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SUPPLEMENTAL RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION AND REMEDIAL INVESTIGATION AND FEASIBILITY STUDY WORK PLAN VOLUME 1 OF 2 NAS KEY WEST FL

12/1/1995

ABB ENVIRONMENTAL SERVICES INC

0060

SUPPLEMENTAL RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION AND REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

WORKPLAN, VOLUME I

NAVAL AIR STATION KEY WEST
KEY WEST, FLORIDA

UNIT IDENTIFICATION CODE: N60201
CONTRACT NO. N62467-89-D-0317/114

DECEMBER 1995

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA
29419-9010

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SUPPLEMENTAL RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION AND REMEDIAL INVESTIGATION

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KEY WEST, FLORIDA

Unit Identification Code: N60201

Contract No. N62467-89-D-0317/114

Prepared by:

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Dudley Patrick, Code 1858, Engineer-in-Charge

December 1995

CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, ABB Environmental Services, Inc., hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/114 are complete and accurate and comply with all requirements of this contract.

DATE: December 8, 1995

NAME AND TITLE OF CERTIFYING OFFICIAL: Robin Futch, P.G.
Task Order Manager

NAME AND TITLE OF CERTIFYING OFFICIAL: Richard Hicks, P.G.
Project Technical Lead

(DFAR 252.227-7036)

This document Supplemental Resource Conservation and Recovery Act Facility and Remedial Investigation Workplan and Sampling and Analysis Plan, U.S. Naval Air Station, Key West Florida has been prepared under the direction of a Florida Registered Professional Geologist. The professional opinions rendered in this workplan were developed in accordance with commonly accepted procedures consistent with applicable standards of practice. If conditions are determined to exist that differ from those described, the undersigned geologist should be notified to evaluate the effects of any additional information on the assessment and recommendations in this document. This document was prepared for U.S. Naval Air Station, Key West, Florida, and should not be construed to apply to any other site.

Richard Hicks
Professional Geologist
State of Florida License No. 56

December 6, 1995
Date

FOREWORD

To meet its mission objectives, the U.S. Navy performs a variety of operations, some requiring the use, handling, storage, or disposal of hazardous materials. Through accidental spills and leaks and conventional methods of past disposal, hazardous materials may have entered the environment in ways unacceptable by today's standards. With growing knowledge of the long-term effects of hazardous materials on the environment, the Department of Defense (DOD) initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities.

One of these programs is the Installation Restoration (IR) program. This program complies with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA), the Resource Conservation and Recovery Act (RCRA), and the Hazardous and Solid Waste Amendments (HSWA) of 1984. These acts establish the means to assess and clean up hazardous waste sites for both private-sector and Federal facilities.

The program that has been adopted to address present hazardous material management is RCRA and the HSWA (RCRA/HSWA) corrective action program. RCRA ensures that solid and hazardous wastes are managed in an environmentally sound manner. The law applies to facilities generating or handling hazardous waste. The HSWA corrective action program is designed to identify and clean up releases of hazardous substances at RCRA permitted facilities.

The RCRA/HSWA program is conducted in four stages as follows:

- RCRA Facility Assessment (RFA),
- RCRA Facility Investigation (RFI),
- Corrective Measures Study (CMS), and
- Corrective Measures Implementation (CMI).

The Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), the U.S. Environmental Protection Agency (USEPA), and the Florida Department of Environmental Protection (FDEP, formerly the Florida Department of Environmental Regulation [FDER]), oversee the Navy environmental program at Naval Air Station (NAS) Key West. All aspects of the program are conducted in compliance with State and Federal regulations, as ensured by the participation of these regulatory agencies.

Questions regarding the RCRA program at Naval Air Station Key West should be addressed to the Installation Restoration program coordinator at (305) 293-2061.

EXECUTIVE SUMMARY

ABB Environmental Services, Inc., under the Comprehensive Long-term Environmental Action, Navy (CLEAN) Contract, No. N62467-89-D-0317/114, has prepared this Supplemental Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and Remedial Investigation (RI) workplan on behalf of the U.S. Navy for the Naval Air Station (NAS) Key West. This draft Supplemental RFI/RI Workplan is being prepared in accordance with the Hazardous and Solid Waste Amendment (HSWA) permit No. FL6-170-022-952, issued by the U.S. Environmental Protection Agency (USEPA) on July 31, 1990, and effective until August 30, 2000. It presents the proposed investigation methods and sampling summaries by site for conducting the supplemental RFI/RI at NAS Key West. This workplan supplements the previous RFI/RI work that was conducted by IT Corporation from 1992 through 1994.

NAS Key West is located in Key West, Florida, in southern Monroe County. A RCRA Facility Assessment (RFA) for NAS Key West was conducted by USEPA Region IV in 1989. The RFA identified seven solid waste management units (SWMUs) at NAS Key West. All seven of the SWMUs were recommended for further sampling. Subsequent to the RFA, eight additional sites have been identified at NAS Key West. Collectively these sites include a total of nine SWMUs and six Installation Restoration (IR) sites at NAS Key West. The RCRA corrective action program for the nine SWMUs is being implemented in accordance with RCRA and the NAS Key West HSWA permit. The Remedial Investigation and Feasibility Study (RI/FS) activities for the six IR sites are being implemented in accordance with the National Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as amended by SARA. A Corrective Action Management Plan (CAMP) has been prepared to describe the strategy to implement the RCRA Corrective Action Program at NAS Key West (ABB-ES, 1995).

The purpose of the NAS Key West CAMP was to outline the strategy for finalizing completion of the RFI/RI assessment to confirm and characterize the nature and extent of confirmed releases of hazardous substances to the environment at NAS Key West. The initial RFI/RI confirmed the presence of contamination at specific sites. The supplemental RFI/RI will further characterize the nature and extent of confirmed contamination in accordance with the requirements of HSWA Permit No. FL6-170-022-952.

The purpose of this Supplemental RFI/RI Workplan is to provide information common to all of the SWMU and IR sites being investigated at NAS Key West including sampling and analytical methodology, data evaluation, risk assessment methodology, characterization and assessment of facility-wide background data, and the ecological characterization of the sites. Because the information contained in this workplan is common to all SWMUs and IR sites, it will not be repeated in future RFI/RI reporting but will be referenced.

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
AIMD	Aircraft Intermediate Maintenance Building
AOCs	Areas of Concern
AQUIRE	Aquatic Information Retrieval
ARARs	applicable or relevant and appropriate requirements
AWQC	Ambient Water Quality Criteria
BEI	Bechtel Environmental, Inc.
BHC	benzenehexachloride
bls	below land surface
CAMP	Corrective Action Management Plan
CAR	Contamination Assessment Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action, Navy
CLP	Contract Laboratory Program
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COMREL	Community Relations
CPCs	chemicals of potential concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	contract required detection limit
CRQL	contract required quantitation limits
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DOD	Department of Defense
DQOs	data quality objectives
ECPC	ecological contaminants of potential concern
EIC	Engineer-in-Charge
EPC	exposure point concentration
ERA	Ecological Risk Assessment
°F	degrees Fahrenheit
FDEP	Florida Department of Environmental Protection
FDER	Florida Department of Environmental Regulation
FKAA	Florida Keys Aqueduct Authority
FSWQs	Florida Surface Water Quality Standards
GC/MS	gas chromatograph and mass spectrometry
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Tables
HHCPC	Human Health Chemicals of Potential Concern
HHRA	Human Health Risk Assessment

GLOSSARY (Continued)

HI	Hazard Index
HQs	Hazard Quotient
HSW	hazardous waste
HSWA	Hazardous and Solid Waste Amendments
IAS	Initial Assessment Study
IR	Installation Restoration
IRA	Interim Remedial Action
IRIS	Integrated Risk Information System
mg/cm^2	milligrams per square centimeter
$\mu g/\ell$	micrograms per liter
MCLs	maximum contaminant level
mg/ℓ	milligrams per liter
mg/kg	milligrams per kilogram
mgd	million gallons per day
msl	mean sea level
NACIP	Naval Assessment and Control of Installation Pollutants Program
NCP	National Contingency Plan
NAS	Naval Air Station
NEESA	Naval Energy and Environmental Support Activity
NOV	Notice of Violation
P.G.	Professional Geologist
PAH	polynuclear aromatic hydrocarbon
PCBs	polychlorinated biphenyls
PM	Program Manager
PRE	preliminary risk evaluation
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAC	Remedial Action Contractor
RAM	Responsibility Assignment Matrix
RBC	risk based concentration
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RfC	reference concentration
RfD	reference dose
RFI/RI	RFI and Remedial Investigation
RFI	RCRA Facility Investigation
RGOs	remedial goal options
RI/FS	remedial investigation and feasibility study
RME	reasonable maximum exposure
RPF	Relative Potency Factor
RTVs	Reference Toxicity Values

GLOSSARY (Continued)

SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SOUTHNAV-FACENGCOM	Southern Division, Naval Facilities Engineering Command
SQL	sample quantitation limit
SVOC	semivolatile organic compound
SWMUs	solid waste management units
TAL	target analyte list
TCLP	Toxicity Characteristics Leaching Procedure
TF	trichlorotrifluoromethane
TICs	tentatively identified compounds
TOM	Task Order Manager
UCL	upper confidence limit
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	volatile organic compound

1.0 INTRODUCTION

This document presents a summary of basic station information, including physiography and topography, regional geology, and hydrogeology and findings from the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and Remedial Investigation (RFI/RI) completed and detailed in a Final Report dated June 1994 (IT Corporation, 1994) to support the implementation of the Supplemental RFI/RI Workplan for Naval Air Station (NAS), Key West, Florida (Figure 1-1). The RFI/RI is being conducted at NAS Key West in compliance with the requirements of the Hazardous and Solid Waste Amendments (HSWA) permit (FL6-170-022-952) issued July 31, 1990, and effective until August 30, 2000; the approved Corrective Action Management Plan (CAMP) (ABB Environmental Services, Inc. [ABB-ES], 1995); the National Contingency Plan (NCP); and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A total of fifteen sites, identified at NAS Key West, shown on Figure 1-2 and described in Table 1-1, include:

- nine solid waste management units (SWMUs) - SWMUs 1,2,3,4,5,6,7,8,9;
- four installation restoration (IR) sites - IR 1,3,7,8; and
- two areas of concern (AOCs) - AOC A and AOC B.

1.1 PURPOSE. The purpose of the RFI/RI activities at NAS Key West is to provide data that will be used to:

- characterize the nature and extent of releases from SWMUs, IR sites, and AOCs;
- characterize the potential pathways of contaminant migration in the soil, surface water, and groundwater;
- identify potential receptors;
- assess potential risks to human health and the environment; and
- determine whether contaminants released from a SWMU, IR site, or AOC require further corrective measures to mitigate the risk to human health or the environment.

1.2 SCOPE. Initial RFI/RI field activities were conducted by IT Corporation from January 1992 through April 1992, December 1992 through February 1993, and March 1994 through December 1994. Field activities at NAS Key West included the following tasks:

- monitoring well installation,
- surface and subsurface soil sample collection,
- surface water and sediment sample collection,
- groundwater sample collection,
- monitoring well and sample location topographic survey,
- tidal influence studies of selected monitoring wells and piezometers,
- biological inventory of terrestrial and aquatic habitats, and

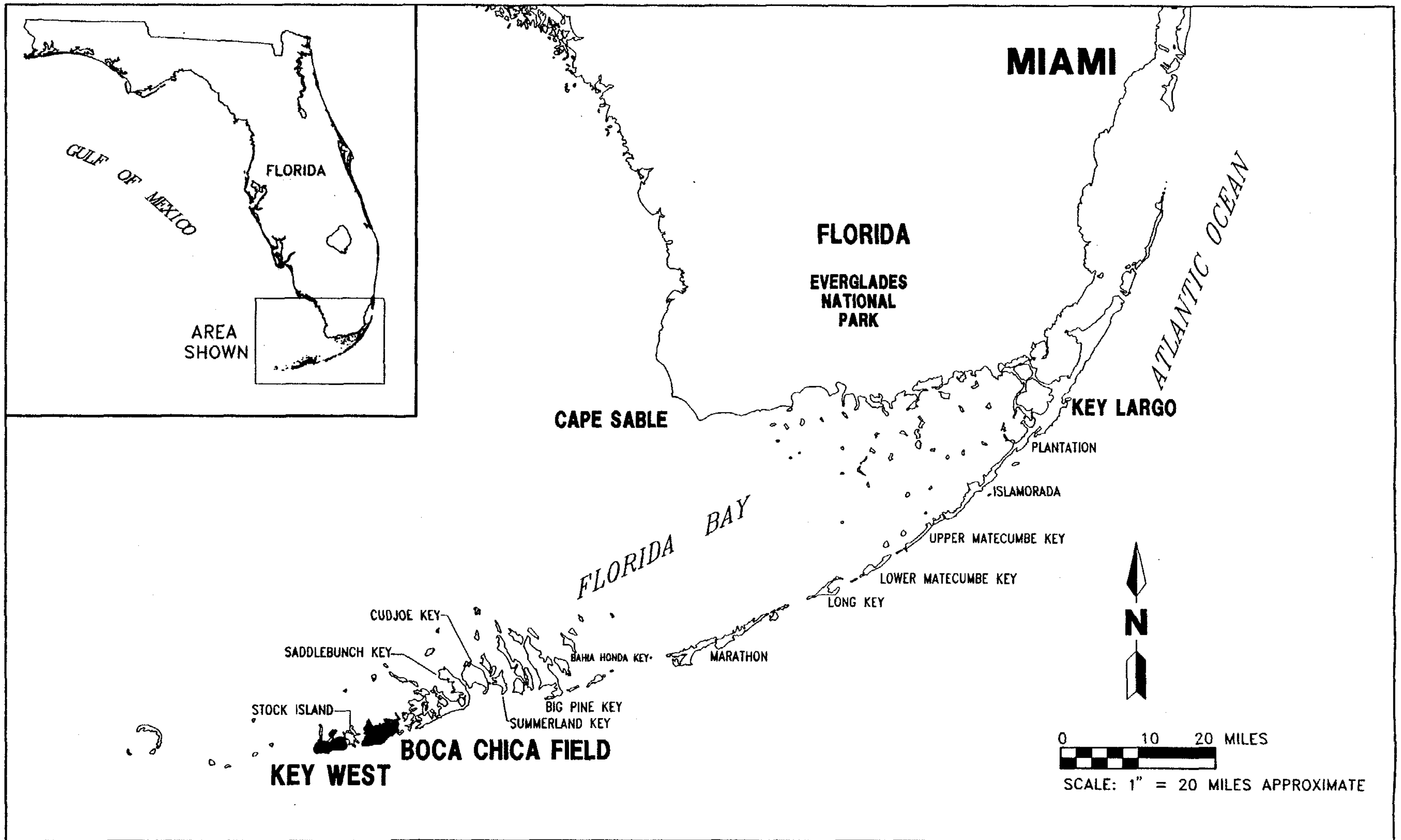

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FIGURE 1-1
FACILITY LOCATION MAP
NAS KEY WEST

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

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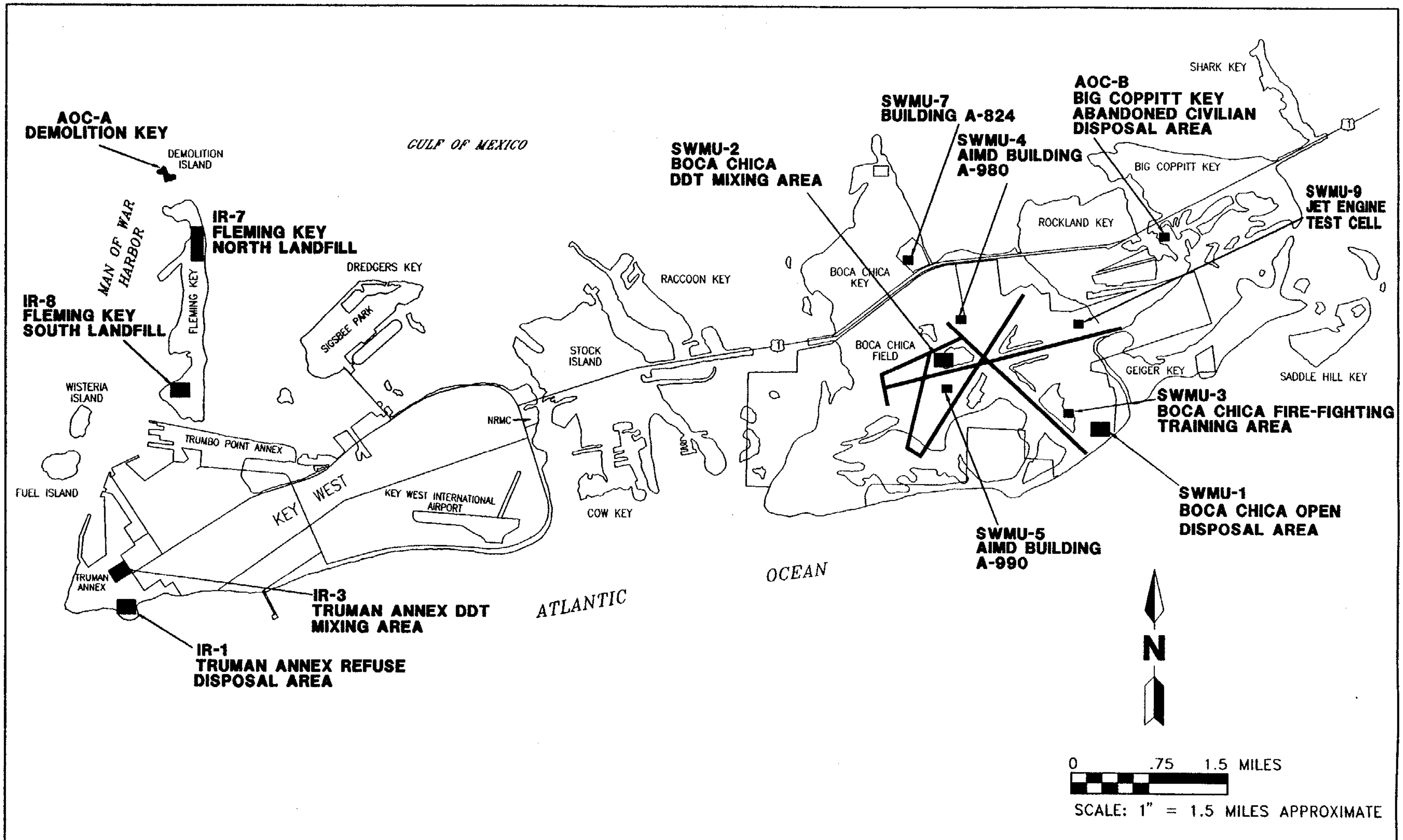

FIGURE 1-2
LOCATION OF SOLID WASTE MANAGEMENT UNITS, AREAS OF CONCERN, AND INSTALLATION RESTORATION SITES

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

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Table 1-1
Solid Waste Management Unit (SWMU), Installation Restoration (IR) Sites, and Area of Concern (AOC) Summary

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Regulatory Program	Site No.	Description
RFI	SWMU 1	Boca Chica Open Disposal Area
RFI	SWMU 2	Boca Chica DDT Mixing Area
RFI	SWMU 3	Boca Chica Fire-Fighting Training Area
RFI	SWMU 4	Boca Chica AIMD Building A-980
RFI	SWMU 5	Boca Chica AIMD Building A-990
RFI	SWMU 6	Wastewater Treatment Plant[1]
RFI	SWMU 7	Boca Chica Building A-824
RFI	SWMU 8	HSW Storage Building[1]
RFI	SWMU 9	Jet Engine Test Cell (A-969)
RI	IR 1	Truman Annex Refuse Disposal Area
RI	IR 3	Truman Annex DDT Mixing Area
RI	IR 7	Fleming Key North Landfill
RI	IR 8	Fleming Key South Landfill
RI	AOC A	Demolition Key Open Disposal Area
RI	AOC B	Big Coppitt Key Abandoned Civilian Disposal Area

[1]These SWMUs are permitted separately, currently in operation, and not included in the RFI/RI program.

Notes: RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
SWMUs = solid waste management units.
DDT = dichlorodiphenyltrichloroethane.
AIMD = Aircraft Intermediate Maintenance Department.
HSW = hazardous waste.
RI = Remedial Investigation.
IR = Installation Restoration.
AOC = area of concern.

- laboratory analyses of selected Appendix IX Groundwater Monitoring List parameters (40 Code of Federal Regulations [CFR] 264).

This Supplemental RFI/RI Workplan describes: (1) existing site conditions and (2) rationale and description of activities that will be used in conducting the supplemental RFI/RI.

Due to the involvement of numerous contractors in the NAS Key West RFI/RI program, a Responsibility Assignment Matrix (RAM) has been developed to ensure proper communication and coordination of all field assessment and excavation activities conducted onsite. Table 1-2 outlines the RAM for the RFI/RI program at NAS Key West.

1.3 OVERVIEW OF DOCUMENT. The planning documents to support the supplemental RFI/RI program consist of two volumes:

- Volume I, RFI/RI workplan; and
- Volume II, RFI/RI Sampling and Analysis Plan (SAP).

Together these two volumes outline the scope of work for the supplemental RFI/RI program. The Supplemental RFI/RI Workplan (Volume I) includes the following sections:

- 1.0 Introduction,
- 2.0 Facility Background,
- 3.0 NAS Key West RFI/RI Program Activities,
- 4.0 Data Management Plan, and
- 5.0 Project Management Plan.

The supplemental RFI/RI SAP (Volume II) focuses on the field investigation and laboratory analysis and includes the following sections:

- 1.0 Project Description;
- 2.0 and 3.0 Field Sampling Plan; and
- 4.0 Quality Assurance Project Plan (QAPP).

During the course of the excavation of the RFI/RI program activities, modifications to the scope of work or procedures used in sample collection may be required to satisfy program objectives. In the event that factors or conditions are revealed that require a modification to the workplan, technical memoranda will be used to convey the proposed modification. The modification would be enacted upon gaining consensus between USEPA, FDEP, and Navy reviewers and the contractors responsible for executing the program.

Table 1-2
Responsibility Assignment Matrix

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

ACTION	BEI	SDIV	ABB	B&R	NAS	ROICC	EPA	FDEP
INTERIM REMEDIAL ACTIONS								
Delineation Plan	L	R	R	NA	R	I	A	A
Delineation Sampling	L	S	O	I	O	O	I	I
Delineation Report	L	R	I	I	R	I	A	A
Interim Removal Activities	L	S	I	I	O	O	I	I
Confirmation Sampling Plan[1]	L	R	I	I	R	I	A	A
Confirmation Sampling	L	S	I	I	I	O	I	I
Confirmation Sampling Report[2]	L	R	I	I	I	NA	R	R
Remediation Workplan[3]	L	A	I	I	R	R	R	R
Action Memorandum for Removal Actions	L	R	I	I	A	I	R	R
Public Notice for Removal Actions	S	S	S	S	L	I	I	I
Construction Report	L	A	I	I	I	I	I	I
RFI/RI IMPLEMENTATION								
Prepare Final RFI/RI Workplan	I	A	L	R	R	I	A	A
Prepare Ecological Risk Assessment Technical Memorandum	I	A	R	L	R	I	A	A
Implement RFI/RI Workplan	NA	S	NA	L	S	NA	NA	NA
Implement Risk Assessment Workplan	NA	S	NA	L	S	NA	NA	NA
Prepare Draft RFI/RI Report & Risk Assessment	I	R	NA	L	R	I	R	R
Prepare Final RFI/RI Report & Risk Assessment	I	A	NA	L	R	I	A	A
Prepare Final Corrective Measures Workplan	I	A	L	R	R	I	A	A
Conduct Corrective Measures Study	NA	S	NA	L	S	NA	NA	NA
Prepare Draft Corrective Measures Study Report	I	R	NA	L	R	I	R	R
Prepare Final Corrective Measures Report	I	A	NA	L	R	I	A	A
Conduct Community Relations Program	I	S	S	S	L	I	S	S
Prepare Community Relations Plan	I	A	L[4]	L[4]	A		A	A

[1] Included in Delineation Sampling Report.
[2] Included in Construction Report (Remediation Report).
[3] Includes Project Plan Revision documents.
[4] ABB Environmental Services, Inc., lead through 31 December 1995; B&R becomes lead after January 1996.

Notes: NA = not applicable.
L = lead.
A = approve.
S = support.
R = review and comment.
I = information.
O = oversight inspection.

2.0 FACILITY BACKGROUND

2.1 FACILITY DESCRIPTION. NAS Key West is located in southern Monroe County, approximately 150 miles southwest of Miami on the two westernmost islands of the Florida Keys (Boca Chica and Key West). It is connected to the mainland by the Overseas Highway (U.S. Highway No. 1). A regional map showing the Florida Keys is presented on Figure 1-1.

Several naval installations located in various parts of the lower Florida Keys comprise what is known as the Naval Complex at Key West. Most of these are located in the vicinity of Key West and Boca Chica Key. The entire complex encompasses approximately 5,000 acres. NAS Key West is the host activity of the Naval Complex. The air station is located on Boca Chica Key and encompasses 3,250 acres. Additional areas that are part of the complex include Trumbo Point, Sigsbee Key, Fleming Key, Demolition Key, Truman Annex on Key West, and Big Coppitt Key.

In 1823, a U.S. naval base was first established on Key West for removing pirates from the Florida Keys. The base was expanded during the Mexican War, the Spanish-American War, and again during World War I, with periods of inactivity in between. In 1939, a seaplane base was opened, and in 1942, the Boca Chica airfield was built. At this time, an aboveground pipeline was constructed to bring water from the mainland to support the increased military operation during World War II. This pipeline is still in use as the primary conduit of drinking water to the Keys. During World War II, Key West Naval Station was established as the Sixth Naval District Headquarters. Since that period, the role of the military at NAS Key West has decreased. The Naval Station was disestablished in 1973, resulting in the relocation of Navy submarine units, the Undersea Diving School, and the Fleet Sonar School. A Marine unit was transferred from Key West in 1977. During the late 1970's, several other operations were transferred or downgraded.

Currently, NAS Key West maintains aviation operations, a research laboratory, communications intelligence, counter-narcotics air surveillance operations, a weather service, and several other activities. In addition to the naval activities and units, other Department of Defense (DOD) and Federal agencies are located at NAS Key West. Defense activities include U.S. Air Force squadrons, U.S. Army Special Forces Division, U.S. Coast Guard, and a Defense Property Disposal Office.

Key West is approximately 4 miles long and 1.5 miles wide; Boca Chica Key is approximately 3 miles long and 3 miles wide. The city of Key West is the county seat of Monroe County and has a residential population of 24,832 (1990 U.S. Census). The principal industry is tourism, with about 1,225,000 tourists visiting annually. The major sources of employment in Key West are: tourism, fishing, wholesale and retail trade, services, construction, finance, insurance, real estate, Federal government, State and local government, and transportation industries. The city of Key West consists of commercial and residential areas. Boca Chica Key is used mainly as a military base.

2.2 EXISTING SITE CONDITIONS. The following subsections present a summary of existing conditions common to all sites located at NAS Key West.

2.2.1 Physiography and Topography The NAS Key West Complex is situated in the southeastern Coastal Plain physiographic province. The topography of the Coastal Plain in southern Florida is controlled by a series of ancient marine reefs, which formed during the Pleistocene period when sea level was higher than at present.

The land surface exhibits little relief. Ground elevations in the Key West area average between 4 and 5 feet above mean sea level (msl), with the highest point on Key West being approximately 18 feet above msl. The area is characterized by a sparse veneer of residual soil and surface vegetation overlying eroded limestone. The topography of the Lower Keys is generally smooth and flat in the center of the key and slopes gently toward the shoreline (White, 1970). With the exception of central Key West, most areas are located within the 100-year flood plain.

2.2.2 Climate The Lower Keys have the lowest rainfall of the Florida Keys, 35 to 40 inches per year, with an average annual rainfall of 39.4 inches (McKenzie 1990, McVicar and Lin, 1984). About 75 to 80 percent of rainfall occurs during the wet season between June and November; the remainder of the year is relatively dry (McKenzie, 1990). Temperature is fairly uniform across the Florida Keys, with a July average temperature of 84 degrees Fahrenheit (°F), a January average temperature of 64 to 70 °F, and an average annual temperature of 76.3 °F (McKenzie, 1990). Freezing temperatures are rare in the Florida Keys due to the proximity to the Gulf Stream and the Gulf of Mexico, both of which modify advancing cold fronts. Freezes, when they occur, have the long-lasting effect of killing cold-sensitive species that might otherwise become established (McKenzie, 1990). Easterly tradewinds and sea breezes suppress summer heat from June to September (IT Corporation, 1993).

Hurricanes normally form in the warm, moist air over the tropical seas around the Lesser Antilles and occasionally in the Caribbean. They tend to move in a westerly to northwesterly direction, gradually turning northward and eastward. The majority of hurricanes approach Key West from the south and east; however, severe hurricanes have struck Key West from all directions. It is estimated that 75 percent of all damage that occurs during a hurricane is caused by tidal flooding (IT Corporation, 1994).

Precipitation is characterized by dry and wet seasons. During the period of December through April, the Keys receive approximately 25 percent of their annual precipitation total. The bulk of the annual rainfall, approximately 53 percent, falls in the period of June through October. Rainfall usually occurs in advance of a cold front in the form of a few heavy showers, or occasionally five to eight light showers per month.

Rainfall runoff from Key West is carried to the tidal waters by overland flow or storm drains that drain approximately 50 percent of the island's surface area; however, much of the rainfall percolates directly into the subsurface.

2.2.3 Soil Undisturbed soil in the Keys consists of shallow marl over limestone with the substrata rock appearing at the surface in numerous outcroppings. Many areas of Key West, such as Fleming Key, have been filled and graded. The soil on Key West is classified as urban by the U.S. Soil Conservation Service, and has variable properties (IT Corporation, 1994). Residential areas are primarily paved. Other major soil groups on Key West and Boca Chica Key are Udorthents, which consist of gravelly sand and marl, and Cudjoe, which is composed of marl and weathered bedrock (IT Corporation, 1993).

__2.2.4 Surface Water Hydrology__ The surface water regime in the Florida Keys is dominated by the surrounding saltwater bodies, the Atlantic Ocean and the Gulf of Mexico. The Florida Department of Environmental Protection (FDEP) classifies surface water in the Florida Keys as Class III Waters-Recreational-Propagation and Management of Fish and Wildlife. In the immediate area of NAS Key West are the Great White Heron National Wildlife Refuge and the Key West National Wildlife Refuge which are classified by FDEP as Outstanding Florida Waters and are afforded the highest protection by the State. These waters are considered to be of exceptional recreational and ecological significance to the residents of Florida.

Freshwater recharge reaches the Lower Keys directly through rainfall. The nearly flat topography and porous nature of exposed limestone allows much of this rainfall to infiltrate to shallow groundwater tables, forming freshwater lenses. Remaining rainfall is carried to tidal waters by overland flow or via storm drains found in most of the more developed areas. Accelerated runoff and increased saltwater intrusion due to development of canals from housing, mosquito control, and marinas decrease the freshwater lens on the Florida Keys, shorten the period residents may draw on freshwater supplies, and affect water quality. During the dry season, freshwater tends to disappear quickly by seepage to the sea and evaporation. Evaporation exerts an important effect on the Florida Keys' hydrologic budget, with transpiration affecting a more localized and confined area on individual islands (Schomer and Drew, 1982).

__2.2.5 Public Water Supply and Groundwater Use__ Potable water is supplied to all of the Florida Keys by the Florida Keys Aqueduct Authority (FKAA). The water is drawn from wells near Florida City in southeastern Dade County and pumped 130 miles along a water main that parallels U.S. Highway No. 1 and terminates in Key West. Water is distributed from the water main along its length. In 1984, the FKAA supplied the city of Key West with an average flow of 11.7 million gallons per day (mgd). The Navy received 14.35 percent of the average flow (Personal Communication, 1995)

Alternative sources of potable and nonpotable water are used in the Florida Keys, including private cisterns, private wells, home desalinization systems, and bottled water. The Monroe County Health Department recognizes the public water supply as the only potable water supply source available on Key West. In addition to managing the centralized public water supply system, the FKAA has the authority to regulate all potable water supplies in the Keys, including alternative sources of water such as those mentioned above. Those residences using a dual system of private and public water are required to use a reduced pressure valve to prevent water from back flowing into the water supply system.

Private wells in the freshwater lens in the Surficial Aquifer are used for potable and nonpotable water. The number of people who use water from wells in Key West for drinking purposes is unknown. The best estimate of the number of people using local groundwater for drinking water is less than 500 people. The freshwater lens averages 5 feet in thickness below the center of the western half of Key West. The lens contains between 20 and 30 million gallons of freshwater, depending on the season. Underlying the freshwater lens is a 40-foot transition zone of brackish water.

2.2.6 Hydrogeology and Geology The Lower Keys are underlain by an oolitic member of the Pleistocene Miami Limestone. The Miami Oolite consists of rock units of calcium carbonate and tiny ooloids or spherical calcareous grains that were created through eustatic elevation of limestone. The Key Largo Limestone underlies the Miami Oolite on all the Lower Keys. It consists of cemented remains of ancient coral reefs, fossils, and shells. Hoffmeister (1974) reported that the Miami Oolite is 27 feet thick and that the Key Largo Limestone is greater than 270 feet thick in the western part of Key West. The Key Largo Limestone is generally more porous than the Miami Oolite but it contains only salt water.

The surficial aquifer is unconfined and composed of the highly permeable, porous, solution-riddled Miami Oolite that allows recharge from rainfall to quickly seep into the ocean and saltwater to easily intrude into the aquifer. The surficial aquifer is the principal aquifer of concern in the area because it is used as a potable water resource to a limited extent and because it exists as a groundwater to surface water contaminant migration route. The water table is located at depths ranging from 0.8 to 2.4 feet above msl at the center of the island and from 0.4 to 2.2 msl near the coast. The water table fluctuates constantly as a result of tidal effects. Head differentials associated with tidal variations near the shore can further accelerate groundwater movement in the area. A reconnaissance water-quality sampling study completed in 1990 by the U.S. Geological Survey (USGS), in cooperation with the South Florida Water Management District, indicated that the freshwater lens contains water which does not meet Florida drinking water standards. It is also highly susceptible to contamination. The Key Largo Limestone lies below the Surficial Aquifer (Figure 2-1). This is a limestone remnant reef structure that is extremely permeable, possessing many solution holes and caverns. The Tamiami Formation lies below the Key Largo limestone layer and represents a major water-producing zone in south Florida. Below the Florida Keys, the Tamiami Formation is between 300 and 900 feet below land surface (bls) and contains mineralized water that is not of adequate quality for drinking water. The Hawthorn and Tampa Formations underlie the Tamiami Formation and together act as an aquiclude confining the underlying limestones. Intermittent lenses within this layer are of poor drinking quality in the Florida Keys. The Suwannee Limestone, a fossiliferous limestone, represents the top of the water-producing zone in the Keys. The water is of good enough quality to be used for drinking water, after some treatment. The Avon Park Limestone lies 1,300 feet bls, and, although it has a higher transmissivity than the Suwannee Limestone and supplies large quantities of drinking water in central Florida, the quality of water obtained from this formation is poor in the Florida Keys.

2.3 PREVIOUS INVESTIGATIONS. Several investigations of the sites at NAS Key West have been performed in the past. Table 2-1 provides a regulatory chronology of the investigations and related activities that have been conducted at NAS Key West up to the present HSWA permit. The documents listed in this chronology and below provide specific details about previous investigations that have been conducted at NAS Key West.

