# Final
# Remedial Investigation Work Plan
# Landfill Areas 1 and 2
# Former Ramey Air Force Base
# Aguadilla, Puerto Rico

Contract Number DACA21-96-D-0018
Task Order No. 0008

**June 2000**

IT CORPORATION
A Member of The IT Group

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**US Army Corps of Engineers**
Savannah District

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# Aguadilla, Puerto Rico

**Total Environmental Restoration**
**Contract No. DACA21-96-D-0018**
**Task Order No. 0008**

**Prepared for:**

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# Table of Contents

**Page**


List of Tables ..... v
List of Figures ..... vii
List of Acronyms ..... viii
1.0 Project Description ..... 1-1
1.1 Introduction ..... 1-1
1.2 Scope ..... 1-1
1.3 Objectives ..... 1-1
2.0 Site Background and Existing Conditions ..... 2-1
2.1 Site Description ..... 2-1
2.1.1 Topography ..... 2-1
2.1.2 Climate ..... 2-1
2.1.3 Regional Geology ..... 2-2
2.1.4 Local Geology ..... 2-3
2.1.5 Soils ..... 2-3
2.1.6 Local Hydrogeology ..... 2-3
2.1.7 Surface Water Hydrology ..... 2-4
2.1.8 Water Supply ..... 2-5
2.2 Existing Conditions ..... 2-5
2.3 Previous Investigation ..... 2-6
3.0 Field Sampling Plan ..... 3-1
3.1 Data Collection Strategy ..... 3-1
3.1.1 Data Uses and Quality Assurance/Quality Control Sampling ..... 3-1
3.1.2 Rationale for Selection of Sample Analyses ..... 3-2
3.1.2.1 Landfill Area 1 ..... 3-2
3.1.2.2 Landfill Area 2 ..... 3-3
3.1.3 Selection of Sampling Locations ..... 3-3
3.2 Sampling and Field Procedures ..... 3-3
3.2.1 Surface Soil Sampling Procedures ..... 3-4
3.2.2 Direct-Push Subsurface Soil Sampling Procedures ..... 3-4
3.2.3 Geotechnical Soil Samples ..... 3-6
3.2.4 Monitoring Well Sampling Procedures ..... 3-6
3.2.5 QA/QC Sampling ..... 3-7
3.2.6 Karst Investigation ..... 3-7

## Table of Contents (Continued)

Page


3.2.7 Decontamination Procedures ..... 3-8
3.2.8 Sample Custody and Tracking Procedures ..... 3-9
3.2.9 Documentation ..... 3-9
3.2.10 Field Instrument Calibration ..... 3-9
3.3 Sample Analysis ..... 3-9
3.4 Investigation-Derived Waste ..... 3-10
3.4.1 Technical Rationale ..... 3-11
3.4.2 Solid Investigation-Derived Waste ..... 3-12
3.4.3 Liquid Investigation-Derived Waste ..... 3-12
3.4.4 Other Investigation-Derived Waste ..... 3-13
4.0 Human Health Baseline Risk Assessment ..... 4-1
4.1 Conceptual Site Exposure Model ..... 4-1
4.1.1 Physical Setting ..... 4-1
4.1.2 Source of Contamination Potentially Released at Site ..... 4-3
4.1.3 Media of Interest ..... 4-3
4.1.4 Release Mechanisms and Transport Pathways ..... 4-3
4.1.5 Receptors and Exposure Pathways ..... 4-4
4.1.5.1 Landfill Area 1 ..... 4-4
4.1.5.2 Landfill Area 2 ..... 4-5
4.1.6 Evaluating Exposure to Soil ..... 4-6
4.2 Baseline Risk Assessment Tasks ..... 4-7
4.2.1 Phase One: Screening Human Health Risk Assessment ..... 4-8
4.2.1.1 Selecting Chemicals of Potential Concern ..... 4-8
4.2.1.2 Background Screening ..... 4-9
4.2.1.3 Exclusion of Essential Elements ..... 4-9
4.2.1.4 Risk-Based Screening ..... 4-9
4.2.1.5 Chemicals Not Detected ..... 4-10
4.3 Phase Two: Baseline Human Health Risk Assessment ..... 4-10
4.3.1 Data Evaluation ..... 4-11
4.3.2 Exposure Assessment ..... 4-14
4.3.3 Receptor Scenarios ..... 4-14
4.3.3.1 Off-Site Consumer of Animal Agriculture Products ..... 4-16
4.3.3.2 Youthful Trespasser ..... 4-16

