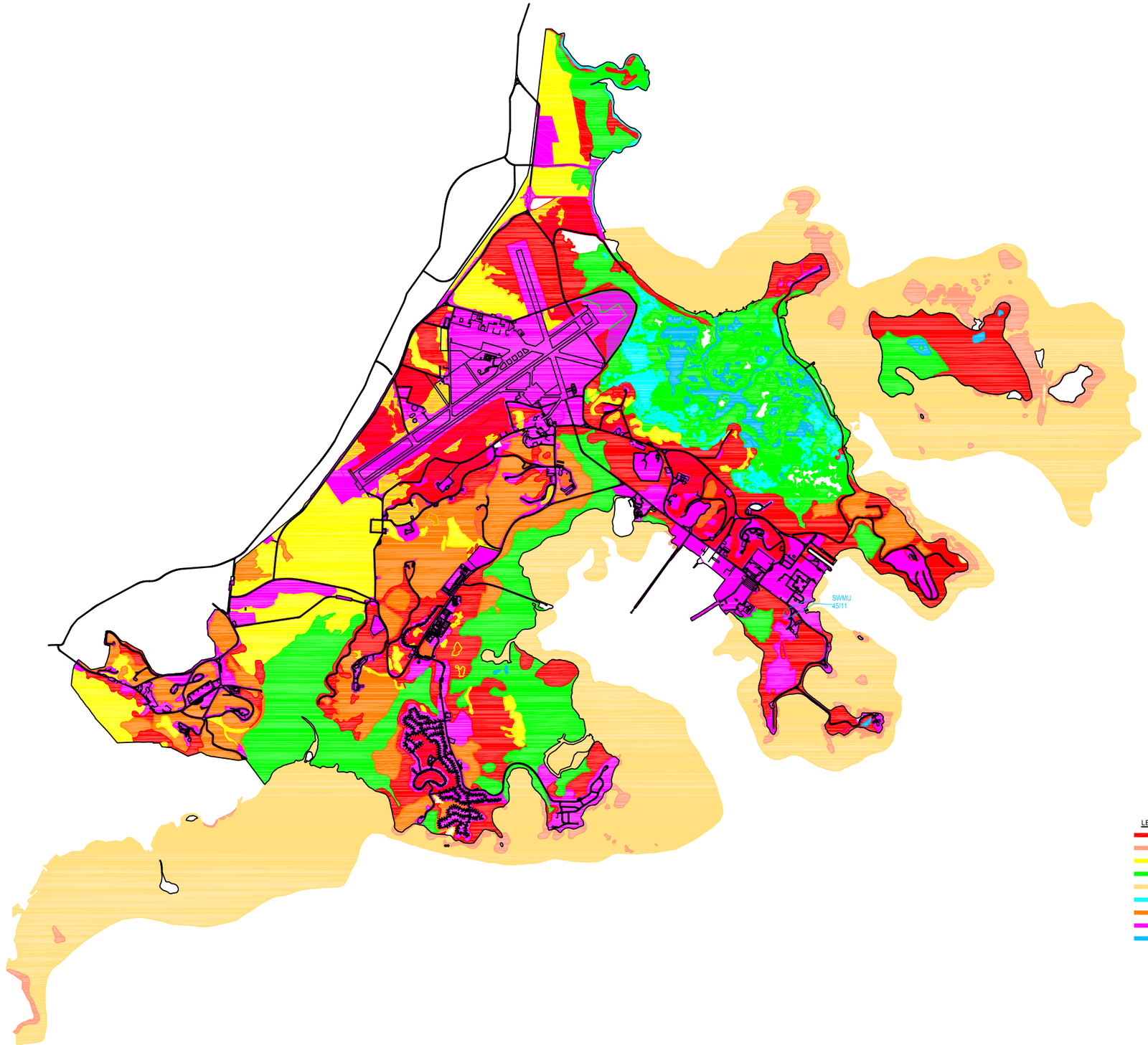
SOURCE: GEO-MARINE, INC., SEPTEMBER 6, 2000.

2500 0 1250 2500

1 inch = 2500 ft.

FIGURE 2-2
SWMU/AOC LOCATION MAP

NAVAL ACTIVITY PUERTO RICO

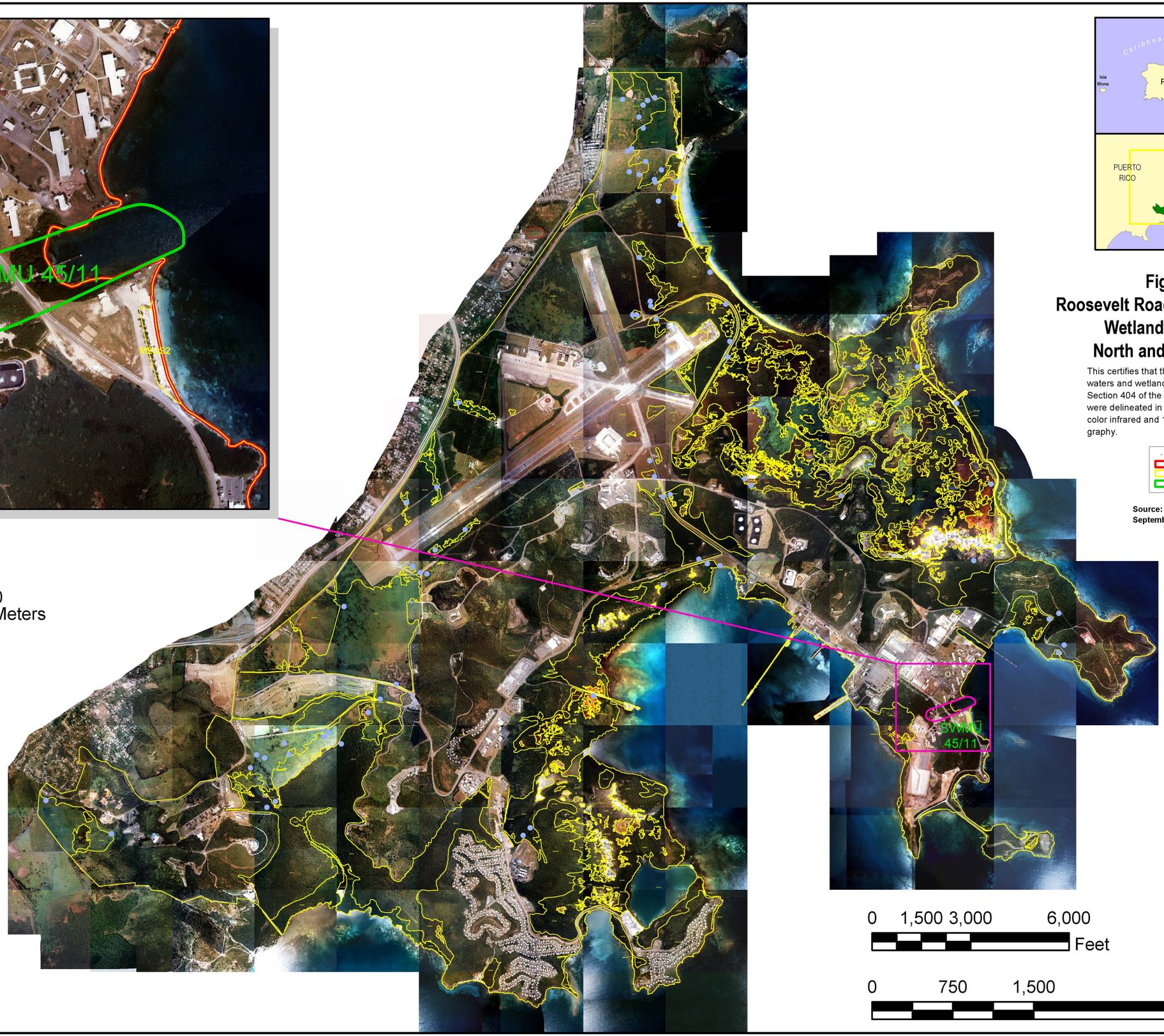


SOURCE: GEO-MARINE, INC.

REVISIONS						
	DRAWN GLB/RRR REVIEWED MEK S.O.# 106547 CADD# 106547F02	NORTH		NAVAL ACTIVITY PUERTO RICO PUERTO RICO BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker	"TERRESTRIAL AND AQUATIC HABITAT OCCURRING AT NAVAL ACTIVITY PUERTO RICO" SCALE 1" = 600' DATE MARCH 2006	FIGURE 2-3

0 250 500 1,000 Feet

0 100 200 400 Meters



0 1,500 3,000 6,000 Feet

0 750 1,500 3,000 Meters

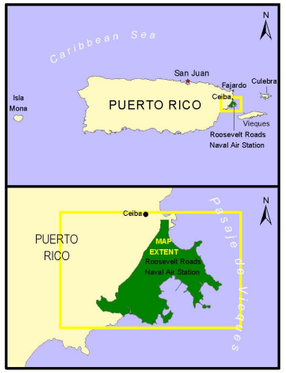


Figure 2-4
Roosevelt Roads Naval Air Station Wetlands Delineation North and East Sections

This certifies that this plat identifies potential waters and wetlands regulated persuant to Section 404 of the Clean Water Act. Wetlands were delineated in December, 1999 from 1993 color infrared and 1998 true color aerial photo-graphy.