- As part of the Naval Assessment and Control of Installation Pollutants Program (NACIP), an Initial Assessment Study (IAS) was performed by Envirodyne Engineers, Inc. at NAS Key West and Boca Chica Field. In the IAS report (Envirodyne, May 1985) additional evaluation was recommended

Table 2-1
Resource Conservation and Recovery Act (RCRA)
Corrective Action Program Chronology

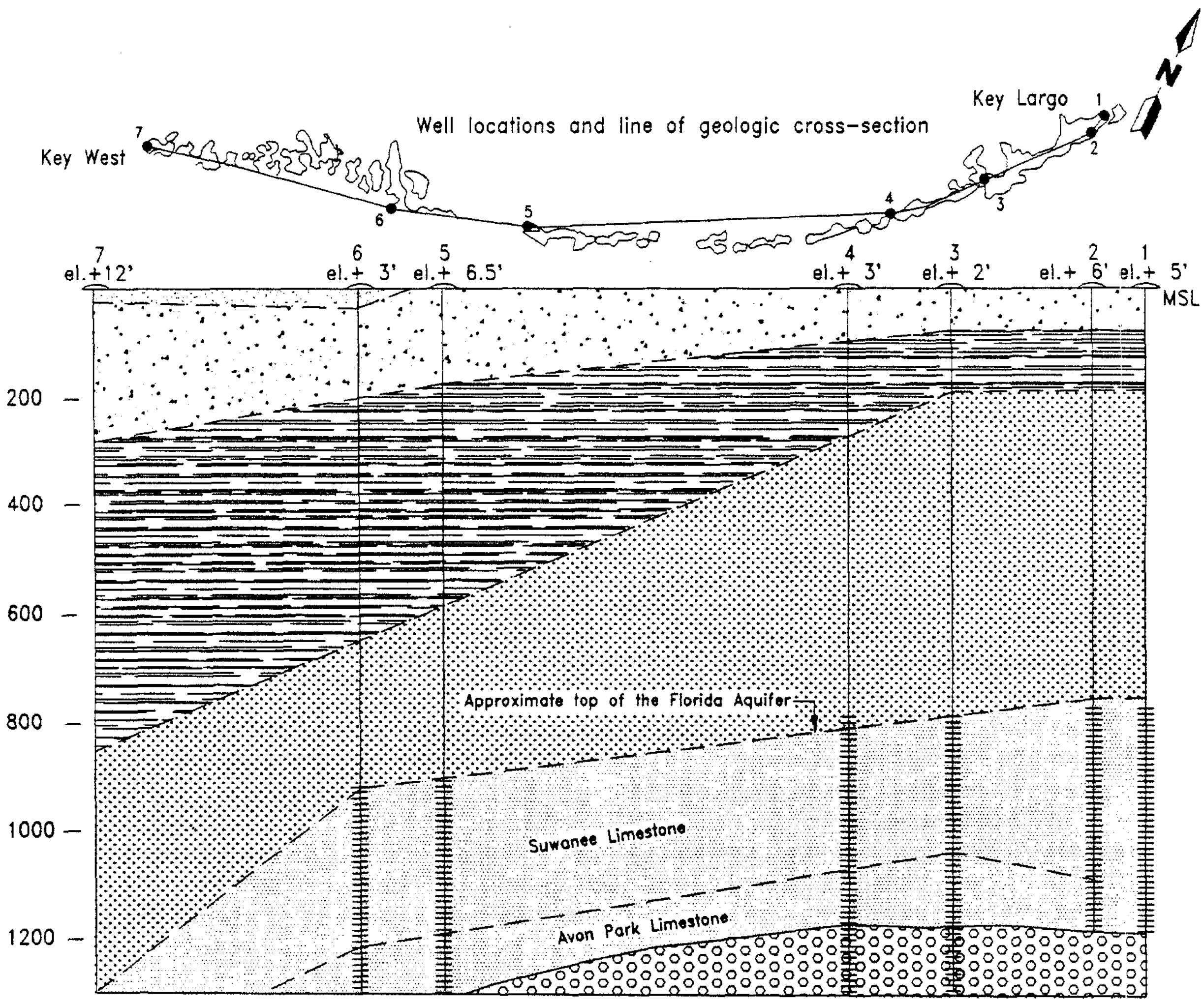
Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Date	Event
May 1985	Initial Assessment Study (IAS) submitted for regulatory review.
June 1985	Subsurface hydrocarbon investigation conducted at Trumbo Point Annex.
August 16, 1985	Florida Department of Environmental Regulation (FDER; since renamed Florida Department of Environmental Protection [FDEP]) comments on IAS.
August 26, 1985	U.S. Environmental Protection Agency (USEPA) comments on IAS.
December 1985	Plan of Action for Verification Study (VS) submitted for regulatory review.
March 1987	VS final report submitted for regulatory review.
April 12, 1987	Environmental audit conducted at Truman Annex.
June 17, 1987	VS final report approved by FDER.
April 12, 1988	USEPA conducts Visual Site Inspection (VSI).
August 25, 1988	Draft RCRA Facility Assessment (RFA) prepared by USEPA.
October 2, 1989	Technical Review Committee (TRC) meeting for NAS Key West held.
October 1989	Final Draft Community Relations (COMREL) Plan Outline submitted for regulatory review.
October 1989	Baseline Risk Assessment Workplan (Site 3) submitted for regulatory review.
October 1989	Remedial Investigation (RI) Workplan submitted for regulatory review.
1989	Contamination Investigation Workplan for Sites 2 and 9 submitted for regulatory review.
January 17, 1990	FDER comments on RI Workplan, COMREL Plan, and Baseline Risk Assessment (Site 3).
February 1990	Final report of site inspections for Sites 2 and 9 submitted for regulatory review.
February 1990	Final report of Baseline Risk Assessment (Site 3) submitted for regulatory review.
February 1990	Final Treatability Study Implementation Plan (Site 9) submitted for regulatory review.
May 30, 1990	FDER enters into Consent Order No. 90-0115 regarding waste minimization and employee training and education.
June 22, 1990	TRC meeting for NAS Key West Part B permit held
August 30, 1990	Federal Hazardous and Solid Waste Amendments (HSWA) permit No. H044-144053 issued.
December 1990	Comprehensive Hazardous Waste Minimization Survey conducted at Naval Air Station (NAS) Key West by U.S. Navy.
March 26, 1991	TRC Meeting held at NAS Key West.
May 1991	Final Remedial Investigation (RI) Phase I report submitted for regulatory review.
July 1991	RCRA Facility Investigation (RFI) Health and Safety Plan submitted for regulatory review.
July 1991	Final Implementation of Pilot Study at Trumbo Point Fuel Farm report submitted for regulatory review.
November 1991	Draft RFI workplan submitted for regulatory review.
February 1992	Draft RFI/RI workplan submitted for regulatory review.
March 1992	Corrective Measures Study (CMS) plan for Boca Chica dichlorodiphenyl trichloroethane (DDT) Mixing Area submitted for regulatory review.
June 15, 1992	CMS plan for Boca Chica DDT Mixing Area approved by FDEP.
July 7, 1992	FDEP comments on draft RFI workplan.
September 22, 1992	USEPA comments on draft RFI/RI workplan.

Table 2-1 (Continued)
Resource Conservation and Recovery Act (RCRA)
Corrective Action Program Chronology

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Date	Event
November 25, 1992	FDEP comments on draft RFI/RI workplan.
1992	FDEP enters into Consent Order No. 92-0867 for RCRA violations and wastewater treatment plan violations.
October 1993	Draft RFI/RI report submitted for regulatory review.
December 1993	FDEP comments on draft RFI/RI report.
June 7, 1994	Final RFI/RI report submitted for regulatory review.
June 28, 1994	Florida hazardous waste (HSW) storage facility permit No. H044-230669 issued.
June 19, 1995	Draft supplemental RFI/RI workplan submitted for regulatory review.
August 8, 1995	Draft Corrective Measures Study workplan submitted for regulatory review.



Miami Oolite (Pleistocene)

Key Largo Limestone (Pleistocene)

Tamiami Limestone (Miocene)

Hawthorn Formation/Tampa Limestone (Miocene)

Suwannee/Avon Park Limestone (Oligocene) (Eocene) NOTE: these are two separate units (see above)

Boulder zone

Source: Envirodyne Engineers, Inc., 1985.

FIGURE 2-1
GEOLOGIC CROSS-SECTION OF THE FLORIDA KEYS

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KET WEST, FLORIDA

H:/9560/120300/NP/12-05-95

for six sites, including the Boca Chica Open Disposal Area, the Boca Chica DDT Mixing Area, the Boca Chica Fire Fighting Area, the Truman Annex Refuse Disposal Area, The Truman Annex DDT Mixing Area, and Fleming Key South Landfill (Fleming Key North Landfill was later added to the list).

- Geraghty and Miller, Inc. later performed this work (Geraghty and Miller, March 1987).

- Blasland, Bouck, and Lee completed a series of cleanup activities at the Building A-824 site in March 1991 (Blasland, Bouck, and Lee, 1991).

- During the period between October 1993 to February 1994, ABB-ES conducted a petroleum contamination assessment to prepare a Contamination Assessment Report (CAR) (ABB-ES, June 1994) at the Jet Engine Test Cell; field activities for the assessment included installing and sampling groundwater monitoring wells, advancing soil borings, and conducting aquifer characterization studies in order.

- IT Corporation conducted soil, surface water/sediment, and groundwater sampling at all of the SWMUs and IR sites as part of the original RFI/RI sampling program, and reported findings of these activities in the RFI/RI Final Report (IT Corporation, June 1994).

- In the summer of 1995, subsequent to the submittal of the draft supplemental RFI/RI workplan in June 1995, Bechtel Environmental, Inc. (BEI), the Remedial Action Contractor (RAC) for the installation, began implementing Interim Remedial Actions (IRAs) at some of the sites. Delineation and characterization samples that are included in the IRA will be used to supplement the previous data, thereby reducing the scope of sampling in some cases. The IRA sampling data available to date are considered preliminary but have been considered in the developmental and revision of the supplementary RFI/RI sampling program scope.

3.0 NAS KEY WEST SUPPLEMENTAL RFI/RI PROGRAM ACTIVITIES

3.1 RATIONALE AND SCOPE OF SUPPLEMENTAL RFI/RI SAMPLING ACTIVITIES. This section describes the supplemental RFI/RI program activities proposed for the sites at NAS Key West. The rationale and scope of supplemental sampling activities are described in conjunction with a description of site history and previous sampling investigation results. Information regarding sampling techniques that will be used to conduct the sampling can be found in the RFI/RI Workplan prepared by IT Corporation (1993) and approved by both the FDEP and USEPA. That workplan is fully adopted as the basis for this Supplemental RFI/RI Workplan, and variations to it are described in the accompanying SAP (Volume II).

This supplemental RFI/RI sampling program scope was developed to provide, on a site-specific basis, sufficient data to satisfy program requirements and base appropriate action (remediation, No Further Action, etc.). In general, the rationale for specific sampling tasks includes addressing a need to provide more information on which appropriate risk assessment criteria can be developed. For specific sites, additional information may be required to characterize the nature and extent of contamination or to assess the success of an IRA. The rationale for sampling, on a site-by-site basis, is discussed below.

Considered in the development of the sampling scope for this supplemental program is the fact that IRA-associated sampling work has been conducted by the RAC and more sampling is to be conducted during subsequent phases of the IRAs at certain sites and that these data can be used for RFI/RI site characterization purposes. As the IRAs at the designated sites are completed, it is possible that the RFI/RI site characterization sampling scope will be further modified. The rationale for sampling as part of this supplemental RFI/RI program has been developed to address data needs and include related activities that extend outside the areas of removal and subsequent verification sampling or monitoring well replacement as a result of removal actions. IRA delineation sampling activities performed subsequent to submittal of the draft RFI/RI workplan in June 1995 were coordinated with ABB-ES in order to also address the characterization sampling needs of this program. As a result of the intentional collection of certain soil, sediment, and surface water samples by the IRA contractor to meet RFI/RI sampling objectives the scope of supplemental sampling activities for some of the sites has been reduced from what was proposed in the draft workplan. Preliminary findings from the IRA sampling have also been used to guide placement of additional sampling locations that would be necessary to satisfy the RFI/RI program objectives. The IRA sampling data will be incorporated into subsequent documents.

3.1.1 Background Characterization

3.1.1.1 **Boca Chica Key Sites** During the RFI/RI conducted by IT and detailed in the RFI/RI Report (IT, 1994), 25 background samples were collected from surface soil, sediment, surface water, and groundwater at five sites. Out of 25 samples collected, only 9 of the samples (surface soil-4, surface water-3, and groundwater-2) were retained. The analytical results suggested that some of the designated background samples were contaminated with organic compounds or high concentrations of inorganics when compared to environmental samples collected from the SWMUs and IR sites.

Based on these analytical results and the need for a separate background data set for Boca Chica Key sites, additional background samples (surface soil, surface water, sediment, and groundwater) are being proposed and are discussed below by media. These include both site-specific and facility-wide background samples. Facility-wide background sampling locations will be determined upon review of pertinent maps and actual site observations. The recommended facility-wide background locations will be formally proposed to USEPA and FDEP in a technical memorandum. Concurrence will be reached on the locations prior to sampling.

Surface Soil. The surface soil at Boca Chica Key are classified as rockland; compacted, made land; and coastal beach, dunes, and water (IT, 1994). Background surface soil samples (0-1 foot bls) are proposed for collection at each SWMU and AOC and at random locations facility-wide in each of the soil types. The specific sampling locations are discussed in the accompanying SAP for each site. In general, surface soil samples are proposed to be collected in locations hydraulically upgradient from the sites.

In addition to the proposed site-specific samples proposed, additional background surface soil samples will be collected at nine facility-wide locations, three per soil type. The final locations will be determined in the field. These locations will be selected based on a review of site aerial photographs and historical maps and will be collected at locations that are not likely to have been subject to extensive human activity and previous development.

Subsurface Soil. No subsurface soil background samples are proposed due to the shallow depth of surface soil and the presence of rock at or near the surface.

Surface Water and Sediment. Due to the proximity of the sites to open marine waters, no site-specific surface water and sediment background samples are proposed. However, because of groundwater discharges to Class III marine environments up to three background sediment and surface water samples are proposed around Boca Chica Key. Their locations will be verified in the field during the investigation and will be collected at locations that are not likely to have been subject to extensive human activity or previous development based on review of aerial photographs.

Groundwater. Hydraulically upgradient monitoring wells are proposed at each of the following SWMUs: 1, 2, 3, 4, 5, 7, and 9.

Analytical Protocols. The site-specific background samples collected on Boca Chica Key will be analyzed for Appendix IX pesticides organics (40 CFR 264, Groundwater Monitoring List) and USEPA Contract Laboratory Program (CLP) target analyte list (TAL) metals and cyanide. Facility-wide background samples will be collected for analysis of Appendix IX pesticides and TAL metals.

3.1.1.2 **Truman Annex Sites** During the RFI/RI conducted by IT Corporation and detailed in the RFI/RI Report (IT, 1994), 15 background samples were collected from surface soil, sediment, surface water, and groundwater at 4 sites. Out of a total of 15 samples collected from all media, only 5 of the samples (sediment-1, surface water-2, and groundwater-2) were retained. The analytical results suggested that some of the background samples were contaminated with organic compounds or high concentrations of inorganics when compared to other environmental samples collected at the site.

Based on the analytical results, additional background samples for surface soil, surface water, sediment, and groundwater are proposed and are discussed below by media.

Surface Soil. The surface soil at Truman Annex is classified as shallow fill for the entire facility. Background surface soil samples (0-1 foot bls) are proposed for collection at each site and at random locations facility-wide. The specific sampling locations are discussed in the accompanying SAP. In general, surface soil samples are proposed to be collected at locations hydraulically upgradient from the sites.

In addition to the site specific samples proposed, surface soil samples will be collected at five locations that will be selected in the field. These locations will be selected based on a review of site aerial photos and historical maps and will be collected in locations that have not been subject to extensive human activity and previous development.

Subsurface Soil. No subsurface soil background samples are proposed due to the shallow depths of surface soil and the presence of rock at or near the surface.

Surface Water and Sediment. Due to the proximity of the sites to open marine waters, no site specific background samples are proposed. Up to five background sediment and surface water samples that are representative of the overall environmental setting are proposed. Their locations will be selected in the field during the investigation and will be collected at locations that are not likely to have been subject to extensive human activity or previous development based on review of aerial photographs.

Groundwater. Hydraulic upgradient monitoring wells are proposed for only one site at Truman Annex. The rest of the IR sites already have monitoring wells that are hydraulically upgradient from the site or in not hydraulically influenced by the site. The existing newly installed background wells will be sampled during the supplemental RFI/RI field program.

Analytical Protocols. All of the site-specific background samples collected at Truman Annex will be analyzed for the Appendix IX organics (40 CFR 264, Groundwater Monitoring List) and CLP TAL metals and cyanide. Facility-wide background samples will be analyzed for Appendix IX pesticides and TAL metals.

3.2 SITE DESCRIPTIONS AND PROPOSED SAMPLING ACTIVITIES. Supplemental data are required in addition to the soil, surface water/sediment, and groundwater sampling data obtained in previous investigations in order to further characterize the nature, extent, distribution, and relevance of potential contaminants at these sites. Descriptions of the sites and the rationale and methodologies for sampling are discussed in this section.

3.2.1 Solid Waste Management Units (SWMUs) All of the SWMUs are located within the Naval facility on Boca Chica Key (Figure 1-2). They include a disposal area (SWMU 1), a former DDT storage building and mixing site (SWMU 2), a former fire-fighting training area (SWMU 3), areas surrounding three buildings where evidence of discharge of waste materials has been detected (SWMUs 4, 5, and 7), and a jet engine test cell location (SWMU 9). A description of each SWMU is provided below.

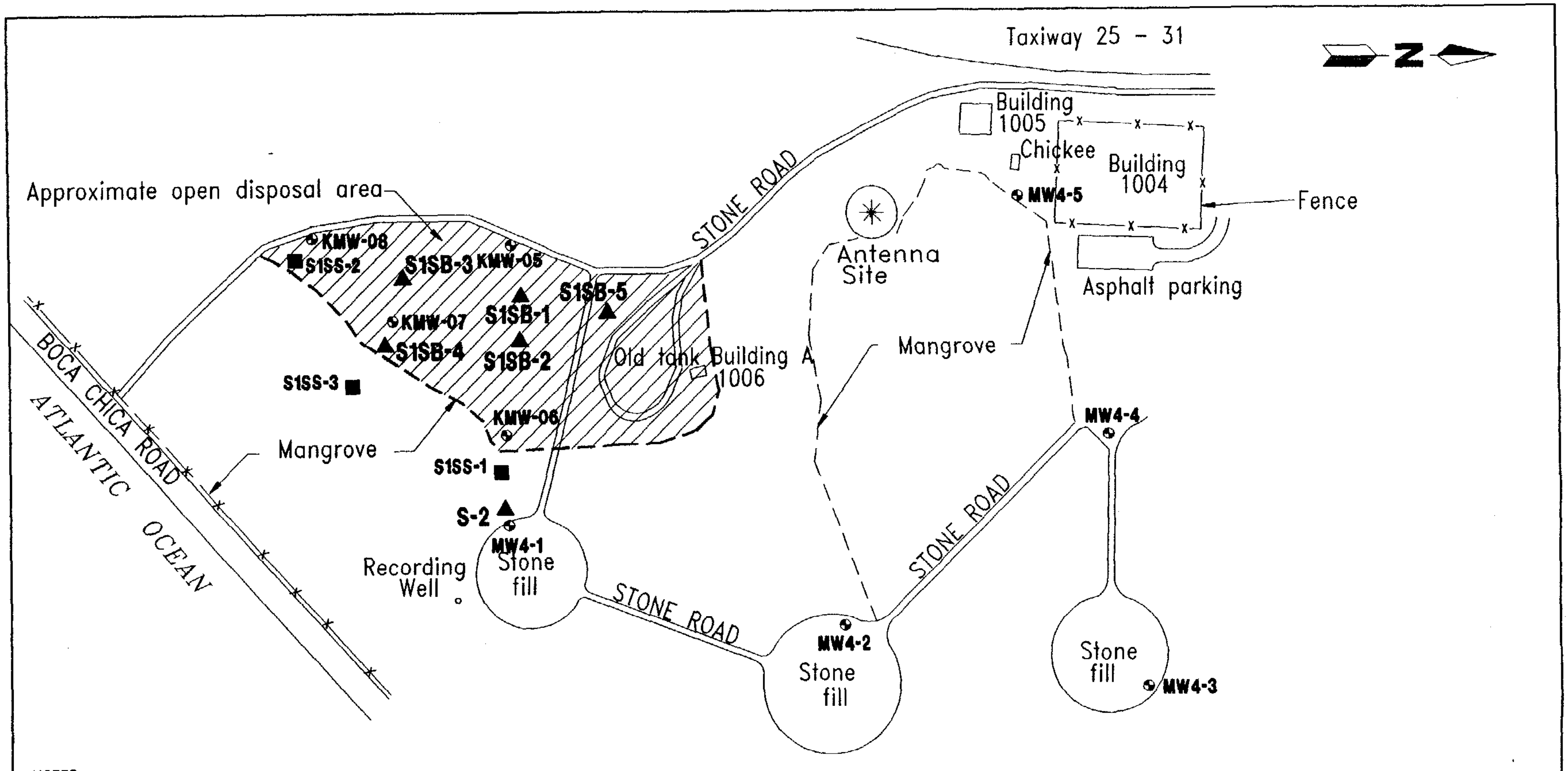
SWMU 1: Boca Chica Open Disposal Area. This site, originally designated as Site No. 4 in initial assessment activities, consists of a former open disposal and burning area located in the southeastern part of Boca Chica Key, between the perimeter road and mangrove swamp fringing Geiger Creek and the Atlantic Ocean. It was operated from 1942, when the NAS activity was first established on Boca Chica, until the mid-1960's. SWMU 1 reportedly received general refuse and waste associated with aircraft maintenance activities. The list of possible wastes that it received includes waste oil, hydraulic fluid, paint thinner, and solvents. It has been estimated that the site received 2,600 tons of waste each year. Three abandoned aboveground fuel storage tanks were at one time located in the northwestern part of the site. The area of waste disposal and burning (approximately 4 acres) is evidenced by debris present near the eastern edge of the site (Figure 3-1). SWMU 1 is relatively flat with low vegetation and mangroves growing along its perimeter. Tidal flooding probably inundates parts of the site along the edge of the mangroves. This site is designated as habitat for the endangered Lower Keys marsh rabbit. Shell and gravel roads along the edge of the site were built to access remote antenna sites that are no longer in use, although the site is adjacent to an operating communications center.

The supplemental field activities at SWMU 1 will include surface soil sampling to characterize background conditions, surface water and sediment sampling to further delineate contaminants detected in earlier activities, and monitoring well installation and groundwater sampling to characterize background and verify previously-detected contamination (Table 3-1). Because the site adjoins wetland areas and previous work has sufficiently characterized surface soil within the disposal area, soil sampling will be restricted to offsite, non-inundated areas that require characterization along the boundary of the disposal area for use in background comparison. Part of this requirement was satisfied during the IRA sampling program.

Surface water and sediment samples will be collected in areas along the disposal area perimeter where the extent of contamination has not been sufficiently delineated, particularly within the mangroves located to the south-southeast of the main disposal area. Some of the surface water and sediment sampling scope was performed during the IRA, but additional locations are being proposed to satisfy RFI/RI program objectives.

Groundwater sampling will be conducted to characterize background (hydraulically upgradient) groundwater quality and areas hydraulically downgradient as necessary, particularly with respect to lead, mercury, cyanide, vinyl chloride, and chrysene. A monitoring well hydraulically upgradient from the site will be installed to characterize background groundwater quality. As many as three additional monitoring wells may need to be installed to replace existing wells that likely will be destroyed by IRAs that are to be performed prior to the execution of this workplan.

SWMU 2: Boca Chica DDT Mixing Area. This site (previously identified as Site No. 5) is the former location of Building 915 and surrounding area that was used for storage and mixing of pesticides (Figure 3-2). Two aboveground tanks on concrete foundations (a 500-gallon mixing tank and a 1,000-gallon storage tank) were located to the west of the building. DDT mixing operations were conducted from the mid-1940's to the early 1970's at this location. The building was demolished in 1982. The site currently exists as a vacant, sparsely vegetated lot that is approximately ¼ acre in extent.SWMU 2 is located on the northern edge



NOTES:

SWMU Solid waste management unit

RFI/RI Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation

Source: IT Corporation, 1994.

LEGEND

- ■ Previous sediment and surface water sampling location
- ⊕ Monitoring well location
- ▲ Previous soil sampling location
- Proposed monitoring well and groundwater sampling location

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FIGURE 3-1
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
SWMU NO. 1, BOCA CHICA
OPEN DISPOSAL AREA

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

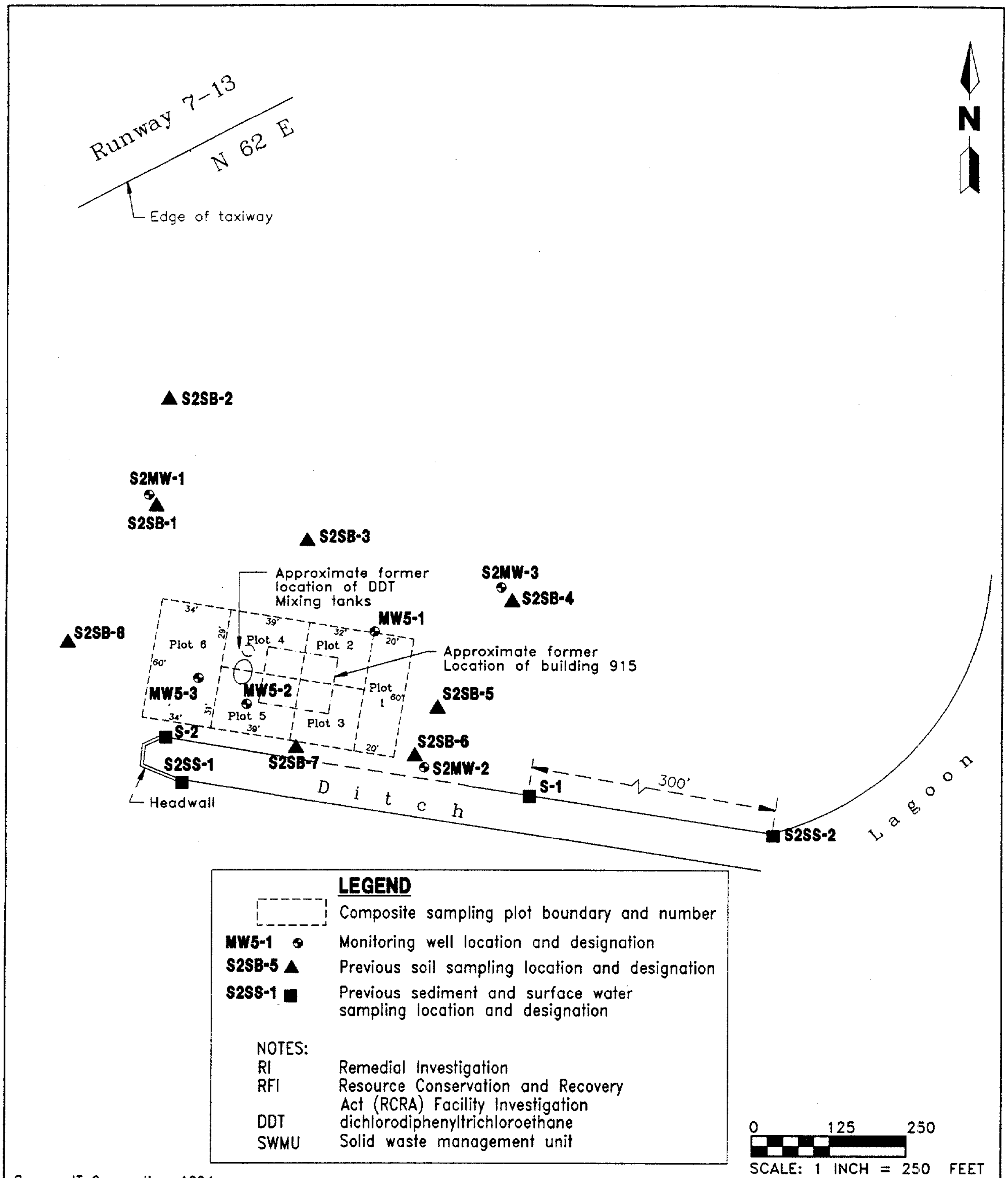
Table 3-1
Previous Sampling Results
SWMU 1, Boca Chica Open Disposal Area

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
Verification Study[1]			
Groundwater	4/4	µg/ℓ	xylenes-35; arsenic-65;
Surface soil samples	2		ND
RFI/RI[2]			
Groundwater	7/11	µg/ℓ	antimony-251; arsenic-94.5; cyanide-310; lead-39.2; mercury-5.4; vinyl chloride-3.2; lead[3]
Surface soil samples	6	mg/kg	aldrin-0.11; antimony-3,930; arsenic-4.5; nickel-0.32; zinc-129
Sediment samples	3	mg/kg	4,4'-DDD-0.210; 4,4'-DDE-0.110; cadmium-94.1; copper-3,930; lead-12,300; mercury-1.90; silver-2.6J; zinc-3120
Surface water samples	3	µg/ℓ	copper-58.9; lead-83.3; mercury-0.32; zinc-129

[1]Geraghty and Miller, 1987.
[2]IT Corporation, 1994.
[3]Toxicity Characteristic Leaching Procedure.

Notes: SWMU = solid waste management unit.
µg/ℓ = micrograms per liter.
ND = none detected above method detection limits.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
RFI/RI = RFI and Remedial Investigation.
mg/kg = milligram per kilogram.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethene.
J = estimated concentration.



Source: IT Corporation, 1994.

FIGURE 3-2
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
SWMU NO. 2, BOCA CHICA
DDT MIXING AREA

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SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

of a man-made ditch that drains a lagoon that has formed in a borrow pit. The ditch is the only outlet from the lagoon and can transport water northward where it eventually discharges into Boca Chica Channel. The surface water gradient in the ditch fluctuates tidally but has not been measured. The lagoon and ditch are inhabited by fish and wading birds and support mangroves and other plant life.

The primary objectives of supplemental sampling activities at SWMU 2 are to further characterize background soil characteristics in the immediate area surrounding the site, determine the extent to which pesticides have migrated within the canal system that adjoins the site, and delineate the area of groundwater contamination with respect to contaminants that were detected in previous work (IT, 1994) (Table 3-2).

Previous surface soil data indicated that the area of pesticide residue has not been defined. Therefore, the scope of IRA sampling activities also included soil sampling in outlying areas to further assess the areal extent of pesticides. Soil sampling data from the IRA should satisfy RFI/RI program objectives. Additional sediment and surface water samples were also collected during IRA sampling to assess the extent that pesticides have migrated within the ditch where it continues offsite. Soil and sediment data, considered preliminary, seem to indicate anthropogenic low-level concentrations of pesticides in the surrounding soil and sediment. No further sampling of soil sediment or surface water is proposed at this time.

The distribution of pesticides within groundwater at the site was not completely delineated in previous work (IT, 1994). The scope of work at this site includes installing and sampling additional monitoring wells that will be located to supplement existing data and complete the delineation.

<u>SWMU 3: Boca Chica Fire Fighting Training Area</u>. The former fire-fighting training area (Figure 3-3) is located west of the southern blimp pad. The site contains junk aircraft and vehicles that were once ignited with JP-5 fuel, waste oil, or hydraulic fluid for use in training. The area also contains two unlined circular pits approximately 20 feet in diameter and 2 to 3 feet in depth that also received the combustible liquids which were ignited. The pits are surrounded by gravel aprons.

The fire-fighting training area is flat and open. Approximately 200 feet to the south and west is a lagoon that is fringed by a thick growth of mangroves.Supplemental RFI/RI activities at SWMU 3 will include sampling of sediment and surface water and monitoring well installation and groundwater sampling. Because concentrations of lead in sediment collected in the original RFI/RI program from the lagoon shoreline may be attributable to other sources, this will include collection of sediment samples at locations within the mangrove fringe between the site and the lagoon (Table 3-3). Data from the new locations will be used to assess whether the lead is attributable to the site or other potential sources. Monitoring well installation and groundwater sampling are proposed to delineate the extent of vinyl chloride previously detected in groundwater samples.

<u>SWMU 4: Boca Chica AIMD (Aircraft Intermediate Maintenance Building) Building A-980</u>. AIMD Building A-980 (Figure 3-4) was constructed in the late 1960's at a location that had been filled with 6 feet of crushed lime rock. Between 1981 and 1987, two in-ground plastic 55-gallon drums (tank locations A and B on Figure

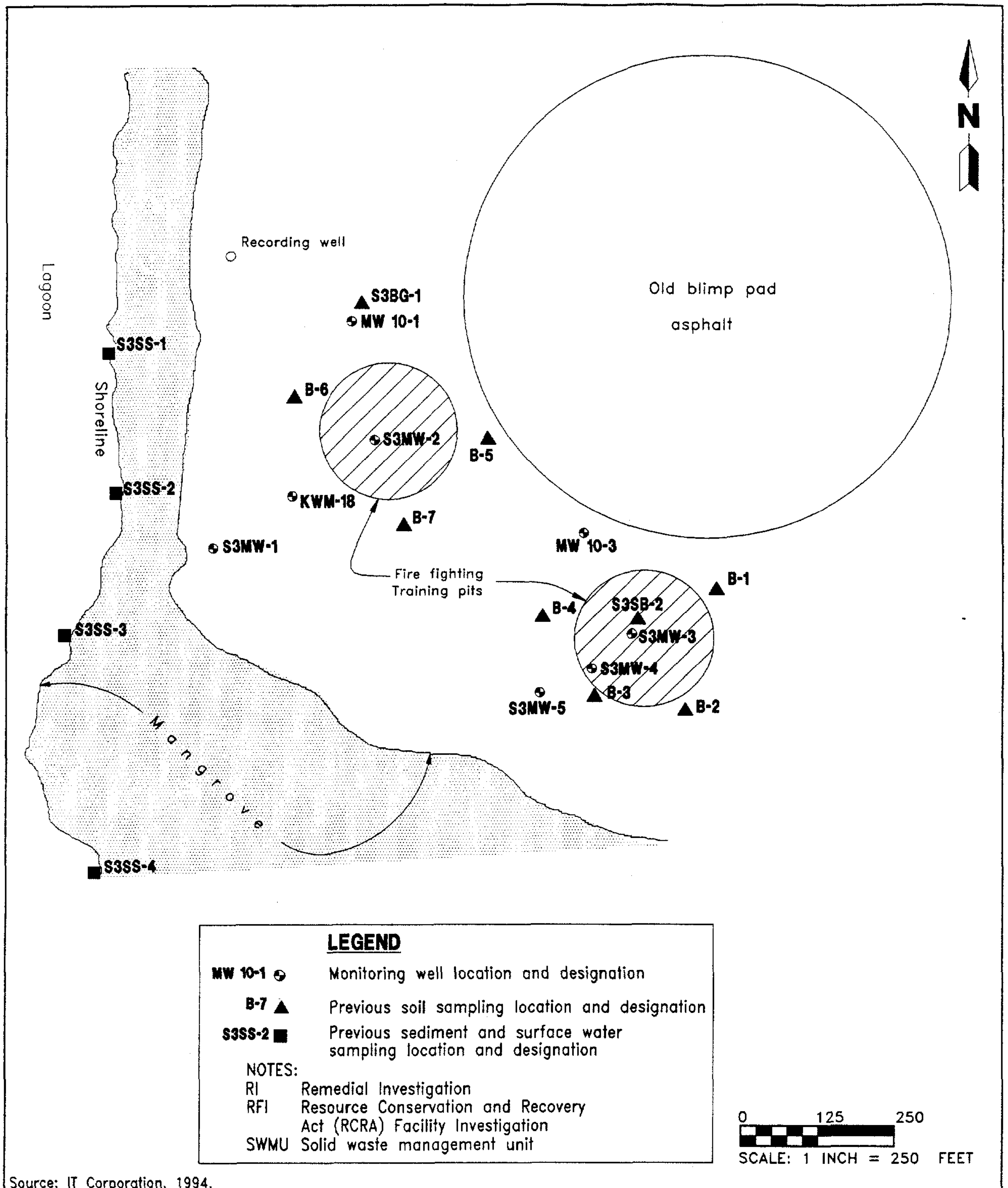
Table 3-2
Previous Sampling Results
SWMU 2, Boca Chica DDT Mixing Area

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
Verification Study[1]			
Soil samples 0-1 foot	6	mg/kg	4,4'-DDT-936; delta-BHC-27
1-2 feet	6		4,4'-DDT-81
2-3 feet	6		4,4'-DDT-95
Preliminary RI[2] Groundwater	3/3	µg/ℓ	benzene-90; 1,2 dicholoroethene-1000; 4,4'DDE-22; alpha-BHC-16; beta-BHC-6.1; delta-BHC-15
Soil samples	8		
Sediment samples	2	µg/ℓ	4,4'-DDT-2,500; 4,4-DDE-2,800; 4,4-DDD-13,000
Surface water samples	2	µg/ℓ	4,4-DDD-0.24
RFI/RI[3]			
Groundwater	5/5		antimony-88; benzene-54; cis-2,3-dichloroethene-770; 4,4'-DDE-3.8; 4,4-DDD-47; 4,4'-DDT-6.9; vinyl chloride-3.0J
Sediment samples	2	mg/kg	copper-37.3; lead-24; 4,4-DDD; 4,4'DDE-0.300; 4,4'-DDT-1.2; cadmium-2.3; mercury-0.11; zinc 109
Surface water samples	1	µg/ℓ	ND
Surface Soil samples		mg/kg	4,4'DDE-29; 4,4'-DDT-200; 4,4-DDD-340; linane-0.670; arsenic-6.2J; nickel-3.3J; chlordane-24

[1]Geraghty and Miller, 1987.
[2]IT Corporation, 1991.
[3]IT Corporation, 1994.