**Page**


4.3.3.3 Farm Worker ..... 4-17
4.3.3.4 Groundskeeper ..... 4-19
4.3.3.5 Resident ..... 4-19
4.3.3.6 Construction Worker ..... 4-20
4.3.4 Quantification of Exposure-Point Concentrations ..... 4-20
4.3.4.1 Exposure-Point Concentrations in Ambient Air ..... 4-20
4.3.4.2 Exposure-Point Concentrations in Fruits and Vegetables ..... 4-24
4.3.4.3 Exposure-Point Concentrations in Beef ..... 4-24
4.3.5 Quantification of Chemical Intake Rates ..... 4-25
4.3.5.1 Inhalation of COPC in Air ..... 4-26
4.3.5.2 Incidental Ingestion of COPC in Soil ..... 4-26
4.3.5.3 Dermal Contact with COPC in Soil ..... 4-26
4.3.5.4 Ingestion of COPC in Beef ..... 4-27
4.3.5.5 Ingestion of COPC in Fruits and Vegetables ..... 4-28
4.3.6 Toxicity Assessment ..... 4-28
4.3.6.1 Evaluation of Carcinogenic Effects ..... 4-29
4.3.6.2 Evaluation of Noncancer Effects ..... 4-31
4.3.6.3 Target Organ Toxicity ..... 4-32
4.3.6.4 Dermal Toxicity Values ..... 4-33
4.3.6.5 Sources of Toxicity Information Used in the Risk Assessment ..... 4-33
4.3.6.6 Gastrointestinal Absorption Factors ..... 4-34
4.3.6.7 Toxicological Profiles ..... 4-35
4.3.7 Risk Assessment ..... 4-35
4.3.7.1 Carcinogenic Effects of Chemicals ..... 4-35
4.3.7.2 Noncancer Effects of Chemicals ..... 4-37
4.3.8 Uncertainty Analysis ..... 4-37
4.3.9 Summary and Conclusions ..... 4-39
5.0 Screening Level Ecological Risk Assessment ..... 5-1
5.1 Summary of Historical Sampling Results ..... 5-1
5.1.1 Landfill Area 1 ..... 5-1
5.1.2 Landfill Area 2 ..... 5-2
5.2 Site Description ..... 5-2
5.2.1 Site History ..... 5-2

## Table of Contents (Continued)

**Page**


5.2.2 Site Setting ..... 5-2
5.2.3 Ecological Description ..... 5-3
5.3 Screening Level Ecological Risk Assessment ..... 5-3
5.3.1 Ecological Conceptual Site Model ..... 5-3
5.3.1.1 Landfill Area 1 ..... 5-3
5.3.1.2 Landfill Area 2 ..... 5-4
5.3.2 Step 1, Preliminary Screen and Abiotic Hazard Quotients ..... 5-5
5.3.3 Step 2, Problem Formulation ..... 5-6
5.4 Baseline Ecological Risk Assessment ..... 5-7
6.0 Project Organization ..... 6-1
6.1 USACE Personnel ..... 6-1
6.2 IT Personnel ..... 6-2
7.0 Schedule ..... 7-1
8.0 Site Safety and Health Plan ..... 8-1
9.0 References ..... 9-1
Appendix A – Example Forms
Appendix B – Site-Specific Safety and Health Plan

## List of Tables


| Table | Title | Follows Tab |
|---|---|---|
| 2-1 | Monitoring Well Construction Details for Landfill Area 1 | |
| 2-2 | Monitoring Well Construction Details for Landfill Area 2 | |
| 2-3 | Inorganic Groundwater Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-4 | Organic Groundwater Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-5 | Inorganic Groundwater Analytical Results from Landfill Area 2 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-6 | Organic Groundwater Analytical Results from Landfill Area 2 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-7 | Inorganic Surface Soil Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-8 | Organic Surface Soil Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-9 | Inorganic Surface Soil Analytical Results from Landfill Area 2 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-10 | Organic Surface Soil Analytical Results from Landfill Area 2 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-11 | Inorganic Surface Water Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-12 | Organic Surface Water Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-13 | Inorganic Sediment Sample Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-14 | Organic Sediment Sample Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 | |
| 2-15 | Inorganics Subsurface Soil Analytical Results, Monitoring Well RMW1-1, Landfill Area 1, June 1997 | |
| 2-16 | Organic Subsurface Soil Analytical Results, Monitoring Well RMW1-1, Landfill Area 1, June 1997 | |
| 2-17 | Inorganic Subsurface Soil Analytical Results, Monitoring Well RMW1-4, Landfill Area 1, June 1997 | |
| 2-18 | Organic Subsurface Soil Analytical Results, Monitoring Well RMW1-4, Landfill Area 1, June 1997 | |