Data form locations
Roosevelt Roads base boundary
Wetland boundaries
SWMU's

N

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

FIGURE 2-5
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT
SWMU 45
NAVAL ACTIVITY PUERTO RICO, PUERTO RICO

SYSTEM: M - MARINE

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

SYSTEM: E - ESTUARINE

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

SYSTEM: R - RIVERINE

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

SYSTEM: L - LACUSTRINE

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

SYSTEM: P - PALUSTRINE

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

MODIFIERS

WATER REGIME

Non-Tidal		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

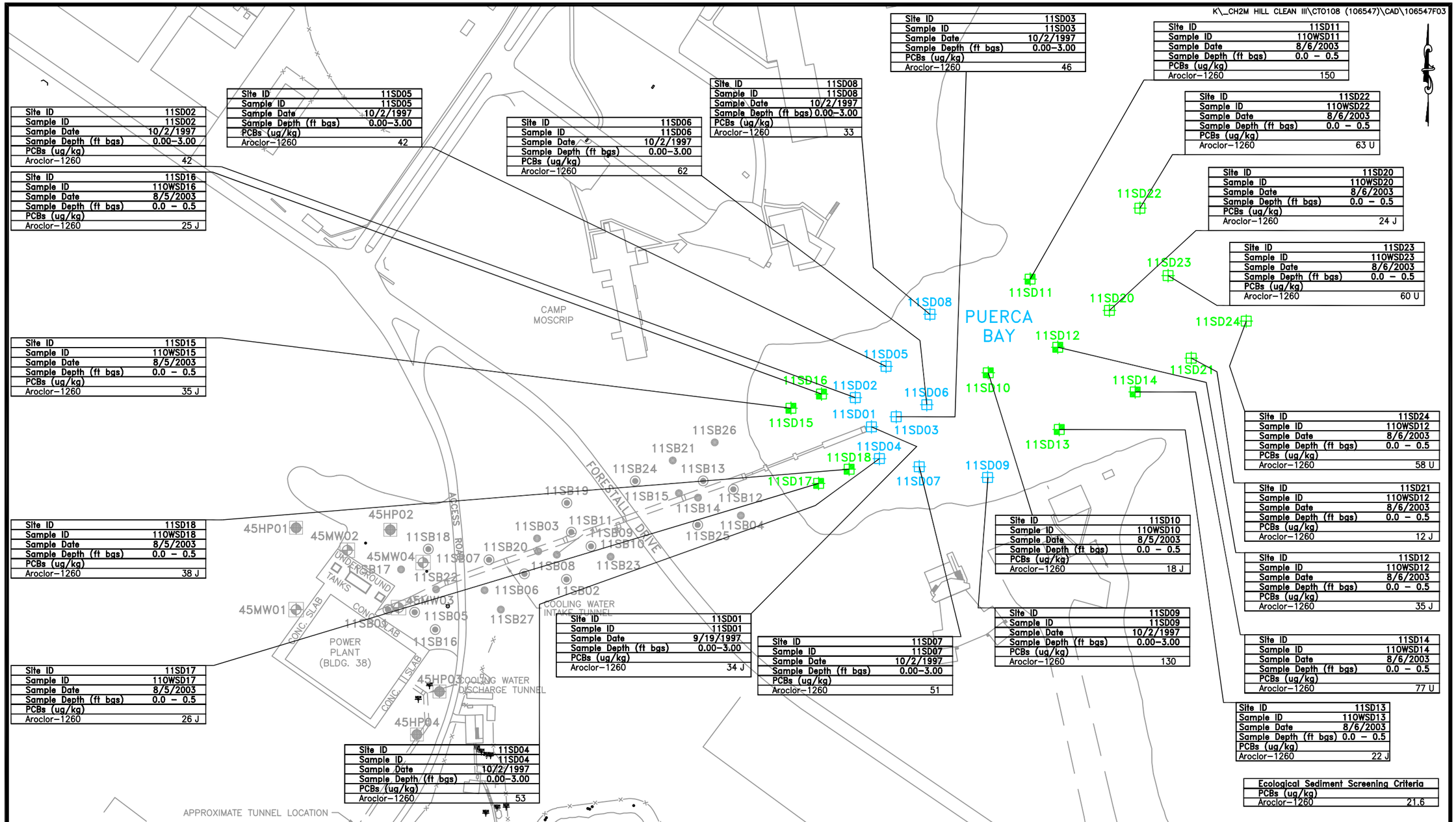
g Organic
n Mineral

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

K:_CH2M HILL CLEAN III\CTO108 (106547)\CAD\106547F03



Site ID	11SD02
Sample ID	11SD02
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	42

Site ID	11SD16
Sample ID	110WSD16
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	25 J

Site ID	11SD15
Sample ID	110WSD15
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	35 J

Site ID	11SD18
Sample ID	110WSD18
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	38 J

Site ID	11SD17
Sample ID	110WSD17
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	26 J

Site ID	11SD05
Sample ID	11SD05
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	42

Site ID	11SD06
Sample ID	11SD06
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	62

Site ID	11SD08
Sample ID	11SD08
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	33

Site ID	11SD03
Sample ID	11SD03
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	46

Site ID	11SD11
Sample ID	110WSD11
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	150

Site ID	11SD22
Sample ID	110WSD22
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	63 U

Site ID	11SD20
Sample ID	110WSD20
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	24 J

Site ID	11SD23
Sample ID	110WSD23
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	60 U

Site ID	11SD24
Sample ID	110WSD12
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	58 U

Site ID	11SD21
Sample ID	110WSD12
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	12 J

Site ID	11SD12
Sample ID	110WSD12
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	35 J

Site ID	11SD14
Sample ID	110WSD14
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	77 U

Site ID	11SD13
Sample ID	110WSD13
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	22 J

Site ID	11SD10
Sample ID	110WSD10
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
PCBs (ug/kg)	
Aroclor–1260	18 J

Site ID	11SD09
Sample ID	11SD09
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	130

Site ID	11SD01
Sample ID	11SD01
Sample Date	9/19/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	34 J

Site ID	11SD07
Sample ID	11SD07
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	51

Site ID	11SD04
Sample ID	11SD04
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
PCBs (ug/kg)	
Aroclor–1260	53

Ecological Sediment Screening Criteria	
PCBs (ug/kg)	
Aroclor–1260	21.6

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)
- MONITOR WELL LOCATION (1996 RFI)
- SEDIMENT SAMPLE LOCATION (2003 ADDITIONAL DATA COLLECTION INVESTIGATION)
- SURFACE WATER\SEDIMENT SAMPLE LOCATION (2003 ADDITIONAL DATA COLLECTION INVESTIGATION)

150 0 75 150

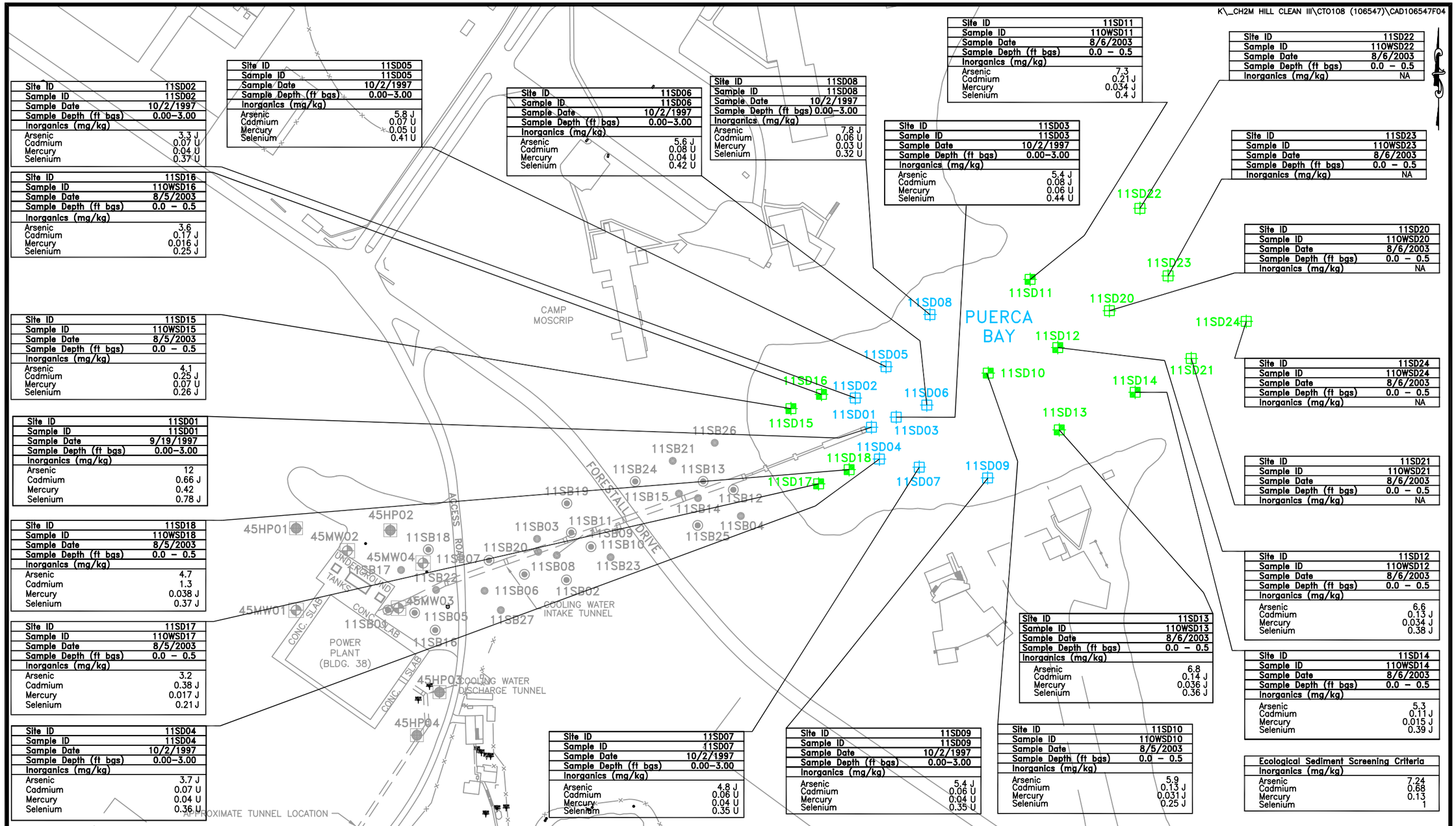
1 inch = 150 ft.

Baker

FIGURE 3–1
AROCLOR–1260 OPEN WATER MARINE SEDIMENT DATA
SWMU 45

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

K_CH2M HILL CLEAN III\CTO108 (106547)\CAD106547F04



Site ID	11SD02
Sample ID	11SD02
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	3.3 J
Cadmium	0.07 U
Mercury	0.04 U
Selenium	0.37 U

Site ID	11SD05
Sample ID	11SD05
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	5.8 J
Cadmium	0.07 U
Mercury	0.05 U
Selenium	0.41 U

Site ID	11SD06
Sample ID	11SD06
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	5.6 J
Cadmium	0.08 U
Mercury	0.04 U
Selenium	0.42 U

Site ID	11SD08
Sample ID	11SD08
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	7.8 J
Cadmium	0.06 U
Mercury	0.03 U
Selenium	0.32 U

Site ID	11SD11
Sample ID	110WSD11
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	7.3
Cadmium	0.21 J
Mercury	0.034 J
Selenium	0.4 J

Site ID	11SD22
Sample ID	110WSD22
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	NA

Site ID	11SD03
Sample ID	11SD03
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	5.4 J
Cadmium	0.08 J
Mercury	0.06 U
Selenium	0.44 U

Site ID	11SD23
Sample ID	110WSD23
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	NA

Site ID	11SD16
Sample ID	110WSD16
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	3.6
Cadmium	0.17 J
Mercury	0.016 J
Selenium	0.25 J

Site ID	11SD20
Sample ID	110WSD20
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	NA

Site ID	11SD15
Sample ID	110WSD15
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	4.1
Cadmium	0.25 J
Mercury	0.07 U
Selenium	0.26 J

Site ID	11SD24
Sample ID	110WSD24
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	NA

Site ID	11SD01
Sample ID	11SD01
Sample Date	9/19/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	12
Cadmium	0.66 J
Mercury	0.42
Selenium	0.78 J

Site ID	11SD21
Sample ID	110WSD21
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	NA

Site ID	11SD18
Sample ID	110WSD18
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	4.7
Cadmium	1.3
Mercury	0.038 J
Selenium	0.37 J

Site ID	11SD12
Sample ID	110WSD12
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	6.6
Cadmium	0.13 J
Mercury	0.034 J
Selenium	0.38 J

Site ID	11SD13
Sample ID	110WSD13
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	6.8
Cadmium	0.14 J
Mercury	0.036 J
Selenium	0.36 J

Site ID	11SD17
Sample ID	110WSD17
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	3.2
Cadmium	0.38 J
Mercury	0.017 J
Selenium	0.21 J

Site ID	11SD14
Sample ID	110WSD14
Sample Date	8/6/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	5.3
Cadmium	0.11 J
Mercury	0.015 J
Selenium	0.39 J

Site ID	11SD04
Sample ID	11SD04
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	3.7 J
Cadmium	0.07 U
Mercury	0.04 U
Selenium	0.36 U