Notes: SWMU = Solid Waste Management Unit.
DDT = dichlorodiphenyltrichloroethane.
mg/kg = milligrams per kilogram.
BHC = benzene hexachloride.
RI = Remedial Investigation.
µg/kg = micrograms per kilogram.
DDE = dichlorodiphenyldichloroethene.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
ND = none detected above method detection limits.
J = estimated concentration.



Source: IT Corporation, 1994.

FIGURE 3-3
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
SWMU NO. 3, BOCA CHICA, FIREFIGHTING TRAINING AREA

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SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

Table 3-3
Previous Sampling Results
SWMU 3, Boca Chica Fire Fighting Training Area

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
Verification Study[1]			
Groundwater	2/2		ND
Surface soil samples	9		NA
Preliminary RI[2]			
Groundwater	3	µg/ℓ	benzene-11; ethylbenzene-15; naphthalene-39
Surface soil samples	9		ND
Sediment samples	NC		
Surface water samples	NC		
RFI/RI[3]			
Groundwater	6/7	µg/ℓ	1,1-dichloroethane-19; antimony-161; benzene-1J; naphthalene-40; vinyl chloride-17
Surface soil samples	4		ND
Sediment samples	4	µg/ℓ	copper-78.7; lead-136; mercury-0.14; zinc-88.9
Surface water samples	4	µg/ℓ	copper-25.1; lead-14.4

[1]Geraghty and Miller, 1987.
[2]IT Corporation, 1991.
[3]IT Corporation, 1994.

Notes: SWMU = solid waste management unit.
ND = none detected above method detection limits.
NA = not analyzed.
RI = Remedial Investigation.
µg/ℓ = micrograms per liter.
NC = none collected.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
J = estimated concentration.

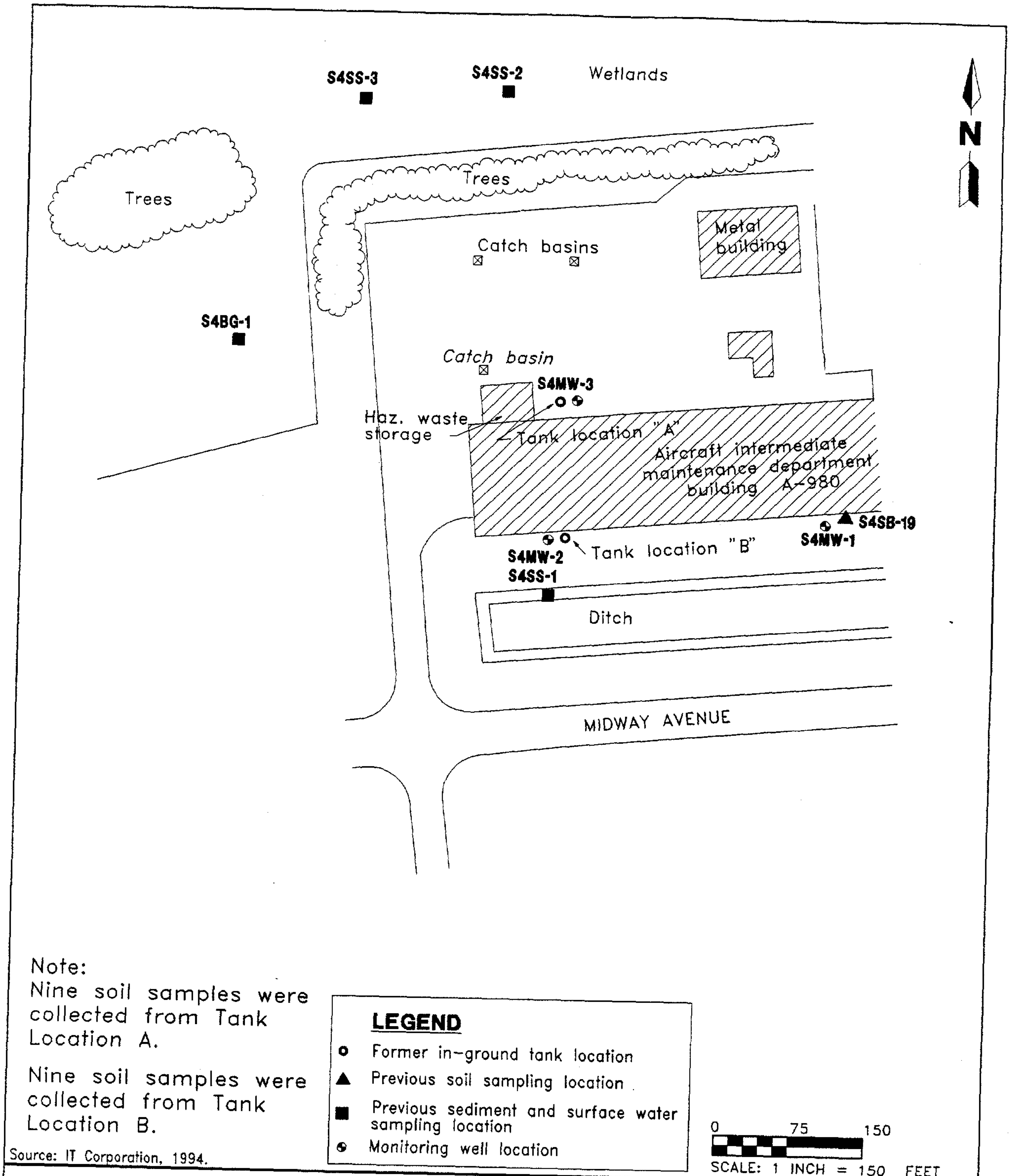

FIGURE 3-4
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
SWMU NO. 4, AIMD BUILDING A-980

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SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

2-5) were used to receive and store solvents and oil mixtures that were generated during maintenance activities within the building. The drums were removed in 1989. In August 1981, a 55-gallon plastic drum was installed in-ground on the north side of Building A-980 and was used to collect approximately 3 gallons per month of hazardous waste from the spillage of a 70 percent trichlorotrifluoromethane (TF) freon 113 and 30-percent electrical insulating oil (coolanol-35R) mixture. This in-ground drum was abandoned in May 1987. The second drum, on the south side of the building, was in use at the AIMD during the same time period by the Tire Shop. This drum received a mixture of 96 percent water, 2 percent PD680 (solvent), 2 percent Turco (a phenolic based aircraft cleaner), and a residue of a PCA 44 Type C (emulsifier cleaner). The Navy ceased using this drum as well. The contents of the drums at the two facilities were routinely pumped out every 60 to 90 days and disposed of by NAS Key West personnel.

These drums were gravity fed by a piping system which drained the various mixtures from the interior of the building to the tanks. The north drum was connected to a floor drain inside Building A-980. This drain collected incidental spillage from the work area operations. The drain pipe consisted of a 2-inch polyvinyl chloride (PVC) pipe and was encased in cement mortar. The drain carried the spillage directly into the in-ground tanks, and there reportedly have been no leaks in the drain. The south drum was connected to a dip tank via a similar floor trench drain. The dip tank was used by the Tire Shop for the rinsing of aircraft wheel rims during routine maintenance. Upon receipt of a Notice of Violation (NOV) from FDER and dated May 11, 1987, NAS Key West cut and plugged the connecting piping and discontinued the use of the in-ground drums for wastewater collection. The NOV was issued because stained soil was observed during an inspection of the building. In December 1989, both drums were removed and a 6-inch layer of soil from around and under each drum was excavated disposed of offsite.

Building A-980 is surrounded on all sides by drainage ditches, and a mosquito control lagoon is located to the north. The ditches and lagoon are hydraulically connected by an open drainage ditch to Florida Bay, located to the north.

Field activities at this site include collection of sediment and surface water samples, installing monitoring wells and sampling groundwater. Additional sediment and surface water samples will be collected to assess the extent of lead concentrations previously detected above background screening values within the wetland area adjoining the site to the north (Table 3-4). Resampling existing monitoring wells and installing and sampling new monitoring wells are included in the supplemental activities to delineate the extent of cyanide and chlorinated solvents that were previously detected in groundwater samples collected during original RFI/RI sampling (IT, 1994).

<u>SWMU 5: Boca Chica AIMD Sand Blasting Building A-990</u>. The sand blasting area is located at the western end of the airfield adjacent to Building A-990 (Figure 3-5). Since the early 1970's, it has been the site of sand blasting of ground handling and ground support vehicles and equipment (known as ground support equipment), aircraft parts, and other metal objects and pieces of equipment. The sand blasting area measures approximately 65 feet by 90 feet. The area is level and open. A concrete-lined drainage ditch, south of the buildings, collects stormwater runoff from the area and transports it westward into a culvert and ultimately to a mangrove swamp several hundred yards away.

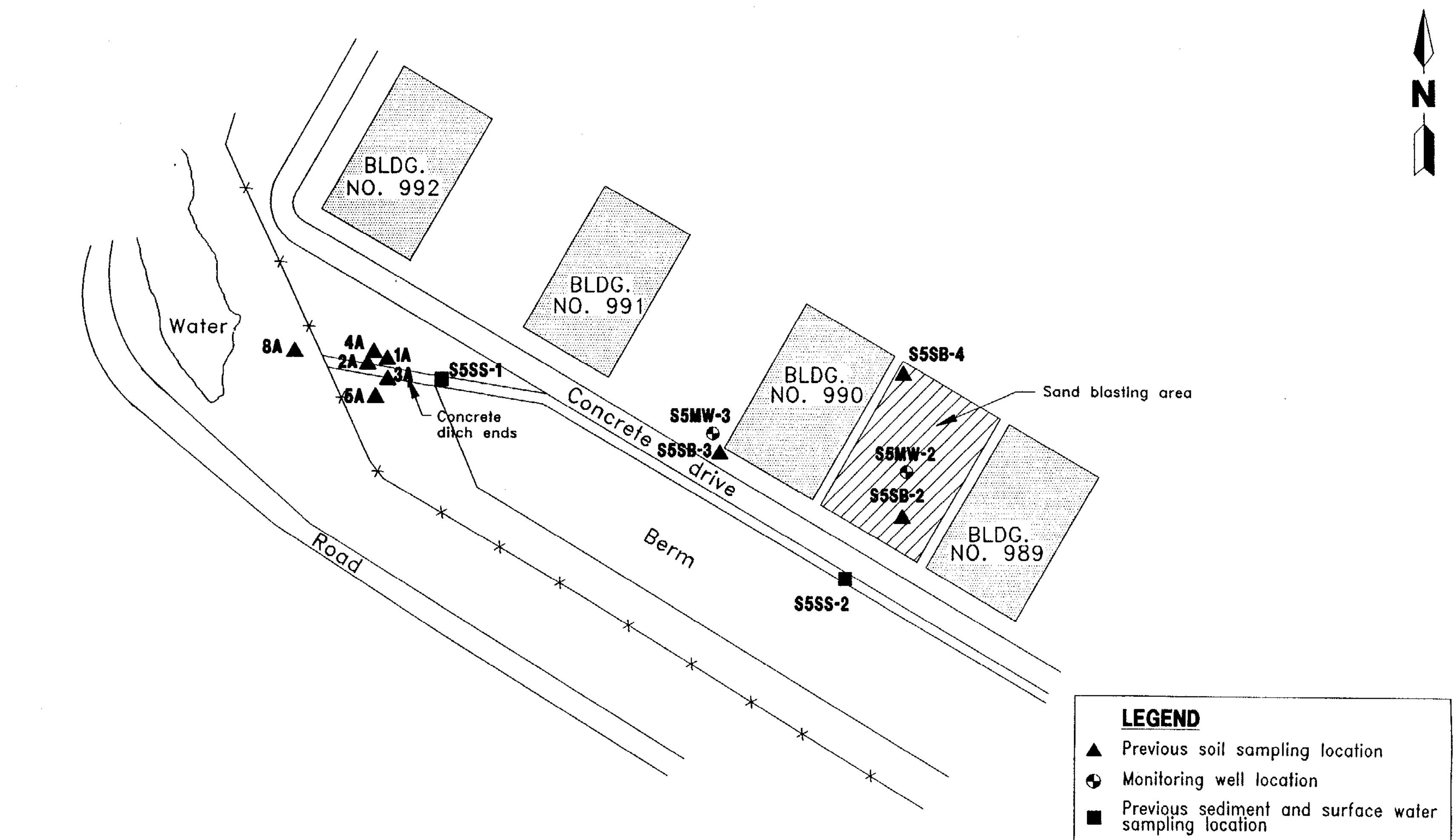
Table 3-4
Previous Sampling Results
SWMU 4, Boca Chica AIMD Building A-980

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
RFI/RI[1]			
Groundwater	3/3	μg/ℓ	cyanide-250; 1,1-dichloroethane-4.5; vinyl chloride-2.7
Soil samples - surface	6	μg/ℓ	beryllium-0.27B
Soil samples - subsurface	13	mg/kg	beryllium-0.2B
Sediment samples	4	mg/kg	antimony-8.8; lead-28.1; phenanthrene-0.06
Surface water	4	μg/ℓ	lead-80.4

[1]IT Corporation, 1994.

Notes: SWMU = solid waste management unit.
AIMD = Aircraft Intermediate Maintenance Building
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
RI = Remedial Investigation.
μg/ℓ = micrograms per liter.
mg/kg = milligrams per kilogram.
B = detected in blank.



Source: IT Corporation, 1994.

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SCALE: 1 INCH = 200 FEET

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FIGURE 3-5
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
SWMU NO. 5, AIMD BUILDING A-990

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

Supplemental field activities at this site address delineation of contamination within sediment and surface water and groundwater that was detected in IT's RFI/RI program (1994) (Table 3-5). Sediment and surface water sampling is required to delineate the extent of metals contamination along the reach of the concrete-lined ditch and surface water body to which it discharges. Because only two monitoring wells are present at this site and cyanide has been detected above background screening values at one existing location, this scope of work will include resampling the two existing monitoring wells and installing two additional wells to delineate the contamination and assess the groundwater flow gradient and direction.

SWMU 7: Boca Chica Building A-824. Building A-824, located north of US 1 across from the main Boca Chica Naval activity (Figure 3-6), is a former hazardous waste storage site. A cleanup of possible hazardous material was performed and completed in 1991. The building is currently used for storage of empty drums, old transformers, and houses a solvent recycling operation.

The west side of the site is lined by a swamp that is connected to the Gulf of Mexico. Approximately 30 feet north of the building is a small pond. The dimensions of this surface water body are approximately 20 feet by 20 feet. The depth of the pond is unknown. Running from approximately 20 feet from the northwest corner of the building, down the west side of the property, is a drainage ditch. This ditch is approximately 2 feet deep, was cut through the oolitic limestone, and drains the overflow from the pond to the marsh. The sediment in the ditch is eroded from the limestone and fill material present at the surface of the site. Approximately six inches of water are present in the ditch. The water consists of runoff from the site and overflow from the pond.

Previous RFI/RI sampling data indicate that an area of soil contamination by hydrocarbons exists along the entrance road, outside the site boundary (Table 3-6). Further assessment of the extent of this area of hydrocarbon-contaminated soil is necessary to confirm that it is unrelated to SWMU 7 and to determine its origin. Further assessment of contamination by pesticides, PCBs, and metals in sediment and surface water within the ditch and stormwater pond adjacent to Building A-824 is also necessary. Previous sampling did not include the stormwater pond or areas hydraulically downgradient within the ditch.

SWMU 9: Boca Chica Jet Test Cell (Building A-969). The Jet Engine Test Cell site, associated with Building A-969, is located in the northeastern part of the Boca Chica Key airfield. The site is used for testing of recently repaired jet engines. There are no other activities conducted within proximity of the site. Jet engine testing activities are performed under a canopy located in the central part of the site (Figure 3-7). The area is surrounded by a circular concrete pad approximately 60 feet in diameter. The jet engines are fueled from a bermed, 5,000-gallon aboveground storage tank containing JP-5 that has been in use since 1987. Building A-969 is located 50 feet southeast of the testing area. The concrete area that extends east of the canopy was the former jet engine testing area. A small shed, located at the eastern end of the concrete pad, is used for storage of various equipment, oils, and jet fuel. Gas path cleaners are also stored on the eastern side of the shed.

The site is bordered on the south by an asphalt road that parallels a runway. The entire area is flat and open and covered with grass, where it is not paved.

Table 3-5
Previous Sampling Results
SWMU 5, Boca Chica AIMD Building A-990

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
RFI/RI[1]			
Groundwater	2/2	µg/ℓ	cyanide 250
Surface soil samples	3	mg/kg	beryllium-0.26B
Subsurface soil samples	6	mg/kg	beryllium-0.14B
Sediment samples	2	mg/kg	arsenic-8.6; cadmium-120; chromium-428; copper-38.9; lead-966; zinc-824
Surface water samples	2	µg/ℓ	cadmium-9.7; chromium-58.2; copper-13.6; lead-68.9

[1]IT Corporation, 1994.

Notes: SWMU = solid waste management unit.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
RFI/RI = RFI and Remedial Investigation.
µg/ℓ = micrograms per liter.
mg/kg = milligrams per kilogram.
B = detected in blank.

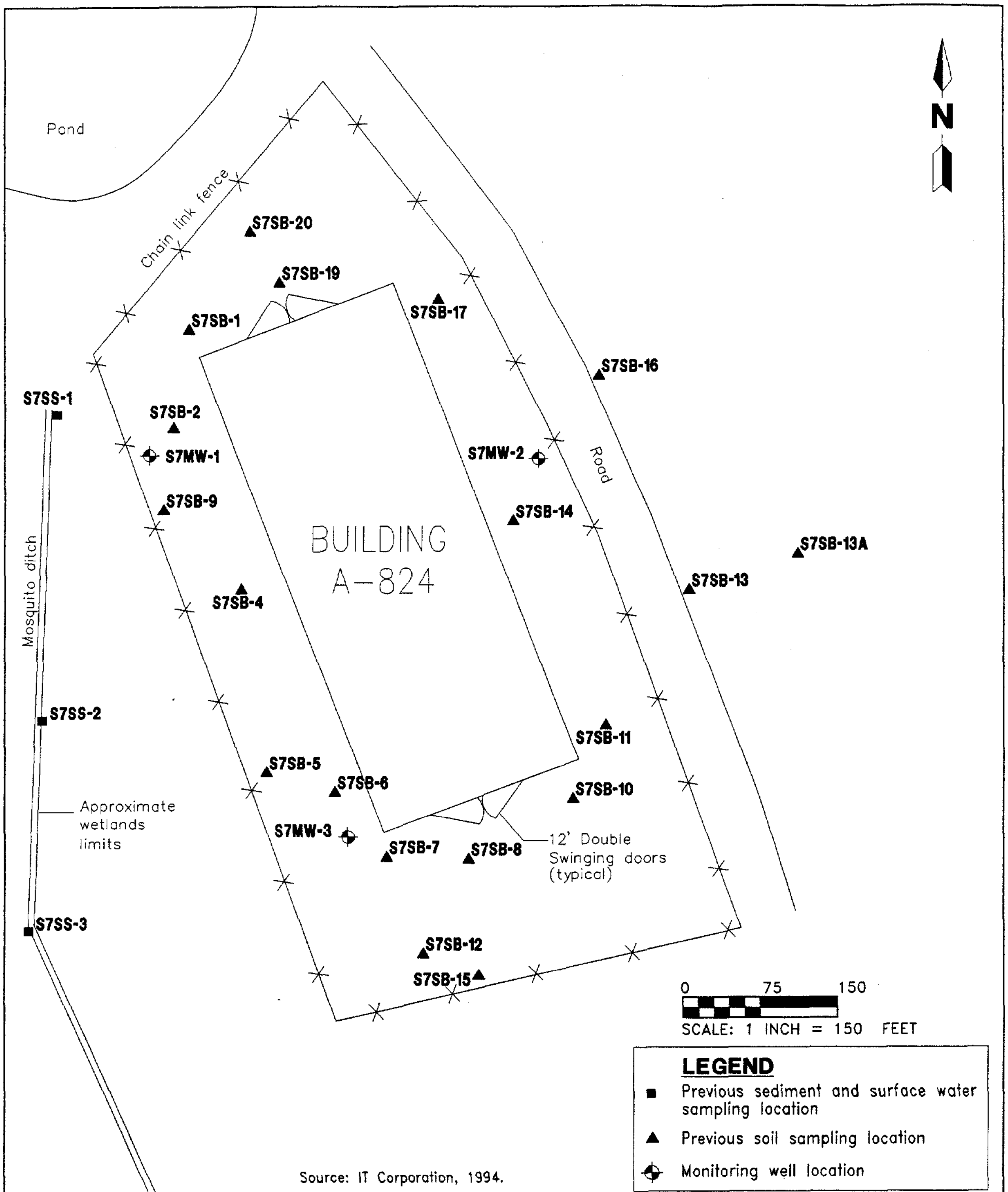

FIGURE 3-6
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
SWMU NO. 7, BUILDING A-824

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SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

Table 3-6
Previous Sampling Results
SWMU 7, Boca Chica Building A-824

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
RFI/RI[1]			
Groundwater	3/3	µg/ℓ	antimony-48.6B
Surface soil samples	21	mg/kg	aroclor-19; arsenic-10.9
Sediment samples	3	mg/kg	4,4'-DDD-0.058; 4,4'-DDE-0.45; antimony-7; aroclor-1260-0.37; cadmium-2.8; gamma-chlordane-0.003J; lead-86.5; mercury-1.8; silver-29.1; zinc-382
Surface water samples	3	µg/ℓ	

[1]IT Corporation, 1994.

Notes: SWMU = solid waste management unit.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
RFI/RI = RFI Remedial Investigation.
µg/ℓ = micrograms per liter.
mg/kg = milligrams per kilogram.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroetheylene.
J = estimated concentration.

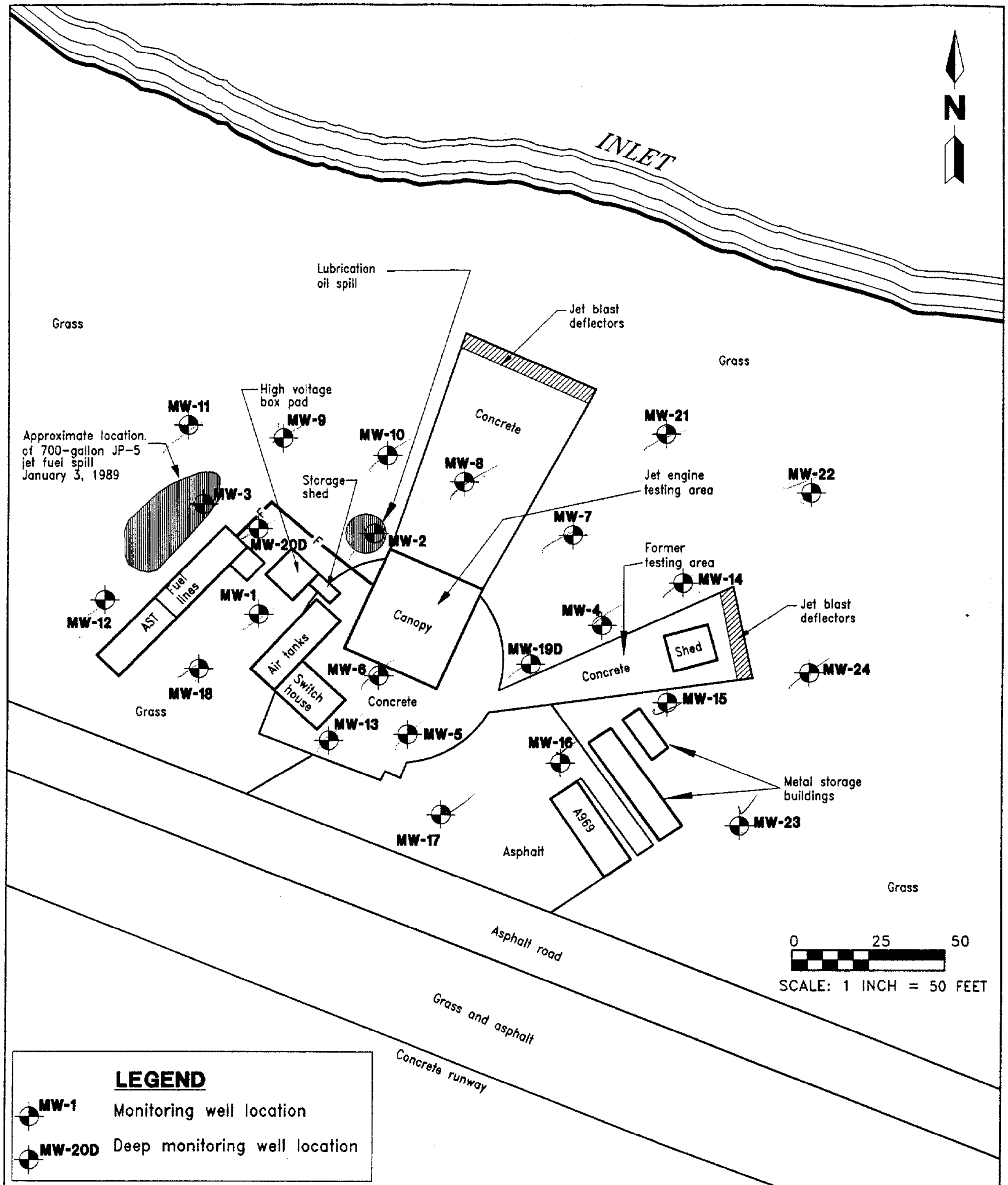

FIGURE 3-7
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
SWMU NO. 9, JET ENGINE TEST CELL

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SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

An inlet of Florida Bay is located north of the site, approximately 250 feet from the canopy.

The petroleum contamination assessment performed at this site (ABB-ES, 1994) did not delineate the source or extent of chlorinated solvent-related contamination in soil and groundwater nor did it include assessment of potential contamination present in the nearby inlet (Table 3-7).

Supplemental field activities will include surface and subsurface soil sampling to assess and delineate the source area(s) of chlorinated solvents. The groundwater monitoring program conducted by the RAC contractor should satisfy RFI/RI program objectives for groundwater monitoring. Alternative interim groundwater remediation measures have been proposed for this site by the RAC and will likely be implemented prior to the supplemental RFI/RI field activities. The IRA program objective for this site was to delineate the extent of the chlorinated solvent contamination within groundwater and to install a source control measure, i.e., pump and treat groundwater system if necessary. To meet this objective supplemental groundwater samples were collected from the existing monitoring wells and from temporary well points that were installed as part of the IRA.

Collection of sediment and surface water samples from the inlet north of the site also will be included in the supplemental RFI/RI program.

3.2.2 Installation Restoration Sites

IR Site 1: Truman Annex Refuse Disposal Area. The Truman Annex Refuse Disposal Area (IR Site 1) is located along the southern shore of Truman Annex on Key West (Figure 3-8). The site is reported to cover an area of approximately 7 acres, including the antenna field and the area to the immediate north. A fence surrounds the site, and access is strictly controlled. The shoreline has erosion protection consisting of large concrete rubble and debris. The main sewer outfall line for Key West runs through the property.

From 1952 until the mid-1960's the Truman Annex Refuse Disposal Area was used for general refuse disposal and open burning. No restrictions were placed on the types of wastes disposed at the site. General refuse, waste paint thinners, and solvents may have been disposed of at the site.

The required supplemental field activities at IR Site 1 included surface soil sampling to delineate the area of surface soil contamination and to characterize background conditions, resampling of surface water and sediment samples to confirm findings of earlier activities, and monitoring well installation and groundwater sampling to characterize background and verify previously-detected levels of contamination (IT, 1994) (Table 3-8).

Prior to the sampling of this site for the IRA, the area of surface soil contamination had not been sufficiently delineated to evaluate the exposure threat to contaminated surface soil. The IRA sampling program included sampling the entire site on a grid pattern, focusing on metals. A part of the gridded area may be removed during the IRA, based on observed levels of lead. Preliminary data from the IRA sampling appear to sufficiently address RFI/RI sampling program requirements.

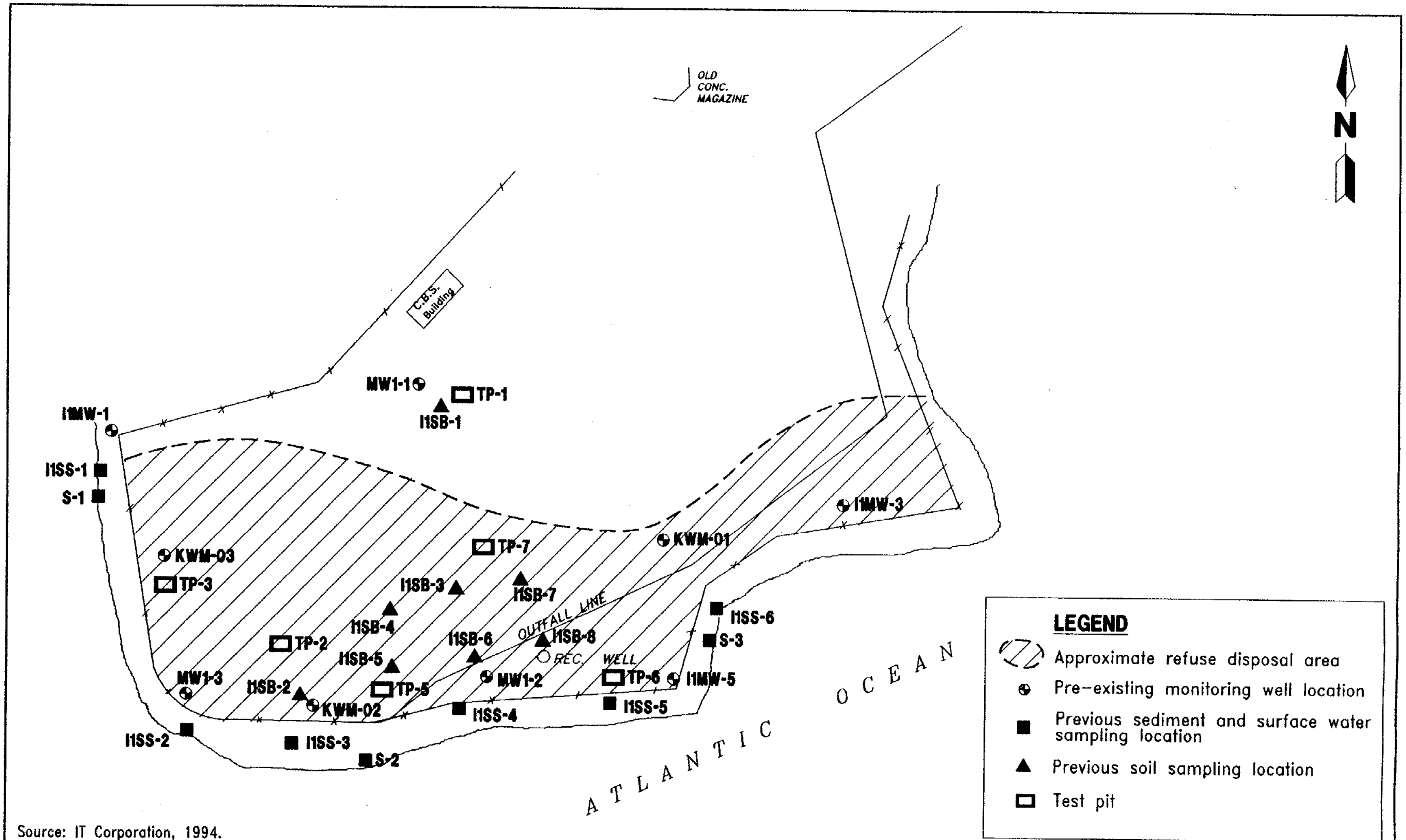
Table 3-7
Previous Sampling Results
SWMU 9, Boca Chica Jet Engine Test Cell (Building A-969)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
CAR[1]			
Groundwater	24/24	$\mu g/\ell$	benzene-56; ethylbenzene-70; naphthalene-110; total naphthalenes-340; trans-1,2-dichloroethene-2,800; cis-1,2-dichloroethene-980; trichloroethene-41

[1]Contamination Assessment Report (ABB-ES, 1994).

Notes: SWMU = solid waste management unit.
CAR = Contamination Assessment Report.
$\mu g/\ell$ = micrograms per liter.



Source: IT Corporation, 1994.

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SCALE: 1 INCH=200' FEET

FIGURE 3-8
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
IR NO. 1, TRUMAN ANNEX
REFUSE DISPOSAL AREA

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

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Table 3-8
Previous Sampling Results
IR 1 - Truman Annex Refuse Disposal Area

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
Verification Study[1]			
Groundwater	4/4		ND
Soil samples	4	$\mu g/\ell$[2]	lead
Preliminary RI[3]			
Groundwater	3/3	$\mu g/\ell$	alpha chlordane-1.10
Surface soil samples	3	$\mu g/\ell$[2]	ND
Sediment samples	3	$\mu g/\ell$	aroclor 1260-2,300
Surface water samples	NC		
RFI/RI[4]			
Groundwater	3/9	$\mu g/\ell$	lead[2],170; chromium-394; copper-3,570; zinc-711,300; mercury-14.6; antimony-563; heptachlor epoxide-0.63; beta BHC-1.40; 4,4'-DDE-0.11; nickel-196; cadmium-42.3
Surface soil samples	6	mg/kg	lead-10,600; nickel-10.8; arsenic-8.1
Subsurface soil samples	2	mg/kg	nickel-78.4; arsenic-38; aroclor-1,260; ethylbenzene-0.56J
Sediment samples	6	mg/kg	arsenic-9; antimony-6.8; aroclor 1,258-0.12; aroclor 1260-10.0; dieldrin-0.012; 4,4'-DDD-0.036; 4,4'-DDE-0.037; 4,4'-DDT-0.11; lead-75.5; zinc-150
Surface water samples	6		ND

[1]Geraghty and Miller, 1987.
[2]Extraction Procedure Toxicity.
[3]IT Corporation, 1991.
[4]IT Corporation, 1994.

Notes: IR = Installation Restoration.
ND = none detected above method detection limits.
$\mu g/\ell$ = micrograms per liter.
RI = Remedial Investigation.
NC = none collected.
BHC = benzenehexachloride.
DDE = dichlorodiphenyldichloroethylene.
mg/kg = milligrams per kilogram.
J = estimated concentration.
DDD = dichlorodiphenyldichloroethane.
DDT = dichlorodiphenyltrichloroethane.

Regulatory reviewers believe that collection of sediment and surface water samples at the original RFI/RI field program locations is necessary to verify the presence or absence of contamination indicated in earlier findings (IT, 1994) (FDEP, 1995). Collection of additional data at these locations should provide a statistically representative data set for risk assessment.

In response to regulatory comments, two additional monitoring wells will be installed, one in a hydraulically upgradient location for background and another on the edge of the fill area. Groundwater will be sampled at the two new monitoring wells and will be resampled at four existing well locations to verify previous detections of metals and pesticides (IT, 1994). Previously detected concentrations of metals could be attributable to turbidity, therefore, all samples will be collected using a low-flow sampling technique with a peristaltic pump.

IR Site 3: Truman Annex DDT Mixing Area. The Truman Annex DDT Mixing Area (IR Site 3) is located at the former site of NAS Building 265 and is depicted in detail on Figure 3-9. The site covers an area of about ¼ acre and is located approximately 1,100 feet inland from the coastline in an area that is subject to restricted vehicular and pedestrian traffic. Fort Street, which is the westernmost street of an adjacent residential area, is located to the northeast of the site. The site is underlain by highly permeable soil with no surface water drainage or holding features present. The site is surrounded by a chain link fence and the one gate is kept locked. The surface of the site is flat and covered by tall grass and weeds.

From the 1940's to the early 1970's, the location was used as a DDT mixing area. Powdered DDT concentrate was mixed with water and temporarily stored in 55-gallon drums both inside and outside the former building. The mixed solution was then transferred to trucks for disposal. Discharges at the site were from accidental spillage or possibly mixing and rinsing activities.

The primary objectives of supplemental sampling activities at IR Site 3 are to delineate and further characterize background surface soil in the immediate area surrounding the site and to delineate the area of groundwater contamination with respect to contaminants that were previously detected (IT, 1994) (Table 3-9). Surface soil data from the earlier RFI/RI program suggest that the area of pesticide contamination may not have been completely defined or that it is possible that outlying areas with pesticide residue in surface soil may reflect background. Therefore, the scope of this workplan includes additional surface soil sampling in outlying areas to assess the areal extent of pesticide, contaminants, and determine whether existing outlying surface soil reflect background. The surface soil data will supplement by soil sampling results from the IRA performed by the IR RAC. Preliminary data from the IRA sampling indicated that additional locations would need to be included for soil sampling in order to satisfy RFI/RI program objectives. The area and distribution of pesticides within groundwater at the site has also not been completely delineated in previous work (IT, 1994). The scope of this workplan includes installing and sampling additional monitoring wells at locations delineate pesticides in groundwater.