## List of Tables *(Continued)*


| Table | Title | Follows Tab |
|---|---|---|
| 2-19 | Inorganic Subsurface Soil Analytical Results, Monitoring Well RMW2-1, Landfill Area 2, June 1997 | |
| 2-20 | Organic Subsurface Soil Analytical Results, Monitoring Well RMW2-1, Landfill Area 2, June 1997 | |
| 2-21 | Inorganic Subsurface Soil Analytical Results, Monitoring Well RMW2-2, Landfill Area 2, June 1997 | |
| 2-22 | Organic Subsurface Soil Analytical Results, Monitoring Well RMW2-2, Landfill Area 2, June 1997 | |
| 2-23 | Inorganic Subsurface Soil Analytical Results, Monitoring Well RMW2-3, Landfill Area 2, June 1997 | |
| 2-24 | Organic Subsurface Soil Analytical Results, Monitoring Well RMW2-3, Landfill Area 2, June 1997 | |
| 2-25 | Inorganic Subsurface Soil Analytical Results, Monitoring Well RMW2-4, Landfill Area 2, June 1997 | |
| 2-26 | Organic Subsurface Soil Analytical Results, Monitoring Well RMW2-4, Landfill Area 2, June 1997 | |
| 2-27 | Inorganic Subsurface Soil Analytical Results, Monitoring Well RMW2-5, Landfill Area 2, June 1997 | |
| 2-28 | Organic Subsurface Soil Analytical Results, Monitoring Well RMW2-5, Landfill Area 2, June 1997 | |
| 3-1 | Landfill Area 1 and Landfill Area 2 Sampling Requirements | |
| 3-2 | Sampling and Analytical Requirements for Landfill Area 1 and Landfill Area 2 | |
| 4-1 | Human Receptors for the Landfills | |
| 4-2 | Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors, Landfill Sites | |

## List of Figures


| Figure | Title | Follows Tab |
|---|---|---|
| 1-1 | Location Map | |
| 1-2 | Site Vicinity Map | |
| 2-1 | Site Map - Landfill 1 | |
| 2-2 | Site Map, Landfills 1 and 2 | |
| 2-3 | Site Map, Landfill Area 2 | |
| 3-1 | Proposed Sample Location Map, Landfill Area 1 | |
| 3-2 | Proposed Sample Location Map, Landfill Area 2 | |
| 4-1 | Human Health Conceptual Site Exposure Model, Landfill 1 | |
| 4-2 | Human Health Conceptual Site Exposure Model, Landfill 2 | |
| 5-1 | Seven-Step (Formerly Eight-Step) Ecological Risk Assessment Process for Superfund | |
| 5-2 | Ecological Conceptual Site Model, Landfill 1 | |
| 5-3 | Ecological Conceptual Site Model, Landfill 2 | |
| 6-1 | Organization Chart | |
| 7-1 | Landfill Schedule | |

## List of Acronyms

| | |
|---|---|
| ABS | absorption factor |
| Accutest | Accutest Laboratories, Inc. |
| AF | adherence factor |
| AFB | Air Force Base |
| AHQ | abiotic hazard quotient |
| ASTM | American Society for Testing and Materials |
| AT | averaging time |
| BERA | baseline ecological risk assessment |
| bgs | below ground surface |
| BHHRA | baseline human health risk assessment |
| BNA | base neutral/acid extractables |
| BW | body weight |
| CFR | Code of Federal Regulations |
| $cm^2$ | cubic centimeter |
| CO | contracting officer |
| COPEC | chemical(s) of potential ecological concern |
| COPC | chemical(s) of potential concern |
| COR | CO representative |
| CSEM | conceptual site exposure model |
| CT | central tendency |
| °F | degrees Fahrenheit |
| DOE | U.S. Department of Energy |
| DQO | data quality objective |
| E&E | Ecology and Environment, Inc. |
| ED | exposure duration |
| EF | exposure frequency |
| EPA | U.S. Environmental Protection Agency |
| EQB | Environmental Quality Board, Commonwealth of Puerto Rico |
| FI | food ingestion rate |
| FID | flame ionization detector |
| $f_{oc}$ | fractional organic carbon |
| g/day | grams per day |