Site ID	11SD07
Sample ID	11SD07
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	4.8 J
Cadmium	0.06 U
Mercury	0.04 U
Selenium	0.35 U

Site ID	11SD09
Sample ID	11SD09
Sample Date	10/2/1997
Sample Depth (ft bgs)	0.00–3.00
Inorganics (mg/kg)	
Arsenic	5.4 J
Cadmium	0.06 U
Mercury	0.04 U
Selenium	0.35 U

Site ID	11SD10
Sample ID	110WSD10
Sample Date	8/5/2003
Sample Depth (ft bgs)	0.0 – 0.5
Inorganics (mg/kg)	
Arsenic	5.9
Cadmium	0.13 J
Mercury	0.031 J
Selenium	0.25 J

Ecological Sediment Screening Criteria	
Inorganics (mg/kg)	
Arsenic	7.24
Cadmium	0.68
Mercury	0.13
Selenium	1

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)
- MONITOR WELL LOCATION (1996 RFI)
- SEDIMENT SAMPLE LOCATION (2003 ADDITIONAL DATA COLLECTION INVESTIGATION)
- SURFACE WATER\SEDIMENT SAMPLE LOCATION (2003 ADDITIONAL DATA COLLECTION INVESTIGATION)

150 0 75 150

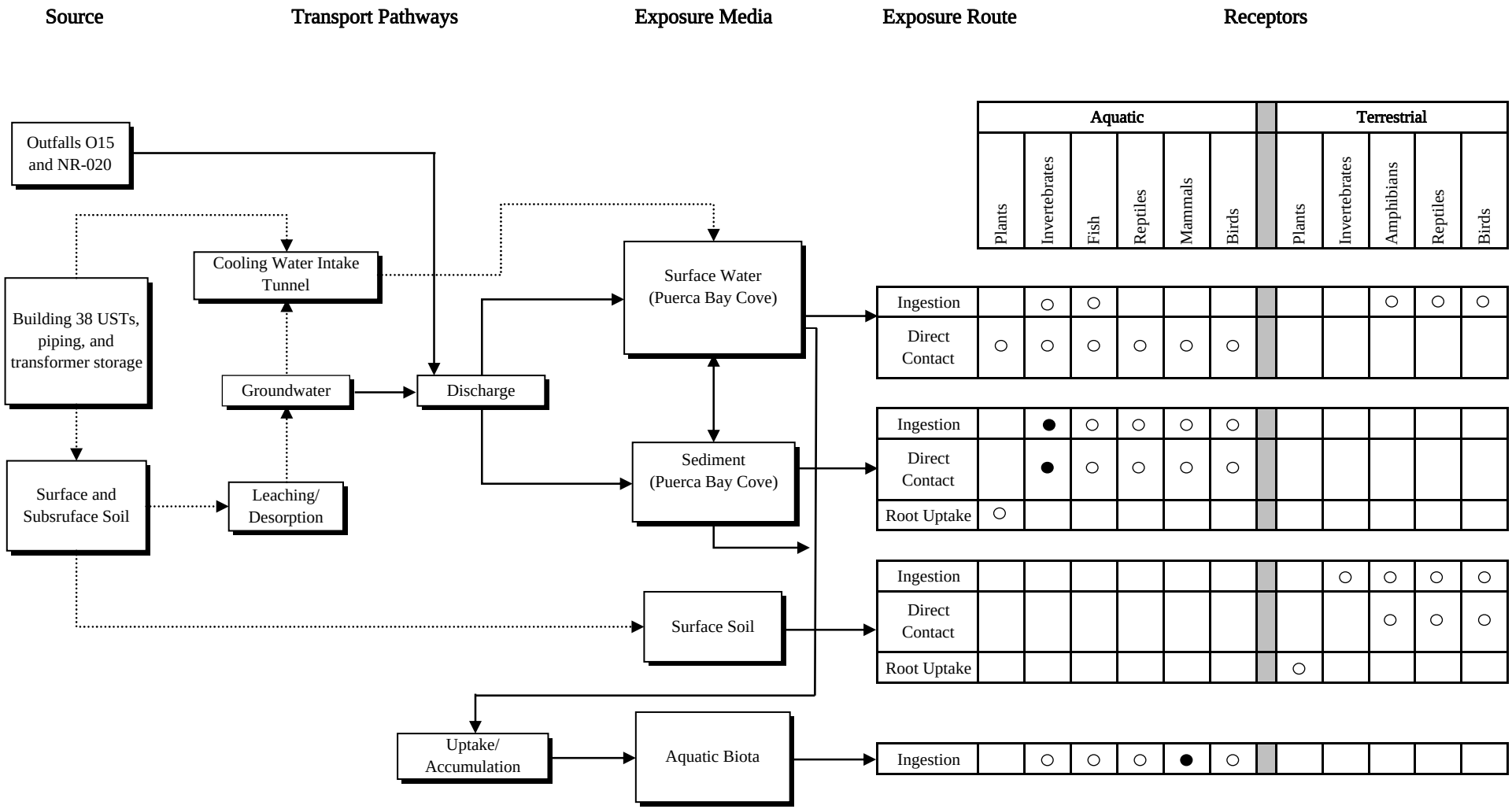
1 inch = 150 ft.

Baker

FIGURE 3–2
ARSENIC, CADMIUM, MERCURY AND SELENIUM OPEN WATER MARINE SEDIMENT DATA – SWMU 45

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

FIGURE 3-3
REFINED CONCEPTUAL MODEL
SWMU 45 - AREA OUTSIDE BUILDING 38 (THE FORMER POWER PLANT)
STEP 3B AND STEP 4 OF THE AQUATIC BASELINE ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

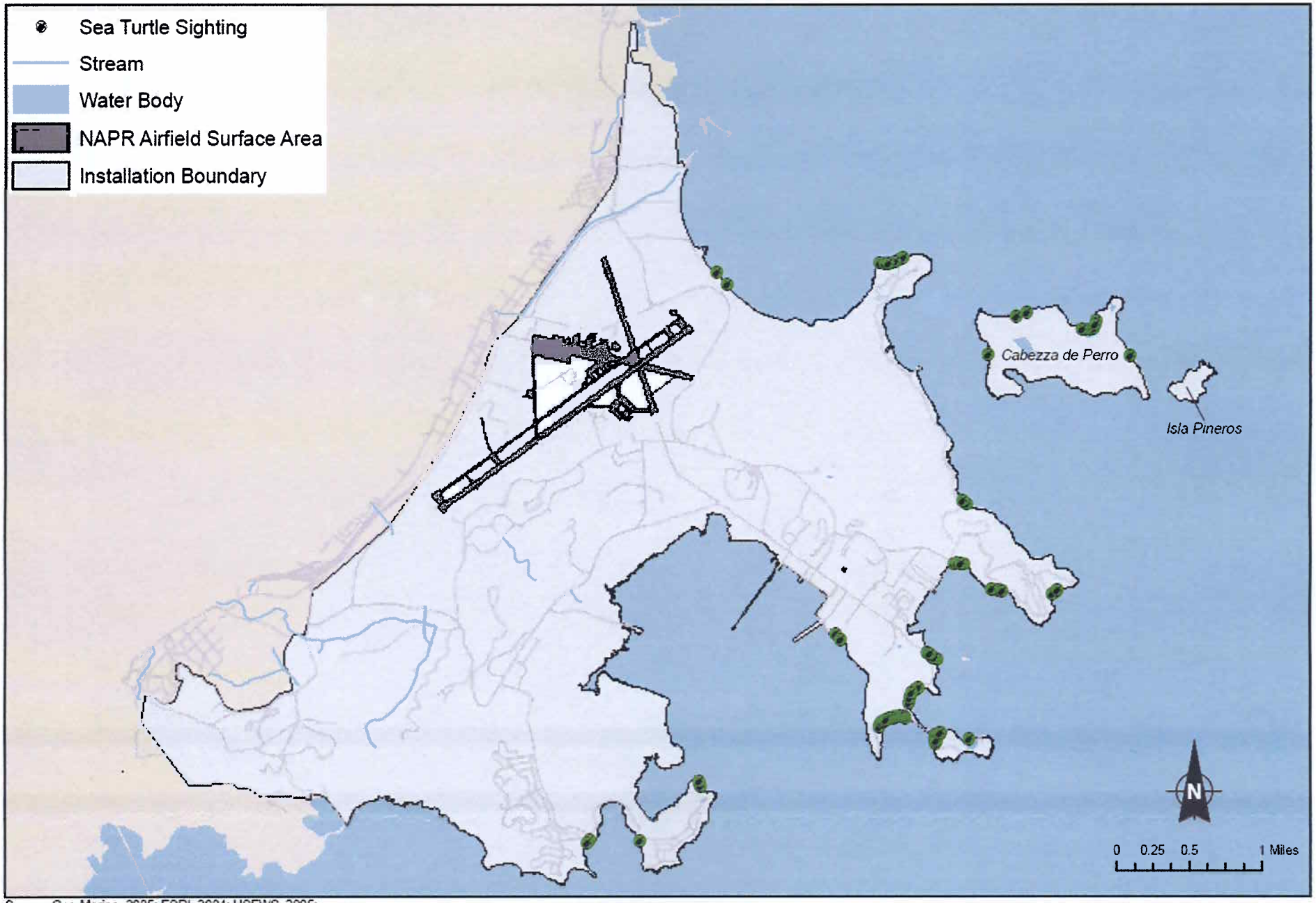


Potentially complete and significant pathway

Potentially complete and significant historical pathway

● Potential for unnacceptable risk identified, receptor/pathway quantitatively evaluated in BERA

○ No potential for unnacceptable risk identified, no further evaluation required in BERA