IR Site 7: Fleming Key North Landfill. The Fleming Key North Landfill (IR Site 7) covers approximately 30 acres on the northern end of Fleming Key and is shown in detail on Figure 3-10. The site currently houses the U.S. Department of

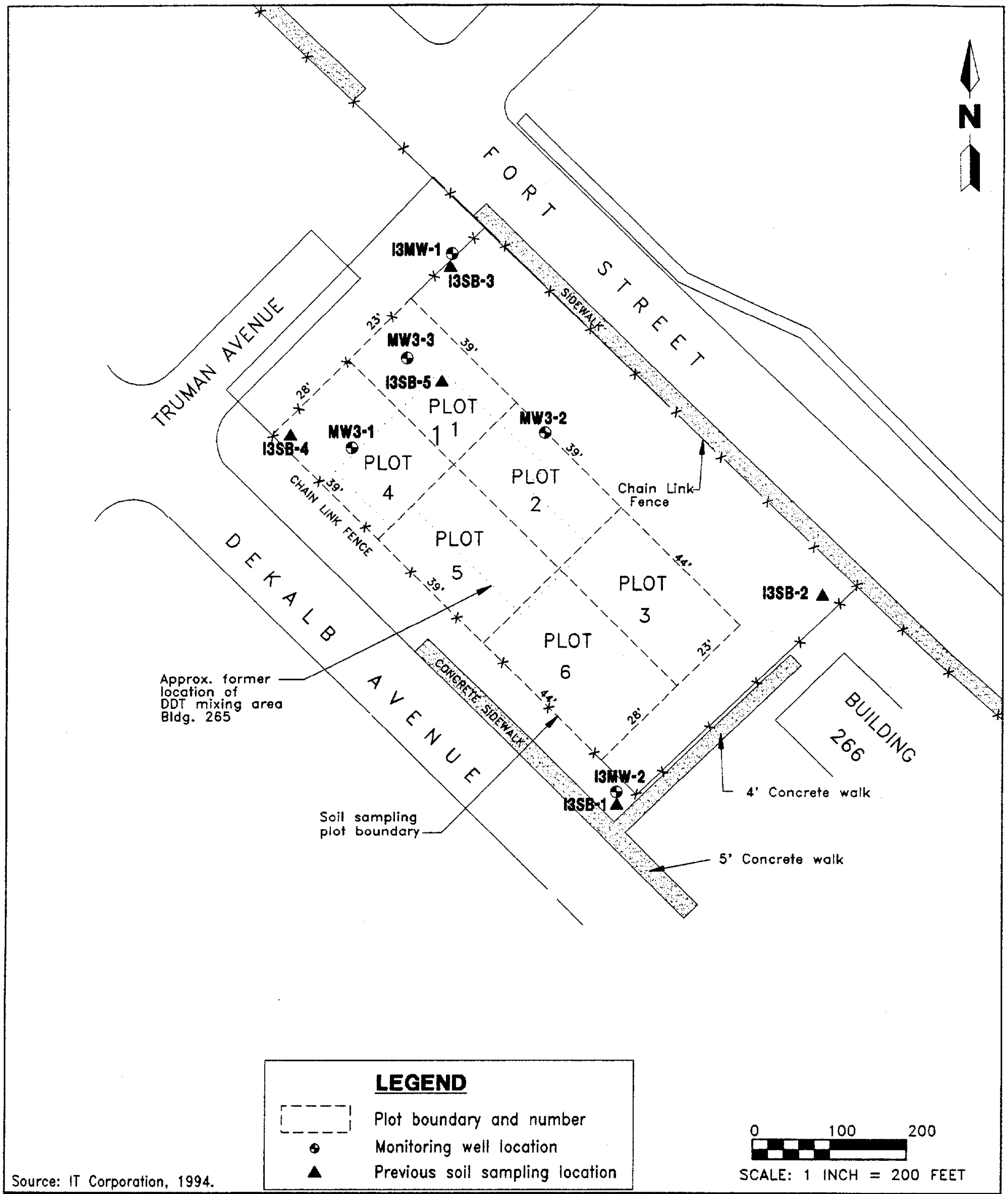

FIGURE 3-9
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
IR NO. 3, TRUMAN ANNEX
DDT MIXING AREA

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SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

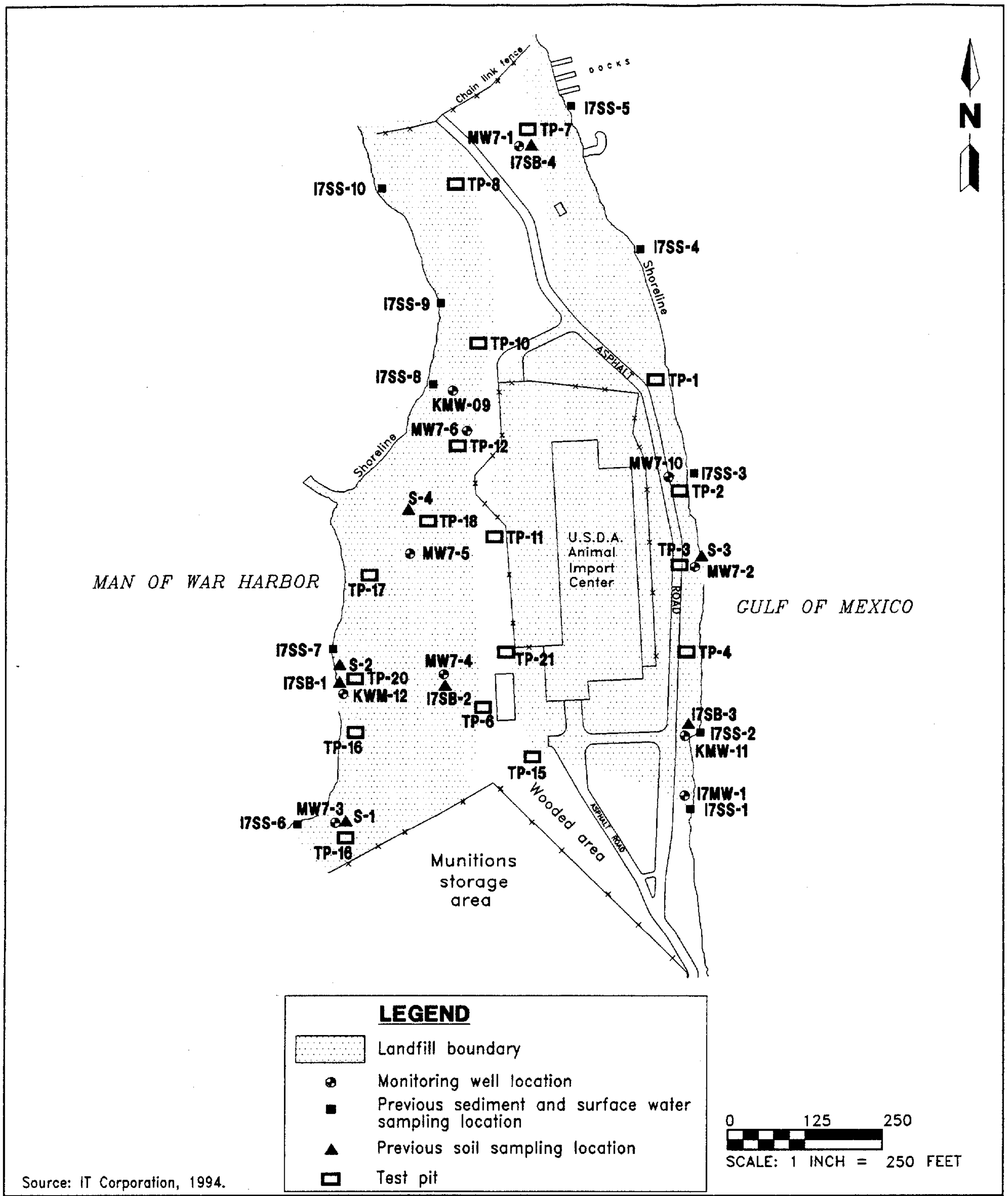
Table 3-9
Previous Sampling Results
IR 3 - Truman Annex DDT Mixing Area

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
Verification Study[1]			
Groundwater	NC		
Soil samples			
0-1 foot	6	mg/kg	4,4'-DDT-27.1; dieldrin-0.87; chlordane-4.5
1-2 feet	6	mg/kg	4,4'-DDT-1.38; dieldrin-1.40
2-3 feet	6	mg/kg	4,4'-DDT-0.95; dieldrin-1.20
Preliminary RI[2]			
Groundwater	3/3	μg/ℓ	alpha BHC-0.11; beta BHC-7.0; dieldrin-1.8; 4,4'-DDD-2.1; heptachlor epoxide-0.14
Surface soil samples	5	μg/ℓ[3]	4,4'-DDT-220,000; 4,4'-DDD-83,000; 4,4'-DDE-33,000; dieldrin-28,000
Sediment samples	NC		
Surface water samples	NC		
RFI/RI[4]			
Groundwater	2/2	μg/ℓ	4,4'-DDD-2.17; 4,4"-DDE-0.84; 4,4'-DDT-0.5; aluminum-2830; antimony-83.2; beta BHC-0.58; delta BHC-1.5; dieldrin-1.2; lead-26.9
Surface soil samples	4	mg/kg	arsenic-213; lead-1050; 4,4'-DDE-61; 4,4'-DDD-26; 4,4'-DDT-14;
Subsurface soil samples	6	mg/kg	arsenic-213; lead-10050; 4,4'-DDE-61; 4,4'-DDD-26; 4,4'-DDT-14; dieldrin-1.9
Sediment samples	NC		
Surface water	NC		

[1]Geraghty and Miller, 1987.
[2]IT Corporation, 1991.
[3]Extraction Procedure Toxicity.
[4]IT Corporation, 1994.

Notes: IR = Installation Restoration.
NC = none collected.
mg/kg = milligrams per kilogram.
DDT = dichlorodiphenyltrichloroethane.
RI = Remedial Investigation.
μg/ℓ = micrograms per liter.
BHC = benzene hexachloride.
DDD = dichlorodiphenyldichloroethane.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.



Source: IT Corporation, 1994.

FIGURE 3-10
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
IR NO. 7, FLEMING KEY
NORTH LANDFILL

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SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

Agriculture (USDA) Animal Import Center. South of the site is a munitions storage area for NAS Key West. North of the site is a small Army Special Forces base. Docks are present on the northeastern edge and on the west side of the island for launching and docking Army boats. The site is generally flat with trees, brush, and mangroves along the western shoreline. The eastern shoreline has grass cover and concrete rubble riprap for erosion protection. The northwestern part of the site is wooded. The remainder of the site is open area covered grass.

From 1952 to 1962, the site was used as the landfill for NAS Key West and the city of Key West. Approximately 4,000 to 5,000 tons of unknown wastes reportedly were disposed of annually. The wastes were placed in trenches typically 25 feet wide, 10 feet deep, and 500 to 1,000 feet long (IT, 1994).

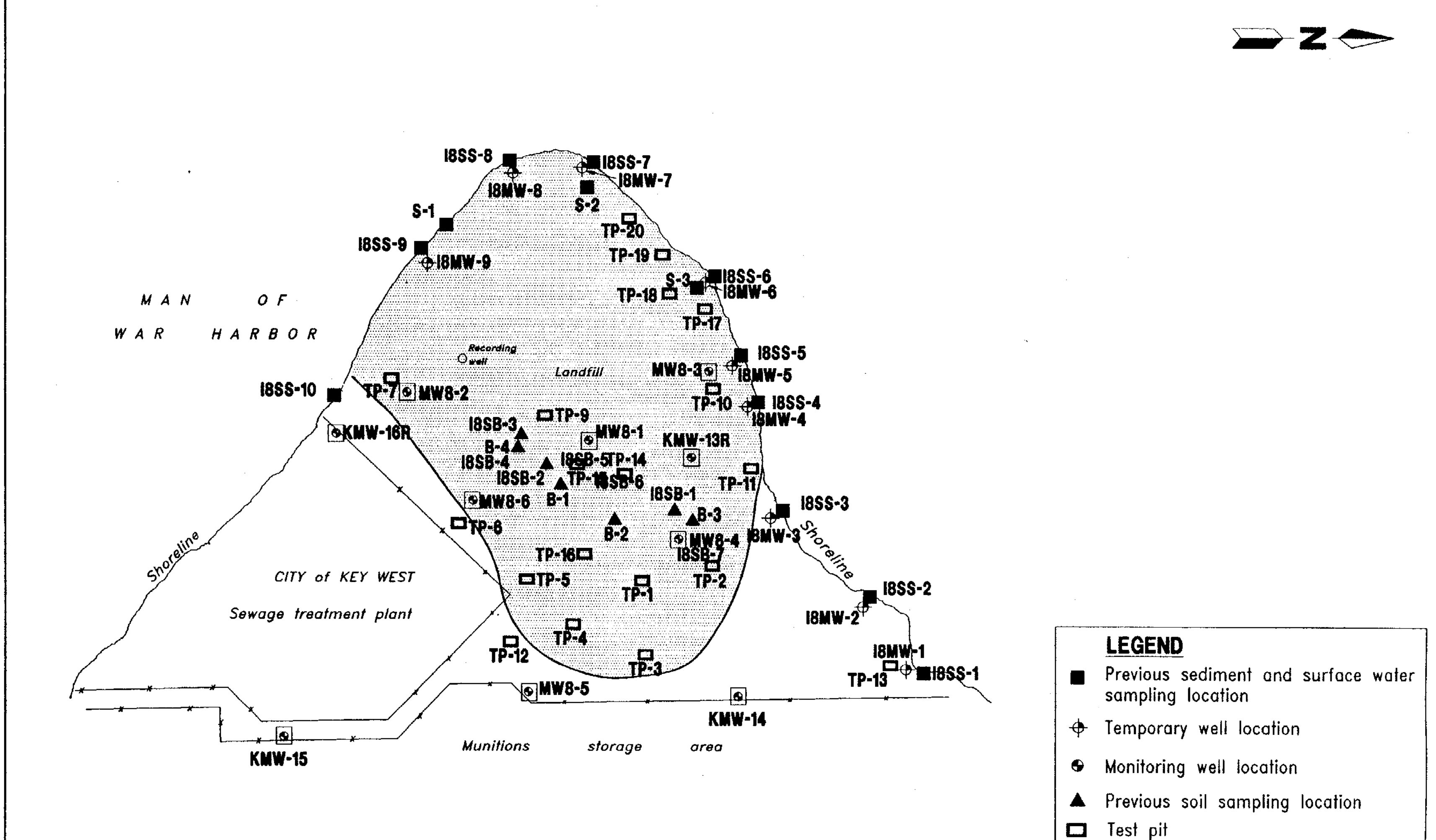
In 1977, a building housing the USDA Animal Import Center was constructed over a part of the landfill. During the construction phase, wastes were excavated and transferred to an area immediately to the west of the construction site and buried under a soil and rock cover. Currently, the entire landfill area is covered with soil and is vegetated by either grass or trees.

Supplemental field activities at IR Site 7 will include sampling of sediment, surface water and groundwater. Sampling data from previously collected surface soil should be sufficient for risk assessment studies (Table 3-10). Sediment and surface water will be sampled at locations previously sampled in the RFI/RI to confirm and verify the earlier findings in accordance with regulatory reviewer comments (IT, 1994) (FDEP, 1995). Groundwater samples will be collected from all permanent existing monitoring well locations to confirm and verify concentrations of previously detected metals and pesticides. Many of the analytes detected in groundwater samples collected during previous RFI/RI activities were from temporary wells that could have yielded nonrepresentative samples that were biased by turbidity.

<u>IR Site 8: Fleming Key South Landfill</u>. The Fleming Key South Landfill (IR Site 8) covers approximately 45 acres on the southern end of Fleming Key and is shown in detail on Figure 3-11. The southeastern portion of the site area is bordered by the City of Key West Sewage Treatment Plant. A munitions storage area is located along the east boundary of the site. The remainder of the site is bordered by ocean water. Dense vegetation covers most of the site, with Australian pine located around the borders. The southwestern area of the site contains piles of metal debris (heavy equipment, desks, marine equipment, etc.) as well as construction debris. There are buses, buoys, trailers, etc., along the northwest portion of the landfill.

As much as 8,000 tons of unknown wastes reportedly were disposed at the landfill annually between 1962 and 1982. The waste disposal activities of the city of Key West were combined with those of the Navy from 1968 to 1982 at this site. Waste materials and fill from Sigsbee Key (Dredgers Key) were also disposed of at the site between 1948 and 1951.

The open trench disposal method was practiced at this site, with the trenches being constructed in a manner similar to that at Fleming Key North Landfill. The trenches were partially full of sea water when waste disposal occurred. Combustible wastes were taken to the western portion of the site and burned. The



Source: IT Corporation, 1994.

0 150 300
SCALE: 1 INCH = 300 FEET

FIGURE 3-11
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
IR NO. 8,
FLEMING KEY SOUTH LANDFILL

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

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Table 3-10
Previous Sampling Results
IR 7 Fleming Key North Landfill

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
Verification Study[1]			
Groundwater	4/4	mg/ℓ	copper-0.07; mercury-0.062; arsenic-0.007
Soil samples	NC		
Preliminary RI[2]			
Groundwater	6	NR	antimony; chromium; cadmium; mercury; nickel; lead
Surface soil samples	4	NR	
Sediment samples	1	NR	
Surface water samples	NR		
RFI/RI[3]			
Groundwater	9/19	µg/ℓ	4,4'-DDD-0.73; 4,4'-DDE-0.28; 4,4'-DDT-0.42; aluminum-581; antimony-464; arsenic-61.8; chromium-269; cadmium-6.1; copper-5560; lead-2,000; mercury-49; nickel-409; thallium 17.6; vanadium-229
Surface soil samples	2	mg/kg	nickel-3.6
Subsurface soil samples	2	mg/kg	antimony-50.3; aroclor 1242-0.97; arsenic-8.4; nickel-9.2
Sediment samples	10	mg/kg	lead-32.5; mercury-0.24; phenanthrene-0.34
Surface water samples	10	µg/ℓ	cyanide-810; mercury-0.25

[1]Geraghty and Miller, 1987.
[2]IT Corporation, 1991.
[3]IT Corporation, 1994.

Notes: IR = Installation Restoration.
µg/ℓ = micrograms per liter.
NC = none collected.
NR = no liter results available.
µg/ℓ = micrograms per liter.
BHC = benzene hexachloride.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethene.
DDT = dichlorodiphenyltrichloroethane.
mg/kg = milligrams per kilogram.

ash and unburned wastes were then deposited in the western portion of the landfill.

Field activities at this site include collection of sediment and surface water samples, surface soil samples, and groundwater samples. Limited surface soil sampling is proposed. Sediment and surface water samples will be collected from the same locations as in the original RFI/RI program for the purpose of verifying the previous data (in accordance with regulatory review comments) (FDEP, 1995) (Table 3-11). Groundwater samples will be collected from existing permanent monitoring wells to confirm and verify concentrations of previously detected metals and assess the contribution of turbidity to the metals findings previously reported (IT, 1994).

AOC Site A: Demolition Key Open Disposal Area. Demolition Key Open Disposal Area (AOC-A) is on the northern half of Demolition Key, a manmade dredge spoil island used historically for explosives disposal. Demolition Key is approximately 6 feet above msl at its highest point and is shown on Figure 3-12. The Key consists of two land masses; however, this investigation will address only the northern land mass where disposal of explosives took place. The Key is constructed from dredge materials, which implies that the soil and subsurface are quite porous.

Demolition Key in its entirety comprises approximately 24 acres and is surrounded by both the Atlantic Ocean and the Gulf of Mexico. The Key is accessible only by water transportation and is an off-limits restricted area. No permanent surface water features are present on the Key. The Key contains several explosive generated craters approximately 10 feet by 5 feet in size and 4 to 5 feet deep. Distribution of rainfall is through percolation to the groundwater and runoff into the surrounding surface water. The shoreline currently is supporting a mangrove community and Australian pines have invaded the island interior.

The supplemental activities at this site address additional work to assess the presence and nature of contaminants within sediment and surface water offshore from the ordnance demolition and burning and groundwater onsite area. Prior to initiating any work onsite an unexploded ordnance survey will be conducted on the site. Only two sediment samples were collected in the original RFI/RI program (IT, 1994) (Table 3-12). Combined with the additional sediment and surface water data, existing surface soil data should be sufficient for development of risk criteria, considering the main pathway for exposure is via surface water and sediment. Three temporary monitoring wells are also proposed for this site.

AOC Site B: Big Coppitt Key Abandoned Civilian Disposal Area. Big Coppitt Key Abandoned Civilian Disposal Area (AOC-B) is located on Big Coppitt Key to the east of Boca Chica Key (Figure 3-13). The site encompasses approximately 10 acres, of which approximately 0.7 acre is improved and approximately 1.6 acres is occupied by a dead-end canal. At the southeastern end is an old disposal area containing discarded car and truck body and frame parts in a horseshoe-shaped area approximately 1 to 2 feet thick and covering 4,000 square feet. A mangrove swamp encompasses the site. The ground elevations at the site vary from sea level up to approximately 2 feet above sea level. Surface water exists in the mangrove wetlands and all runoff from precipitation appears to drain directly into the canal and into the mangrove wetlands. There is a culvert that appears to connect the south end of the canal with the mangroves.

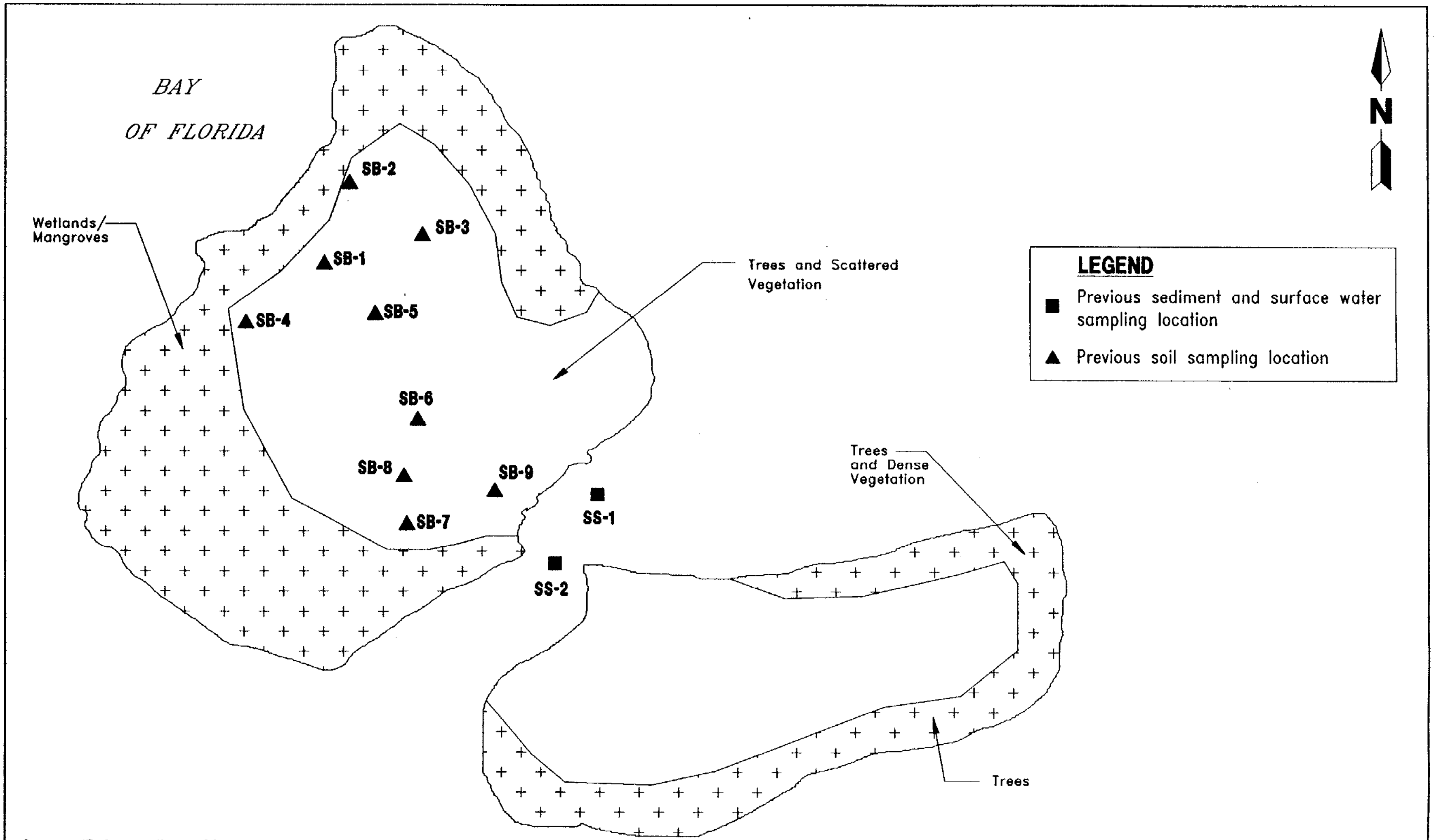
Table 3-11
Previous Sampling Results
IR 8 Fleming Key North Landfill

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
Verification Study[1]			
Groundwater	5	mg/kg	arsenic 0.007; copper 0.06; mercury 0.075
Soil samples	NC		
Preliminary RI[2]			
Groundwater	6	μg/ℓ	chlorobenzene-63
Surface soil samples	NC		
Sediment samples	NC		
Surface water samples	3	μg/ℓ	aroclor 1242-1.10
RFI/RI[3]			
Groundwater	19/19	μg/ℓ	aluminum-2,800; alpha BHC-0.15; antimony-236; arsenic-104; copper-327; lead-553; thallium-11.6
Surface soil samples	1	mg/kg	
Subsurface soil samples	4	mg/kg	arsenic-3.0; nickel-5.9
Sediment samples	10	mg/kg	arsenic-8.1; barium-.3; lead-53.1; mercury-0.20; fluorene-0.32; phenanthrene-0.150
Surface water samples	10	μg/ℓ	mercury-0.2; tin-94.6

[1]Geraghty and Miller, 1987.
[2]IT Corporation, 1991.
[3]IT Corporation, 1994.

Notes: IR = Installation Restoration.
mg/kg = milligrams per kilogram.
NC = none collected.
RI = Remedial Investigation.
μg/ℓ = micrograms per liter.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
BHC = benzene hexachloride.



Source: IT Corporation, 1994.

0 100 200
SCALE: 1 INCH = 200 FEET

FIGURE 3-12
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
AOC SITE A, DEMOLITION KEY OPEN DISPOSAL AREA

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

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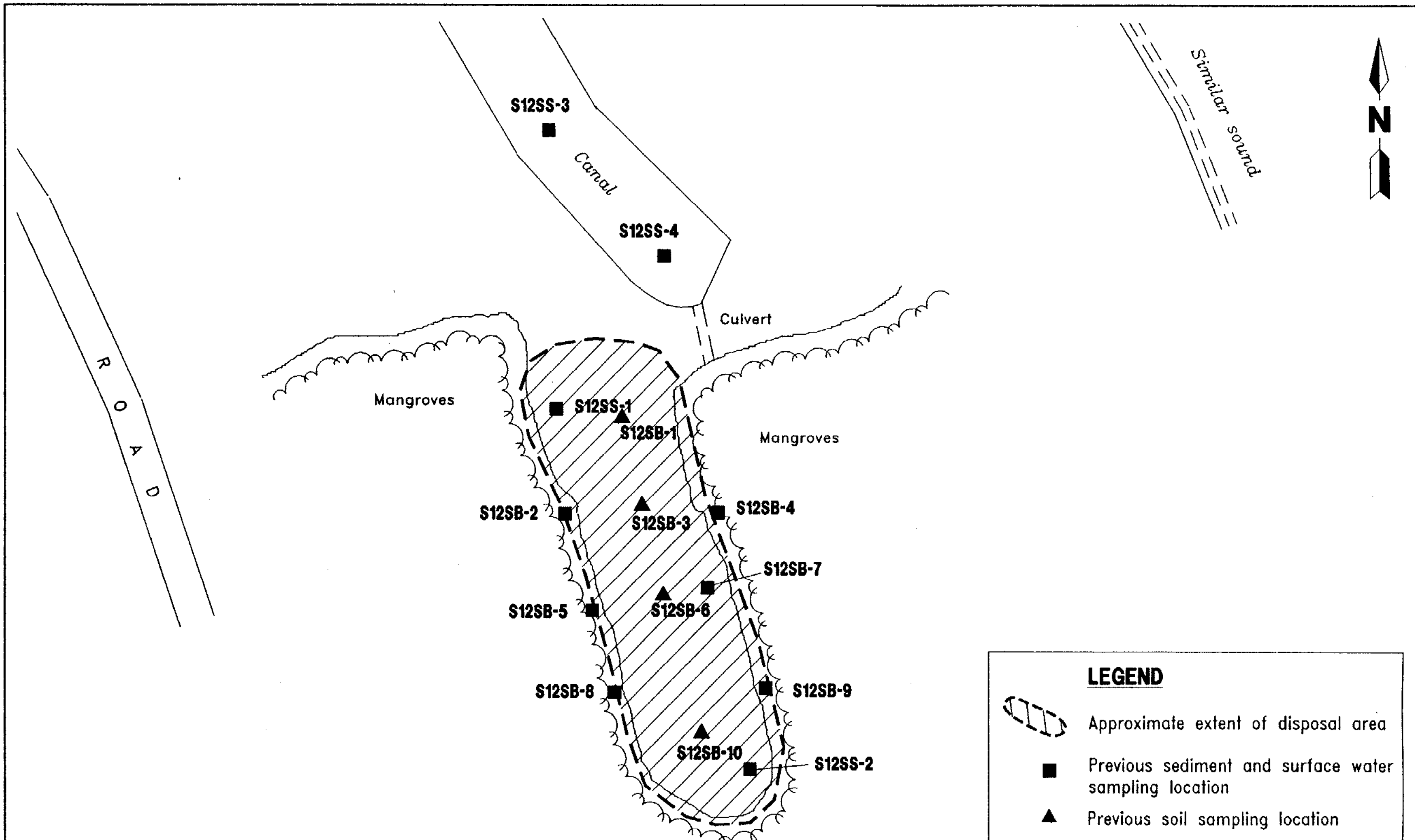
Table 3-12
Previous Sampling Results
AOC A - Demolition Key Open Disposal Area

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
RFI/RI[1]			
Groundwater	[3]0/1	μg/ℓ	antimony-249; cadmium-52.2; copper-4,070; lead-1,610; nickel-116; zinc-23,500
Surface soil samples	9	mg/kg	beryllium-0.36, lead-2,100; pyrene-34.3; lead[2]-22.9
Sediment samples	2	mg/kg	ND
Surface water samples	NC		

[1]IT Corporation, 1994.
[2]Toxicity Characteristic Leaching Procedure.
[3]The groundwater sample was collected from a soil boring location.

Notes: AOC = area of contamination.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
RFI/RI = RFI Remedial Investigation.
μg/ℓ = microgram per liter.
mg/kg = milligram per kilogram.
ND = none detected above
NC = none collected.



Source: IT Corporation, 1994.

0 125 250
SCALE: 1 INCH 250' FEET

FIGURE 3-13
PREVIOUS INVESTIGATION AND SAMPLING LOCATIONS
AOC SITE B, BIG COPPITT KEY
ABANDONED CIVILIAN DISPOSAL AREA

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

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The site is an abandoned civilian disposal area used for disposal of discarded car and truck body and frame parts. The Navy purchased this property to comply with the Federal Aviation Agency requirements for an Aircraft Compatibility Usage Installation Zone.

Supplemental field activities at AOC B will be limited to resampling of sediment and surface water and installation of three temporary monitoring wells. Because the disposal area lies within a tidal fluctuation zone surrounded by mangrove swamp, soil exposure and groundwater migration would not be of concern. The sediment and surface water samples will be collected from approximately the same locations as those sampled in the previous RFI/RI sampling program (IT, 1994) (Table 3-13). Resampling will occur after the IRA is completed by the RAC.

3.3 SUMMARY BY SITE.

Sampling Summary. A summary of the specific sampling tasks by site and analyte requirements is presented in Tables 3-14 and 3-15. The number of samples and targeted analytes by site are summarized in detail in the accompanying SAP (Volume II).

Ecological Risk Assessment Methodology. The methodology proposed for conducting the ecological risk assessment is presented in Appendix A.

Human Health Risk Assessment Methodology. The methodology proposed for conducting the human health risk assessment is presented in Appendix B.

Table 3-13
Previous Sampling Results
AOC B- Big Coppitt Key Abandoned Civilian Disposal Area

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Investigation	No. of Wells/Samples	Units	Maximum Concentration of Contaminants Detected
RFI/RI[1]			
Groundwater	[3]0/3	µg/ℓ	antimony-240; arsenic-83.4; cadmium-6.2; chromium-428; lead-309; mercury-2.4; nickel-161
Surface soil samples	4	mg/kg mg/ℓ[2]	arsenic-9; nickel-24.3; tin-14.7
Sediment samples	10	mg/kg mg/ℓ[2]	antimony-8.9; arsenic-27.1; cadmium-15.6; chromium-67.4; copper-875; lead-237; mercury-0.22
Surface water samples	4	µg/ℓ	arsenic-70.3; beryllium-1.6; chromium-115; copper-72.6; lead-71; mercury-0.24; nickel-49.6; zinc-1290

[1]IT Corporation, 1994.
[2]Toxicity Characteristic Leaching Procedure.
[3]Groundwater samples were collected from selected soil boring locations.

Notes: AOC = area of contamination.
RFI = Resource Conservation and Recovery Act (RCRA) Facility Investigation.
RFI/RI = RFI and Remedial Investigation.
µg/ℓ = micrograms per liter.
mg/kg = milligrams per kilogram.

Table 3-14
Field Program Sampling Summary

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Site	Surface Soil/ Subsurface Soil	Monitoring Wells	Groundwater Samples	Sediment Samples	Surface Water Samples
SWMU 1: Boca Chica Open Disposal Area					
Field Samples	0	3	3	3	3
Background Samples	4SS	1	1	0	0
SWMU 2: Boca Chica DDT Mixing Area					
Field Samples	0	3	5	0	0
Background Samples	0	1	1	0	0
SWMU 3: Boca Chica Fire Fighting Training Area					
Field Samples	0	3	5	5	5
Background Samples	0	1	1		
SWMU 4: Boca Chica AIMD Building A-980					
Field Samples	0	3	5	3	3
Background Samples	2SS	1	1	1	1
SWMU 5: Boca Chica AIMD Building A-989					
Field Samples	1SS	0	2	3	3
Background Samples	0	2	2	1	1
SWMU 7: Boca Chica Building A-824					
Field Samples	4SS	0	3	4	4
Background Samples	0	0	0	1	1
SWMU 9: Jet Engine Test Cell Building A-969					
Field Samples	5SS/5SB	4	8	5	5
Background Samples	0	0	0	0	0
FACILITY-WIDE BACKGROUND - Boca Chica Key Field Samples	9SS			3	3
IR-1: Truman Annex Open Disposal Area					
Field Samples	0	1	10	7	7
Background Samples	0	1	1		
IR-3: Truman Annex DDT Mixing Site					
Field Samples	0	3	6	0	0
Background Samples	6SS/4SB	1	1	0	0
IR-7: Fleming Key North Landfill					
Field Samples	0	0	9	10	10
Background Samples	0	0	0	0	0

Table 3-14 (Continued)
Field Program Sampling Summary

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Site		Surface Soil/ Subsurface Soil	Monitoring Wells	Groundwater Samples	Sediment Samples	Surface Water Samples
IR-8:	Fleming Key South Landfill					
	Field Samples	4SS	0	10	10	10
	Background Samples	0	0	0	0	0
AOC A:	Demolition Key Open Disposal Area					
	Field Samples	0	3	3	6	6
	Background Samples	0	0	0	0	0
AOC B:	Big Coppitt Key Abandoned Civilian Disposal					
	Area	0	3	3	10	10
	Field Samples	0	0	0	0	0
	Background Samples					
FACILITY-WIDE BACKGROUND - Truman Annex						
	Field Samples	5SS	0	0	5	5

Table 3-15
Field Program Analytical Sampling Summary

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Site	Volatile Organic Compounds[1]	Semivolatile Organic Compounds[2]	Pesticides and PCBs[3]	Target Analyte List Inorganics[4]
SWMU 1: Boca Chica Open Disposal Area				
Groundwater Samples	4	4	4	[5]4
Soil Samples (SS/SB)	4SS	4SS	4SS	[5]4SS
Sediment Samples	3	3	3	[5]3
Surface Water Samples	3	3	3	[5]3
SWMU 2: Boca Chica DDT Mixing Area				
Groundwater Samples	6	6	0	0
Soil Samples (SS/SB)	0	0	0	0
Sediment Samples	0	0	0	[5]5
Surface Water Samples	0	0	0	[5]5
SWMU 3: Boca Chica Fire Fighting Training Area				
Groundwater Samples	6	6	0	0
Soil Samples (SS/SB)	0	0	0	0
Sediment Samples	0	0	0	[5]5
Surface Water Samples	0	0	0	[5]5
SWMU 4: Boca Chica AIMD Building A-980				
Groundwater Samples	6	6	0	[5]6
Soil Samples (SS/SB)	2SS	2SS	2SS	2SS
Sediment Samples	0	4	0	4
Surface Water Samples	0	4	0	4
SWMU 5: Boca Chica AIMD Building A-989				
Groundwater Samples	2	2	0	[5]4
Soil Samples (SS/SB)	0	0	0	4SS
Sediment Samples	0	0	0	4
Surface Water Samples	0	0	0	4
SWMU 7: Boca Chica Building A-8				
Groundwater Samples	0	0	3	3
Soil Samples (SS/SB)	0	0	4SS	4SS
Sediment Samples	0	0	5	5
Surface Water Samples	0	0	5	5
SWMU 9: Jet Engine Test Cell Building A-969				
Groundwater Samples	8	8	8	[5]8
Soil Samples (SS/SB)	5SS/5SB	5SS/5SB	5SS/5SB	[5]5SS/5SB
Sediment Samples	5	5	5	[5]5
Surface Water Samples	5	5	5	[5]5
FACILITY-WIDE BACKGROUND - Boca Chica Key				
Groundwater Samples	0	0	0	0
Soil Samples (SS/SB)	9	9	9SS	[5]9SS
Sediment Samples	3	3	3	[5]3
Surface Water Samples	3	3	3	[5]3

See notes at end of table.