| | |
|---|---|
| g/kg | grams per kilogram |
| GAF | gastrointestinal absorption factor |
| HEAST | Health Effects Assessment Summary Table |
| HI | hazard index |
| HQ | hazard quotient |
| IDW | investigation-derived waste |
| ILCR | incremental lifetime cancer risk |
| IRIS | Integrated Risk Information System |
| IT | IT Corporation |
| $\mu g/m^3$ | micrograms per cubic meter |
| µg/mg | micrograms per milligram |
| $m^3$/day | cubic meters per day |
| $m^3$/hour | cubic meters per hour |
| MDC | maximum detected concentration |
| $mg/cm^2$ | milligrams per cubic centimeter |
| mg/day | milligrams per day |
| mg/kg | milligrams per kilogram |
| mg/kg-day | milligrams per kilograms per day |
| msl | mean sea level |
| NCEA | National Center for Environmental Assessment |
| OSHA | Occupational Safety and Health Administration |
| OVA | organic vapor analyzer |
| PAH | polynuclear aromatic hydrocarbon |
| PCB | polychlorinated biphenyl |
| PEF | particulate emission factor |
| PM | project manager |
| ppm | parts per million |
| PRASA | Puerto Rico Aqueduct and Sewer Authority |
| QA/QC | quality assurance/quality control |
| RBC | risk-based concentration |
| RBSL | risk-based screening level |
| RCRA | Resource Conservation and Recovery Act |
| redox | oxidation-reduction potential |

## List of Acronyms *(Continued)*

| | |
|---|---|
| RfC | reference concentration |
| RfD | reference dose |
| RI | remedial investigation |
| RME | reasonable maximum exposure |
| SA | surface area |
| SAP | installation-wide sampling and analysis plan |
| SF | slope factor |
| SLERA | screening level ecological risk assessment |
| SSHP | site-specific safety and health plan |
| SV | screening value |
| SVOC | semivolatile organic compound |
| TAL | target analyte list |
| TCLP | toxicity characteristics leaching procedure |
| TERC | Total Environmental Restoration Contract |
| TM | technical manager |
| TOC | total organic carbon |
| TPH | total petroleum hydrocarbon |
| UCL | upper confidence limit |
| URF | unit risk factor |
| USACE | U.S. Army Corps of Engineers |
| USDA | U.S. Department of Agriculture |
| USGS | U.S. Geological Survey |
| UTL | upper tolerance limit |
| VOC | volatile organic compound |
| WP | work plan |

# 1.0 Project Description

## 1.1 Introduction

Through the Total Environmental Restoration Contract (TERC) No. DACA21-96-D-0018, Task Order No. 8, the Savannah District of the U.S. Army Corps of Engineers (USACE) retained IT Corporation (IT) to conduct a remedial investigation (RI) for Landfill Areas 1 and 2 at the former Ramey Air Force Base (AFB) in Aguadilla, Puerto Rico. This work plan (WP) has been prepared to support the RI activities.

The former Ramey AFB is located in the extreme northwestern corner of the island of Puerto Rico, near the city of Aguadilla, and occupies approximately 4,357 acres (Figure 1-1). Presently, the U.S. Coast Guard occupies approximately 125 acres, and the Puerto Rico Port Authority now owns and operates a municipal airport and an industrial park at the former Base. Portions of the former base also are leased to local farmers (Ecology & Environment, Inc. [E&E] 1997).

Figure 1-2 shows the locations of Landfill Areas 1 and 2. Landfill Area 1 is believed to cover approximately 6 acres on an 18-acre tract leased by the Puerto Rico Port Authority to a local farmer who uses the land for grazing. Landfill Area 2 is believed to cover approximately 20 acres on a 65-acre tract leased by the Puerto Rico Port Authority to another local farmer who uses the land for grazing and growing crops (E&E, 1997).

## 1.2 Scope

The scope of the RI for the Landfill Areas 1 and 2 encompasses conducting a document review; preparing a site-specific WP, which includes a field sampling plan and site-specific safety and health plan (SSHP); mobilizing and conducting the field investigation activities; and preparing the investigation report.

## 1.3 Objectives

The objectives of this task order are to conduct a RI to determine the presence of soil and groundwater contamination resulting from the potential release of leachate from Landfill Areas 1 and 2 at the former Ramey AFB. The primary objective will be to collect and analyze soil and groundwater samples to determine if past releases from the site have resulted in contaminant concentrations above action criteria. Another objective will be to evaluate data from the investigation to determine the need for additional investigations and/or corrective actions at the sites in accordance with the Environmental Quality Board, Commonwealth of Puerto Rico ([EQB] 1990).

# 2.0 Site Background and Existing Conditions

The former Ramey AFB is located north of the city of Aguadilla, on the extreme northwestern tip of the island of Puerto Rico. The approximately 4,357-acre Base was acquired by the U.S Government between 1939 and 1963 and was utilized as a fully operational AFB until its deactivation in 1973 (USACE, 1999).