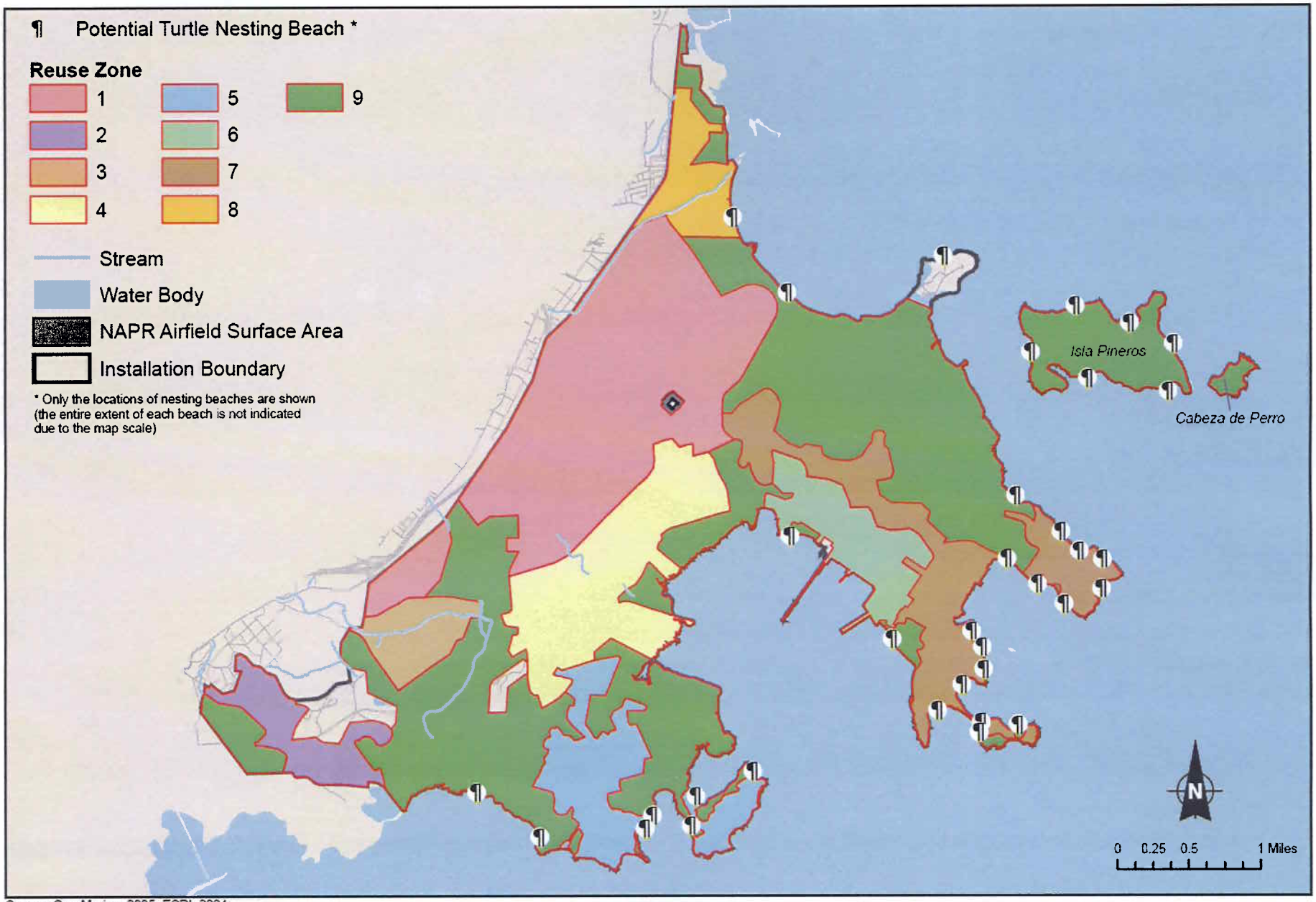


Source: Geo-Marine, 2005; ESRI, 2004; USFWS, 2005;

Cumulative sea turtle sightings from March 1984 through March 1995 obtained from weekly aerial surveys of NAPR

Figure from: Geo-Marine, Inc. 2005. *Draft Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads).* December 2005.

FIGURE 3-4
NAPR Sea Turtle Sightings
SWMU 45 – Former Power Plant
Naval Activity Puerto Rico
Ceiba, Puerto Rico

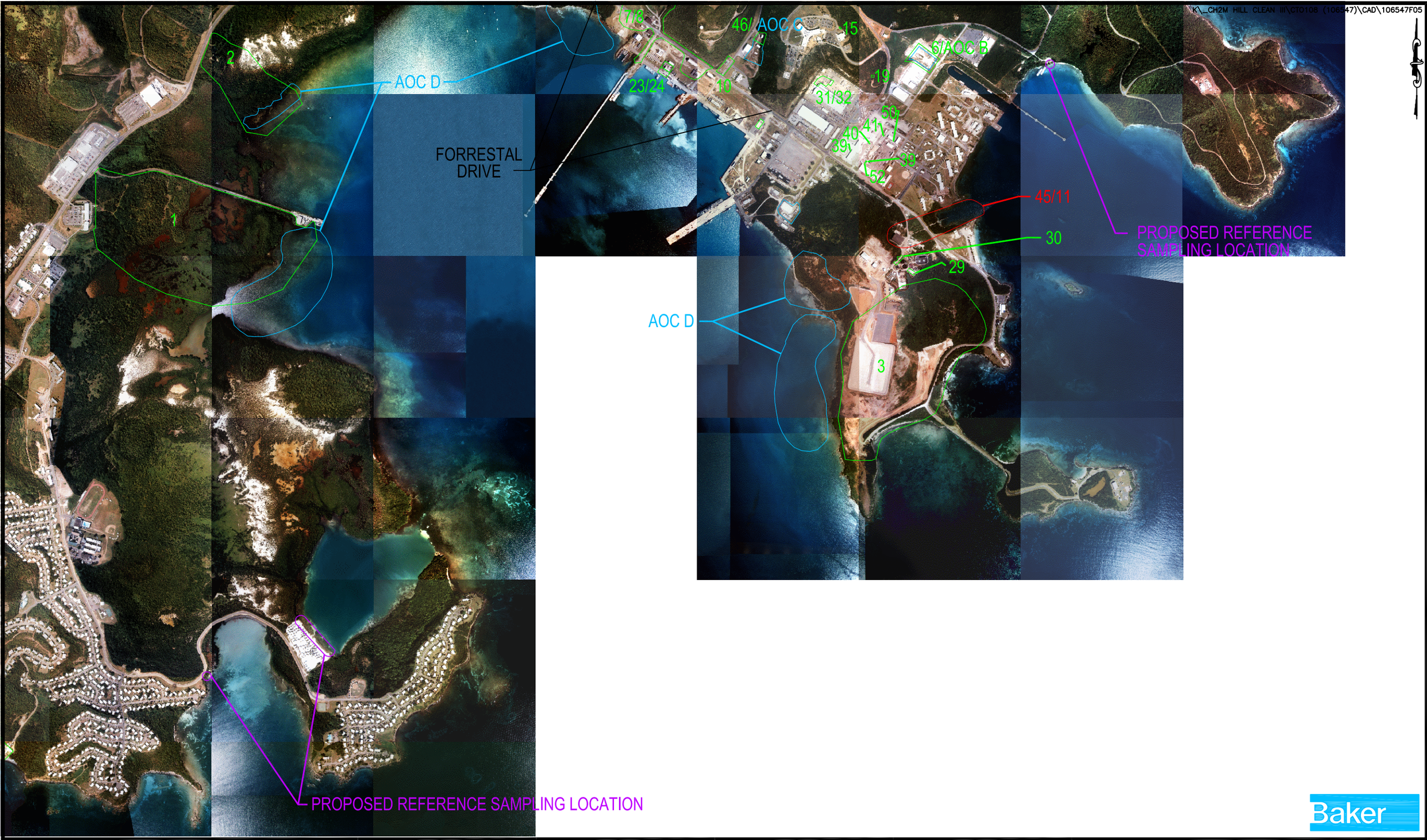


Source: Geo-Marine, 2005; ESRI, 2004;

Cumulative nest sightings from 2002 and 2004 weekly beach nest surveys.

Figure from: Geo-Marine, Inc. 2005. *Draft Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads)*. December 2005.

FIGURE 3-5
NAPR Potential Sea Turtle Nesting Habitat
SWMU 45 – Former Power Plant
Naval Activity Puerto Rico
Ceiba, Puerto Rico



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LEGEND

1 – SWMUs

AOC D – AOCs

45/11 – AREA OF WHICH THIS INVESTIGATION PERTAINS TO

– PROPOSED REFERENCE SAMPLING LOCATIONS

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

1500 0 750 1500

1 inch = 1500 ft.

FIGURE 5-1
PROPOSED REFERENCE SAMPLING LOCATIONS

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

LEGEND

1 – SEDIMENT SAMPLING GRID

150 0 75 150
1 inch = 150 ft.

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FIGURE 5–2
PROPOSED SEDIMENT SAMPLING PROGRAM

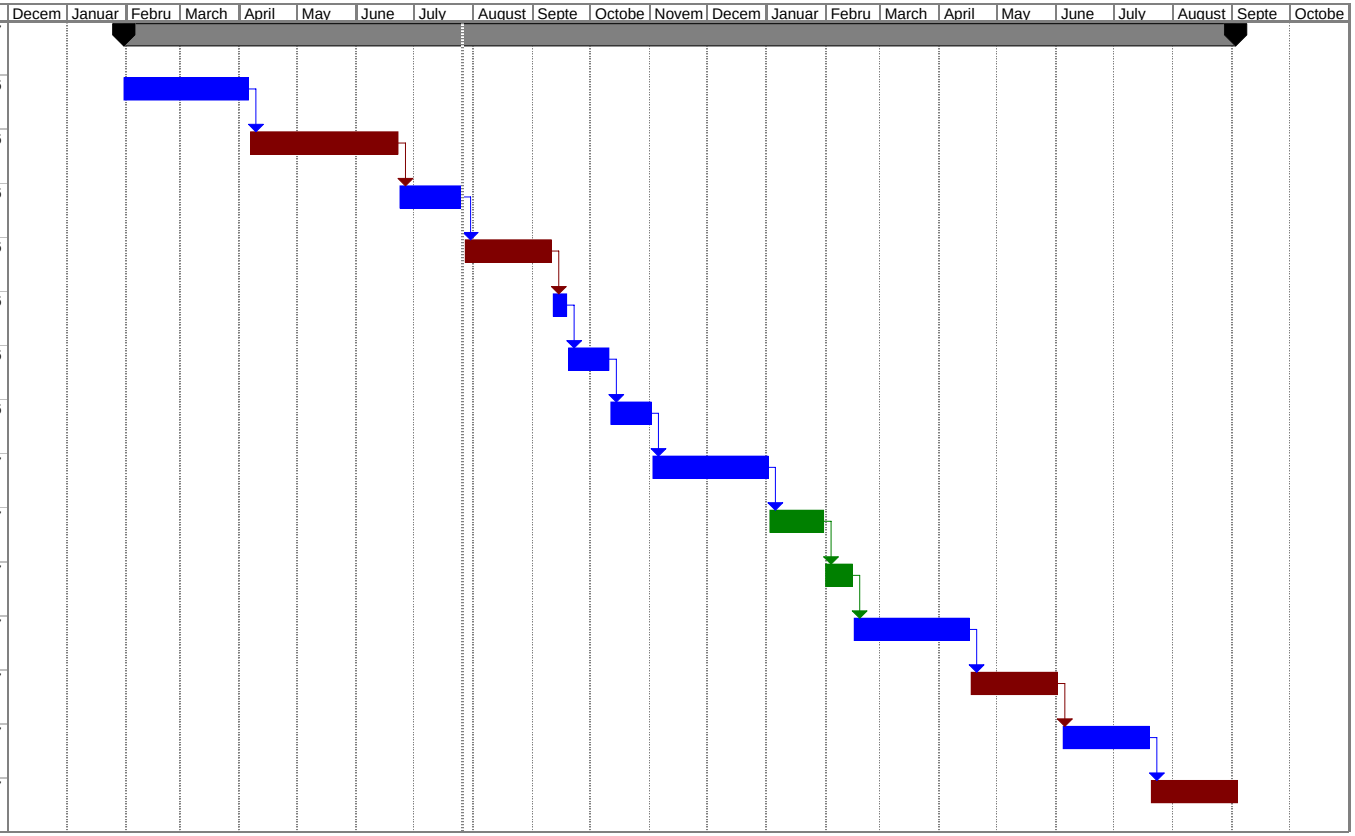
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