Table 3-15 (Continued)
Field Program Analytical Sampling Summary

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Site	Volatile Organic Compounds[6]	Semivolatile Organic Compounds[7]	Pesticides and PCBs[8]	Target Analyte List Inorganics[9]
IR-1: Truman Annex Open Disposal Area				
Groundwater Samples	0	0	11	[5]11
Soil Samples (SS/SB)	0	0	0	0
Sediment Samples	0	7	7	[5]7
Surface Water Samples	0	7	7	[5]7
IR-3: Truman Annex DDT Mixing Site				
Groundwater Samples	0	0	7	7
Soil Samples (SS/SB)	0	0	6SS/0SB	6SS/0SB
Sediment Samples	0	0	0	0
Surface Water Samples	0	0	0	0
IR-7: Fleming Key North Landfill				
Groundwater Samples	0	0	9	0
Soil Samples (SS/SB)	0	0	0	0
Sediment Samples	0	0	10	0
Surface Water Samples	0	0	10	0
IR-8: Fleming Key South Landfill				
Groundwater Samples	0	0	10	0
Soil Samples (SS/SB)	0	0	4SS	0
Sediment Samples	0	0	10	0
Surface Water Samples	0	0	10	0
AOC A Demolition Key Open Disposal Area				
Groundwater Samples	3	3	0	3
Soil Samples (SS/SB)	0	0	0	0
Sediment Samples	0	6	6	[5]6
Surface Water Samples	0	6	6	[5]6
AOC B: Big Coppitt Key Abandoned Civilian Disposal Area				
Groundwater Samples	3	3	3	[5]3
Soil Samples (SS/SB)	0	0	0	0
Sediment Samples	0	0	10	[5]10
Surface Water Samples	0	0	10	[5]10
FACILITY-WIDE BACKGROUND - Truman Annex				
Groundwater Samples	0	0	0	0
Soil Samples (SS/SB)	0	0	5SS	5SS
Sediment Samples	0	0	5	5
Surface Water Samples	0	0	5	5

[1] Appendix IX (U.S. Environmental Protection Agency [USEPA] Method 624M/SW 8240).
[2] Appendix IX (USEPA Method 624M/SW 8240).
[3] Appendix IX (USEPA Method 625M/SW 8270).
[4] Target Analyte Metals (EPA 200 Series).
[5] Cyanide (EPA Method 335.1).
[6] USEPA Method 602.
[7] USEPA Method 610.
[8] USEPA Method 608/SW 8080.
[9] USEPA 200 Series.

4.0 DATA MANAGEMENT PLAN

The data management plan describes how the results of sampling and field measurements will be assessed, validated, documented, tracked, and reported. Project documentation procedures, filing requirements, and formats used to report data and conclusions are described in this section.

4.1 DATA ASSESSMENT. Data collected from investigative activities include survey data and laboratory analytical data. Final data uses include site characterization and assessment, and the development of effective corrective measures, where necessary.

All data collected as part of the RFI/RI program will be assessed and evaluated upon completion of the field program. These data will be used to develop recommendations and conclusions about the nature and extent of potential releases of hazardous waste or constituents from the sites. If needed, these data will be used to support a Corrective Measures Study (CMS).

4.2 DATA VALIDATION. Laboratory data will be validated in conformance with USEPA Functional Guidelines for Evaluating Organic Analyses (USEPA, 1988a) and Functional Guidelines for Evaluating Inorganic Analyses (USEPA, 1988b) and Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program (Naval Energy and Environmental Support Activity [NEESA], 1988) appropriate to USEPA Level III or NEESA Level C data. These guidelines provide a systematic procedure for evaluating laboratory quality assurance (QA) and quality control (QC) measures such as holding times, surrogate recoveries, matrix spike results, gas chromatograph and mass spectrometry (GC/MS) tuning, instrument calibration, compound identification, and method performance.

Validated data will be prepared in three initial formats: raw laboratory data, data marked with validation qualifiers, and corrected or validated data. The validated data will then be used for site characterization, ecological and human health risk assessment, and corrective measures studies, if required.

4.3 FACILITY MAPS. The following maps will be prepared:

- base map showing important features, including potential receptors;
- study areas; and
- sampling and field measurement locations.

4.4 DATA PRESENTATION FORMAT. The reduction of field and analytical data will consist of summarizing water level measurements, soil boring logs, well logs, field parameters, and analytical results. These summaries will be presented as tables, illustrations, and/or graphs. Chemical data and some physical data will be stored and managed using a data management system. The system will be capable of sorting so that data can be retrieved and ordered by medium, location, parameter, etc. and presented in a tabular format.

Graphical presentation of the data and site conditions will also be included in the final reports. Sampling locations, boundaries, plume definition, potential receptors, etc. will be illustrated onsite maps based upon the results of the collected data. Geologic cross sections and horizontal and vertical concentration profiles will be plotted.

Raw data will be included in report appendices in spreadsheet format. The spreadsheet format will allow the display of more samples per page and provide information on field and laboratory blanks and associated environmental samples. At a minimum, the information shown in the example in Table 4-1 will be presented. Other information may be added to assist in review. Data on calibration, tuning, spikes, surrogates, and duplicates will also be provided in a report on precision, accuracy, representativeness, comparability, and completeness (PARCC) of the analytical data.

Table 4-1
Data Format Example, Final Report

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Analyte	Sample Limit	Sample Results	Sample Results
Sample Number		J25019	J25020
Date Sampled		03/18/87	11/25/87
Sample Prep. Date		11/25/87	11/25/87
Sample Analysis Data		11/26/87	11/26/87
Sample Numbers of Associated Analytes, Field, Trip and Equipment Blanks		J4455667	L4455667
Volatile Organic Compounds (μg/kg)			
Tetrachloroethane	5	50	50
Chlorobenzene	5		
Semivolatile Organic Compounds (μg/kg)			
Bis(2-ethylhexyl)phthalate	330		750
2-methylnaphthalene	330		2,500
Inorganic compounds (mg/kg			
Lead	10	360	25
Petroleum Hydrocarbons			
Total Petroleum hydrocarbons	1	0.611	0.268
Oil and Grease	1		

Source: Oak Ridge Gaseous Diffusion Plant, 1988.

Notes: μg/kg = microgram per kilogram.
mg/kg = milligram per kilogram.

5.0 PROJECT MANAGEMENT PLAN

This section identifies key roles in the project and program organization and specifics on the proposed project schedule.

5.1 KEY PROJECT PERSONNEL. The following highlights key individuals in the ABB-ES Comprehensive Long-term Environmental Action, Navy (CLEAN) program and this RFI/RI program. Project organization is depicted on Figure 5-1.

Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM). SOUTHNAVFACENGCOM is responsible for establishing policy guidance for the CLEAN program. SOUTHNAVFACENGCOM awards contracts, approves funding, and has primary control of report release and interagency communication.

SOUTHNAVFACENGCOM Engineer-in-Charge (EIC). The SOUTHNAVFACENGCOM EIC, Mr. Dudley Patrick, is responsible for the technical and financial management of the RFI/RI activities at NAS Key West. Mr. Patrick is the primary project contact. He prepares the project statement of work; manages the project scope, schedule, and budget; and provides technical review and approval of all deliverables. Mr. Patrick will be responsible for approving changes in the scope of work identified during Project Manager's Meetings.

ABB-ES Task Order Manager (TOM). The TOM for the RFI/RI program is responsible for evaluating the appropriateness and adequacy of the technical and engineering services provided. He/she is responsible for financial and schedule management and for ensuring that the project fulfills and remains within the contracted scope of work. He/she will be responsible for identifying necessary changes in the scope of work during Project Manager's Meetings. The TOM is also responsible for the daily conduct of work, including integration of input from supporting disciplines and subcontractors and will serve as the primary project contact.

RFI/RI Technical Leader. The Technical Leader for this project is responsible for developing the technical scope and evaluating the appropriateness and adequacy of technical services on this project.

Internal Review Committee. An Internal Review Committee, consisting of senior technical staff from the CLEAN team, supports the TOM by reviewing technical aspects of the project so that services: (1) reflect the accumulated experience of the firm, (2) are produced according to corporate policy, and (3) meet the necessary objectives of the project. The primary function of the committee is to support defensible data, interpretations, and conclusions.

QA Coordinator. The TOM is supported by a QA coordinator who will report to the Program Manager (PM). The QA Coordinator, will oversee the implementation of appropriate NEESA and USEPA protocols. The QA Coordinator will also work with the TOM to establish QC procedures.

Health and Safety Coordinator. The Health and Safety Coordinator, is responsible for project team compliance with corporate health and safety requirements and the CLEAN program Health and Safety Plan (HASP). Conformance with safety protocols will be assessed though periodic site visits and daily supervision by the site leaders.

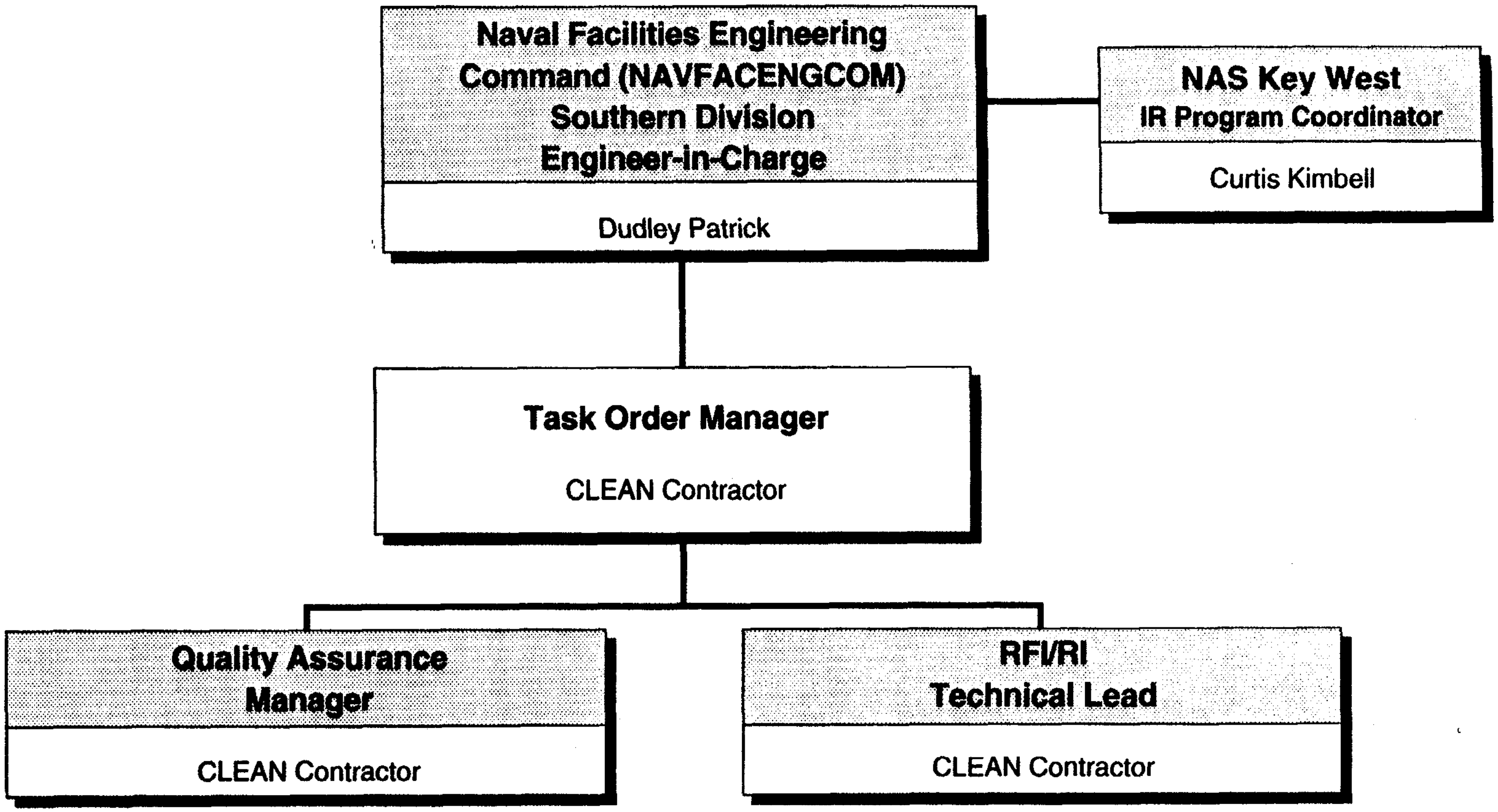

FIGURE 5-1
PROJECT ORGANIZATION

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

8530-03-028 ORG CHART 112795 MAW

5.2 PROJECT SCHEDULE. A tentatively proposed project schedule for the RFI/RI program at NAS Key West is summarized on Figure 5-2.

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PMW.11.95

ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR
NOTICE TO PROCEED	17APR95		0
PROJECT MANAGEMENT	10JUL95	2MAY97	475
CLOSEOUT	21MAR97	8MAY97	35
COMPLETE		8MAY97	0
PREPARE DRAFT SUPPLEMENTAL RFI/RI WORKPLAN	17APR95	7JUN95	38
SUBMIT DRAFT SUPPLEMENTAL RFI/RI WORKPLAN		17JUN95	0
REGULATORY REVIEW OF RFI/RI WORKPLAN	8JUN95	30AUG95	60
PREPARE FINAL SUPPLEMENTAL RFI/RI WORKPLAN	31AUG95	22NOV95	60
SUBMIT FINAL SUPPLEMENTAL RFI/RI WORKPLAN		7DEC95	0
FIELD PROGRAM	21DEC95	27MAR96	70
SUBCONTRACTOR DRILLING	21DEC95	27MAR96	70
SUBCONTRACTOR SURVEYING	21DEC95	27MAR96	70
LABORATORY ANALYSIS	26DEC95	26APR96	89
DATA VALIDATION	26JAN96	24MAY96	86
PREPARE DRAFT SUPPLEMENTAL RFI/RI REPORT	27MAY96	3OCT96	94
SUBMIT DRAFT SUPPLEMENTAL RFI/RI REPORT		3OCT96	0
REGULATORY REVIEW OF SUPPLEMENTAL RFI/RI REPORT	4OCT96	26DEC96	60
PREPARE RESPONSE TO COMMENTS ON SUPP. RFI/RI RPT	27DEC96	6FEB97	30
PREPARE FINAL SUPPLEMENTAL RFI/RI REPORT	7FEB97	20MAR97	30
SUBMIT FINAL SUPPLEMENTAL RFI/RI REPORT		20MAR97	0

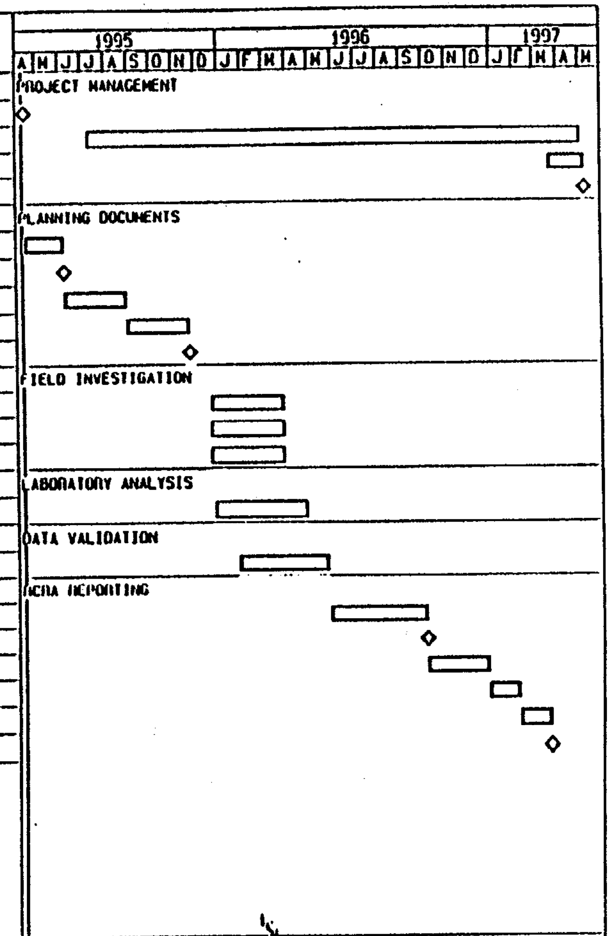

ABB E.S. INC. / NAVY CLEAN PROGRAM
NAVAL AIR STATION KEY WEST
SUPPLEMENTAL RFI/RI WORKPLAN

PROJECT SCHEDULE

Date	Revision	Checked	Approved

(c) Primavera Systems, Inc.

FIGURE 5-2
PROJECT SCHEDULE

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

8530-03-028 SCHEDULE 112795 MAW

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APPENDIX A

ECOLOGICAL RISK ASSESSMENT METHODOLOGY

Ecological Risk Assessment Methodology The Ecological Risk Assessment (ERA) at NAS Key West will evaluate actual or potential adverse effects to ecological receptors associated with exposure(s) to environmental contamination. The following sections describe the proposed approach for the ERAs at NAS Key West. There are six primary components of the ERA process including: (1) problem formulation, (2) hazard assessment, (3) exposure assessment, (4) effects assessment, (5) risk characterization, and (6) uncertainty analyses. Each component is described separately in the following subsections.

The ERA will be conducted in accordance with the "Risk Assessment Guidance for Superfund: Environmental Evaluation Manual" (USEPA, 1989a), and "Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference Document" (USEPA, 1989b) and USEPA's draft "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1994). In addition, recent supplemental risk assessment guidance such as USEPA "Eco Update Bulletins" (USEPA 1991: 1992a; 1992b) will be incorporated into this ERA, where appropriate. Figure A-1 shows the framework for the proposed ecological risk assessment.

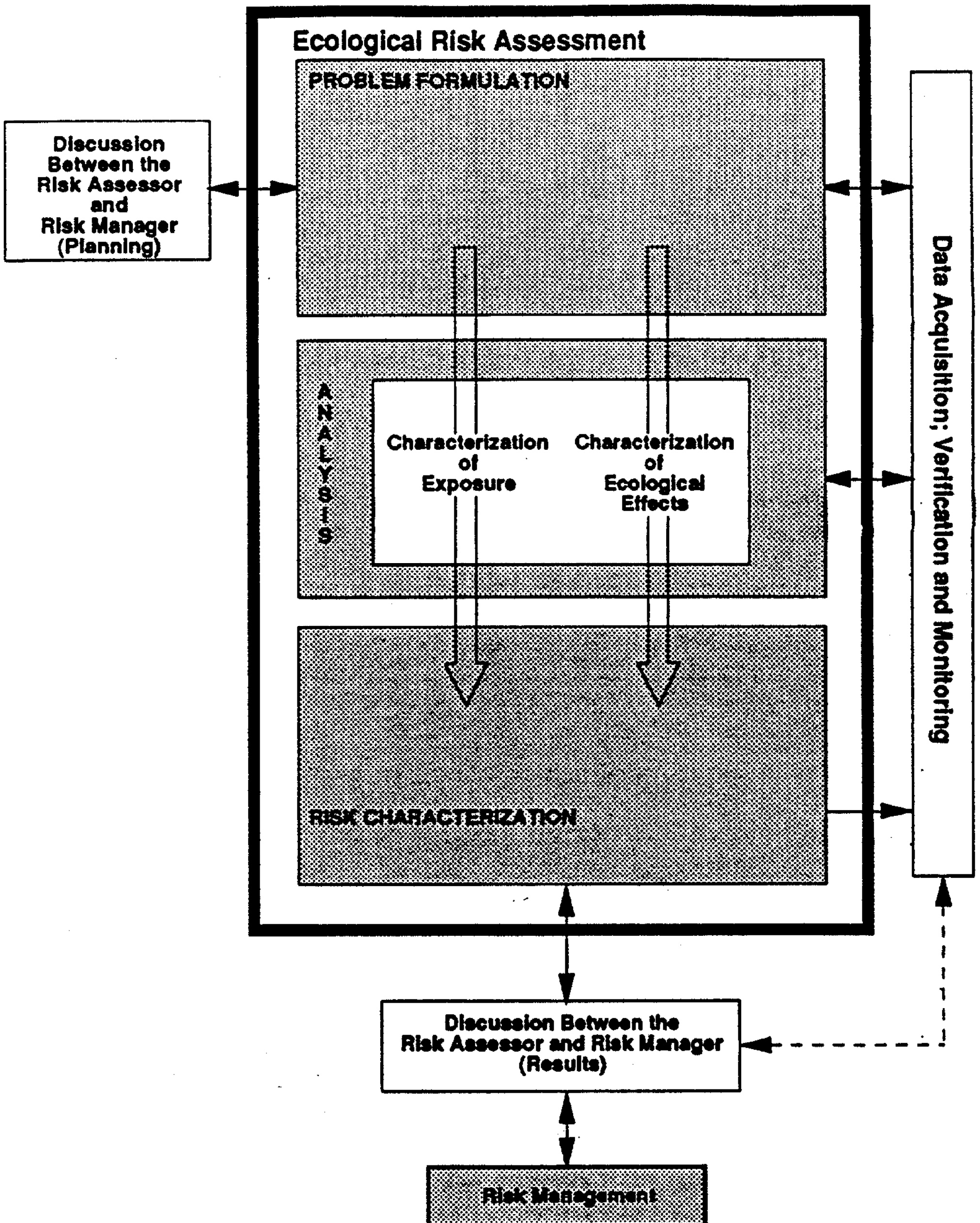
Decisions regarding overall risk to ecological receptors will be based on the weight of evidence from the results of both predictive and field methodologies.

Problem Formulation Problem formulation at NAS Key West will involve the development of conceptual models for each of the sites evaluated in the baseline ERAs. The conceptual models will identify exposure routes for the following four groups of ecological receptors: terrestrial and wetlands wildlife (mammals, birds, and reptiles), aquatic life (fish, invertebrates, and plants), terrestrial plants, and terrestrial invertebrates. These models will be re-evaluated and revised based on information collected during the supplemental RFI/RI. Preliminary information for inclusion in the problem formulation stage is presented in the following subsections.

Figure A-2 presents a flow chart of the ecological risk assessment process. Rather than conducting baseline ecological risk assessments at all of the RFI/RI sites, a phased approach is proposed in order to minimize costs, permit technical flexibility, ensure that the needs of the ecological risk assessment are incorporated into the analytical sampling program, and to ensure that the risk assessments provide the required information to help make risk-based management decisions.

A thorough review of contaminant data at each site will be completed after the existing analytical data have been summarized, reorganized and thoroughly reviewed. Following the data review and an initial site inspection, a problem formulation phase of work will evaluate whether environmental contamination at a site may pose a risk to ecological receptors. Based on the problem formulation step, recommendations will be made regarding the need for further studies to support the ecological risk assessments. At some sites, no further action may be necessary or additional data may be needed to fill data gaps. A baseline ecological risk assessment may be recommended at certain sites. For these sites, the methodology presenting on Figure A-2 will be followed.

Screening Level Risk Evaluation IT Corporation (1994) conducted preliminary screening level ecological risk evaluations at the 12 of the RFI/RI sites. An initial review of the data evaluated in the ecological screening assessments



Source: USEPA, 1992.

FIGURE A-1 FRAMEWORK FOR ECOLOGICAL RISK ASSESSMENT	SUPPLEMENTAL RFI/RI WORKPLAN NAS KEY WEST KEY WEST, FLORIDA

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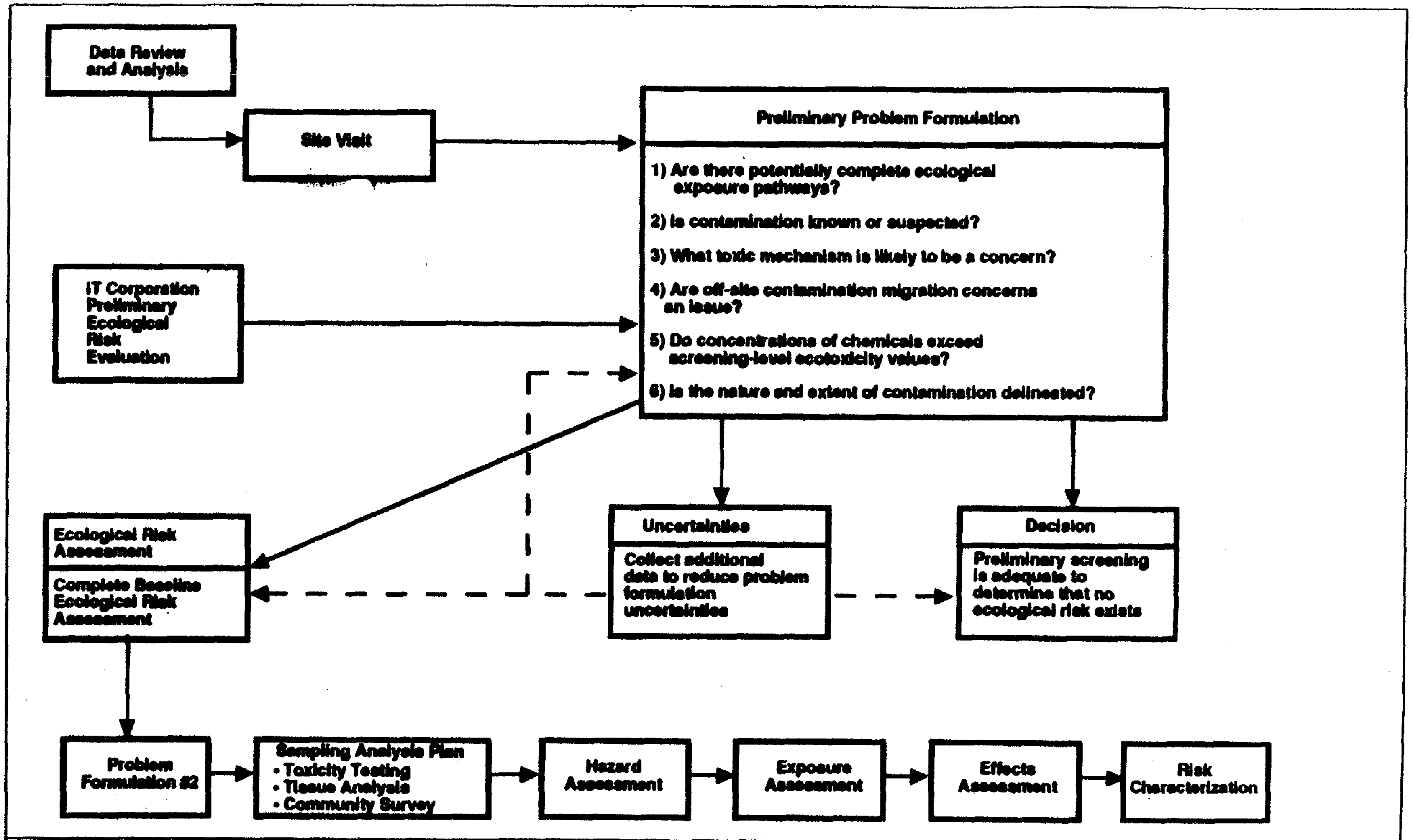

FIGURE A-2

ECOLOGICAL RISK ASSESSMENT PROCESS

SUPPLEMENTAL RFI/RI WORKPLAN

NAS KEY WEST
KEY WEST, FLORIDA

indicates that the RFI/RI sites can be grouped "high," "medium," and "low," with low signifying a low likelihood of risk to ecological receptors at the site, and high indicating that additional ecological investigation may be required. Table A-1 shows the preliminary ecological risk ranking for each site. The following subsections present a synopsis of the preliminary screening-level ecological risk evaluation conducted by IT Corporation (1994).

IR Site 1: Truman Annex Refuse Disposal Area. IR Site 1 is a 7-acre antenna farm covered with mown grass. Limited terrestrial habitat exists at IR Site 1. A coastal beach and the Atlantic Ocean lie adjacent to the southern end of this site. Ecological receptors at the site may include occasional terrestrial wildlife, invertebrates, and plants, as well as marine vertebrates, invertebrates, and plants (IT, 1994).

Contaminated media at IR Site 1 includes surface soil, surface water, sediment, and groundwater. During the RFI/RI investigation, arsenic, lead, and nickel were detected in surface soil samples at concentrations above background screening levels. In surface water, concentrations of tin were detected, and sediment samples contained polychlorinated biphenyls (PCBs), 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, arsenic, antimony, lead, mercury, and zinc. Groundwater monitoring wells placed near the sewer outfall discharge point into the Atlantic Ocean contained 4,4'-DDE and several inorganic chemicals at concentrations above background screening levels. Based on the presence of PCBs, pesticides, and inorganics in environmental media at IR-Site 1, and the proximity to the Atlantic Ocean, risks to marine terrestrial and ecological receptors at the site may be a concern. The site was ranked "high" in the IT Corporation (1994) Screening Level Risk Evaluation.

IR Site 3: Truman Annex DDT Mixing Area. IR Site 3 is a ¼-acre area of sparse grass enclosed in chain-link fence. No surface water exists in the immediate vicinity of the site. The site provides minimal habitat for ecological receptors, which may include terrestrial invertebrates and plants and an occasional small mammal or bird (IT, 1994).

Contaminated media at IR Site 3 include surface soil and groundwater. During the RFI/RI investigation, concentrations of 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, dieldrin, arsenic, and lead were detected in surface soil above background screening levels. The highest detected concentrations of 4,4'-DDE was 66 mg/kg, and lead was detected at 1,050 mg/kg.

Based on the lack of ecological exposure pathways (i.e., the lack of habitat) and the ¼-acre surface area at the site, IR Site 3 was considered to have a low probability of adverse ecological risk, and was ranked "low" in the Preliminary Screening Level Risk Evaluation conducted by IT Corporation (1994).

IR Site 7: Fleming Key North Landfill. IR Site 7 is a 30-acre area located on Fleming Key that contains the USDA Animal Import Center on the eastern part of the site and is covered with mown grass on the western side. The Gulf of Mexico lies adjacent to the eastern side of this site, and Man of War Harbor is adjacent to the western shore. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, terrestrial plants, as well as marine vertebrates, invertebrates, and plants (IT, 1994).

Table A-1
Ranking of 12 Sites Based on RFI/RI PRE Screening[1]

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Ecological PRE Rank	Site Number	Site Name
High	IR Site-1	Truman Annex Refuse Disposal Area
	IR Site-7	Fleming Key North Landfill
	IR Site-8	Fleming Key South Landfill
	SWMU-1	Boca Chica Open Disposal Area
	SWMU-2	Boca Chica DDT Mixing Area
Medium	SWMU-5	Boca Chica AIMD Building A-990
	SWMU-7	Boca Chica Building A-824
	AOC-A[2]	Demolition Key Open Disposal Area
	AOC-B[2]	Big Coppitt Key Abandoned Civilian Disposal Area
Low	SWMU-3	Boca Chica Fire Fighting Training Area
	SWMU-4	Boca Chica AIMD Building A-980
	IR Site-3	Truman Annex DDT Mixing Area

[1]Source: IT Corporation, 1994.
[2]Ranked by ABB-ES.

Notes: RFI/RI = Resource Conservation and Recovery Act (RCRA) Facility Investigation and Remedial Investigation.
PRE = Preliminary Risk Evaluation.
IR = Installation Restoration.
SWMU = solid waste management unit.
DDT = dichlorodiphenyltrichloroethane.
AIMD = Aircraft Intermediate Maintenance Department.
AOC = area of contamination.

Contaminated media at IR Site 7 include surface soil, surface water, sediment, and groundwater. During the RFI/RI investigation, concentrations of nickel were detected in surface soil. Surface water, samples contained concentrations of cyanide (810 $\mu g/\ell$) and mercury (0.25 $\mu g/\ell$), and sediment samples contained phenanthrene, lead, and mercury. Groundwater monitoring wells, several of which were placed near storm water discharge points into Man of War Harbor and the Gulf of Mexico, contained 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, and several inorganic chemicals at concentrations above background screening levels. The highest detected concentrations of antimony in a groundwater sample was 464 $\mu g/\ell$, and lead was 2,000 $\mu g/\ell$.

Based on the presence of pesticides and inorganics in media at the site, and the proximity to surface water, adverse risks to marine ecological receptors at the site may be a concern. IR Site 7 was ranked "high" in the Preliminary Screening Level Ecological Risk Evaluation conducted by IT Corporation (1994).

<u>IR Site 8: Fleming Key South Landfill</u>. IR Site 7 is a 45-acre pine forest area located on Fleming Key. A fence surrounds the area, which is bordered by a munitions storage area to the east and the City of Key West Sewage Treatment Plant to the south. Man of War Harbor is adjacent to the western shore. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, terrestrial plants, as well as marine vertebrates, invertebrates, and plants (IT, 1994).

Contaminated media at IR Site 8 include surface water, sediment, and groundwater. During the RFI/RI investigation, concentrations of mercury and tin were detected in surface water above background screening standards. Sediment samples contained concentrations of fluorene, phenanthrene, arsenic, lead, and mercury above background screening levels. Groundwater monitoring wells, several of which were placed near stormwater discharge points into Man of War Harbor, contained alpha-benzenehexachloride (BHC), and several inorganic chemicals at concentrations above background screening levels. The highest detected concentration of antimony in groundwater at a concentration of 236 $\mu g/\ell$, and lead at 553 $\mu g/\ell$.

Based on the presence of inorganics in media at the site and the proximity to surface water, adverse risks to marine ecological receptors at the site may be a concern. IR Site 8 was ranked "high" in the Preliminary Screening Ecological Risk Evaluation conducted by IT Corporation (1994).

<u>AOC A: Demolition Key Open Disposal Area</u>. AOC A is a 24-acre dredge spoil island in Man of War Harbor located north of Key West. Ecological receptors at the site include birds, terrestrial invertebrates, terrestrial plants, as well as marine vertebrates, invertebrates, and plants (IT, 1994).

Contaminated media at AOC A include surface soil and groundwater. During the RFI/RI investigation, surface soil samples contained concentrations of aluminum, antimony, arsenic, beryllium, lead, and nickel above background screening standards. The highest detected concentration of arsenic in surface soil samples was 19.3 mg/kg, and lead at 2,100 mg/kg. Sediment samples did not contain inorganics at concentrations that exceed background screening values. A single groundwater sample contained antimony, cadmium, copper, lead, nickel, and zinc at concentrations above background screening levels. Copper was detected in the groundwater sample at a concentration of 4,070 $\mu g/\ell$, and lead was detected at 1,610 $\mu g/\ell$.

AOC A was not ranked by IT Corporation (1994) in the Preliminary Screening Level Ecological Risk Evaluation. It has been assigned a rank of "medium" by ABB-ES based on the potential for adverse risk to ecological receptors.

AOC B: Big Coppitt Key Abandoned Civilian Disposal Area. AOC B is a 10-acre area located in a mangrove swamp on Big Coppitt Key. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and terrestrial plants, as well as aquatic vertebrates, invertebrates, and plants (IT, 1994).