In March 1974, ownership of most of the property was transferred to the Puerto Rico Industrial Development Company. Since March 1974, the U.S. government has transferred numerous parcels of land to federal and local agencies and private companies. The area is now operated by the Puerto Rico Port Authority as the Rafael Hernandez Airport, a municipal airport and industrial park (USACE, 1999). The Base property is currently occupied by the Puerto Rico Port Authority, Puerto Rico National Guard, U.S. Customs, U.S. Coast Guard, educational facilities, several privately-owned businesses, and residential property (E&E, 1997).

## 2.1 Site Description

The following sections briefly describe the conditions found at the former Ramey AFB.

### 2.1.1 Topography

The elevation at the former Ramey AFB ranges from 0 feet above mean sea level (msl) at the north and western coastline to approximately 240 feet above msl. An escarpment is located on the north and west portions of the Base, producing a steep rise in elevation from sea level (the Atlantic Ocean) to approximately 175 feet msl. The flightline portion of the Base is flat and higher than much of the facility, with an approximate elevation of 190 to 230 feet msl (U.S. Geological Survey [USGS], 1960). Rough relief occurs in parts of the former Ramey AFB due to the chemical dissolution of the underlying limestone bedrock. This dissolution has produced such karst features as sinkholes, caves, *mogotes* (haystack hills), dead-end valleys, and many precipitous cliffs (USGS, 1976).

### 2.1.2 Climate

The climate at the former Ramey AFB is classified as tropical-maritime, with temperatures ranging from 74 degrees Fahrenheit (°F) in January to 80°F in July. The average annual precipitation is approximately 60 inches, with the rainy season occurring from May through December (USGS, 1976). Tropical systems occasionally drift over the area producing heavy rainfall and occasional flooding. The wind regime is generally under the influence of prevailing easterly trade winds but is also affected by land and sea breezes. In general, the strongest winds

occur early in the afternoon, and the lightest during the night. Usually the wind is strongest in July and light in autumn (U.S. Department of Agriculture [USDA], 1975).

### *2.1.3 Regional Geology*

The former Ramey AFB is located in the Coastal Plains physiographic region in the Mayaguez area. The coastal plains parallel nearly the entire northern coastline and include most of the area north of the towns of Aguadilla, Moca, San Sebastion, and Lares. The coastal plains are comprised of alluvial and terrace deposits characterized as unstratified, fine- to medium-grained quartz sand, and light to moderate brown clays. These unconsolidated materials are between 0 and 100 feet thick (Monroe, 1969).

The surficial deposits are underlain by limestone of Miocene age and are located in a broad limestone belt that is Puerto Rico's best developed karst region. The geologic formation found beneath the coastal sediments is the Early Miocene Aymamon Limestone. The upper member of this formation is characterized as very pale orange to bright yellow chalk containing fossils and interbedded with hard, vuggy, very pale orange to white limestone, some of which is fossiliferous (Monroe, 1969). The lower member of the Aymamon consists of white to very pale orange, very pure fossiliferous limestone; it is generally indurated into finely crystalline, dense limestone, and is locally a recemented solution breccia (Monroe, 1966, 1969). The Aymamon formation is estimated to be up to 1,000 feet thick beneath the site (Rodriguez-Martinez, 1995). The middle and upper parts of the formation are highly permeable, with as much as 25 percent total porosity (Rodriguez-Martinez, 1995).

Underlying the Aymamon Limestone is the Aguada Limestone, which is characterized as a hard, thick-bedded calcarenite interbedded with chalky limestone and marl (Monroe, 1969). The Aguada Limestone is approximately 300 feet thick. The Aguada is underlain by the Cibao Formation. The Cibao Formation is approximately 700 to 870 feet thick and consists of interbedded calcareous clay, earthy chalk, hard, very fine-grained calcarenite, and soft, nongranular limestone (Monroe, 1969).

The former Ramey AFB is situated on the Aguadilla Uplift. This uplift has resulted in a northwest plunging structural anticline with some faulting reported in the vicinity of the city of Aguadilla. The Base is situated of the east flank of the anticline, with the bedrock dipping to the northeast.

### 2.1.4 Local Geology

Unconsolidated soils encountered during the drilling activities conducted by E&E in 1996 at Landfill Areas 1 and 2 (Figure 2-1) were visually characterized and consisted primarily of brown to orange-brown silty sandy clay and sandy clay (E&E, 1997). At Landfill Area 2, where agricultural crops are grown, a thin (1- to 2-foot thick) veneer of brown silt loam overlies the orange-brown silty sandy clays and sandy clays.