FIGURE 6-1

Revised: July 26, 2006

ECOLOGICAL RISK ASSESSMENT SCHEDULE AT SWMU 45
NAVAL ACTIVITY PUERTO RICO
CEIBA, PUERTO RICO

Task Name	Duration	Start	Finish
SWMU 45	580 edays	1/31/06	9/3/07
Draft Step 3b/4 ERA	65 edays	1/31/06	4/6/06
EPA Review	77 edays	4/6/06	6/22/06
Final Step 3b/4 ERA	33 edays	6/23/06	7/26/06
EPA Review and Approval	45 edays	7/27/06	9/10/06
Field Verificatiopn	7 edays	9/11/06	9/18/06
Data Evaluation	21 edays	9/19/06	10/10/06
Work Plan Revision	21 edays	10/11/06	11/1/06
BERA Field Data Collection	60 edays	11/2/06	1/1/07
Laboratory Analysis	28 edays	1/2/07	1/30/07
Data Validation	14 edays	1/31/07	2/14/07
Draft Step 7 Document	60 edays	2/15/07	4/16/07
EPA Review	45 edays	4/17/07	6/1/07
Final Step 7 Document	45 edays	6/4/07	7/19/07
EPA Review and Approval	45 edays	7/20/07	9/3/07



Project: ERA shedule-SWMU45
Date: 7/26/06

Baker Task EPA Review Lab Project Summary

Appendix A:
Data Collection Quality Assurance Plan Addendum

DRAFT

DATA COLLECTION QUALITY ASSURANCE PLAN ADDENDUM

STEP 3B AND 4 OF THE
BASELINE ECOLOGICAL RISK ASSESSMENT
SWMU 45 – AREA OUTSIDE BUILDING 38 (FORMER POWER PLANT)

NAVAL ACTIVITY PUERTO RICO
CEIBA, PUERTO RICO

CONTRACT TASK ORDER 0108

APRIL 20, 2006

Prepared For:

DEPARTMENT OF THE NAVY
NAVAL FACILITIES
ENGINEERING COMMAND
ATLANTIC DIVISION
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-02-D-3052

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

CH2M Hill
Herndon, Virginia

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PREFACE

This Data Collection Quality Assurance Plan (DCQAP) Addendum provides specific quality assurance information for the Estuarine Wetland Baseline Ecological Risk Assessment at Solid Waste Management Unit (SWMU) 45 – Area Outside Building 38 (Former Power Plant) at Naval Activity Puerto Rico, Ceiba, Puerto Rico. This DCQAP is designed to be used in conjunction with the DCQAP presented within the Final Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker Environmental, Inc. [Baker], 1995). General information that is required for this DCQAP can be found within the Final RFI mentioned above. Site personnel are required to review the information presented in both the DCQAP presented in the Final RFI (Baker, 1995), as well as this DCQAP Addendum prior to conducting field activities.

* Italicized print indicates that information in that section is presented in the Master QAPP and not in this QAPP Addendum.

6.0 PROJECT DESCRIPTION AND ORGANIZATION

Solid Waste Management Unit (SWMU) 45 is located within the property boundary of Naval Activity Puerto Rico (NAPR), and is comprised of two underground storage tanks (USTs), cooling water intake and discharge tunnel, and the Puerca Bay cove. The facility used Bunker C fuel, which was stored in two 50,000-gallon reinforced underground concrete tanks located directly northeast of the building (Naval Energy and Environmental Support Activity [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 over seven hundred feet 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). The discharge tunnel terminates somewhere in the 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. This facility was included as a Solid Waste Management Unit (SWMU) in the Resource Conservation and Recovery Act (RCRA) Part B Permit (United States Environmental Protection Agency [USEPA], 1994), as a result that the USTs and cooling water tunnels represented possible sources of continuing release of organic contaminants.

The RCRA Facility Investigation (RFI) conducted at the site indicated that various environmental media were impacted by past site operations. The additional data collection field investigation was designed to fill identified data gaps necessary to select corrective measures to mitigate human health and ecological risks associated with contamination related to site operations as presented in the Draft Additional Data Collection Work Plan (Baker, 2001). The work plan was written and submitted based on recommendations made in the Revised Draft RFI Report for Operable Unit (OU) 3/5 (Baker, 1999), as well as concurrence of these recommendations by the USEPA.

As part of the Step 3b and 4 of the Baseline Ecological Risk Assessment at SWMU 45 – Area Outside Building 38 (Former Power Plant) (Baker, 2006), collection and analysis of sediment and seagrass tissue samples will be conducted. The specific samples and analyses are presented in the Field Sampling and Analysis Plan (FSAP) portion of the report mentioned above.

The objective of this project is to define the requirements necessary to implement the Steps 3b and 4 of the Baseline Ecological Risk Assessment at SWMU 45 – Area Outside Building 38 (Former Power Plant), and to complete the necessary sampling and reporting which will document the estuarine wetland ecological risk assessment activities.

Baker's primary participants for this project include:

- Mr. John W. Mentz, Baker – Program Manager
- Mr. Mark E. Kimes, P.E., Baker – NAPR Activity Manager/Project Manager
- Mr. John Malinowski, Baker – Senior Ecological Risk Specialist/QA/QC/Field Team Leader
- Ms. Mary Smith, Baker – Ecological Risk Specialist/Environmental Scientist/Site Health and Safety Officer
- Mrs. Heather Govenor Wojdak, Baker – Ecological Risk Specialist/Environmental Scientist
- Mr. Pete Monday, Baker – Site Manager/Environmental Scientist

Mr. Kimes will be responsible for monitoring the budget and schedule of individual tasks and will have the overall responsibility of completing the work plan, overseeing field activities, and

completing the reports for this project. Mr. Malinowski will be technically responsible for ecological risk assessments, with technical input from both Ms. Smith and Mrs. Wojdak. He will also assume the responsibility of team leader while in the field. Mr. Monday will serve as the Site Manager. Ms. Smith will serve as the Site Health and Safety Officer. Geologists, engineers, scientists, biologists, and clerical personnel will support the primary participants as needed.

Overall Quality Assurance/Quality Control (QA/QC) will be the responsibility of Mr. Kimes, while providing senior consulting support and coordination of subcontractor procurement for the project.

Subcontractors will be used to perform laboratory analysis, and data validation. Specific subcontractors have not yet been identified. Baker will perform this investigation with support from the Navy and NAPR.

References:

Baker Environmental, Inc. (Baker), 2006. Final Additional Data Collection Report and Screening Level Ecological Risk Assessment and Step 3A of the Baseline Ecological Risk Assessment for SWMU 45, Naval Activity Puerto Rico, Ceiba, Puerto Rico. Coraopolis, Pennsylvania. 2006.

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Baker, 1995. Final RCRA Facility Investigation, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. Coraopolis, Pennsylvania. September 14, 1995.

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Appendix B:
Health and Safety Plan Addendum

DRAFT

HEALTH AND SAFETY PLAN ADDENDUM

STEPS 3B AND 4 OF THE
BASELINE ECOLOGICAL RISK ASSESSMENT
SWMU 45 – AREA OUTSIDE BUILDING 38 (FORMER POWER PLANT)

NAVAL ACTIVITY PUERTO RICO
CEIBA, PUERTO RICO

CONTRACT TASK ORDER 0108

APRIL 20, 2006

Prepared For:

DEPARTMENT OF THE NAVY
NAVAL FACILITIES
ENGINEERING COMMAND
ATLANTIC DIVISION
Norfolk, Virginia

Under the:

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Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

CH2M Hill
Herndon, Virginia

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A Baker Environmental, Inc. (Baker) Safety Standard Operating Procedures (SOPs)
B Material Safety Data Sheets for Constituents Detected during Previous Sampling at Naval Station Roosevelt Roads
C Chemical/Material Data Sheets for material Stored, Used, or Processed at a SWMU or AOC
D Emergency Procedures for Exposure to Hazardous Materials/Waste

* Italicized print indicates that information in that section is presented in the Master Site HASP and not in this HASP Addendum.

EXECUTIVE SUMMARY

Solid Waste Management Unit (SWMU) 45 is located at NAPR, and is comprised of two underground storage tanks (USTs), cooling water intake and discharge tunnel, and the Puerca Bay cove. This facility was included as a SWMU in the RCRA Part B Permit, as a result that the USTs and cooling water tunnels represented possible sources of continuing release of organic contaminants.

Previous reports indicate that the former power plant operated from the early 1940s through 1949. The facility used Bunker C fuel, which was stored in two 50,000-gallon reinforced underground concrete tanks. Associated with Building 38 are two underground tunnels used to transfer cooling water to and from the building. The intake and discharge cooling water tunnels were sealed with cast-in-place concrete and the storage tanks were backfilled in 1996.

The chemical exposure potential for personnel working at SWMU 45 – Area Outside Building 38 (Former Power Plant) at NAPR is expected to be similar to the chemicals identified by analytical analyses from previous sampling investigations at similar sites. The physical hazards that are potential concerns for work to be conducted at SWMU 45 – Area Outside Building 38 (Former Power Plant) include thermal stress and fall hazards. The environmental hazardous include potentially hazardous flora and fauna at NAPR.

The chemical and physical/environmental hazards associated with the tasks to be conducted at SWMU 45 – Area Outside Building 38 (Former Power Plant) include:

<u>Task 1 - Sediment Sampling</u>

Chemical

- Potential for contaminated material to be splashed onto body or in eyes.
- Ingestion of contaminated material from hand-to-mouth contact.
- Inhalation of volatile constituents or volatile fraction of semi-volatile constituents within the sediments or surface water.
- Absorption of constituents through the skin.

Physical/Environmental

- Muscle strain from boring with sediment corer, sampling with petite ponar dredge.
- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Skin irritation from contact with insects and vegetation.
- Interaction with native and feral (i.e., wild) animal life.

<u>Task 2 – Seagrass Sampling</u>

Chemical

- Potential for contaminated material to be splashed onto body or in eyes.
- Ingestion of contaminated material from hand-to-mouth contact.
- Inhalation of volatile constituents or volatile fraction of semi-volatile constituents within the sediments or surface water.
- Absorption of constituents through the skin.

Physical/Environmental

- Muscle strain from boring with sediment corer.
- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Skin irritation from contact with insects and vegetation.
- Interaction with native and feral (i.e., wild) animal life.

Task 3 - Land Surveying through a GPS Unit

Chemical

- Skin contact with potentially-contaminated material.
- Ingestion of contaminated material from hand-to-mouth contact.

Physical/Environmental

- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Skin irritation from contact with insects and vegetation.
- Interaction with native and feral animal life.

Levels of protection outlined in Section 6.0 were selected based on site-specific and task-specific hazard identification, information obtained from previous investigations and site visits, and previous experience with similar investigations or activities.

Also included within this addendum are current emergency procedures, emergency telephone numbers, and hospital route.

2.0 PROJECT PERSONNEL AND RESPONSIBILITIES

The following personnel are designated to carry out the stated job functions for both project and site activities (Note: One person may carry out more than one job function; personnel identified are subject to change). The responsibilities that correspond with each job function are outlined below.

PROJECT MANAGER: Mark Kimes, P.E.

The project manager will be responsible for assuring that all activities are conducted in accordance with the HASP. The Project Manager has the authority to suspend field activities if employees are in danger of injury or exposure to harmful agents. In addition, the Project Manager is responsible for:

- Assisting the Project Health and Safety Officer (PHSO), as designated below, in Site-Specific HASP development for all phases of the project.
- Designating a SHSO and other site personnel who will assure compliance with the HASP.
- Reviewing and approving the information presented in this HASP.