Contaminated media at AOC B include surface soil, surface water, sediment, and groundwater. During the RFI/RI investigation, concentrations of arsenic, nickel, and tin were detected in surface soil samples at elevated levels. Surface water samples contained inorganics at concentration s the exceed background screening values. The highest detected concentration of mercury was 0.24 $\mu g/\ell$. Sediment samples contained phenanthrene, antimony, arsenic, cadmium, copper, lead, and mercury at concentrations above background screening levels. The highest detected concentration of lead in sediment at 237 mg/kg. AOC B groundwater monitoring wells contained several inorganic chemicals at concentrations above background screening levels. The highest detected concentration of lead was 309 $\mu g/\ell$.

Based on the presence of inorganics in environmental media at the site and the proximity to mangrove wetlands, risks to sensitive ecological receptors at the site may be a concern.

AOC B was not ranked by IT Corporation (1994) in the Preliminary Screening Level Ecological Risk Evaluation. It has been assigned a rank of "medium" by ABB-ES based on its potential for adverse ecological risks.

SWMU 1: Boca Chica Open Disposal Area. SWMU 1 is a 40-acre area located within a mangrove swamp and an area of sparse vegetation on Boca Chica Key. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, terrestrial plants, as well as aquatic vertebrates, invertebrates, and plants (IT, 1994).

Contaminated media at SWMU 1 include surface soil, surface water, sediment, and groundwater. During the RFI/RI investigation concentrations of several polynuclear aromatic hydrocarbons (PAHs), aldrin, lead, and nickel were detected in surface soil samples above background screening values. Surface water samples contained inorganic chemicals at concentrations above background screening values. The highest detected concentration of mercury was 0.32 $\mu g/\ell$. Sediment samples contained concentrations of several PAHs, 4,4'-DDD, 4,4'-DDE, cadmium, chromium, copper, lead, mercury, silver, and zinc. The highest detected concentrations of chromium, copper, and lead in sediment samples was 2,700 mg/kg, 3,930 mg/kg, and 12,300 mg/kg respectively.

Based on the presence of inorganics detected in surface water and sediment samples and the proximity to mangrove wetlands, adverse risks to terrestrial and aquatic ecological receptors at the site may be a concern. SWMU 1 was ranked "high" in the IT Corporation (1994) Preliminary Screening Level Ecological Risk Evaluation.

SWMU 2: Boca Chica DDT Mixing Area. SWMU 2 is a ¼-acre grassy area located near the flight line on Boca Chica Key. A drainage ditch with mangrove habitat runs east to west approximately 10 feet to the south of SWMU 2. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and terrestrial plants, as well as aquatic vertebrates, invertebrates, and plants (IT, 1994).

Contaminated media at SWMU 2 include surface soil and sediment. During the RFI/RI investigation, concentrations of 4,4,'-DDT, 4,4'-DDE, 4,4'-DDE, alpha-BHC, beta-BHC, gamma-BHC (Lindane), chlordane, arsenic, and nickel were detected in surface soil samples. The highest concentration of 4,4'-DDD detected in a surface soil was 240 mg/kg. Sediment samples contained 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, cadmium, copper, lead, mercury, and zinc. The highest concentration of 4,4,'-DDT detected in a sediment was 1.2 mg/kg.

Based on the presence of pesticides in media at the site, and proximity to the drainage ditch and mangroves, adverse risks to terrestrial and aquatic ecological receptors at the site may be a concern. SWMU 2 was ranked "high" in the IT Corporation (1994) Preliminary Screening Level Ecological Risk Evaluation.

SWMU 3: Boca Chica Fire Fighting Training Area. SWMU 3 is a 1-acre area with minimal vegetation located on Boca Chica Key. The site provides minimal terrestrial habitat. A mangrove fringe grows on the banks of a lagoon located approximately 75 feet from the site. Few ecological receptors are likely to occur at the site. Ecological receptors may include occasional terrestrial wildlife, terrestrial invertebrates, and terrestrial plants (IT, 1994).

During the RFI/RI investigation, samples of surface soil, groundwater, surface water, and sediment were collected from the site and a nearby lagoon. Contaminated media at SWMU 3 include groundwater, surface water, and sediment. Although several inorganic chemicals were detected in all media except surface soil, the concentrations were in general not substantially higher than ecological based screening values.

SWMU 3 was ranked "low" in the IT Corporation (1994) Preliminary Screening Level Ecological Risk Evaluation.

SWMU 4: Boca Chica AIMD Building A-980. SWMU 4, comprising two holes which formerly contained USTs, is located at the north and south walls outside of AIMD Building A-980 on Boca Chica Key. The site is very small and does not provide good terrestrial habitat. A ditch and wetlands area are located near the site. Ecological receptors at the site may include occasional terrestrial wildlife, terrestrial invertebrates, terrestrial plants, as well as aquatic vertebrates, invertebrates, and plants (IT, 1994).

Contaminated media potentially associated with SWMU 4 include groundwater, surface water, and sediment. During the RFI/RI investigation, samples of surface soil, groundwater, surface water, and sediment were collected from the site and a nearby drainage ditch. Contaminants did not seem to be related to analytes detected in surface water and sediment samples therefore, the source of phenanthrene, antimony, and lead detected in sediment samples, and lead in surface water samples is not certain.

Based on the lack of ecological habitat and exposure pathways at SMWU 4, the site was ranked "low" in the IT Corporation Preliminary Screening Level Risk Evaluation.

SWMU 5: Boca Chica AIMD Building A-990. SWMU 5 is a 65 by 90 foot area between two buildings located near the flightline on Boca Chica Key. The area is covered with pavement and several inches of black sand-blasting agent. A concrete drainage ditch that collects surface water runoff is located behind the AIMD buildings at the base of an earthen berm. This drainage ditch directs water to a culvert to the west which empties into a tidal area containing mangroves. Sand-blasting agent is present in the drainage ditch. Ecological receptors downgradient from the site may include aquatic vertebrates, invertebrates, and plants (IT< 1994).

Contaminated media at SWMU 5 include surface water and sediment. During the RFI/RI investigation, samples of surface soil, groundwater, surface water, and sediment were collected from the site and a nearby drainage ditch. Surface soil did not contain target analytes representative of paint removal and sand blasting agents. Concentrations of arsenic, cadmium, chromium, copper, lead, and zinc were detected in sediment samples collected in the drainage ditch downstream of the site. The highest concentration of lead detected in a sediment sample was 966 mg/kg. Surface water samples contained inorganics at concentrations slightly above background screening criteria.

Based on the presence of inorganics in the drainage ditch, adverse risks to aquatic ecological receptors at the site may be of concern. SWMU 5 was ranked "medium" in the IT Corporation (1994) Preliminary Screening Level Ecological Risk Evaluation.

SWMU 7: Boca Chica Building A-824. SWMU 7 is a small, grassy area surrounded by a chain-link fence. The site provides no significant terrestrial habitat (IT, 1994). On the west and southwest of the site, approximately 40 feet from Building A-824, there is a small canal containing water that possibly drains to a ponded area to the northwest of the site. Ecological receptors at the site may include aquatic vertebrates, invertebrates, and plants (IT, 1994).

Contaminated media at SWMU 7 include surface soil and sediment. During the RFI/RI investigation, samples of surface soil, groundwater, surface water, and sediment were collected from the site and a nearby canal. PCBs, cyanide and tin were detected in surface soil samples. .

SWMU 7 was assigned a "medium" rank in the IT Corporation (1994) Preliminary Screening Level Ecological Risk Evaluation.

Ecological Hazard Assessment and Selection of Ecological Contaminants of Potential Concern (ECPCs) The Hazard Assessment will include a review of analytical data and selection of ECPCs. ECPCs represent the analytes detected in environmental media (surface soil, surface water, sediment, and groundwater) that are considered in the risk assessment process. The ECPCs are assumed to be associated with hazardous waste practices at NAS Key West.

Pursuant to USEPA national guidance (1989a and 1989b), analytical data for each site at NAS Key West will be evaluated to determine their validity for use in risk assessment. For each site, ECPCs will be selected for each medium of concern (surface soil, sediment, surface water, and groundwater). Analytes will be excluded as ECPCs if:

- the site concentrations are within 5 to 10 times the concentrations detected in associated trip blanks or method blanks,

- they are detected in 5 percent or less of the samples analyzed, or

- the maximum detected concentration is less than 2 times the average concentrations detected in respective background samples.

ECPCs for aquatic life for groundwater, surface water, and sediment samples will be screened based on an additional step. Analytes detected in sediment samples will be excluded as ECPCs if the maximum concentration detected is lower than the USEPA Region IV screening values for sediment. Analytes detected in surface water and groundwater will be excluded as an ECPC if the maximum concentration detected is lower than the USEPA Region IV screening values for surface water. Calcium, magnesium, potassium, and sodium will be excluded as ECPCs for surface water, surface soil, sediment, and groundwater as they are considered to be essential nutrients.

Tentatively identified compounds (TICs) will be evaluated based on suspected presence at each site under consideration, migration potential via each of the identified exposure pathways, and the chemical's toxicity. A list of TICs of concern will be formulated after consideration of these factors. The TICs of concern will be evaluated qualitatively in the ecological risk assessment.

Ecological Exposure Assessment Exposure assessment is the process of estimating or measuring the amount of an ECPC in environmental media (surface soil, surface water, sediment, or groundwater) to which an ecological receptor may be exposed via respective exposure routes (ingestion or direct contact). The following subsections discuss how contaminant exposures will be estimated or measured for aquatic life, terrestrial wildlife, terrestrial plants, and terrestrial invertebrates.

Identification and Characterization of Ecological Receptors and Habitat Potential ecological receptors will be identified based on information obtained during the ecological field survey and literature review. Information will be collected during the ecological survey to describe the plant communities on each waste site and the surrounding area. The plant community information will be used to characterize the habitat provided for terrestrial wildlife species. Information will also be collected to describe the aquatic communities present near several sites at NAS Key West. The ecological field program and literature review is described in the accompanying SAP.

Potential ecological receptors include terrestrial and wetlands wildlife, aquatic life, terrestrial plants, and terrestrial invertebrates. Wildlife species include reptiles, amphibians, birds, and mammals. Potential aquatic receptors include plants, algae, invertebrates, amphibians, and fish.

Identification of Exposure Pathways Exposure pathways will be identified at each site based on information generated in the ecological survey. Exposure pathways describe how ecological receptors may come into contact with contaminated media and include: (1) the contaminant source, (2) the means of transport from source to environmental medium (soil, water, or air), (3) the point of receptor contact (soil, water, or food), and (4) the exposure route (e.g., ingestion, dermal contact, or inhalation). Exposure pathways will be evaluated for aquatic receptors, terrestrial wildlife, terrestrial plants, and terrestrial invertebrates as follows.

Aquatic Receptors. Freshwater and marine organisms potentially exposed to contamination include fish, invertebrates, aquatic plants, and amphibians. Potential exposure pathways for aquatic receptors include direct contact with surface water, sediment, and groundwater (as it discharges to surface water). Aquatic receptors may also be exposed to contamination in sediment as the result of ingestion of the sediment. This pathway will only be evaluated, however, if information is available on the amount of sediment ingested by aquatic organisms and the toxicity of contaminants to aquatic life via the ingestion exposure route. If necessary, as described in the SAP and based on the process outlined on Figure A-2, toxicity tests may be conducted to evaluate exposure to aquatic organisms.

Terrestrial and Wetlands Wildlife. The primary potential exposure route for wildlife at NAS Key West is ingestion of surface soil and food items that are contaminated as a result of accumulation of contamination from soil, surface water, and sediment. Exposures related to dermal contact are possible but not usually evaluated as an assumption is made that fur, feathers, or chitinous exoskeleton limit the transfer of contamination across the dermis. Exposures related to inhalation of dust or vapors are also possible but not often evaluated as this pathway is generally considered an insignificant route of exposure except in unusual circumstances, such as following a spill or release.

A subset of species identified during the ecological characterization will be selected to represent the terrestrial wildlife populations inhabiting the sites and surrounding areas for the purpose of the ERA. Representative species will be chosen to represent the species most likely to be exposed to high contaminant concentrations because of their position in the food web, diet (ingestion rate and food type), home range (contained within the area of soil contamination), and body size. The species selected will be assumed to be representative of other species within the same trophic level.

For each of the representative species, information on life history will be collected including diet, average body weight, food ingestion rates, water ingestion rates, home range, and exposure durations (percent of year that a receptor may reside at the site). This information will be used in simple food web models to evaluate ecological exposure to wildlife receptors.

Terrestrial Plants and Invertebrates. Terrestrial plants and soil invertebrates may be exposed to contamination in surface soil by direct contact with soil.

Terrestrial invertebrates may also be exposed to contamination as a result of incidental ingestion of the soil. Terrestrial plants may be exposed to contamination in groundwater where roots reach a zone of saturation.

If necessary, as described in the SAP and based on the process outlined on Figure SAP, terrestrial toxicity tests may be conducted to evaluate exposure to terrestrial plants and invertebrates.

Chemical Exposure Levels Exposure concentrations for ecological receptors evaluated in the ERA will include the maximum and average (mean) concentrations of ECPCs measured in surface water, sediment, or surface soil at respective sampling locations. Maximum and mean concentrations of the ECPCs measured in surface soil samples will be used to estimate exposures for terrestrial wildlife via a simple model to predict dietary exposures in the diet for each receptor species evaluated. When toxicity tests are conducted, the actual concentrations of contaminants in the environmental media evaluated will be the exposure points evaluated in the risk assessment.

Ecological Effects Assessment The ecological effects assessment will describe the potential adverse effects to ecological receptors associated with the identified ECPCs. The methods that will be used to identify and characterize ecological effects for aquatic life, terrestrial and wetlands wildlife, terrestrial plants, and terrestrial invertebrates are described in the following subsections.

Identification of Endpoints An endpoint is an expected or anticipated effect of a contaminant on an ecological receptor. Assessment endpoints represent the ecological component to be protected, whereas the measurement endpoints approximate or provide a measure of the achievement of the assessment endpoint. The assessment endpoint is conservative, as the purpose of the assessment is to screen for any potential adverse effect to a receptor. Preliminary assessment endpoints will be identified for aquatic receptors, terrestrial wildlife, terrestrial plants, and terrestrial invertebrates as follows. Table A-2 summarizes the endpoints to be used in the Supplemental RFI/RI program for ecological risk assessment.

<u>Aquatic Receptors</u>. The assessment endpoint for aquatic receptors is the survival and maintenance of a well-balanced benthic macroinvertebrate community structure and function. Survival and maintenance of fish and aquatic plant populations is a second assessment endpoint. The measurement endpoints are field-collected and/or literature-derived laboratory toxicity test results that show reduced growth, or adverse effects on reproduction, behavior, or mortality of aquatic receptors.

<u>Terrestrial and Wetland Wildlife</u>. The assessment endpoint selected for wildlife is the maintenance of well-balanced terrestrial populations and communities. The measurement endpoints are laboratory toxicity test results reported in the literature which show reduced growth, adverse effects on reproduction, behavior, or mortality.

<u>Terrestrial Plants and Invertebrates</u>. The assessment endpoint selected for terrestrial plants and soil invertebrates is the survival, growth, and reproduction of terrestrial invertebrate and plant communities. This endpoint will be measured through literature-derived and/or field toxicity testing of

Table A-2
Preliminary Endpoints for Ecological Assessment at Naval Air Station (NAS) Key West

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Media	Receptor	Assessment Endpoint	Measurement Endpoint
Surface/-Groundwater	Aquatic Life (invertebrates, fish, plants and amphibians)	Survival and maintenance of benthic macroinvertebrate community structure and function.	Contaminant concentrations in surface water associated with adverse effects to growth, reproduction or survival of aquatic organisms.
		Survival and maintenance of fish, macroinvertebrate, and aquatic plant populations.	Toxicity testing of water.
Sediment	Aquatic Life (invertebrates, fish, plants and amphibians)	Survival and maintenance of benthic macroinvertebrate community structure and function.	Toxicity testing of sediment.
		Survival and maintenance of fish, macroinvertebrate, and aquatic plant populations.	Contaminant concentrations in sediment associated with adverse effects to growth, reproduction, or survival of aquatic organisms.
Surface Water, Sediment and Surface Soil	Terrestrial and Wetlands Wildlife	Survival of wildlife populations and communities.	Oral contaminant exposure concentrations representing adverse effects to growth, reproduction, or survival of mammalian or avian laboratory test populations.
Surface Soil	Terrestrial Invertebrates	Survival of terrestrial invertebrate communities	Survival and growth of earthworms exposed to surface soil samples in laboratory toxicity tests.
Surface Soil	Terrestrial Plants	Survival, reproduction, and growth of plant communities.	Germination of lettuce seeds exposed to surface soil samples in laboratory toxicity tests.

plant and invertebrate with surface soil samples. Site-specific laboratory toxicity testing will provide a direct measure of the toxicity of the mixture of contaminants in soil to a terrestrial invertebrate and plant species.

Selection of Literature-Derived Toxicity Benchmark Values

Aquatic Receptors. Available toxicity benchmarks for each of the ECPCs in surface water will be identified. State of Florida Surface Water Quality Standards Federal Ambient Water Quality Criteria (AWQC), and Florida Sediment Quality Assessment Guidelines (1994) will be considered. Additional aquatic toxicity information for the ECPCs will be obtained from searches of the USEPA Aquatic Information Retrieval (AQUIRE) database.

Wildlife. Reference Toxicity Values (RTVs) will be determined for each ECPC for both avian and mammalian receptors. The RTV relates the dose of a respective ECPC in an oral exposure with an adverse effect. For each ECPC identified and each representative wildlife species selected, two RTVs will be identified. A lethal RTV will be selected that represents the threshold for lethal effects and is based on an oral LD_{50} (oral dose lethal to 50 percent of a test population). The lethal RTV is one-fifth of the lowest reported LD_{50} for the most closely related test species. One fifth of an oral LD_{50} value is considered to be protective of lethal effects for 99.9 percent of individuals in a test population. An assumption will be made that the value represented by one fifth of an oral LD_{50} would be protective of 99.9 percent of individuals within the terrestrial wildlife populations present at NAS Key West sites and represents a level of acceptable risk.

A sublethal RTV also will be identified that represents a threshold for sublethal effects. Sublethal effects are defined as those based on the measurement endpoint, impairment of reproduction, growth, or survival. When data are available, RTVs will be derived separately for avian and mammalian species. If toxicity information is not available for an ECPC, it will not be possible to identify RTVs and risks associated with the predicted exposure for the respective ECPC cannot be evaluated. The absence of toxicity information for an ECPC will be discussed as part of the uncertainty analyses.

Terrestrial Plants and Invertebrates. Terrestrial phytotoxicity data will be obtained from literature sources. Generally, data will be identified that represent significant phytotoxic endpoints, such as reduction in root weight or decreases in top weight. Because data for each ECPC may not be available, surrogate values may be assigned.

In order to assess potential effects of surface soil contaminants on terrestrial invertebrates (e.g., earthworms), toxicity data for earthworms will be obtained from the literature. In general, toxicity data for reproductive effects, which are generally more sensitive toxicity endpoints than lethality effects, will be chosen as benchmarks.

Risk Characterization The purpose of the Ecological Risk Characterization will be to combine the results of the exposure and effects assessments to characterize the ecological risks at NAS Key West. This section will identify ecological receptors that might be at risk from site-related contamination.

Potential risks to wildlife will be described using the following hazard index approach. The estimated doses or exposure concentrations will be compared to benchmark values identified in the toxicity assessment. Hazard Quotients (HQs) will be calculated for each chemical by dividing the exposure concentration by the benchmark value. These HQs will be summed into a cumulative hazard index (HI). As the HI increases in magnitude, the likelihood for adverse ecological effects increases. When the estimated HQ is less than 1, the contaminant exposure will be assumed to fall below the range considered to be associated with adverse effects for growth, reproduction and survival (of the individual organism), and no risks to the wildlife populations will be assumed. When the HQ or HI is greater than 1, a discussion of the ecological significance will be included. When HIs are greater than 1, an evaluation of the HQs comprising the HI will be completed.

This hazard ranking scheme evaluates potential ecological effects to individual organisms and does not evaluate potential population-wide effects. Contaminants may cause population reductions by affecting birth and mortality rates, immigration, and emigration (USEPA, 1989a). In many circumstances, lethal or sub-lethal effects may occur to individual organisms with little population or community level impacts; however, as the number of individual organisms experiencing toxic effects increases, the probability that population effects will occur also increases. The number of affected individuals in a population presumably increases with increasing HQ or HI values; therefore, the likelihood of population level effects occurring is generally expected to increase with higher HQ or HI values.

Risks for terrestrial and aquatic receptors at sites that undergo toxicity testing will be characterized based on a weight-of-evidence evaluation of the following factors:

- presence or absence of analytes in surface soil, surface water, or sediment samples;

- concentrations of analytes measured in surface soil, surface water, and sediment samples;

- responses of candidate species in laboratory toxicity tests;

- HIs calculated based on surface soil exposures to terrestrial wildlife, plants, and invertebrates;

- concentrations of ECPCs in surface water relative to reported toxicity of the ECPC in laboratory tests (AQUIRE information), Federal AWQC, Florida Sediment Quality Assessment Guidelines (1994) and Florida Surface Water Quality Standards; and

- concentrations of ECPCs in sediment relative to available sediment quality guidelines.

The ecological risk characterization section will also contain a discussion of visual observations of any ecosystem degradation or other symptoms of environmental stress observed during the qualitative ecological survey.

Uncertainty Analyses Uncertainties in the ERA process will be identified and discussed. The emphasis of the uncertainty analyses will be to discuss the assumptions and data gaps of the ERA process that may influence the risk characterization results and assessment conclusions.

__Ecological/Biological Field Sampling Program for SWMU Sites__ An ecological and biological field sampling program for the NAS Key West SWMU sites will be developed based on the process outlined on Figure A-2. In general, the process will include a review of the existing analytical chemistry data, an analysis of the results from the RFI/RI preliminary ecological risk evaluation (IT Corporation, 1994), and a site visit. Information obtained in this step will be used in a preliminary problem formulation for the sites. The preliminary screening and problem formulation may be sufficient to determine that no further action is necessary at an individual site, or if uncertainties exist, additional data may be collected to reduce the uncertainties associated with the preliminary problem formulation. An ecological risk assessment will be completed at each site where the preliminary problem formulation suggests that ecological risk is a concern. The ecological risk assessment will commence with a second problem formulation phase; in this step the need for biological and toxicological sampling on a site-by-site basis will be evaluated. When biological and/or toxicological sampling is required to evaluate ecological risks, an addendum to the SAP will be prepared to provide specific details regarding the sampling event(s). Final recommendations for biological field sampling (toxicity testing, tissue analysis, or a community survey) will be made in an addendum to the SAP. Additional detail regarding the biological and toxicity evaluation tool that will be used at NAS Key West can be found in Volume II (SAP) of this Supplemental RFI/RI workplan.

Results of the RFI/RI (IT Corporation, 1994) preliminary ecological risk evaluations indicate that toxicity sampling may be recommended for SWMU Sites 1, 2, and 5. In addition, tissue contaminant burden analysis may provide information regarding those compounds that bioaccumulate and/or bioconcentrate in food chains. Bioaccumulation and biomagnification of environmental contaminants in plant or animal tissues may need to be evaluated at SWMU Sites 1 and 2, based on concentrations of DDT, lead, mercury, and silver. Table A-3 presents a preliminary set of biological and ecological field sampling recommendations, which will be finalized in future SAPs for the sites.

__Ecological and Biological Field Sampling for IR Sites__ An ecological and biological field sampling program for the NAS Key West IR sites will be developed based on the process outlined on Figure A-2. In general, the process will include a review of the existing analytical chemistry data, an analysis of the results from the RFI/RI preliminary ecological risk evaluation (IT Corporation, 1994), and a site visit. Information obtained in this step will be used in a preliminary problem formulation for the sites. The preliminary screening and problem formulation may be sufficient to determine that no further action is necessary at an individual RI/RFI site, or if uncertainties exist, additional data may be collected to reduce the uncertainties associated with the preliminary problem formulation. An ERA will be completed at each site where the preliminary problem formulation suggests that ecological risk is a concern. The ERA will commence with a second problem formulation phase; in this step the need for biological and toxicological sampling on a site-by-site basis will be evaluated. When biological and/or toxicological sampling is required to evaluate ecological risks, a SAP will be prepared to provide specific details regarding the sampling event(s). Final recommendations for biological field sampling (toxicity testing, tissue analysis, or a community survey) will be made in the SAP. Additional detail regarding the biological and toxicity evaluation tool that may be used at NAS Key West can be found in Volume II (SAP) of this Supplementary RFI/RI workplan.

Results of the RFI/RI (IT Corporation, 1994) preliminary ecological risk evaluations indicate that toxicity sampling may be recommended for IR Sites 1, 7, 8, and AOC A. In addition, tissue contaminant burden analysis may provide

Table A-3
Proposed Ecological Activities at SWMU Sites

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Site ID	Site Name	Toxicity Testing		Tissue Analysis/ Bioaccumulation Study	
		Terrestrial	Aquatic	Terrestrial	Aquatic
SWMU-1	Boca Chica Open Disposal Area	X	X	X	X
SWMU-2	Boca Chica DDT Mixing Area		X		X
SWMU-5	Boca Chica AIMD Building A-990		X		

Notes: X = Based on a review of the RFI/RI (IT Corporation, 1994), biological sampling may be recommended. A final determination regarding the need for and scope of biological sampling at these sites will be made in the Problem Formulation #2 phase of work (see Figure B-2)
SWMU = solid waste management unit.
DDT = dichlorodiphenyltrichloroethane.
AIMD = Aircraft Intermediate Maintenance Department.

Table A-4
Proposed Ecological Activities at IR Sites

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Site ID	Site Name	Toxicity Testing		Tissue Analysis/ Bioaccumulation Study	
		Terrestrial	Aquatic	Terrestrial	Aquatic
IR Site-1	Truman Annex Refuse Disposal Area		X		X
IR Site-7	Fleming Key North Landfill		X		X
IR Site-8	Fleming Key South Landfill		X		
AOC B	Big Coppitt Key Abandoned Civilian Disposal Area		X		

Notes: X = Based on a review of the RFI/RI (IT Corporation, 1994), biological sampling may be recommended. A final determination regarding the need for and scope of biological sampling at these sites will be made in the Problem Formulation #2 phase of work (see Figure B-2).
IR = Installation Restoration.
AOC = area of contamination.

information regarding those compounds that bioaccumulate and/or bioconcentrate in food chains. Bioaccumulation and biomagnification of environmental contaminants in plant or animal tissues may need to be evaluated at IR Sites 1 and 7, based on concentrations of PCBs, DDT, lead, mercury, and silver. Table A-4 presents a preliminary set of biological/ecological field sampling recommendations, which will be finalized in future SAPs for the sites.

REFERENCES

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APPENDIX B

HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

HUMAN HEALTH RISK ASSESSMENT.

B1.0 Human Health Risk Assessment Methodology The Human Health Risk Assessment (HHRA) for RFI/RI activities at NAS Key West will be conducted according to CERCLA guidance for conducting risk assessments. USEPA Region IV has indicated that evaluation of risks for RCRA sites be evaluated per CERCLA risk assessment methods. The following Federal and Region IV USEPA and FDEP guidelines are used to direct and support the HHRA:

Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A (USEPA, 1989a);

- Supplemental Region IV Risk Assessment Guidance (USEPA, 1991a);
- Exposure Factors Handbook (USEPA, 1989b);
- Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors (USEPA, 1991b); and
- Guidance for Data Useability in Risk Assessment (Part A) (USEPA, 1992b)
- Soil Cleanup Goals for the Military Sites (FDEP, 1995)

The State of Florida environmental standards and guidelines are integrated into this supplemental RFI/RI HHRA.

The purpose of the HHRA is to characterize the risks, both current and future, associated with potential exposures to site-related contaminants at NAS Key West.

Risk Screening. A risk screening will be conducted to determine if a site requires a baseline HHRA. Unless it is obvious that there is one or more complete exposure pathways and there is likely to be high levels of exposure and associated human health risks, a preliminary risk evaluation will be conducted to determine if a baseline risk assessment is necessary for each site. The preliminary risk evaluation will determine if there are currently, or might be in the future, completed exposure pathways that could result in exposure and will compare site-related chemical concentrations to conservative risk-based screening values and chemical-specific applicable or relevant and appropriate requirements (ARARs) and guidance values for complete exposure pathways. The preliminary risk evaluation will be similar in nature to the technical approach for selection of chemicals of potential concern described below. If the preliminary risk evaluation determines there are no complete exposure pathways or that chemical concentrations in complete exposure pathways are associated with de minimis risk levels, a recommendation for no further action may be made. For other sites, baseline human health risk assessments will be performed.

Preliminary risk evaluations are recommended for SWMU-2, SWMU-3, SWMU-4, SWMU-5, SWMU-9, IR No. 3, IR No. 7, IR No. 8, AOC SITE A, and AOC SITE B. At each of those areas, available chemical data indicate that soil, surface water, and sediment exposures may not be associated with substantial human health risks. At several of these sites, there is groundwater contamination, but with no current groundwater exposure and unlikely future groundwater exposure, human health risks associated with groundwater appear to be minimal. The groundwater is Class G-III and is not considered potential drinking water source (FDEP, 1992). At several sites, potential for groundwater discharge to surface water

1992). At several sites, potential for groundwater discharge to surface water exists. That potential discharge is associated with potential exposure to chemicals in surface water and possibly to chemicals in fish or shellfish. However, groundwater discharging to the ocean will be diluted by the tremendous volumes of water, and compounds most often considered to be bioaccumulative (mercury and PCBs, for example) are not generally present at elevated concentrations in groundwater. Therefore, in general, these indirect exposures do not appear to be significant from a human health risk perspective.

Antimony has been reported in numerous groundwater samples in several sites. Further investigation of background concentrations of antimony in groundwater in Key West and possible sources of antimony in groundwater is recommended. Although the groundwater is saline, it does not appear that seawater has an antimony content which explains the widespread detection of antimony in groundwater at concentrations in excess of 100 $\mu g/\ell$. Dissolved antimony background concentrations in seawater are reported to be on the order of 0.2 $\mu g/\ell$ (Sturgeon et al., 1985; Miller et al, 1985; Forstner et al., 1981). The mean background concentration of antimony in groundwater at Key West unfiltered, has been reported to be 42 $\mu g/\ell$ (IT Corporation, 1994).

A baseline HHRA is composed of five parts: (1) data evaluation and summarization, (2) identification of Human Health Chemicals of Potential Concern (HHCPCs), (3) an exposure assessment covering both present and future uses of the site, (4) a toxicity assessment of HHCPCs, and (5) a risk characterization with an uncertainty analysis. The following discussions identify in detail the activities involved in the baseline.

<u>B1.1 Data evaluation and summarization</u>. The data evaluation involves numerous activities, including: sort data by medium, evaluate analytical methods, evaluate quantitation limits, evaluate quality of data with respect to qualifiers and codes, evaluate tentatively identified compounds (TICs), compare potential site-related contamination with background, develop data set for use in risk assessment, and identify CPCs. After a brief summary of the sampling and analysis activities conducted to date is presented, a description of each of these activities is provided below.

Sort Data by Medium. The analytical data will be compiled and sorted by medium. For each medium, the amount and quality of the data will be evaluated to determine if a quantitative risk assessment can be conducted. If additional data are required to conduct a baseline risk assessment, a recommendation for further sampling and analysis will be made.

Evaluate the Analytical Methods. A detailed discussion of the analytical methods employed in developing analytical environmental data will be presented in the RFI/RI report. The data used in this risk assessment will be the result of analyses conducted with documented QA/QC procedures. The analytical data will be further evaluated for useability in the quantitative risk assessment by evaluating quantitation limits, evaluating qualified and coded data, comparing concentrations detected in samples to concentrations detected in blanks, and by evaluating TICs.

Evaluate Quantitation Limits. Sample Quantitation Limits (SQLs) will be compared to Federal and State risk-based concentrations (RBCs), standards, and guidance values for each medium evaluated. Analyte-specific SQLs which are above RBCs, standards, or guidelines will be identified so that uncertainties in risk estimates for those analytes can be discussed.

Evaluate Qualified and Coded Data. Both the laboratory and data validators may assign qualifiers to analytical results. The qualifiers assigned by the data validators supersede the laboratory qualifiers. The results of the data validation will be discussed in the RFI/RI report and the validated data, with qualifiers, will be presented in Appendices to that report. All positive detections (whether they are unqualified or qualified with a "J") will be considered detected concentrations for the risk assessment. All nondetects (qualified with a "U" qualifier) will be retained in the risk assessment data set as samples without positive detections. If all sample results for a given analyte in a given medium are non-detects, then that analyte will not be retained as a detected analyte for the purposes of the risk assessment. Any sample results with an "R" validation qualifier will be eliminated from the risk assessment data set because quality control indicates that the result is unusable.

Compare Concentrations Detected in Samples to Concentrations Detected in Blanks. Sample concentrations will be compared to the concentrations in associated blanks in order to distinguish artifacts from actual presence of analytes in environmental samples. The comparisons will be conducted as part of the data validation process which has been previously discussed. Those sample results considered artifacts will be identified in the RFI/RI report.

Evaluate Tentatively Identified Compounds (TICs). TICs (both the identity and concentration are uncertain) will be reviewed. If the number of TICs is small relative to the TAL and Appendix IX chemicals and there is no historical information to suggest the TICs should be present, the TICs will not be quantitatively evaluated. If the number of TICs is large relative to the TAL and Appendix IX chemicals, the TICs will be included in the quantitative evaluation and the uncertainty in the identity and concentrations of these analytes will be fully discussed in the uncertainty analysis.

Develop Data Set For Use In Risk Assessment. Data management concludes with the summarization of data and statistics generation for each data set. Summary tables provide the chemical name, the frequency of detection, the minimum and maximum detected concentrations, the units associated with the results, the minimum and maximum quantitation limits, and the average of the detected concentrations. These tables are produced for each medium at each site.

The selection of surface soil, groundwater, surface water, and sediment, monitoring data will be conducted after a full evaluation of the useability of the available data.

B1.2 Identification of Human Health Chemicals of Potential Concern (HHCPCs)

HHCPCs are selected from all analytes detected at the site. The selection of HHCPCs from all detected analytes in each media is based on the analytes' concentration, frequency of detection, comparison to background, and USEPA and Florida medium-specific screening criteria.

Chemicals that do not contribute significantly to human health risks are removed or "screened" from further consideration as HHCPCs, as recommended by USEPA (1991a). Analytes are excluded as HHCPCs if they meet any of the following criteria.

1. If the maximum detected concentration is less than twice the arithmetic mean of the background concentration (inorganics only) (USEPA, 1991a, 1993a) the analyte is excluded.

2. If the maximum detected concentration is less than the corresponding risk-based or ARAR-based screening concentration(s) the analyte is excluded. Risk-based screening concentrations are obtained from USEPA Region III (USEPA, 1994d) and FDEP (FDEP, 1995). The USEPA RBCs correspond to excess lifetime cancer risks of 1×10^{-6} or an HQ of 0.1. ARAR-based (and guidance-based) screening concentrations (both Federal and State of Florida) include published standards and guidelines.

   Recommended screening concentrations for HHCPC selection include:

   Surface Soil

   1. USEPA Region III RBCs (from USEPA, 1994d with updates). Each RBC is associated with cancer risk not greater than 10^{-6} and hazard quotient not greater than 0.1. Residential RBCs will be applied.

   2. FDEP soil cleanup goals for military sites (FDEP, 1995). Residential RBCs will be applied.

   Subsurface Soil

   1. USEPA Region III RBCs for surface soil will be used as a conservative screening value for direct contact exposures.

   2. FDEP leaching-based soil cleanup goals for the military sites will be used to select subsurface soil human health CPCs where the chemicals have been detected in groundwater.

   Surface Water

   1. USEPA Region III RBCs for tap water (USEPA, 1994d with updates). Each RBC is associated with cancer risk not greater than 10^{-6} and HQ not greater than 0.1.

   2. Florida Surface Water Quality Standards (FSWQS) (Florida Legislature, 1995) as appropriate. Standards for Class III waters will be used as appropriate. Standards based only on aquatic life protection will be identified but will not be used to select human health CPCs.

3. Florida Guidance Concentrations (FDEP, 1994). This compilation includes Florida primary standards, secondary standards, and guidance concentrations for carcinogens, systemic toxicants, and organoleptic considerations.

Sediments

1. USEPA Region III RBCs for soil will be used as a conservative screening value for sediments. Each RBC is associated with cancer risk not greater than 10^{-6} and HQ not greater than 0.1. Industrial or residential values will be selected based on the current and foreseeable future use of each site.