Bedrock was encountered in the landfills at depths ranging from 8 to 66 feet below ground surface (bgs). The Aymamon Limestone was described as a buff to yellow-tan, soft, moderately to heavily weathered, porous and pitted limestone with some iron staining (E&E, 1997). Hardness and color varies slightly with depth. Cuttings from various depths were also observed to contain fossils. Some travertine and clear calcite crystals were observed in rock cuttings at approximately 135 feet bgs at Landfill Area 1. Numerous voids were encountered during the air rotary drilling between 150 and 200 feet bgs, resulting in the loss of circulation at several well locations.

### 2.1.5 Soils

The majority of the soils at the former Ramey AFB are either of the Bejucos-Jobos association or the Coto-Aceitunas association (USDA, 1975). The Bejucos-Jobos association is comprised of strongly leached soils that have a tight, dominantly clayey subsoil. The majority of soils in this classification are well drained and strongly acidic. The Bejucos soils have a dark yellowish-brown, moderately coarse-textured surface layer and a subsoil that is dominantly fine textured and mottled below a depth of about 37 inches. The Jobos soils have a dark grayish-brown, coarse-textured surface layer and a thick, mottled, red and strong brown, compact, fine-textured subsoil.

The Coto-Aceitunas association consists of slightly leached and strongly leached porous soils that are dominantly clayey throughout (USDA, 1975). The major soils of this association are underlain by hard, fragmented limestone and are characterized as deep, gently sloping to sloping, well drained and moderately permeable. The Coto soils are reddish brown, slightly acidic, and fine textured; the Aceitunas soils are dark reddish brown, fine-textured and moderately fine-textured, and very strongly acidic.

### 2.1.6 Local Hydrogeology

The North Coast Limestone aquifer system is comprised of three hydrogeologic units: an upper water table aquifer, a middle confining unit, and a lower confined aquifer. The water table aquifer consists of the Aymamon Limestone and the Aguada Limestone. The lower Aguada

Limestone and the Cibao Formation form the middle confining unit. The lower confined aquifer is comprised of the lower Cibao Formation. The lower aquifer is fragmented into several confined units in the western part and does not seem to be an important source of groundwater in the vicinity of the former Ramey AFB. The major hydrogeologic units of the aquifer system were based on the relative permeability and hydraulic continuity of the units (Rodriguez-Martinez, 1995).

The water table aquifer is contained in karst limestone bedrock. Most of the permeability of the aquifer is the result of secondary porosity caused by the dissolution of the bedrock along joints, fractures, and bedding planes. Because of the karst nature of the aquifer, water levels may fluctuate greatly (plus or minus 10's of feet), thereby affecting groundwater flow directive and velocity. The transmissivities in the water table aquifer range from 200 to more than 280,000 square feet per day (Rodriguez-Martinez 1995).

The water table aquifer is encountered at depths ranging from approximately 195 to 280 feet bgs in the vicinity of former Ramey Air Force Base and the town of Isabella. The water table aquifer in the area of northwestern Puerto Rico ranges in thickness from approximately 900 to 1,035 feet (Rodriguez-Martinez and Hartley, 1994).

The freshwater-saltwater interface was reported at a depth of approximately 190 feet below the top of the water table (455 feet bgs) at Isabella by Rodriguez-Martinez (1995). The freshwater-saltwater mixing zone is included in the saltwater zone. The landward extent of the saltwater zone is unknown in the western part of the limestone aquifer.

Groundwater at Landfill Area 1 was encountered between approximately 214 and 240 feet bgs and flowed toward the east. Groundwater at Landfill Area 2 was encountered between approximately 211 and 223 feet bgs and flowed north and northwest toward the ocean (E&E 1997).

### *2.1.7 Surface Water Hydrology*

Surface water at Landfill Area 1 drains toward an adjacent sinkhole along channels. These narrow drainage channels are approximately 30 feet deep with exposed bedrock at the bottom of the channel. There are swallows along the course of the channels, allowing for direct transport of storm water to the underlying groundwater. The easternmost channel has begun to expose landfill material, which is being transported into the sinkhole during storm events. Ponded storm water can remain in the sinkhole for up to a week after a storm, and water marks as high as 12 feet have been observed in the sinkhole (E&E, 1997).

Inspection of a 1966 map of the Base indicates that the storm flow channels that received runoff from the aircraft apron terminated into a naturally occurring low area (E&E, 1997). The sanitary fill from the Base was placed in the low area as well. A comparison of the 1966 map with current conditions indicates that the 5-acre, 35-foot-deep sinkhole next to Landfill Area 1 has probably developed during the last 30 years and now is gradually capturing the western edge of Landfill Area 1.