PROJECT HEALTH AND SAFETY OFFICER: Warren Lehew, CIH, CSP

The PHSO will be responsible for general development of the HASP and will be the primary contact for inquiries as to the contents of the HASP. The PHSO will be consulted before changes to the HASP can be approved or implemented. The PHSO will also:

- Develop new protocols or modify the HASP as appropriate and issue amendments.
- Resolve issues that arise in the field with respect to interpretation or implementation of the HASP.
- Monitor the field program through a regular review of field health and safety records, on-site activity audits, or a combination of both.
- Determine that all Baker personnel have received the required training and medical surveillance prior to entry onto a site.
- Coordinate the review, evaluation, and approval of the HASP.

SITE MANAGER: Pete Monday

The Site Manager will be responsible for assuring that all day-to-day activities are conducted in accordance with the HASP. The Site Manager has the immediate authority to suspend field activities if employees are subjected to a situation that can be immediately dangerous to life or health. The Site Manager's responsibilities include:

- Assuring that the appropriate health and safety equipment and personal protective equipment (PPE) has arrived on site and that it is properly maintained.
- Coordinating overall site access and security measures, including documenting all personnel arriving or departing the site (e.g., name, company and time).
- Approving all on site activities, and coordinating site safety and health issues with the SHSO.

- Assisting the SHSO in coordinating emergency procedures with the Naval Activity, emergency medical responders, etc., prior to or during site mobilization activities.

- Assuring compliance with site sanitation procedures and site precautions.

- Coordinating activities with Baker and subcontractor personnel.

- Overseeing the decontamination of field sampling equipment.

- Assuming the responsibilities as indicated under "Field Team Leader," in their absence.

SITE HEALTH AND SAFETY OFFICER: Mary Smith

The SHSO will be responsible for the on-site implementation of the HASP. The SHSO also has the immediate authority to suspend field activities if the health or safety of site personnel is endangered, and to audit the subcontractor training, fit testing, and medical surveillance records to verify compliance. These records will be maintained at the Baker Command Post. The SHSO will also:

- Coordinate the pre-entry briefing and subsequent briefings.

- Assure that monitoring equipment is properly calibrated and properly operated.

- Assure compliance with the Standard Operating Procedures (SOPs) in Attachment A.

- Inform personnel of the material safety data sheets (MSDSs) located in Attachments B and C and emergency procedures for exposure to hazardous materials/waste presented in Attachment D.

- Manage health and safety equipment, including instruments, respirators, PPE, etc., that is used during field activities.

- Confirm emergency response provisions, as necessary, in cooperation with Naval Activity, emergency medical care, etc., prior to or during site mobilization activities.

- Monitor conditions during field activities to ensure worker compliance with the HASP and evaluate if more stringent procedures or a higher level of PPE should be implemented, and informing the PHSO and Project Manager.

- Document, as necessary, pertinent information such as accident investigation and reporting, designated safety inspections, a record of site conditions, personnel involved in field activities, and any other relevant health and safety issues. This information will become part of the official site records.

- Oversee the decontamination of personnel and determine safe boundary procedures for activities requiring Level C or higher protection levels.

- Act as the Emergency Coordinator.

FIELD TEAM LEADER: Pete Monday

The Field Team Leader will be responsible for:

- Safety issues relevant to the tasks under their direction.
- Determining safe boundary procedures for activities requiring Level D or D+ protection levels.
- Assuring that PPE is properly maintained.
- Complying with the conditions as outlined under Field Team Members.
- Assuming the responsibilities as indicated under "Site Manager" in their absence.

SUBCONTRACTOR COMPANIES:

Analytical Services: (To Be Determined)

NAVY BRAC PMO SE REPRESENTATIVES:
Mr. Mark E. Davidson (843) 820-5526

ACTIVITY/STATION/BASE REPRESENTATIVES:
Mr. Pedro Ruiz, Public Works Environmental Eng. Div. (787) 865-4429

FEDERAL/STATE/LOCAL REPRESENTATIVES:
Not assigned

3.2 Facility HASP Objective

This "Facility" Health and Safety Plan (HASP) addresses the ecological investigation that is required at SWMU 45 – Area Outside Building 38 (Former Power Plant), with a detailed description of this site in the section that follows.

3.3 Description of SWMU 45 – Area Outside Building 38 (Former Power Plant)

SWMU 45 is located at NAPR, and is comprised two underground storage tanks (USTs), cooling water intake and discharge tunnel, and the Puerca Bay cove. This facility was included as a SWMU in the RCRA Part B Permit, as a result that the USTs and cooling water tunnel represented possible sources of continuing release of organic contaminants.

Previous reports indicate that the former power plant operated from the early 1940s through 1949. The facility used Bunker C fuel, which was stored in two 50,000-gallon reinforced underground concrete tanks. Associated with Building 38 are two underground tunnels used to transfer cooling water to and from the building. The intake and discharge cooling water tunnels were sealed with cast-in-place concrete and the storage tanks were backfilled in 1996.

3.4.5 Task-Specific Hazards

Listed below are summaries for the hazards associated with each task for the investigation to be conducted at SWMU 45 – Area Outside Building 38 (Former Power Plant). Levels of protection outlined in Section 6.0 were selected based on this task-specific hazard identification, information obtained from previous investigations and site visits, and previous experience with similar investigations or activities.

3.4.5.1 Task 1 - Sediment Sampling

Chemical

- Potential for contaminated material to be splashed onto body or in eyes.
- Ingestion of contaminated material from hand-to-mouth contact.
- Inhalation of volatile constituents or volatile fraction of semi-volatile constituents within the sediments or surface water.
- Absorption of constituents through the skin.

Physical/Environmental

- Muscle strain from boring with sediment corer, sampling with petite ponar dredge.
- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Skin irritation from contact with insects and vegetation.
- Interaction with native and feral (i.e., wild) animal life.

3.4.5.2 Task 2 – Seagrass Tissue Sampling

Chemical

- Potential for contaminated material to be splashed onto body or in eyes.
- Ingestion of contaminated material from hand-to-mouth contact.

- Inhalation of volatile constituents or volatile fraction of semi-volatile constituents within the sediments or surface water.
- Absorption of constituents through the skin.

Physical/Environmental

- Muscle strain from boring with sediment corer.
- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Skin irritation from contact with insects and vegetation.
- Interaction with native and feral (i.e., wild) animal life.

3.4.5.3 Task 3 - Land Surveying through a GPS Unit

Chemical

- Skin contact with potentially-contaminated material.
- Ingestion of contaminated material from hand-to-mouth contact.

Physical/Environmental

- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Skin irritation from contact with insects and vegetation.
- Interaction with native and feral animal life.

6.2 Site-Specific Levels of Protection

Based on the information provided in Section 3.0, Site Characterization, the levels of protection and corresponding personal protective equipment have been designated for the following field activities. Upgrading or downgrading the level of protection will be based on real time monitoring, working conditions, and the discretion of the SHSO. Items listed in parentheses are at the discretion of the SHSO, depending on specific site conditions.

Note: No single combination of protective equipment and clothing is capable of protection against all hazards. PPE should be used in conjunction with safe work practices, effective decontamination, and good personal hygiene.

Field Activity	Level of Protection					PPE (Item No.)
	B	C	D +	D	Other	
Sediment Sampling				X		4, 13, 20, 25
GPS Surveying				X		4
Seagrass Tissue Sampling				X		4, 13, 18, 20, 25

EXCEPT IN EMERGENCY SITUATIONS, CHANGES TO THE SPECIFIED LEVELS OF PROTECTION SHALL ONLY BE MADE WITH THE APPROVAL OF THE SHSO AND THE SITE MANAGER, IN CONSULTATION WITH THE PHSO AND PROJECT MANAGER.

8.6 Emergency Hospital Route

An emergency hospital route map (Figure 8-2) showing the location of the local hospital will be posted in the Baker Field Trailer and maintained in the Baker Field Vehicle. Personnel will be informed of the location of the map during the pre-entry briefing. Since the Base Hospital is closed, the hospital to be used for this project is Hospital San Pablo Del Este, located at Avenida General Valero #404, in Fajardo. To get to the hospital, exit the base and take Route 3 north to Fajardo. After passing the Del Este Shopping Center, turn right onto Avenida El Conquistador. Turn Right onto Avenida General Valero (Route 194). The hospital will be on your right.

11.0 HEALTH AND SAFETY PLAN APPROVAL

This HASP has been reviewed by the following personnel prior to submission to LANTDIV.

Warren Lehew	PHSO	_____
Name (print)	Title (print)	Signature
Mark Kimes	Project Manager	_____
Name (print)	Title (print)	Signature
Pete Monday	Site Manager	_____
Name (print)	Title (print)	Signature

TABLES

TABLE 9-1

OSHA TRAINING HISTORY OF BAKER PROJECT PERSONNEL*

Personnel	Title/Role	Training Status	
Mark Kimes	• Project Manager	• 40-hr. training completed:	7/91
		• Supervisory training:	9/91
		• 8-hr. refresher completed:	5/05
		• First Aid Training:	4/03
		• CPR Training:	4/03
		• Medical Surveillance:	4/05
Warren Lehew	• Project Health and Safety Officer	• 40-hr. training completed:	9/99
		• 8-hr. refresher completed:	12/05
		• First Aid Training:	8/00
		• CPR Training:	8/00
		• Medical Surveillance:	8/04
Pete Monday	• Site Manager/Site Health and Safety Officer	• 40-hr. training completed:	3/90
		• Supervisory training:	9/91
		• 8-hr. refresher completed:	5/02
		• First Aid Training:	8/95
		• CPR Training:	8/95
		• Medical Surveillance:	2/05

* Training history for contractor personnel will be maintained at the Command Post.
N/A – Not Applicable

FIGURES

FIGURE 8-1

EMERGENCY TELEPHONE NUMBERS

NSRR	Telephone Number On-Base Phone	Telephone Number Off-Base Phone	Contact*
Security (Police)	4108	(787) 865-4106	Response Operator
Fire (On-Scene Commander)	4333	(787) 865-4333	Response Operator
Hospital (Fajardo)	(9) 787-863-0505	(787) 863-0505	Response Operator
General Base Information	2000	(787) 865-2000	Response Operator
Public Works	4152	(787) 865-4152	Mr. Pedro Ruiz
Florida Poison Information Center	(9) 800-222-1222	(800) 222-1222	Response Operator
Federal Maritime Commission	(9) 954-963-5362 (9) 954-963-5284	(954) 963-5362 (954) 963-5284	Andrew Margolis Eric O. Mintz
CHEMTREC	(9) 1-800-424-9300	1-800-424-9300	Response Operator
EPA National Response Center	(9) (800) 424-8802	(800) 424-8802	Response Operator
Baker Project Manager	(9) 412-269-2009	(412)269-2009	Mr. Mark Kimes
Baker PHSO	(9) 412-269-6068	(412)269-6068	Mr. Warren Lehew
LANTDIV Navy Representative	(9) 757-322-4780	(757)322-4736	Mr. Kevin Cloe
USCG Marine Safety Office, Miami	(9) 305-535-8705	(305) 535-8705	Response Operator

* Remaining points of contact will be identified prior to the start of activities.

Appendix C:
Habitat Characterization of SWMUs 1, 2, and 45

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

Prepared for:

CH2M Hill

Prepared by:

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

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

October 11, 2000

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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.