2. Sediment Quality Guidance Values from "Development of an Approach to the Assessment of Sediment Quality in Florida Coastal Waters" (FDEP, 1993). These values will be identified, but only criteria based on human health risk (if any) will be used in selection of HHCPCs.

Groundwater

1. If groundwater is determined to be Class G-III, minimum criteria for groundwater (FAC 62-302.400) will be considered applicable and possible human exposures will be identified. If no human exposures are identified, human health risk associated with direct exposures to groundwater will not be evaluated.

2. If groundwater is determined to be used as potable water, USEPA RBCs for tapwater, Federal maximum contaminant levels, and Florida groundwater guidance concentrations (including Primary standards, Secondary Standards, and guidance concentrations) (FDEP, 1992 and FDEP, 1994) will be used in HHCPC selection.

   Lead is a special case due to a lack of toxicity data. Based on a USEPA recommendation, a target cleanup level for lead in soil at Superfund sites of 400 mg/kg is used as the screening value (USEPA, 1994a). For groundwater and surface water, the drinking water treatment technology action level of 15 $\mu g/\ell$ is used as a screening value. (USEPA, 1994b).

3. If the frequency of detection is less than 5 percent and the analyte is not an HHCPC in any other media, the analyte is excluded.

<u>**B1.3 Human Health Exposure Assessment**</u>. Exposure assessment estimates the types and magnitudes of potential human exposure to HHCPCs. This process involves four steps:

- characterization of the exposure setting,
- identification of exposure pathways,
- construction of exposure scenarios, and
- quantification of exposures.

B1.4 Characterization of Exposure Setting. The physical characteristics of the site and the nature of the surrounding populations are evaluated to provide a basis for assessing potential exposures. The HHRA summarizes important site characteristics that may influence human contact with site contaminants including surface conditions, soil type, degree of vegetative cover, climate, geology, and conditions that affect the migration of contaminants, such as speed and direction of groundwater flow.

Evaluation of population characteristics includes the location of current populations relative to the site and the daily activities of these populations. The presence and location of potentially sensitive subpopulations, such as children or elderly, are also evaluated.

B1.5 Identification of Exposure Pathways. This step involves the identification of all relevant exposure pathways through which specific populations may be exposed (current and future) to contaminants at the site. An exposure pathway consists of four necessary elements: a source or mechanism of chemical release, a transport or retention medium, a point of human contact, and a route of exposure at the point of contact (USEPA, 1989a).

The first step in defining potential exposure pathways is to identify all sources of contamination (i.e., surface water, groundwater, and surface soil). Once sources are identified, relevant fate and transport mechanisms are evaluated to predict current and potential future exposures. Population characteristics are then used to identify where people may contact contaminated media and the possible routes of exposure (i.e., inhalation, ingestion, or dermal absorption). The receptors to be evaluated are selected based on the current and realistic future use of the sites and surrounding area. Site-specific exposure pathways are identified for each site. For most sites, up to five potentially exposed population scenarios may be used: residents, both child and adult; trespassers, both child and adult; site maintenance worker; full-time onsite worker; and excavation worker. Table B-1 is a list of typical exposure pathway scenarios and Table B-2 illustrates complete exposure pathways by exposure scenario. Each site HHRA identifies and evaluates those exposure pathways likely to be encountered at the site.

Trespasser, full-time on-site worker and site maintenance worker scenarios represent current land use for most sites at NAS Key West. The residential scenarios represent future land use because the land is not currently being used by a residential population but could potentially be used in the future. Groundwater in the area is saline, classified as Class G-III, and is unsuitable for current or future use as drinking water. The excavation and full-time onsite worker scenarios are also considered future land use.

Table B-1
Summary of Anticipated
Exposure Scenarios

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

SWMU or AOC	NAME	CURRENT LAND USE RECEPTORS	EXPOSURE MEDIA AND EXPOSURE ROUTES
SWMU-1	BOCA CHICA OPEN DISPOSAL AREA*	TRESPASSER NEIGHBORHOOD RESIDENT	SOIL - INGESTION, DERMAL SEDIMENT - INGESTION, DERMAL SURFACE WATER - INGESTION, DERMAL GROUNDWATER-TO BE DETERMINED
SWMU-2	BOCA CHICA DDT MIXING AREA	TRESPASSER MAINTENANCE WORKER	SOIL - INGESTION, DERMAL, INHALATION DUST
SWMU-3	BOCA CHICA FIRE-FIGHTING TRAINING AREA	TRESPASSER	SOIL - INGESTION, DERMAL, INHALATION-DUST
SWMU-4	BOCA CHICA AIMD BUILDING A-980	FULL-TIME ON-SITE WORKER	SOIL - INGESTION, DERMAL, INHALATION OF DUST

See notes at end of table.

Table B-1 (Continued)
Summary of Anticipated Exposure Scenarios

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

SWMU or AOC	NAME	CURRENT LAND USE RECEPTORS	EXPOSURE MEDIA AND EXPOSURE ROUTES
SWMU-5	BOCA CHICA AIMD BUILDING A-990	FULL-TIME ON-SITE WORKER	SOIL - INGESTION, DERMAL, INHALATION-DUST
SWMU-7	BOCA CHICA BUILDING A-824	TBD	TBD
SWMU-9	JET ENGINE TEST CELL AREA	FULL-TIME ON-SITE WORKER	TO BE DETERMINED
IR-1	TRUMAN ANNEX REFUSE DISPOSAL AREA	TRESPASSER MAINTENANCE WORKER	SOIL - INGESTION, DERMAL, INHALATION-DUST
IR-3	TRUMAN ANNEX DDT MIXING AREA	TRESPASSER (NEIGHBORHOOD RESIDENT)	SOIL - INGESTION, DERMAL, INHALATION-DUST GROUNDWATER - TO BE DETERMINED

See notes at end of table.

Table B-1 (Continued)
Summary of Anticipated Exposure Scenarios

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

SWMU or AOC	NAME	CURRENT LAND USE RECEPTORS	EXPOSURE MEDIA AND EXPOSURE ROUTES
IR-7	FLEMING KEY NORTH LANDFILL	TO BE DETERMINED	TO BE DETERMINED
IR-8	FLEMING KEY SOUTH LANDFILL	TO BE DETERMINED	TO BE DETERMINED
AOC SITE A	DEMOLITION KEY OPEN DISPOSAL AREA	TRESPASSER	SOIL - INGESTION, DERMAL, INHALATION - DUST
AOC SITE B	BIG COPPITT KEY ABANDONED CIVILIAN DISPOSAL AREA	TRESPASSER	SOIL - INGESTION, DERMAL, INHALATION - TBD SURFACE WATER TO BE DETERMINED SEDIMENT TO BE DETERMINED

Notes: To be determined indicates that additional information is needed to determine if exposure pathways are complete.
*A well survey is recommended for homes on Boca Chica Road which may be down-gradient of SWMU-1.

Table B-2
Complete Exposure Pathways Listed by Exposure Scenario
(for illustration purposes only)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Exposure Medium, Exposure Route	Site Maintenance Worker (adult)	Excavation Worker (adult)	Full-time Onsite Worker (adult)	Adult Resident	Child Resident	Adult Trespasser	Child Trespasser
Surface Soil							
Incidental ingestion	X	X	X	X	X	X	X
Dermal contact	X	X	X	X	X	X	X
Inhalation of particulates	X	X	X	X	X	X	X
Subsurface Soil							
Incidental ingestion		X					
Dermal contact[1]		X					
Inhalation of particulates		X					
Groundwater							
Ingestion				X			
Inhalation of shower vapors[2]				X			
Surface Water							
Incidental ingestion				X	X	X	X
Dermal contact				X	X	X	X
Sediment							
Incidental ingestion				X	X	X	X
Dermal contact[1]				X	X	X	X

[1] Chemical intake resulting from dermal contact with soil, sediment, and surface water is based on dermal guidance (U.S. Environmental Protection Agency [USEPA], 1992d) for children to account for changing surface areas and body weights to estimate the milligrams (mg) (or micrograms [μg]) of contaminant passing through the skin per exposure event. The approach for the adult exposures will follow the dermal guidance based on the surface area remaining constant. According to USEPA guidance (USEPA, 1994c), dermal contact will not be evaluated for groundwater exposure.

[2] Inhalation of volatiles resulting from showering.

The source of contamination or the initial receiving medium is usually the soil. Migration of contaminants from soil occurs through several different mechanisms such as leaching to groundwater, water or wind erosion to other media, and absorption by plants. Analytes may accumulate in plants and animals that are in contact with soil or whose food sources are in direct contact with soil. Mechanisms for migration into air include volatilization (primarily volatile organic compounds [VOCs]) and wind erosion of contaminated soil (all types of contaminants). Overland flow of water can result in migration of contaminants to surface water bodies and sediment. This process can also lead to relocation of the contaminants to other surface soil. Infiltration can result in migration into subsurface soil and into groundwater. Dissolved analytes (primarily soluble VOCs, semivolatile organic compounds [SVOCs], and inorganics) are very mobile and may be transported to wells or discharged to surface water.

B1.6 Exposure Point Concentrations. Concentrations of each HHCPC often vary widely over a site and it would be futile to estimate health risks associated with exposure to all HHCPCs at every concentration detected at the site. Therefore, a single concentration is selected as representative of the actual concentration for each HHCPC in a given medium over the entire site. This value, called the exposure point concentration (EPC), is used in the estimates of health risks at the site. An EPC is selected for each HHCPC.

Due to the role of EPCs in deciding human health risks, USEPA has issued specific guidance on the EPC determination process (USEPA, 1989a) and calculating the concentration term (USEPA, 1992c). This guidance states that the EPC is the lesser of the maximum detected concentration at the site or the 95 percent upper confidence limit (UCL) on the arithmetic mean concentration, assuming a log-normal distribution of concentrations. The following equation is used to calculate the UCL on the arithmetic mean (USEPA, 1991a; 1992c).

$$UCL=e^{\left(\bar{x}+0.5\,s^{2}+\frac{sH}{\sqrt{n-1}}\right)}$$

where

UCL	=	95 percent upper confidence limit of estimated mean,
e	=	constant (base of natural log, approximately equal to 2.718),
x	=	arithmetic mean of log-transformed data,
s	=	standard deviation of log-transformed data,
H	=	H-statistic (Gilbert, 1987), and
n	=	number of samples.

In calculating the 95 percent UCLs, non-detections are assigned a concentration equal to one-half the sample quantification limit. If a sample quantification limit is not available one of the following values is substituted: The contract required quantitation limit (CRQL) for organics; contract required detection limit (CRDL) for inorganics; or method detection limit. In cases where an analyte is detected in three or fewer samples, or there is three or fewer total samples the UCL is not calculated and the EPC is equal to the maximum detected concentration.

B1.7 Quantification of Exposures. The next step is to calculate HHCPC intakes, via each exposure pathway, for each of the potentially exposed populations. Population-related variables are selected that describe the characteristics dependent upon contact rate, age, body weight, body surface area, exposure frequency, exposure duration, and averaging time. When possible, variables such as age, body weight, and body surface area are selected from the following USEPA guidance documents: Standard Default Exposure Factors (USEPA, 1991b), Dermal Exposure Assessment Principles and Applications (USEPA, 1992d), and the Exposure Factors Handbook (USEPA, 1989b). The exposures calculated will be consistent with a Reasonable Maximum Exposure (RME) scenario as described by USEPA,(USEPA, 1989a). Standard default exposure parameters will be utilized in this assessment. In addition, where site-specific exposures may vary from these defaults, factual information will be used to develop additional exposure scenarios.

The general equation for calculating chemical intake from the various media is:

$$Intake\ (mg/kg\text{-}day) = \frac{[C \times CR \times EF \times ED \times CF]}{[BW \times AT]}$$

where

C = chemical concentration, media specific;
CR = contact rate, media specific;
EF = exposure frequency, population specific;
ED = exposure duration, population specific;
CF = conversion factor, media specific;
BW = body weight of hypothetically exposed individual; and
AT = averaging time (for carcinogens, AT=70 years times 365 days per year; for noncarcinogens, AT=ED times 365 days per year).

The specific equations used to calculate intakes from the different exposure pathways and, where possible, the default values used in the risk calculation spreadsheets are provided in Attachment 1.

Some exposure pathways require additional calculations before intake values can be calculated. Following are brief explanations of the additional calculations required for the inhalation of particulates, inhalation of vapors while showering, and dermal absorption.

Inhalation of Particulates from Soil. At sites having the potential for wind erosion, a three-step modeling process is conducted. In the first step, respirable particle-phase emission rates are calculated. In the second, contaminant emission rates on a unit surface area basis are calculated. In the third phase, downwind ambient concentrations are estimated using air dispersion modeling. A complete discussion of the three step process and the associated equations is defined in Attachment 2.

Inhalation of Vapors while Showering. For this exposure scenario, the contaminant concentrations in air are estimated based on release rates of volatiles from shower water. After reviewing the literature, the model selected to predict indoor (bathroom) concentrations is the Foster and Chrostowski (1987) model. This theoretical approach was based on the experimental work of Andelman (1985). The specific equations used to determine concentrations of contaminants in bathroom air are presented in Attachment 3.

Applications, Interim Report (USEPA, 1992d). The permeability constant approach is used to describe the dermal absorption to contaminants in water. For all inorganic chemicals, the model assumes a permeability constant equal to that of water, which is a steady-state condition for all analytes. For organic compounds, a non-steady-state model is used to model the absorption that employs a dermal permeability constant estimated from the compound's octanol-water partition coefficient. A further description of the process used to determine absorption of contaminants from water are presented in Attachment 4.

Dermal Absorption from Soil. The absorbed dose from soil is calculated in accordance with the USEPA Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992d). Percutaneous absorption of chemicals in soil is chemical dependent and matrix dependent. According to USEPA Region IV guidance (USEPA, 1992a), absorption factors used in this risk assessment for organics and inorganics are 0.1 percent and 0.01 percent, respectively. A soil adherence factor of 1 milligram per square centimeter (mg/cm^2) per event is used in the dermal intake equations. The equations used to describe dermal absorption from soil are presented in Attachment 4.

B1.8 Toxicity Assessment. The toxicity assessment evaluates the available evidence on the potential adverse effects associated with exposure to each analyte. With this information, a relationship between the extent of exposure and the likelihood or severity of adverse human health effects is developed. Two steps are typically associated with toxicity assessment: hazard identification and dose-response assessment.

Hazard identification identifies adverse effects that have been associated with exposure to an agent and, more importantly, whether those effects will occur in humans. Characterizing the nature and strength of causation is also a part of the hazard identification step. Each HHRA contains a toxicity profile for each HHCPC found at that site. The toxicity profile describes the physical and toxicological properties of each contaminant.

A dose-response assessment is conducted to characterize and quantify the relationship between intake, or dose, of a HHCPC and the likelihood or severity of a toxic effect, or response. There are two major types of toxic effects evaluated in this risk assessment: carcinogenic and noncarcinogenic.

Following USEPA guidance (USEPA, 1989a), these two endpoints are evaluated separately. For carcinogens, USEPA weight-of-evidence classifications and numerical toxicity factors have been developed and have undergone extensive peer review. Toxicity information used in the toxicity profile is primarily from: Integrated Risk Information System (IRIS), Health Effects Assessment Tables (HEAST), Agency for Toxic Substances and Disease Registration Toxicology Profiles, and the USEPA Environmental Criteria and Assessment Office.

Toxicity factors for carcinogenic analytes include current slope factors, unit risk values, and weight-of-evidence classifications for all carcinogens. For confirmed human carcinogens (USEPA Class A), the cancer type observed in exposed humans is also identified.

Cancer Toxicity Values. A chemical-specific toxicity value, called the Cancer Slope Factor (CSF), developed by the USEPA Carcinogen Risk Assessment Verification Endeavor (CRAVE) group is used to express the dose-response relationship. Another toxicity value developed by the USEPA is the cancer "unit risk." The unit risk describes the relationship between the exposure concentration and the probability of a carcinogenic response during the lifetime of the individual.

As required by USEPA Region IV guidance (USEPA, 1991a), risks associated with dermal exposures (most commonly for soil and water dermal contact) are evaluated using CSFs that are specific to dermally absorbed doses. Most oral CSFs are based on administered doses rather than absorbed doses (trichloroethene's CSF is a notable exception). It is, therefore, necessary to adjust those toxicity values based on administered doses before they are used for evaluation of absorbed doses. For dermal exposures, the toxicity values are adjusted as follows:

$$CSF_{adjusted} = \frac{CSF_{oral}}{ABSEFF_{oral}}$$

where $ABSEFF_{oral}$ is the absorption efficiency in the study that is the basis of the oral toxicity value.

If there is no information available on oral absorption efficiency, the conservative default values (USEPA, 1993a) of 80 percent for volatiles, 50 percent for SVOCs, and 20 percent for inorganics are used.

Each HHRA will provide the relevant information such as the CSF and unit risk as well as identify the critical study on which those values are based, cancer type identified in the study, and weight-of-evidence classification.

Relative Potency Factors (RPFs) for Carcinogenic Polynuclear Aromatic Hydrocarbons (PAHs). Carcinogenic PAHs are a class of compounds with very similar, complex heterocyclic structures. Only one PAH, benzo(a)pyrene, has a published USEPA CSF. For the other carcinogenic PAHs, the toxicity will be addressed by using relative potencies published by USEPA (USEPA, 1993b). The relative potencies identify the relative potency of each compound relative to that of benzo(a)pyrene. Table B-3 lists the relative potencies used in the HHRA at NAS Key West.

RPFs are not CSFs but they are used to calculate CSFs for other RPFs. RPFs are used only in estimating the cancer risk of these compounds and are not used to estimate the noncancer risks.

Noncancer Toxicity Values. The Reference Dose (RfD) is an estimate of a daily human intake, including sensitive subpopulations, that is likely to be without appreciabLE risk of deleterious effects during a lifetime. Most HHCPC RfDs are obtained from IRIS. If these sources do not have an RfD value for a specific chemical, then the USEPA Region IV will be contacted to arrange for a provisional value.

Table B-3
Toxicity Equivalency Factors for
Carcinogenic Polynuclear Aromatic Hydrocarbons (PAHs)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Compound	Relative Potency Factors
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-c,d)pyrene	0.1

Source: U.S. Environmental Protection Agency (USEPA), 1993b.

IRIS and HEAST provide RfD and reference concentration (RfC) values. The RfC will be used for inhalation risk quantifications whenever possible as the method more accurately describes the toxicity associated with the inhalation route of entry. The RfC is a medium-specific concentration that is unlikely to cause deleterious non-carcinogenic effects over a lifetime.

As required by USEPA Region IV guidance (USEPA, 1991a), risks associated with dermal exposures (most commonly for soil and water dermal contact) are evaluated using RfDs that are specific to absorbed doses. Most oral RfDs are based on an administered dose rather than on an absorbed dose. It is, therefore, necessary to adjust those toxicity values based on administered doses before they can be used for evaluation of absorbed doses. For dermal exposures, the toxicity values are adjusted as follows:

$$RfD_{adjusted} = RfD_{oral} \times ABSEFF_{oral}$$

where $ABSEFF_{oral}$ is the absorption efficiency in the study that is the basis of the oral toxicity value.

If there is no information available on oral absorption efficiency, the conservative default values (USEPA, 1993a) of 80 percent for volatiles, 50 percent for SVOCs, and 20 percent for inorganics are used.

Separate sets of RfDs have been developed for several chemicals for evaluating chronic and subchronic exposures. When available, subchronic RfDs are used for evaluating exposures with a duration of less than 7 years but more than 2 weeks (such as for an excavation worker). Chronic RfDs are used when subchronic values are unavailable and when the exposure duration was greater than 7 years. One exception to this rule is the resident child. Although the default child's exposure duration is 6 years, chronic RfDs are used with this scenario. There are no analogous reference values for evaluating acute exposures, those lasting less than 2 weeks.

B1.9 Human Health Risk Characterization. The final step of the risk assessment is the risk characterization. This step involves the integration of the exposure and toxicity assessment into quantitative expressions of potential human health risks associated with HHCPC exposure. Quantitative estimates of both carcinogenic and noncarcinogenic risks are made for each HHCPC and each complete exposure pathway identified in the exposure assessment. A clear distinction will be made between risks associated with current land use and those risks associated with potential future land and groundwater uses.

Carcinogenic Risks. Carcinogenic risks associated with exposure to individual chemicals are estimated by multiplying the chemical intake for each carcinogen by its CSF. This value represents an upper bound of the probability of an individual developing cancer over a lifetime as the result of exposure to a chemical. For each exposure pathway, the chemical-specific risks for all carcinogenic compounds are summed to determine the pathway-specific lifetime cancer risk. The following equations are used to estimate the chemical- and pathway-specific cancer risks.

Chemical-specific Excess Lifetime Cancer Risk.

$$Risk_i = CDI_i \times SF_i$$

where

$Risk_i$ = unitless probability of an individual developing cancer as the result of exposure to a chemical i,

CDI_i = chronic daily intake of chemical i averaged over 70 years (milligrams per kilogram per day [mg/kg-day]), and

SF_i = USEPA cancer slope factor for chemical i $(mg/kg\text{-}day)^{-1}$.

Pathway-specific Incremental Lifetime Cancer Risk

$$Risk_T = \Sigma\, Risk_i$$

where

$Risk_T$ = unitless probability of an individual developing cancer as the result of multiple chemical exposures and

$Risk_i$ = unitless cancer risk estimate for the i^{th} chemical associated with an exposure pathway.

The results from the carcinogenic risk assessment are compared with acceptable risk ranges established by the USEPA and the FDEP risk level of concern. The USEPA's guidelines, established in the National Hazardous Substances and Pollution Contingency Plan (NCP) (USEPA, 1990a) identify acceptable exposure levels as those concentration levels "that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response" (USEPA 1989a). Consistent with USEPA Region IV guidance (USEPA, 1993a, 1993b), if a given medium has a cumulative cancer risk less than 10^{-4} and ARARs are not exceeded, remedial goal options (RGO) would not generally need to be developed for that medium.

The FDEP has stated that any risks greater than 10^{-6} are worthy of further attention. Therefore, risks greater than 10^{-6} will also be identified to provide information concerning the FDEP concerns and RGOs will generally be developed whenever risk exceeds 10^{-6} or when exposure concentrations are greater than FDEP guidance values.

Noncarcinogenic Risks. Noncarcinogenic risk estimates are calculated by dividing specific chemical intake by the appropriate RfD. The result is called the Hazard Quotient (HQ). The HQs for individual compounds within an exposure pathway are summed to obtain the Hazard Index (HI) for that particular pathway.

Following are the equations used to determine the HQs and HIs.

Hazard Quotient

$$HQ_i = \frac{I_i}{RfD_i}$$

where

HQ_i = hazard quotient of chemical i,

I_i = intake of chemical i averaged over the exposure period (mg/kg-day), and

RfD_i = reference dose for chemical i corresponding to the same exposure duration as the intake (mg/kg-day).

Hazard Index

$$HI = \Sigma HQ_i \qquad (8)$$

where

HI = potential for noncarcinogenic effects from multiple chemical exposures and

HQ_i = hazard quotient for i^{th} chemical associated with an exposure pathway.

An HI less than 1 indicates that noncarcinogenic toxic effects are not expected to occur due to HHCPC exposure. An HI greater than 1 indicates a greater possibility of noncarcinogenic toxic effect occurring but the circumstances must be evaluated on a case-by-case basis. Generally, as the HI increases, so does the likelihood that adverse effects might be associated with exposure. However, the relationship between increased risk and larger HI values is not linear.

Remedial Goal Options (RGOs). The RGOs for the chemicals and media of concern will be outlined. This section will include both ARARs based and health risk-based media cleanup level options. The information provided in this section is intended to provide decision-makers with options on which to develop remedial aspects of the Corrective Measures Study.

The RGO section will include tabulated media cleanup levels for each chemical of concern in each land-use scenario evaluated in the baseline risk assessment. A chemical of concern is defined by USEPA Region IV as "chemicals which contribute to a pathway that exceeds a 10^{-4} risk (or whatever remediation level is established as a trigger by the risk manager) or an HI of 1 or greater or exceed a State or Federal chemical-specific ARAR." Chemicals need not be included if their individual carcinogenic risk contribution to the pathway is less than 10^{-6} or their noncarcinogenic HQ is less than 0.1. According to FDEP communications, a chemical of concern is any chemical with an HQ greater than 1. Media cleanup levels are risk-specific and medium- and exposure scenario-specific analyte concentrations that are based on the site-specific exposure parameters (combined ingestion, dermal, and inhalation exposures) and the toxicity information used in the baseline risk assessment.

Tables of media cleanup levels will address both USEPA and FDEP concerns. Each table will address only the chemicals of concern as defined by that specific guidance. Each table will identify, as appropriate, concentrations associated with cancer risk of 10^{-4}, 10^{-5}, and 10^{-6} and concentrations associated with HQs of 0.1, 1, and 10 for each combination of medium, land use, and receptor type (for example, groundwater future use as residential drinking water) that have chemicals of concern associated with them as well as State and Federal chemical-specific ARARs.

RGOs based on subsurface soil values for the protection of groundwater will also be included.

<u>B1.10 Uncertainty Analysis</u>. Uncertainties in the quantification of risk associated with the site are identified and their impacts on risk estimates are discussed in a separate section of the HHRA. Uncertainties in risk analysis can not be avoided; however, their identification, direction of bias, and potential magnitude are useful information for risk managers. These uncertainties can arise from several sources. Some of the more often encountered uncertainties include: uncertainties in the analytical procedures to accurately define the contaminant concentration at the site, uncertainties in obtaining and the use of an exposure point concentration to represent the reasonable maximum contaminant concentration, uncertainties in exposure scenarios, uncertainties in exposure factors used to calculate intake, uncertainties in the appropriateness of toxicity values, and the potential for synergistic or antagonistic interaction between HHCPCs.

The majority of the assumptions made in the risk assessment process are conservative; thus, the estimated risk for each site is probably an overestimate of the actual risk associated with exposure at the site.

The uncertainty section may also include unusual site conditions or extenuating circumstances that may be pertinent to risk management decisions. Other factors such as the inadequacy of toxicity factors to describe all possible HHCPC-receptor interactions and individual differences within the human population may be included in this section.

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ATTACHMENT 1

HUMAN HEALTH EXPOSURE EQUATIONS

Table B1-1
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact Resident (Adult and Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 356\ days/year}$$

Parameter	Symbol	Child Value (Age 1-6)	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific		Chemical Specific	
Soil Ingestion Rate	IR_{soil}	200	100	mg/day	[2]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
Inorganics	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	1×10^{-9}	kg/ug	
Exposure Frequency	EF	350	350	days/year	[2]
Exposure Duration	ED	6	24	years	[2]
Exposure Time [1]	ET	16	16	hours/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Non-cancer		6	24	years	[2]
Surface Area	SA	See Attachment 4	5750	cm^2	[3]
Inhalation Rate	IR_{air}	0.833	0.833	m^3/hour	[2]

See notes at end of table

Table B1-1 (Continued)
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Resident (Adult and Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Parameter	Symbol	Child Value (Age 1-6)	Adult Value	Units	Source
Body Weight	BW	15	70	kg	[2]
Adherence Factor	AF	1	1	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical Specific		unitless	[4]
Concentration in Air	CA	Chemical Specific		mg/m^3	See Appendix E

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Attachment 2.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992.
[4] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.

Table B1-2
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Trespasser (Adult and Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 356\ days/year}$$

Parameter	Symbol	Child Value (Age 6-16)	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific		Chemical Specific	
Soil Ingestion Rate	IR_{soil}	100	100	mg/day	[2]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
Inorganics	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	1×10^{-9}	kg/ug	
Exposure Frequency	EF	30	24	days/year	Assumption
Exposure Duration	ED	11	19	years	[2]
Exposure Time [1]	ET	4	4	hours/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Non-cancer		11	19	years	[2]

See notes at end of table.

Table B1-2 (Continued)
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Trespasser (Adult and Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Parameter	Symbol	Child Value (Age 6-16)	Adult Value	Units	Source
Surface Area	SA	Site Specific	5750	cm^2	[3]
Inhalation Rate	IR_{air}	0.833	0.833	m^3/hour	[2]
Body Weight	BW	40	70	kg	[2,5]
Adherence Factor	AF	1	1	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical Specific		unitless	[4]
Concentration in Air	CA	Chemical Specific		mg/m^3	See Attachment 2

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Attachment 2.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992.
[4] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.
[5] USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; July 1989.

Table B1-3
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Site Worker (Adult)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 356\ days/year}$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Parameter	Symbol	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific	Chemical Specific	
Soil Ingestion Rate	IR_{soil}	118 [2]	mg/day	[3]
Fraction Ingested	FI	100%	unitless	Assumption
Conversion Factor				
Inorganics	CF	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	kg/ug	
Exposure Frequency	EF	12	days/year	Assumption
Exposure Duration	ED	25	years	[3]
Exposure Time [1]	ET	8	hours/day	Assumption
Averaging Time	AT			
Cancer		70	years	[3]
Non-cancer		25	years	[3]
Surface Area	SA	5750	cm^2	[4]
Inhalation Rate	IR_{air}	0.833	m^3/hour	[3]
Body Weight	BW	70	kg	[3]

See notes at end of table.

Table B1-3 (Continued)
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Site Worker (Adult)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Parameter	Symbol	Adult Value	Units	Source
Adherence Factor	AF	1	mg/cm^2-event	[4]
Absorption Fraction	ABS_d	Chemical Specific	unitless	[5]
Concentration in Air	CA	Chemical Specific	mg/m^3	See Attachment 2

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Attachment 2.
[2] Calculated based on the following assumptions from Hawley, J.K., 1985. Assessment of Health Risk From Exposure to Contaminated Soil. Risk Analysis, 5:(4):28
-inside surface area of the hand is 14% of total surface area of the hand
surface area of hand (male) - 840 cm^2 (USEPA, 1992 [4])
inside surface area of hand (male) - 0.14 x 840 cm^2 = 118 cm^2
- adult ingests soils covering one-half of inside surface area of the hands two times per day
0.5 x 118 cm^2 x 2/day = 118 cm^2;
Use soil adherence factor of 1 mg/cm^2;
118 cm^2/day x 1 mg/cm^2 = 118 mg/day
[3] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".
[4] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992
[5] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992

Table B1-4
Exposure Parameters for Surface and Subsurface Soil Ingestion, Inhalation, and Dermal Contact
Excavation Worker (Adult)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 356\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific	Chemical Specific	
Soil Ingestion Rate	IR_{soil}	118 [2]	mg/day	[3]
Fraction Ingested	FI	100%	unitless	Assumption
Conversion Factor				
Inorganics	CF	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	kg/ug	
Exposure Frequency	EF	30	days/year	Assumption
Exposure Duration	ED	1	years	[3]
Exposure Time [1]	ET	8	hours/day	Assumption
Averaging Time	AT			
Cancer		70	years	[3]
Non-cancer		1	years	[3]
Surface Area	SA	5,750	cm^2	[4]
Inhalation Rate	IR_{air}	2.5	m^3/hour	[3]
Body Weight	BW	70	kg	[3]
Adherence Factor	AF	1	mg/cm^2-event	[4]

See notes on following page.

Table B1-4 (Continued)
Exposure Parameters for Surface and Subsurface Soil Ingestion, Inhalation, and Dermal Contact
Excavation Worker (Adult)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Parameter	Symbol	Adult Value	Units	Source
Absorption Fraction	ABS_d	Chemical Specific	unitless	[5]
Concentration in Air	CA	Chemical Specific	mg/m^3	See Attachment 2

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Attachment 2.

[2] Calculated based the following assumptions from Hawley, J.K, 1985, Assessment of Health Risk from Exposure to Contaminated Soil. Risk Analysis, 5(4):289:
- inside surface area of the hand is 14% of total surface area of hand
- surface area of hand (male) - 840 cm^2 (USEPA, 1992 [4])
  inside surface area of hand (male) - .14 x 840 cm^2 = 118 cm^2
- adult ingests soils covering one-half of inside surface area of the hands two times per day
  .5 x 118 cm^2 x 2/day = 118 cm^2/day
  Use soil adherence factor of 1 mg/cm^2:
  118 cm^2/day x 1 mg/cm^2 = 118 mg/day

[3] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".

[4] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992

[5] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.

Table B1-5
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact Occupational Worker (Adult)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 356\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific	Chemical Specific	
Soil Ingestion Rate	IR_{soil}	50	mg/day	[2]
Fraction Ingested	FI	100%	unitless	Assumption
Conversion Factor				
Inorganics	CF	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	kg/ug	
Exposure Frequency	EF	250	days/year	[2]
Exposure Duration	ED	25	years	[2]
Exposure Time [1]	ET	8	hours/day	Assumption
Averaging Time	AT			
Cancer		70	years	[2]
Non-cancer		25	years	[2]
Surface Area	SA	2300	cm^2	[3]
Inhalation Rate	IR_{air}	0.833	m^3/hour	[2]

See notes at end of table.

Table B1-5 (Continued)
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Occupational Worker (Adult)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Parameter	Symbol	Adult Value	Units	Source
Body Weight	BW	70	kg	[2]
Concentration in Air	CA	Chemical Specific	mg/m^3	See Attachment 2
Adherence Factor	AF	1	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical Specific	unitless	[4]

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Attachment 2.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992
[4] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.

Table B1-6
Exposure Parameters for Sediment Ingestion and Dermal Contact
Resident (Adult and Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{sediment} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 1-6)	Adult Value	Units	Source
Concentration in Sediment	CS	Chemical Specific		Chemical Specific	
Sediment Ingestion Rate	$IR_{sediment}$	200	100	mg/day	[1]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
Inorganics	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	1×10^{-9}	kg/ug	
Exposure Frequency	EF	100	100	days/year	Assumption
Exposure Duration	ED	6	24	years	[1]
Averaging Time	AT				
Cancer		70	70	years	[1]
Non-cancer		6	24	years	[1]
Surface Area	SA	See Attachment 4	5750	cm^2	[2]
Body Weight	BW	15	70	kg	[2]
Adherence Factor	AF	1	1	mg/cm^2-event	[2]
Absorption Fraction	ABS_d	Chemical Specific		unitless	[3]

References:

[1] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".
[2] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992
[3] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.

Table B1-7
Exposure Parameters for Sediment Ingestion and Dermal Contact
Trespasser (Adult and Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{sediment} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 6-16)	Adult Value	Units	Source
Concentration in Sediment	CS	Chemical Specific		Chemical Spe	
Sediment Ingestion Rate	$IR_{sediment}$	100	100	mg/day	[1]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
Inorganics	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	1×10^{-9}	kg/ug	
Exposure Frequency	EF	100	100	days/year	Assumption
Exposure Duration	ED	11	19	years	[1]
Averaging Time	AT				
Cancer		70	70	years	[1]
Non-cancer		11	19	years	[1]
Surface Area	SA	Site Specific	5,750	cm^2	[2]
Body Weight	BW	40	70	kg	[1,4]
Adherence Factor	AF	1	1	mg/cm^2-event	[2]
Absorption Fraction	ABS_d	Chemical Specific		unitless	[3]

References:

[1] U.S. Environmental Protection Agency (USEPA), 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".
[2] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992
[3] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.
[4] USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; July 1989.

Table B1-8
Exposure Parameters for Surface Water Ingestion and Dermal Contact Resident (Adult and Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CW \times IR_{surface\ water} \times CF1 \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = PC_{event} \times CW \times CF1 \times CF2$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED \times EV}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 1-6)	Adult Value	Units	Source
Concentration in Surface Water	CW	Chemical Specific		Chemical Spe	
Surface Water Ingestion Rate	$IR_{surface\ water}$	0.13	0.13	liters/day	[1]
Conversion Factor					
	CF1	0.001	0.001	mg/ug	
	CF2	0.001	0.001	liters/cm^3	
Exposure Frequency	EF	100	100	days/year	Assumption
Exposure Duration	ED	6	24	years	Assumption
Event Frequency	EV	1	1	events/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Non-cancer		6	24	years	[2]
Surface Area	SA	Site Specific	5,750	cm^2	[3]
Body Weight	BW	15	70	kg	[2]
Diffusion Depth per Event	PC_{event}	Chemical Specific		cm/event	[4]

References:

[1] USEPA, 1988. Superfund Exposure Assessment Manual; EPA/540//1-88/001; April 1989.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992
[4] Calculated per USEPA, 1992 [3]; See Appendix D.