### 2.1.8 Water Supply

Potable water at the former Ramey AFB is supplied by the Puerto Rico Aqueduct and Sewer Authority (PRASA). PRASA reports that domestic water supply in the vicinity of the former Ramey AFB is obtained from several surface water reservoirs located between 5 and 10 miles south and southeast, and upgradient of the Base. A site visit and file review by E&E revealed no indication of private supply wells for domestic use (E&E, 1997). A water supply well used by U.S. Customs was discovered on a site visit by IT personnel. The former Ramey AFB did maintain a supply well (or wells) and a water tower for potable use, but this equipment has fallen into extreme disrepair and appears unusable (E&E, 1997).

## 2.2 Existing Conditions

***Landfill Area 1.*** Landfill Area 1 covers approximately 6 acres. Topographic relief in the area of Landfill Area 1 is approximately 70 feet and slopes toward a sinkhole immediately west of the disposal area. This sinkhole is approximately 35 feet deep and 5 acres in size. A 3-acre hill is located immediately north of the landfill area, and an aircraft apron used to store inoperable and scrap aircraft is located north of the site. Figure 2-1 shows the locations of the aircraft apron, the sinkhole, the hill, and the area where the sanitary waste was disposed. The time period or nature of disposals at this site have not been determined from existing records. However, a 1966 map of the Base refers to Landfill Area 1 as a "sanitary fill" area. An aerial photograph indicates that disposals were occurring in 1970, but this is the only information on disposals discovered to date. Figure 2-2 is an overlay of a 1983 aerial photograph on the Base map that shows both Landfill Areas 1 and 2.

Some of the landfilled material has become exposed at the surface due to erosion, especially along the western edge of the landfill. Construction debris and scrap metal are present on the ground surface and are believed to be present below grade. There has also been some public dumping of refuse south and east of the AFB landfill area. Some medical waste of unknown origin has been observed in the sinkhole, and is believed to have been transported into the

sinkhole during storms. The medical waste appears to have been placed in fabric bags, then disposed of in the landfill. The medical waste includes intravenous bags and tubing, latex gloves, and syringes (E&E, 1997).

***Landfill Area 2.*** Landfill Area 2 (Figure 2-3) is a flat-lying grass-covered 20-acre tract currently used by a tenant for grazing and crop growing. No records of disposal activities at this site have been located to date. Two geophysical surveys were previously conducted at Landfill Area 2, but the results may not be conclusive because of techniques used and spacing of the sensors. Landfill Area 2 is reported to have received municipal, household garbage from a former adjacent Air Force housing development called "Tropical Acres." There are several old building foundations that appear to have been built when the Base was operating (E&E, 1997). A pond was recently constructed by the USACE and altered by the tenant farmer to use for drinking water for cattle. A broad shallow sinkhole is located about 200 feet north of the burial area. A small part of the burial area drains into the sinkhole, but for the most part, the slope of the landfill area is toward the south.

### *2.3 Previous Investigation*

The initial investigation of environmental conditions of Landfill Areas 1 and 2 took place in 1996 and 1997 and was conducted by E&E of Pensacola, Florida. During that investigation, nine groundwater monitoring wells were drilled and samples collected from each well. There are four existing wells at Landfill Area 1 and five at Landfill Area 2. Construction details of these wells are shown in Tables 2-1 and 2-2. Soil samples were collected during boring operations for the monitoring wells. The top 2 feet of the soil boring was used to assess surface soil conditions, and the remainder of the boring was used for subsurface soil assessment. Also, a sediment and surface water sample was collected from the sinkhole at Landfill Area 1. All samples were analyzed for volatile organic compounds (VOC); base neutral/acid extractables (BNA); total petroleum hydrocarbons (TPH), both diesel and gasoline range; target analyte list (TAL) metals; pesticides; and polychlorinated biphenols (PCB).

***Groundwater Sampling Results.*** Of the four groundwater samples analyzed from Landfill Area 1, the only chemicals detected above U.S. Environmental Protection Agency (EPA) Region III risk-based concentrations (RBC) were iron, chloroform, and trichloroethylene. These results are shown in Tables 2-3 and 2-4. The five samples collected from Landfill Area 2 showed elevated concentrations of manganese, iron, aluminum, chloroform, and bromodichloromethane. The groundwater analytical results from Landfill Area 2 are provided in Tables 2-5 and 2-6 (E&E, 1997).