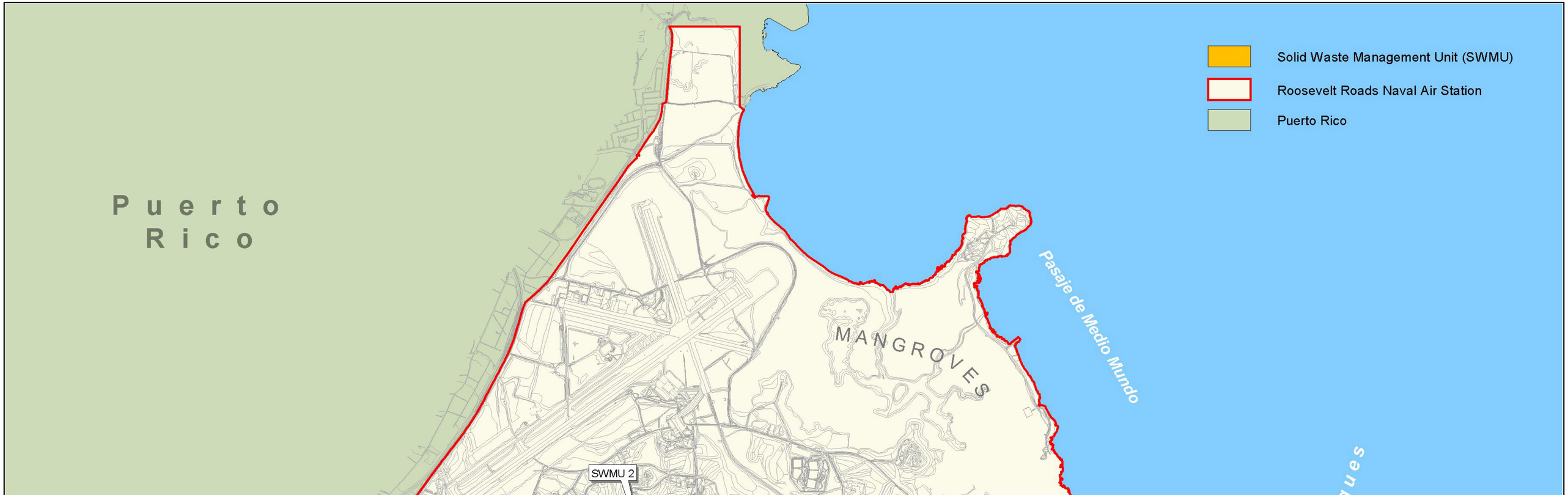


Figure 2. Location of SWMU 1,2 and 45, Roosevelt Roads, Puerto Rico.

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.

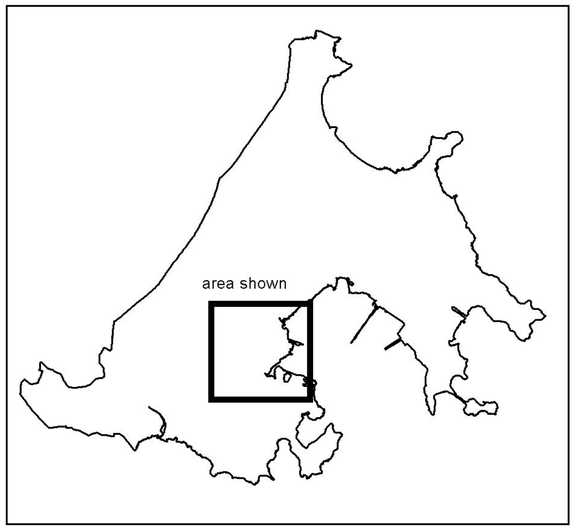
The black mangroves were located inland between the red mangroves and the coastal upland forest community. Species composition consisted of saline tolerant plants as the result of periodic saturation with highly saline water. The site had sparse vegetation cover (approximately 25 percent) and plants 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*.

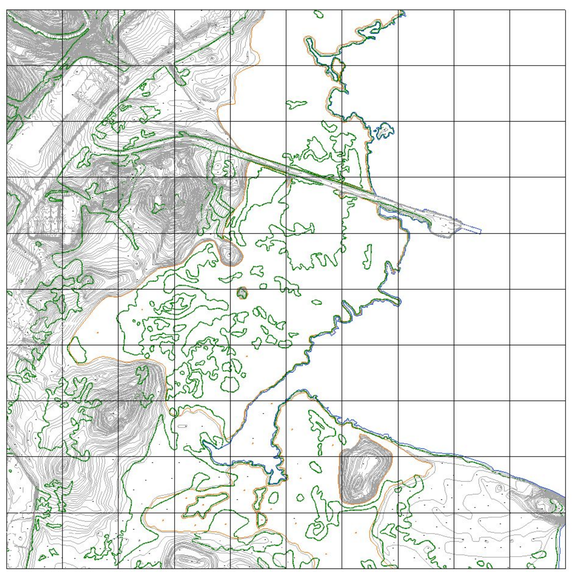
The coastal scrub forest community also showed signs of soil disturbance and had vegetation similar to the upland forest community. However, the coastal scrub had less topographic relief, fewer trees, and larger grassy patches than the upland forest. Vegetation cover in the coastal scrub was approximately 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.



U.S. Naval Station Roosevelt Roads, Puerto Rico



Topography

N

800 0 800 1600 Feet

200 0 200 400 600 Meters

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.

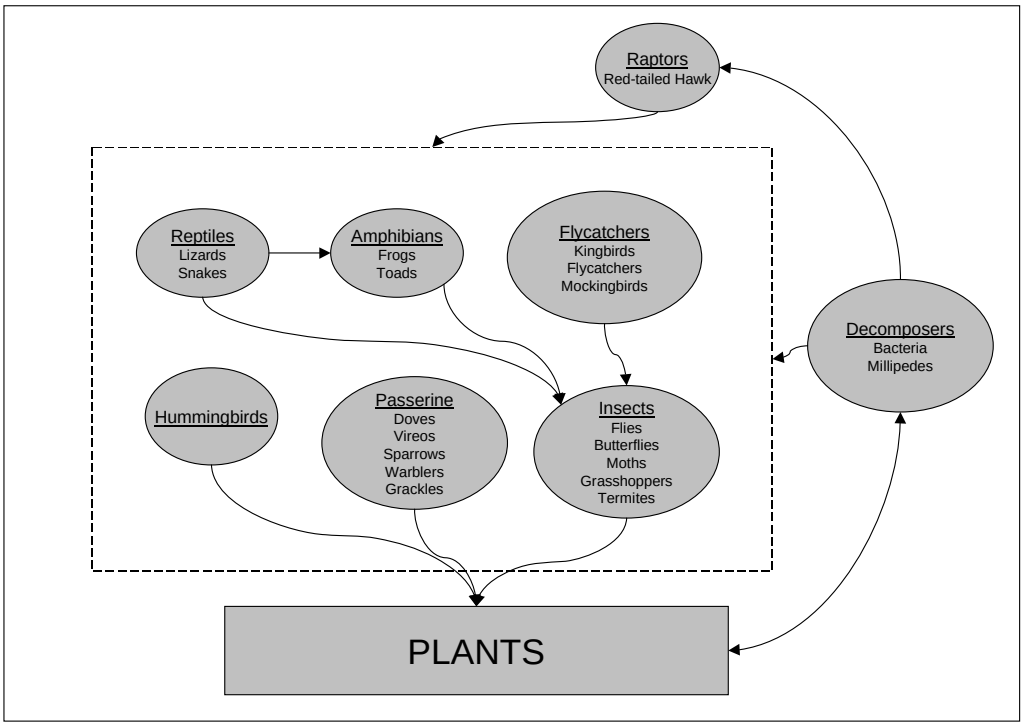


Figure 6. Generalized Food Web for the Upland Coastal Forest and Coastal Scrub Forest Communities at NAVSTA Roosevelt Roads.

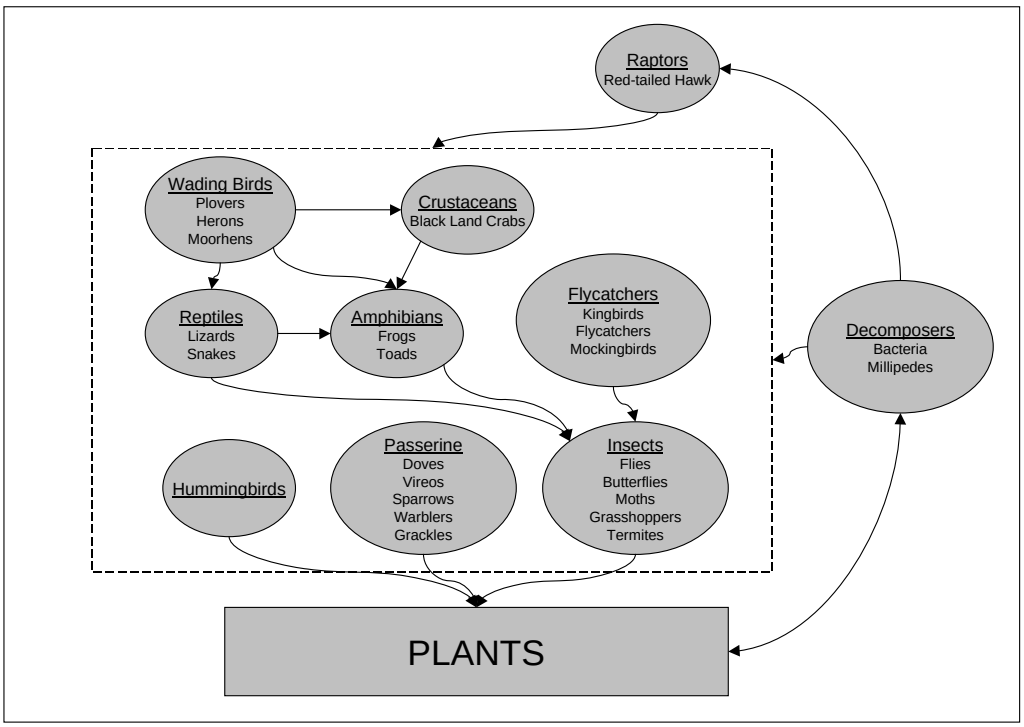


Figure 7. Generalized Food Web for Mangrove Communities at NAVSTA Roosevelt Roads.

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.