Table B1-9
Exposure Parameters for Surface Water Ingestion and Dermal Contact
Trespasser (Adult and Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$INTAKE_{ing} = \frac{CW \times IR_{surface\ water} \times CF1 \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = PC_{event} \times CW \times CF1 \times CF2$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED \times EV}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 6-16)	Adult Value	Units	Source
Concentration in Surface Water	CS	Chemical Specific		Chemical Spe	
Surface Water Ingestion Rate	$IR_{surface\ water}$	0.13	0.13	liters/day	[1]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
	CF1	0.001	0.001	mg/ug	
	CF2	0.001	0.001	liters/cm^3	
Exposure Frequency	EF	100	100	days/year	Assumption
Exposure Duration	ED	11	19	years	[2]
Event Frequency	EV	1	1	events/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Non-cancer		11	19	years	[2]
Surface Area	SA	Site Specific	5,750	cm^2	[3]
Body Weight	BW	40	70	kg	[2,5]
Diffusion Depth per Event	PC_{event}	Chemical Specific		cm/event	[4]

References:

[1] U.S. Environmental Protection Agency (USEPA), 1988. Superfund Exposure Assessment Manual; EPA/540/1-88/001; April 1988.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992
[4] Calculated per USEPA, 1992 [3]; See Appendix D.
[5] USEPA, 1989, Exposure Factors Handbook; EPA/600/8-89/043; May 1989.

Table B1-10
Exposure Parameters for Groundwater Ingestion and Inhalation
Adult Residents

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

$$Intake_{ing} = \frac{CW \times IR_{groundwater} \times CF1 \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA_{air} \times ET \times EF \times ED}{CF2 \times AT \times 356\ days/year}$$

Parameter	Symbol	Adult Value	Units	Source
Concentration in Groundwater	CW	Chemical Specific	µg/liter	
Water Ingestion Rate	IR_{water}	2	liters/day	[2]
Conversion Factor	CF1	0.001	mg/ug	
	CF2	24	hours/day	
Exposure Frequency	EF	350	days/year	[2]
Exposure Duration	ED	30	years	[2]
Averaging Time	AT			
Cancer		70	years	[2]
Non-cancer		30	years	[2]
Body Weight	BW	70	kg	[2]
Concentration Shower Air	CA_{air}	See Attachment 3	µg/m³	[3]
Exposure Time [1]	ET	0.2	hours/day	[4]

References:

[1] Exposure Time is a parameter used only in inhalation of volatiles while showering; See Attachment 3.

[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters".

[3] This parameter is modeled; See Attachment 3.

[4] USEPA, 1989. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part A) EPA/540/1-89/002; December, 1989.

ATTACHMENT 2

INHALATION OF PARTICULATES FROM SOIL

INTRODUCTION

This evaluation has been conducted to estimate levels of site contaminants that would occur in ambient air as a result of wind erosion at NAS Key West. To estimate atmospheric concentrations of fugitive air contaminants, a three step modelling process was conducted. In the first step, respirable particle-phase emission rates are calculated. In the second, contaminant emission rates on a unit basis are calculated. In the third phase, downwind ambient concentrations are estimated using air dispersion modeling. Each of these steps are discussed below. Calculations for the theoretical site are shown in the attached tables (Table 2-1).

STEP 1: ESTIMATION OF PM_{10} EMISSIONS FROM WIND EROSION

Emission rates for respirable particle-phase contaminants were estimated using equations developed by the USEPA for wind erosion by Cowherd and others (1985). Airborne respirable particulate matter is defined as particles with an aerodynamic diameter less than or equal to 10 μm and is denoted with the symbol PM_{10}. Ambient air concentrations were then estimated using air dispersion modeling.

The equations presented in Cowherd and others, are intended to provide a methodology for rapid assessment of the inhalation exposure to respirable particulate emissions from surface contamination sites under emergency situations. Consequently, the models are based on a number of simplifying assumptions and yield order-of-magnitude estimates of atmospheric concentrations. The results of this quantitative assessment of potential inhalation exposure at this site should be reviewed with this fact in mind.

For estimating emissions from wind erosion for surface areas not completely covered by vegetation, two emission factor equations have been developed by Cowherd and others, 1985. Selection of the appropriate equation depends on whether the contaminated site's surface material is classified as having a "limited reservoir" or an "unlimited reservoir" of erodible surface particles. The critical feature of "unlimited" erosion potential is that contaminated soil is entrained at a lower wind velocity than for the "limited" case. Surface soil containing a high percentage of silts and lacking either vegetation or large nonerodible elements are assumed to contain an unlimited reservoir of surface erodible particles. This is based on the aggregate size distribution of surface particles, which is best determined with a sieve size analysis. In the absence of such an analysis at NAS Key West, an unlimited reservoir was assumed. The application of the unlimited reservoir model to this site represents a conservative case as the surface soil are unlikely to contain a large percentage of silts because of the geological age of the soil (i.e., the majority of the silts have already been eroded).

A conservative estimate of the PM_{10} emission factor (E_{10}) for the contaminated surface with "unlimited" erosion potential was calculated using an emission factor derived by Gillette (1981) based on field measurements of highly erodible soil. The following equation was used:

where

E_{10} = PM_{10} emission factor (g/m^2-sec)

1x10^{-5} = empirical constant (g/m^2-sec)

V = fraction of the contaminated surface area with continuous vegetative cover

[u] = mean annual wind speed (m/s)

u_t = threshold value of wind speed at 7 m (m/s)

F(x) = function to estimate unlimited erosion

x = dimensionless ratio = 0.886 u_t/[u].

and

$$u_t = \frac{1}{0.4} \times \ln\frac{z}{z_0} \times u^*$$

where u^* = friction velocity

z = height above surface (m)

z_0 = roughness height (m)

For values of x greater then 2:

$$F(x) = 0.18\ (8\ x^3 + 12\ x)\ e^{-x^2}$$

All parameters in the above equation were calculated from site-specific data where possible. The values used in estimating the emission factor for wind erosion are given in Step 1 of Table D-11.

STEP 2. ESTIMATION OF CONTAMINANT EMISSION RATES

Contaminant-specific emission rates were estimated from (1) the PM_{10} emission factors, (2) the mass fraction of contaminant in PM_{10} emissions, and (3) the contaminated surface area. These parameters were used in the following equation to calculate contaminant emission rates (Q_{10}):

$$Q_{10} = 1 \times f \times E_{10} \times A$$

where

Q_{10} = contaminant emission rate as PM_{10} (μg/sec)

f = mass fraction of contaminant in PM_{10} emissions (mg contaminant/kg PM_{10})

E_{10} = PM_{10} emission rate (g PM_{10}/m^2-sec)

A = contaminated surface area (m^2), and

1 = conversion factor (1000 ug contaminant/mg contaminant)* (kg PM_{10}/1000 g PM_{10})

The values for f were estimated by assuming that the mass fraction of the contaminant in the inhalable particles emitted (PM_{10}) is equal to the mass fraction of the contaminant in the soil. The surface area available for wind erosion was assumed to be the area of the excavation for each scenario.

STEP 3. AIRBORNE CONTAMINANT CONCENTRATION

Air dispersion modeling is used to predict off-site contaminant air concentrations based on the PM_{10} emission rate. Many different forms of dispersion models exist for a variety of applications. For this situation, the box model was selected because it is most appropriate to use when receptors are less than 100 meters from the edge of an area source. The model overpredicts concentrations by a factor of approximately four to six when compared with the Gaussian dispersion model, ISCST, for the "downwind distances" to exposure points of interest in this assessment (McCarthy and Burbank, 1990). The box model is a good screening model for a public health risk assessment because the concentrations estimated with the box model are protective of public health. If no risk is indicated using box model concentrations, the potential for adverse impacts to public health are considered negligible.

The box model is a basic analytical and physical model representing diffusion from an area source. The box encloses the area source and is bounded by the ground as its base and the mixing height (H) of the mean vertical displacement of emissions, which is a function of atmospheric stability and downwind distance to the point of exposure. Within the box, mixing is assumed to be complete. The box has a width (W) equal to the width of the area source and the box is aligned so that its length lies in the direction of the wind, which passes through its end with a constant velocity (U). The ventilation rate, defined as the volume of air passing through the box, is equal to U x H x W. The downwind mixing height (H) of the box is determined from the following equation presented by Pasquill (1975) for neutral stability:

$$X = 6.25 \ x \ z_0 \ [(\frac{H}{z_0}) \ \ln(\frac{H}{z_0}) - 1.58 \ (\frac{H}{z_0}) + 1.58]$$

where

- X = downwind distance from the leading edge of the area source to the receptor (m)
- H = downwind mixing height (m)
- z_0 = roughness height (m)

The roughness height, z_0, was selected to be 0.02 meters based on the roughness height of grassland provided by Cowherd and others, 1985. This roughness height provides a more conservative estimate of emissions than assuming non-vegetated conditions. The downwind distance to the receptor is measured to the closest exposure points for potentially exposed populations. For the purposes of this evaluation, a distance of 1 meter was assumed (the receptor is at the source). The ambient 24-hour contaminant concentration (C_{10}) was estimated by the following box model equation:

$$C_{10} = \frac{Q_{10} \ x \ a}{U \ x \ H \ x \ W}$$

where

- C_{10} = concentration of contaminant at distance X ($\mu g/m^3$)
- Q_{10} = particle-phase emission rate from wind erosion ($\mu g/sec$)
- a = fraction of 24 hours during which emissions occur
- U = average wind speed (m/sec)
- H = downwind mixing height (m)

W = width of area perpendicular to wind (m)

The input values for this equation are shown in Step 3 in Table 2-1. This results in a conservative estimate of the 24-hour average concentration of contaminants to which an individual may be exposed to at the contaminant source on days in which wind erosion occurs. This concentration, the downwind contaminant concentration resulting from wind erosion, per unit of contaminant soil concentration (C_{10})is multiplied by the concentration of each CPC to obtain downwind contaminant concentrations.

Table B2-1
Step 1: Calculate PM10 Emissions from Wind Erosion

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

EQUATION 1

E10 = (1x10-5) x (1-V) x ([u]/ut)3 x F(x) — Cowherd, Eqn. 4-4

where:

E10	=	PM10 emission factor (g/m2-s)
1 x 10-5	=	empirical constant
V	=	fraction of the contaminated surface area with continuous vegetative cover
[u]	=	mean annual wind speed (m/s) (Cowherd, Table 4-1)
ut	=	threshold value of wind speed at 7 m (m/s)
F(x)	=	function plotted in Cowherd, Fig. 4-3
x	=	dimentionless ratio = 0.866 x ut/[u]

EQUATION 2

ut = (1/0.4) x ln(z/z0) x u* — Cowherd, Eqn. 4-3

where:

z	=	height above surface (m)
z0	=	roughness height (m)
u*	=	friction velocity (m/s)

EQUATION 3

for x>2:

F(x) = 0.18 x (8x3 + 12x) x (exp(-x2)) — Cowherd, Appendix B

Table B2-1 (Continued)
Step 1: Calculate PM10 Emissions from Wind Erosion

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Variable	Value	Units	Source
z	7	m	Cowherd
z0	0.02	m	Cowherd, Figure 3-6
u*	0.63	m/s	Assumption
ut	9.14	m/s	Calculated from Equation 2
[u]	3.8	m/s	Cowherd, Table 4-1, Jacksonville, Florida
x	2.13	unitless	Calculated from 0.886 x ut/[u]
F(x)	0.2	unitless	Calculated from Equation 3 or Cowherd Figure 4-3
V	0.6	fraction	Assumption based on site visit
E10	5.68 x 10-8	m/s	Calculated from Equation 1

Table B2-1(Continued)
Step 2: Calculate PM10 Emissions from Wind Erosion

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

EQUATION 4

Q10 = f x E10 x A — Cowherd Eqn.

where:

Q10	=	contaminant emission rate (ug contaminant/s)
f	=	fraction of PM10 with contaminant (mg contaminant/kg soil) (assumed to equal soil concentration in mg contaminant/kg soil)
E10	=	PM10 emission rate (g PM10/m2-s)
A	=	area (m2)
1	=	conversion (1000 ug contaminant/mg contaminant) x (kg PM10/1000 g PM10)

Variable	Value	Units	Source
f	1	mg/kg	Assumption
A	33600	m2	Assumption
E10	5.68 x 10 -8	g PM10/m2-s	Calculated from Step 1 (Equation 1)
Q10	1.91 x 10 -3	ug/s	Calculated from Equation 4

Table B2-1(Continued)
Step 3: Calculate Airborne Contaminant Concentration

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

EQUATION 5

$$C10 = \frac{Q10 \times a}{\text{Ventilation Rate}}$$ Box Model

$$= \frac{Q10 \times a}{U \times H \times W}$$

where:

C10	=	airborne contaminant concentration (ug/m3)
Q10	=	contaminant emission rate (ug/s)
U	=	wind speed (same as [u] from Step 1) (m/s)
H	=	downwind mixing height (m)
W	=	width of area perpendicular to wind (m)
a	=	fraction of 24 hours during which activity occurs

EQUATION 6

H is calculated in an iterative fashion based on the desired value of X from the following equation:

$X = 6.25 \times (z0) \times [(H/z0) \times \ln(H/z0) - 1.58 \times (H/z0) + 1.58]$ Pasquill, 1975

where:

X	=	downwind distance from leading edge of area source to receptor (m)
H	=	downwind mixing height (m)
z0	=	roughness height (same as in Step 1) (m)

Table B2-1(Continued)
Step 3: Calculate Airborne Contaminant Concentration

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Variable	Value	Units	Source
Q10	1.91 x 10 -3	ug/s	Calculated from Step 2 (Equation 4)
a	1	unitless	
U	2.45	m/s	Cowherd, Table 4-1, Jacksonville, Florida (same as [u] from Step 1)
H	0.276	m	Calculated in Equation 6
W	140	m/s	
z0	0.02	m	Cowherd, Figure 3-6 (same as Step 1)
X	1	m	Calculated from Equation 3 or Cowherd Figure 4-3
C10	2.02 x 10 -5	ug/m3 per mg/kg	Calculated from Equation 6

REFERENCES

Cowherd, C., G.E. Muleski, P.J. Englehart, and D.A. Gillette (1985), Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites, prepared for USEPA Office of Health and Environmental Assessment, Washington, D.C.; EPA/600/8-85/002.

Gillette, D.A., 1981, Production of Dust that May Be Carried Great Distances, in Desert Dust: Origin Characteristics, and Effect on Man; edited by T. Pewe; Geological Society of America Special Paper 186.

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Pasquill, F. 1975, The Dispersion of Materials in the Atmospheric Boundary Layer - The Basis for Generalization, in Lectures on Air Pollution and Environmental Impact Analysis, American Meteorological Society, Boston.

USEPA, 1988, Supplement B to Compilation of Air Pollutant Emissions Factors, Volume I: Stationary Point and Area Sources, USEPA Office of Air Quality Planning and Standards, AP-42, September, 1988.

ATTACHMENT 3

CALCULATION OF AIR CONCENTRATIONS USING THE SHOWER MODEL

INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES) calculated concentrations of VOCs in groundwater that could volatilize during a shower. After reviewing the literature, the model selected by ABB-ES to predict indoor (bathroom) concentrations is that presented by Foster and Chrostowski (1987). This theoretical approach is based on the experimental work of Andelman (1985). Andelman measured air concentrations of trichloroethylene and chloroform in a bench scale shower assembly. Foster and Chrostowski (1987) developed a model from these experimental data. ABB-ES modified the input parameters from the bench scale design to be representative of a typical bathroom.

CALCULATIONS

Parameter values used in the following equations can be found in Table 3-1.

The equation used to calculate air concentrations in the bathroom is shown below:

$$C(voc) = \frac{S}{R} \times (e^{RD_s} - 1) \times e^{-Rt}$$

where

C(voc)	= concentration of VOC in bathroom ($\mu g/m^3$)
S	= VOC generation rate ($\mu g/m^3$-min)
R	= air exchange rate (min^{-1})
D_s	= duration of shower (min)
t	= time at which concentration is being calculated (min)

R, the air exchange rate, is calculated as the volumetric flowrate through the bathroom (m^3/min) divided by the volume of the bathroom (m^3).

S, the VOC source generation rate, is calculated based on the concentration of the contaminant in the water, emission of compound from a droplet, flowrate of water, and volume of room for dilution. S is calculated from the following series of equations:

$$S = \frac{C_{wd} \times FR}{SV}$$

where

C_{wd}	= concentration in water droplet ($\mu g/\ell$)
FR	= flow rate in shower (l/min)
SV	= shower volume (m^3)

C_{wd} is calculated as follows:

$$C_{wd} = C_{wo} \times [1 - e^{(\frac{-K_{al} \times t_s}{60d})}]$$

Table B3-1
Empirical Constants for the Shower Model

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Constant	Symbol	Value	Unit	Source
Liquid-film mass transfer for CO2	Kl(CO2)	20	cm/hr	Calculated
Gas-film mass transfer from H2O	Kg(H2O)	3000	cm/hr	Calculated
Molar gas constant x Temperature	RT	0.024	atm-m3/mole	
Reference temperature	T1	293	K	
Temperature of shower water	Ts	318	K	Assumption
Viscosity of water at shower temperature	us	0.6178	cp	Calculated
Viscosity of water at reference temperature	u1	0.65	cp	Calculated
Shower droplet free-fall time	ts	1.5	sec	Assumptions
Droplet diameter	d	1	mm	Foster and Chrostowski, 1987
Flow rate in shower	FR	20	l/min	Assumption
Volume of shower area	SV	12	m3	Assumption
Air exchange rate	R	0.03	min-1	Calculated
Time in shower	Ds	12	min	USEPA, 1989b
Time at which concentration is being calculated	t	12	min	Assumption

Foster, S.A. and Chrostowski, P.C., 1987. Inhalation Exposures to Volatile Organic Contaminants in the Shower

where

C_{wo} = concentration in groundwater (µg/ℓ)

K_{al} = temperature correction of the mass transfer coefficient, K_L ((cm/hr)

t_s = shower water droplet free-fall time (sec)

d = droplet diameter (mm)

The term $K_{al}/60d$ combines both the rate of transfer and the available interfacial area across which volatilization can occur. The value 1/60d equals the specific interfacial area, 6/d, for a spherical shower droplet of diameter d multiplied by conversion factors (hr/3600 sec and 10 mm/cm).

K_{al} is calculated according to:

$$K_{al} = K_L \times [\frac{T_1 \times u_s}{T_s \times u_1}]^{-0.5}$$

where

K_L = mass-transfer coefficient (cm/hr)

T_1 = reference temperature (K)

u_s = viscosity of water at reference temperature (cp)

T_s = temperature of shower water (K)

u_1 = viscosity of water at shower temperature (cp)

K_L is calculated according to:

$$K_L(voc) = \frac{1}{\frac{1}{k_l(voc)} + \frac{RT}{H \times k_g(voc)}}$$

where

$k_l(voc)$ = chemical-specific liquid mass-transfer coefficient (cm/hr)

$k_g(voc)$ = chemical-specific gas mass-transfer coefficient (cm/hr)

RT = molecular gas constant (R) x temperature (T) (atm-m^3/mole)

H = Henry's Law Constant (atm-m^3/mole)

The input values of k_l and k_g are based on the mass transfer coefficients of CO_2 and water. They are calculated for the particular compound of interest according to the following equations:

$$k_l(voc) = k_l(CO_2) \times [\frac{44}{MW(voc)}]^{0.5}$$

$$k_g(voc) = k_g(H_2O) \times [\frac{18}{MW(voc)}]^{0.5}$$

where

$k_l(CO_2)$ = liquid mass-transfer coefficient for carbon dioxide (cm/hr)
$k_g(H_2O)$ = gas mass-transfer coefficient for water (cm/hr)
MW(voc) = molecular weight of VOC

ASSUMPTIONS

Several assumptions were made to complete this modeling effort. The more important ones involve the volume of the bathroom and the air exchange rate (see Equations 1 and 2). A bathroom volume of $12m^3$ was assumed. For the purposes of this model, it was also assumed that the air between the shower area and the rest of the bathroom was well mixed. The volumetric flowrate through the bathroom was assumed to be 0.4 m^3/min, which gives an effective air exchange rate of 1.8 air changes/hour. Few measurements have been done on ventilation rate in bathrooms. ABB-ES considers this value to be a conservative estimate given that most homes have air exchange rates of 0.5 to 2.0 changes/hour. Bathrooms may have higher ventilation rates than the entire house due to the effect of local exhaust fans, if present, or the opening of windows.

Another assumption is implicit in the use of Equation 1. This equation calculates VOC concentrations at time (t), which is assumed to equal the duration of shower use (D_S). Thus, the resulting concentrations represent maximum concentrations at the end of the shower. In reality, an individual would experience an integrated exposure that would gradually increase during shower usage and decrease again after the water was turned off. ABB-ES made the simplifying assumption that the peak concentrations would persist for the duration of exposure. This is a conservative assumption that is protective of public health.

REFERENCES

Andelman, J.B., 1985, Inhalation Exposure in the Home to Volatile Organic Contaminants in Drinking Water; Sci. Total Environ.; Vol. 47, pp. 443-460.

Foster, S.A. and Chrostowski, P.C., 1987, Inhalation Exposures to Volatile Organic Contaminants in the Shower; paper presented at the 80th Annual Meeting of the Air Pollution Control Association; New York, New York; June 1987.

ATTACHMENT 4

DERMAL GUIDANCE SUMMARY

ABSORBED DOSE CALCULATION - DERMAL EXPOSURE TO WATER

The absorbed dose is calculated per the USEPA Dermal Exposure Assessment: Principles and Applications, Interim Report, January 1992. The permeability constant approach is used for dermal exposures to contaminants in water.

The **steady state approach for inorganics** is used here. The dose absorbed per unit area per event is:

$$DA_{event} = PC_{event} \times C_w \times CF_1 \times CF_2$$

where:

DA_{event} = Dose absorbed per unit area per event (mg/cm^2-event)

$$PC_{event} = K_{pw} \times t_{event}$$

PC_{event} = Diffusion depth per event (cm/event)
K_{pw} = Permeability constant from water (cm/hr)
C_w = Concentration of chemical in water ($\mu g/\ell$)
t_{event} = Duration of a single event (hr/event)
CF_1 = Units conversion factor (liter/ 10^3 cm^3)
CF_2 = Units conversion factor (mg/ 10^3 ug)

The **"unsteady-state approach for organics"** is used here. The dose absorbed per unit area per event is:

$$DA_{event} = PC_{event} \times C_W \times CF_3 \times CF_4$$

$$PC_{event} = 2 \times K_p \times (6\tau t_{event} / \pi)^{0.5}$$

where: $t < t^*$

and

$$DA_{event} = PC_{event} \times C_W \times CF_5 \times CF_6$$

$$PC_{event} = K_p \times ((t_{event} / (1 + B)) + 2\tau ((1 + 3B) / (1 + B))$$

where

$t > t^*$ and

where

K_p = Permeability constant from water (cm/hr)
C_w = Concentration of chemical in water ($\mu g/\ell$)
τ = $l_{sc}^2 / 6\ D_{sc}$ (hr)
l_{sc} = Thickness of stratum corneum (10 um)
D_{sc} = Stratum corneum diffusion coefficient (cm^2/hr)
t_{event} = Duration of a single event (hr/event)
π = Pi (dimensionless)
$t*$ = Time to reach steady state (hr)
B = Octanol water partition coefficient divided by 10^4 (dimensionless)
CF_3 = Units conversion factor ($mg/10^3\ ug$)
CF_4 = Units conversion factor ($liter/10^3\ cm^3$)
CF_5 = Units conversion factor ($mg/10^3\ ug$)
CF_6 = Units conversion factor ($liter/10^3\ cm^3$)

For a given compound, the values for B, K_p τ, and t^* can be found in Table 5-8 of the dermal guidance document (USEPA, 1992).

Once the dose per event (DA_{event}) is calculated, the dermally absorbed dose (DAD) for use in risk calculations can be derived as follows:

Dermally absorbed dose for use in risk calculations is derived generally (for adults who are no longer growing) as follows:

$$DAD_{adult} = DA_{event} \times EV \times EF \times ED \times SA\ /\ BW \times AT$$

For children, to account for changing surface areas and bodyweights, the dermally absorbed dose is calculated as follows:

$$DAD_{child} = (DA_{event} \times EV \times EF\ /\ AT) \sum_{i=m}^{n} (SA_i \times ED_i\ /\ BW_i)$$

where

EV = Event frequency (events/day)
EF = Exposure frequency (days/year)
AT = Averaging time (days). For noncarcinogenic effects, AT = ED, and for carcinogenic effects AT = 70 years or 25,550 days.
SA_i = Surface area exposed at age i (cm^2)
ED_i = Exposure duration at age i (years)
BW_i = Bodyweight at age i (kg)

Bathing or Swimming Exposure. For bathing and swimming, USEPA recommends that whole body surface area be used to represent skin surface area available for contact with water. For adults, using 50^{th} and 95^{th} percentile whole body SA values, the default SA values are 20,000 cm^2 and 23,000 cm^2 (Table 4-1). For children, the default values for each age group would be equal to the 50th percentile and 95^{th} percentile whole body SA values. Estimated bodyweights are the average of the 50^{th} percentile female and male weights (Table 4-1).

Values of

$$\sum_{i=m}^{n} (SA_i \times ED_i \; / \; BW_i)$$

for commonly used age ranges are presented in Table 4-2.

Wading Exposure. For wading, it is assumed that the entire surface area of the feet, lower legs, and hands is exposed to the surface water during the entire exposure event. This assumption is for shallow water situations. Averaging surface areas over the 6 childhood years yields the following: hands represent 5.5 percent of total body surface area, lower leg represents 12.8 percent of total body surface area, and the feet represent 7 percent of total body surface area. Therefore, the feet, lower legs and hands represent approximately 25 percent of total body surface area for children ages 1 through 6 (Table 4-3). This value is the same value which USEPA identifies as the per cent of total body surface area which is available for soil contact (USEPA, 1992). This value, 25 percent of total body surface area is used here to represent surface area available for waders of all ages. Table 4-4 presents the wading information for typically evaluated age groups.

ABSORBED DOSE CALCULATION - DERMAL EXPOSURE TO SOIL

The absorbed dose is calculated per the USEPA Dermal Exposure Assessment: Principles and Applications, Interim Report, January 1992. The calculation of the estimated dermally absorbed dose per unit area per event is:

$$DA_{event} = C_{soil} \times AF \times ABS \times CF$$

where

DA_{event}	=	Dose absorbed per unit area per event (mg/cm^2-event)
C_{soil}	=	Contaminant concentration in soil (mg/kg)
AF	=	Adherence factor of soil to skin (mg/cm^2-event)
ABS	=	Absorption fraction (dimensionless)
CF	=	Units conversion factor (10^{-6} kg/mg)

Dermally absorbed dose for use in risk calculations is derived generally (for adults who are no longer growing) as follows:

$$DA_{adult} = DA_{event} \times EF \times ED \times SA \; / \; BW \times AT$$

For children, to account for changing surface areas and bodyweights, the dermally absorbed dose is calculated as follows:

KW_RFIRI.WKP
PMW.11.95

Table B4-1
Exposure Parameters for Dermal Contact With Water

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Age	Total Surface Area (cm^2)				Body Weight (kg)			Derivation of DA event (Dose absorbed / unit area / event)			
	Bathing and Swimming		Wading (25% Total Surface Area)								
	Male 50th Percentile[1]	Male 95th Percentile[1]	Male 50th Percentile	Male 95th Percentile	Male 50th Percentile[2]	Female 50th Percentile[2]	Average of Male and Female	Swimmer 50th Percentile	Swimmer 95th Percentile	Wader 50th Percentile	Wader 50th Percentile
1<23	5398	6104	1350	1526	11.5	10.5	11	490.7	554.9	122.7	138.7
2<3	6030	6820	1508	1705	13.4	12.6	13	463.8	524.6	116.0	131.2
3<4	6640	7640	1660	1910	15.3	14.6	14.95	444.1	511.0	111.0	127.8
4<5	7310	8450	1828	2112.5	17.4	16.4	16.9	432.5	500.0	108.1	125.0
5<6	7930	9180	1983	2295	19.3	18.8	19.05	416.3	481.9	104.1	120.5
6<7	8660	10600	2165	2650	21.9	21	21.45	403.7	494.2	100.9	123.5
7<8	9360	11100	2340	2775	24.4	23.5	23.95	390.8	463.5	97.7	115.9
8<9	10000	12400	2500	3100	27.3	27.3	27.3	366.3	454.2	91.6	113.6
9<10	10700	12900	2675	3225	29.7	29.6	29.65	360.9	435.1	90.2	108.8
10<11	11800	14800	2950	3700	34.5	34.3	34.4	343.0	430.2	85.8	107.6
11<12	12300	16000	3075	4000	36.4	40	38.2	322.0	418.8	80.5	104.7
12<13	13400	17600	3350	4400	42.1	45.2	43.65	307.0	403.2	76.7	100.8
13<14	14700	18100	3675	4525	47.7	48.6	48.15	305.3	375.9	76.3	94.0
14<15	16100	19100	4025	4775	55.5	52.8	54.15	297.3	352.7	74.3	88.2
15<16	17000	20200	4250	5050	60.2	53.9	57.05	298.0	354.1	74.5	88.5
16<17	17600	21600	4400	5400	63.6	55.3	59.45	296.0	363.3	74.0	90.8
17<18	18000	20900	4500	5225	65.7	58.3	62	290.3	337.1	72.6	84.3
18<75	20000	23000	5000	5750	75.9	61.5	68.7	291.1	334.8	72.8	83.7
Child - 6 years old (Sum ages 1<7)								2651.3	30066.6	662.8	766.7
Child from 2 to 8 years (Sum ages 2<8)								2551.4	2975.2	637.8	743.8
Child from 6 to 16 years (Sum ages 6<17)								3690.4	4545.3	922.6	1136.3
Adult - 24 years old (18<75 multiplied by 24)								6986.9	8034.9	1746.7	2008.7
Adult - 30 years old (Sum Child + Adult)								9638.2	11101.6	2409.5	2775.4

[1] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4B-3).
[2] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 5A-3).
[3] SAs based on equation SA = K x BW(2/3). K calculated from age 2<3 data.

Table B4-2
Summary of Age Adjusted, Bodyweight-Normalized Surface Area Exposed While Bathing or Swimming

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Age Range	Duration of Exposure to Water (Bathing or Swimming)	Sum of terms for Average Case (50th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)	Sum of Terms for Reasonable Maximum Exposure (95th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)
1 thru 6	6 years	2651.3	3066.6
2 thru 8	6 years	2551.4	2975.2
6 thru 16	11 years	3690.4	4545.3
18 thru 41	24 years	6986.9	8034.9
1 thru 30	30 years	9638.2	11101.6

Table B4-3
Surface Area Exposed to Surface Water for Waders (Child)

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Age	Mean Percentage (%) of Whole Body Surface Area			95th Percentile Whole Body Surface Area[3] (cm²)	Estimated Surface Area (cm²) (Mean % Whole Body SA x Whole Body SA)			Estimated SA for Hands, Lower Legs, and Feet Ages 1 thru 6 (cm²)
	Hands[1]	Lower Legs[2]	Feet[1]		Hands[1]	Lower Legs[2]	Feet[1]	
1<2	5.68	12.8	6.27	46,104	346.7	781.3	382.7	1,510.7
2<3	5.3	12.8	7.07	6,820	361.5	873.0	482.2	1,716.6
3<4	6.07	12.8	7.21	7,640	463.7	977.9	550.8	1,992.5
4<5	5.7	12.8	7.29	8,450	481.7	1,081.6	616.0	2,179.3
5<6	5.7	12.8	7.29	9,180	523.3	1,175.0	669.2	2,367.5
6<7	4.71	12.8	6.9	10,600	499.3	1,356.8	731.4	2,587.5
Mean (Age 1 thru 6)	5.5	12.8	7.0	8,132	449.4	1,040.9	569.6	2,060.0

[1] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4-3).
[2] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4-2). The percent of whole body surface area for the lower legs is taken from table 4-2 (adults) because no value for children is reported.
[3] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4B-3)
[4] See Table D-13.

Table B4-4
Summary of Age Adjusted, Bodyweight-Normalized Surface Area Exposed While Wading[1]

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Age Range	Duration of Exposure to Water (Wading)	Sum of terms for Average Case (50th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)	Sum of Terms for Reasonable Maximum Exposure (95th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)
1 thru 6	6 years	662.8	766.7
2 thru 8	6 years	637.8	743.8
6 thru 16	11 years	922.6	1,136.3
18 thru 41	24 years	1,746.7	2,008.7
1 thru 30	30 years	2,409.5	2,775.4

[1] See Table D-13.

$$DA_{child} = (DA_{event} \times EF / AT) \sum_{i=m}^{n} (SA_i \times ED_i / BW_i)$$

where

EF	=	Exposure frequency (events/year)
AT	=	Averaging time (days). For noncarcinogenic effects, AT = ED, and for carcinogenic effects AT = 70 years or 25,550 days.
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Bodyweight at age i (kg)

For the typical case, USEPA recommends SA for head and hands only and for the "reasonable worst case," the SA of the head, hands, forearms, and lower legs as the SA available for contact with soil. USEPA simplifies these assumptions by saying that 25 percent of the total body surface area would be available for soil contact. For adults, using 50^{th} and 95^{th} percentile whole body SA values, the default SA values are 5000 cm^2 and 5800 cm^2 (Table 4-5). For children, the default values for each age group would be equal to 25 percent of the 50^{th} percentile and 95^{th} percentile whole body SA values. Estimated bodyweights are the average of the 50^{th} percentile female and male weights (Table 4-5).

Values of

$$\sum_{i=m}^{n} (SA_i \times ED_i / BW_i)$$

for commonly used age ranges are presented in Table 4-6.

Table B4-5
Exposure Parameters for Dermal Contact With Soil

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Age	Total Surface Area (cm²)		SA Available for Soil Contact (cm²) (.25 x Total Surface Area)		Body Weight (kg)			Derivation of DAevent (Dose absorbed / unit area / event)	
	Male 50th Percentile[1]	Male 95th Percentile[1]	Male 50th Percentile	Male 95th Percentile	Male 50th Percentile[2]	Female 50th Percentile[2]	Average of Male and Female	50th Percentile	95th Percentile
1<23	5398	6104	1350	1526	11.5	10.5	11	122.7	138.7
2<3	6030	6820	1508	1705	13.4	12.6	13	116.0	131.2
3<4	6640	7640	1660	1910	15.3	14.6	14.95	111.0	127.8
4<5	7310	8450	1828	2113	17.4	16.4	16.9	108.1	125.0
5<6	7930	9180	1983	2295	19.3	18.8	19.05	104.1	120.5
6<7	8660	10600	2165	2650	21.9	21	21.45	100.9	123.5
7<8	9360	11100	2340	2775	24.4	23.5	23.95	97.7	115.9
8<9	10000	12400	2500	3100	27.3	27.3	27.3	91.6	113.6
9<10	10700	12900	2675	3225	29.7	29.6	29.65	90.2	108.8
10<11	11800	14800	2950	3700	34.5	34.3	34.4	85.8	107.6
11<12	12300	16000	3075	4000	36.4	40	38.2	80.5	104.7
12<13	13400	17600	3350	4400	42.1	45.2	43.65	76.7	100.8
13<14	14700	18100	3675	4525	47.7	48.6	48.15	76.3	94.0
14<15	16100	19100	4025	4775	55.5	52.8	54.15	74.3	88.2
15<16	17000	20200	4250	5050	60.2	53.9	57.05	74.5	88.5
16<17	17600	21600	4400	5400	63.6	55.3	59.45	74.0	90.8
17<18	18000	20900	4500	5225	65.7	58.3	62	72.6	84.3
18<75	20000	23000	5000	5750	75.9	61.5	68.7	72.8	83.7
Child - 6 years old (Sum ages 1<7)								662.8	766.7
Child from 2 to 8 years (Sum ages 2<8)								637.8	743.8
Child from 6 to 16 years (Sum ages 6<17)								922.6	1136.3
Adult - 24 years old (18<75 multiplied by 24)								1746.7	2008.7
Adult - 30 years old (Sum Child+ Adult)								2409.5	2775.4

[1] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4B-3)
[2] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 5A-3)
[3] SAs based on equation SA = K x BW(2/3).
K calculated from age 2<3 data.

Table 4-6
Summary of Age Adjusted, Bodyweight-Normalized Surface Area Exposed to Soil[1]

Supplemental RFI/RI Workplan
Naval Air Station Key West
Key West, Florida

Age Range	Duration of Exposure to Soil	Sum of terms for Average Case (50th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)	Sum of Terms for Reasonable Maximum Exposure (95th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)
1 thru 6	6 years	662.8	766.7
2 thru 8	6 years	637.8	743.8
6 thru 16	11 years	922.6	1136.3
18 thru 41	24 years	1746.7	2008.7
1 thru 30	30 years	2409.5	2775.4

REFERENCES

USEPA, 1989, Exposure Factors Handbook; Office of Health and Environmental Assessment, Washington, D.C.; USEPA/600/8-89/043; 1989.

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