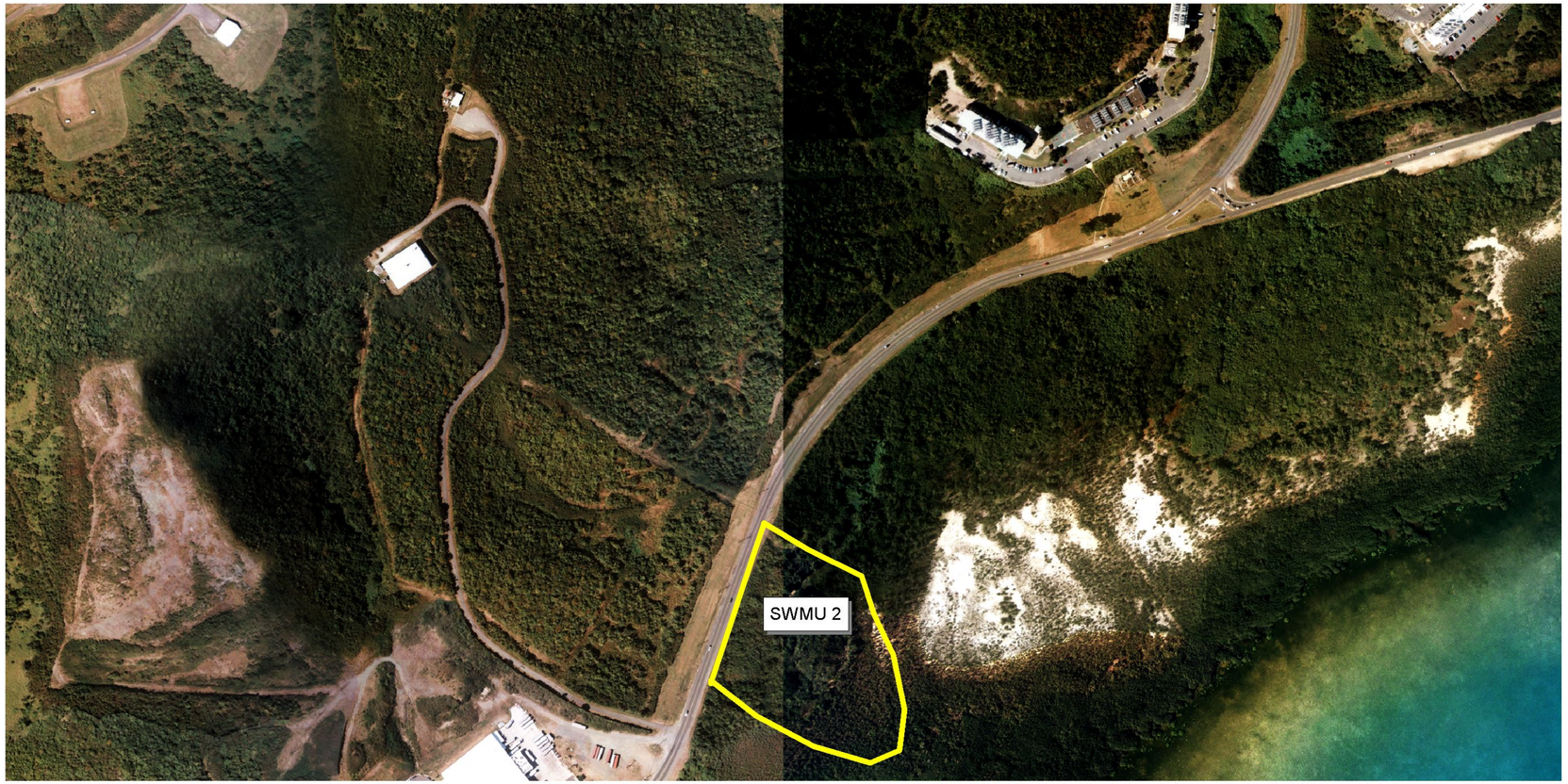
Food Web

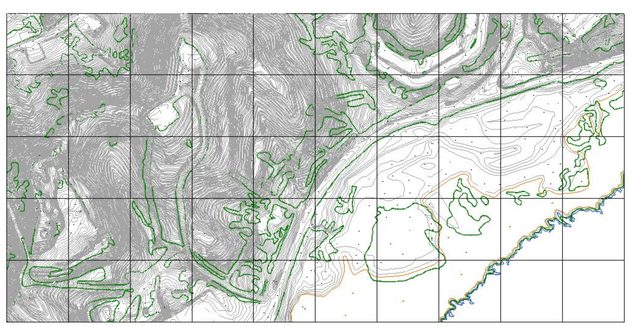
Figures 6 and 7 present generalized food webs for the upland coastal forest and mangrove communities, respectively.

Table 5

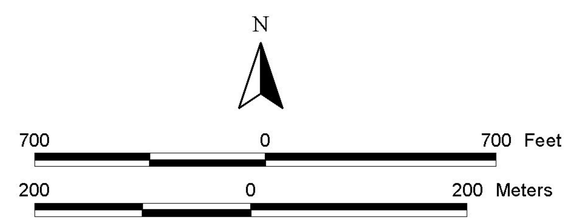
Wildlife Observed at SWMU 2

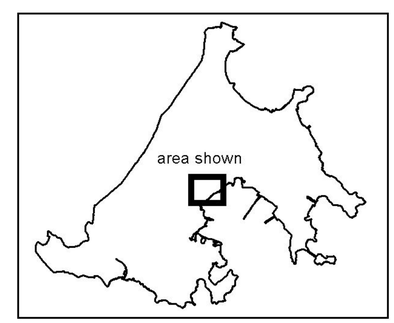
English Name	Scientific Name	Local Name
Upland Coastal Forest		
Reptiles and Amphibians		
Lizard	*Anolis cristatellus*	not known
Lizard	*Anolis pulchellus*	not known
Frog	*Eleutherodactylus sp.*	not known
Frog	*Leptodactylus albilabris*	not known
Birds		
Red-tailed Hawk	*Buteo jamaicensis*	Guaraguao 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





Topography





U.S. Naval Station Roosevelt Roads, Puerto Rico

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

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

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

SWMU 45

Terrestrial Area

Vegetation Community Description

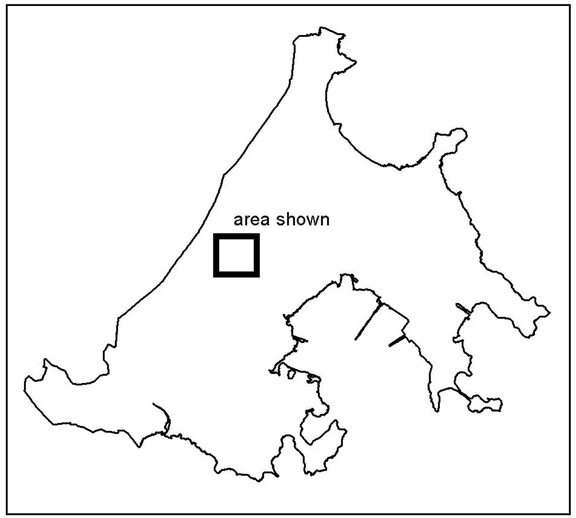
SWMU 45 included areas outside of Building 38, the right-of-way for the cooling water tunnels, and a small cove in Puerca Bay (Figure 11). Building 38 is located along a dirt access road south of Forrestal Drive. Grounds maintenance and building maintenance activity appeared to have been abandoned a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

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

The small cove at Puerca Bay was shallow and had been excavated for the water cooling tunnels. The fringe of the bay had near 100 percent shrub cover and little to no herbaceous vegetation. *Thespesia populnea* shrubs dominated the community. There were also sparse black mangroves, *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.



U.S. Naval Station Roosevelt Roads, Puerto Rico

Topography

400 0 400 800 Feet

90 0 90 180 270 360 Meters

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 A

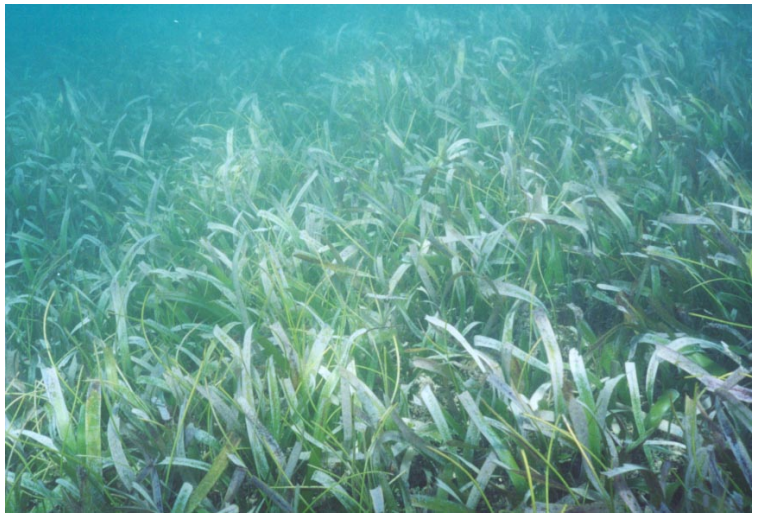
Photographs

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

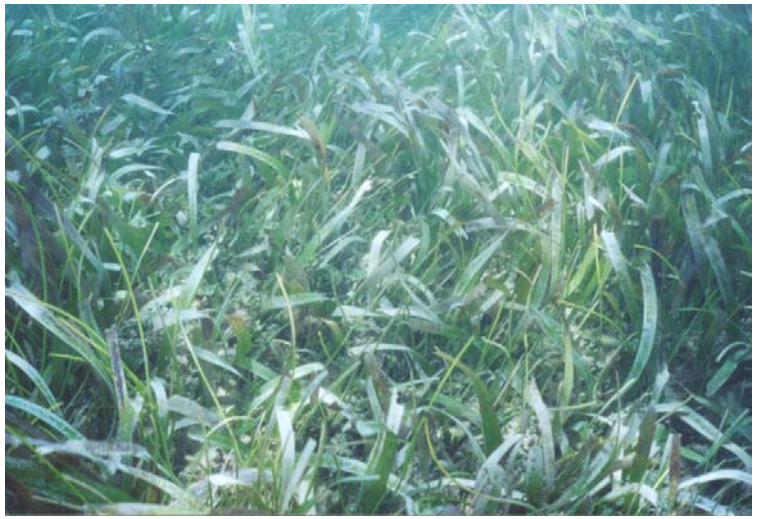
Photogragh 2. Rocky subtidal habitat and seagrass bed interface with calcareous green algae (*Halimeda incrassata)*, turtle grass (Thalassia testudinum) and porous sea rods (*Pseudoplexaura sp.*).

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

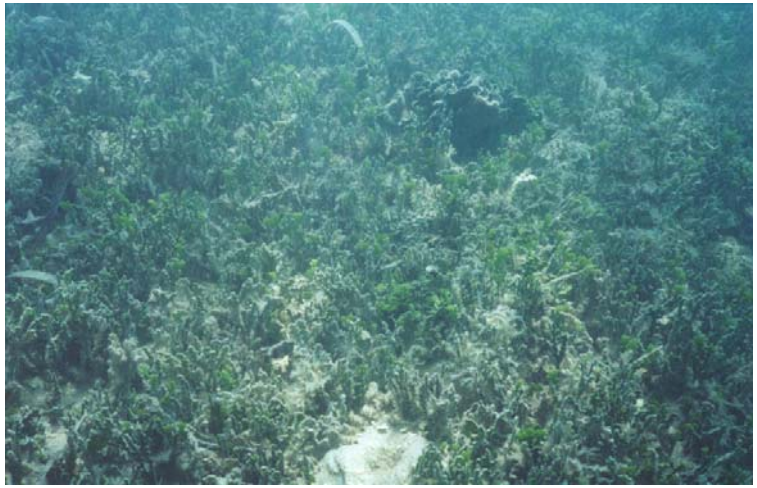
Photograph 4. Rocky subtidal habitat with red-boring sponge (*Cliona sp.*), porous sea rod (*Pseudoplexaura sp.*) and knobby brain coral (*Diploria clivosa*).



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

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

July 18, 2000

Prepared for:
Geo-Marine, Inc.
Centro Punta Del Este, Suite 201
Fajardo, Puerto Rico 00738

Prepared by:
Dial Cordy and Associates Inc.
115 Professional Drive, Suite 104
Ponte Vedra Beach, FL 32082

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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

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