***Surface Soil Sampling Results.*** Surface soil was sampled during drilling operations for the installation of groundwater monitoring wells at both Landfill Areas 1 and 2. The surface soil samples were collected from the first 2 feet in the soil boring for each of the nine wells. The analytes that were detected above established threshold levels at both landfills were arsenic, iron, thallium, antimony, and chromium. One sample from Landfill Area 2 was slightly above the EPA Region III residential RBC for manganese. These detections may be naturally occurring concentrations of these constituents in native soils of the region. This will be determined upon evaluation of these concentrations and those found in the background soil study (IT, 2000a). The results of previous surface soil sample analyses are summarized in Tables 2-7, 2-8, 2-9, and 2-10 (E&E, 1997).

***Surface Water and Sediment Sampling Results.*** One surface water sample and one sediment sample were collected during the initial investigation at Landfill Area 1. There were no parameters detected above Puerto Rico Water Quality Standards in the surface water sample. The analytes detected above screening values in the sediment sample were arsenic, magnesium, and three semivolatile organics. Tables 2-11 through 2-14 summarize the analytical results from the surface water and sediment sampling (E&E, 1997).

***Subsurface Soil.*** Subsurface soil samples were collected from seven of the borings which were converted into groundwater monitoring wells. Subsurface soil samples were collected from 4 to 6 feet, 9 to 11 feet, and 15 to 17 feet at Landfill Area 1 (RMW1-1, RMW1-4), and from 4 to 6 feet, 9 to 11 feet, 14 to 16 feet, 19 to 21 feet, 24 to 26 feet, 29 to 31 feet, and 34 to 36 feet at Landfill Area 2 (RMW2-1 through RMW2-5). The only constituents detected above the EPA Region III industrial RBCs are arsenic, total chromium, acetone, toluene, thallium, and carbon disulfide. The inorganic elements detected above RBCs may be naturally occurring. This will be determined when the background soil study is completed and results are compared. Acetone is a common laboratory contaminant. During preparation of the risk assessment, quality assurance/quality control (QA/QC) data will be scrutinized to determine if detected concentrations represent background levels. No volatile organics, pesticides, or petroleum hydrocarbons were detected in subsurface soil samples. These analytical results are included in Tables 2-15 through 2-28.

# 3.0 Field Sampling Plan

An installation-wide sampling and analysis plan (SAP) (IT, 2000b) was prepared in accordance with the USACE, Savannah District SAP (USACE, 1994) and USACE EM200-1-3. While specific references are made in this WP to the installation-wide SAP, work will be conducted in accordance with the USACE SAP.

The purpose of the RI at Landfill Areas 1 and 2 is to support a remedial decision for these areas by determining the presence and nature of contamination in groundwater, surface soil, and subsurface soil. Prior to any sampling, near-surface geophysics may be performed to more precisely determine the landfill boundaries. The geophysical work plan, if applicable, will be presented in a separate document.

Samples from all media will be collected and submitted for chemical analysis. Sample locations will be adjusted as necessary based upon the results of any geophysics and on-site conditions. The results of these analyses will be used to prepare a risk assessment for the landfill areas.

## 3.1 Data Collection Strategy

Data collected as part of this RI may be used to prepare a risk assessment to determine what effects, if any, the contaminants in surface soil, subsurface soil, or groundwater might have on humans and the environment. It is estimated that a total of 9 groundwater, 44 surface soil, and a minimum of 40 subsurface soil samples will be collected and analyzed by the off-site laboratory. As there are currently no natural surface water bodies on either landfill, no surface water or sediment samples are currently proposed. The samples will be analyzed for VOCs, semivolatile organic compounds (SVOC) (often referred to as BNA organic compounds), TAL metals, TPH (both diesel and gasoline range), pesticides, and PCBs. Table 3-1 lists the numbers of samples to be collected at both Landfill Areas 1 and 2, and the analytical methods for each sample.

### 3.1.1 Data Uses and Quality Assurance/Quality Control Sampling

The data collected in this sampling effort will be compared to background values to determine if there is a significant variance between background and the samples collected at Landfill Areas 1 and 2. If the presence of contamination is indicated, a risk assessment will be conducted to determine what affects, if any, the contamination might have on human health and the environment. The results of the risk assessment will determine the need for a remedial action, further investigation, or a long-term monitoring decision.

The decision-making process for the data quality objectives (DQO) is provided in Chapter 3.0 of the SAP (IT, 2000a). All definitive confirmation sample analyses will be performed in an off-site fixed-base laboratory. All data collected will be required to meet the overall objectives of the RI. To ensure that the data meet these objectives, QA/QC samples will be collected during the field investigation. Frequencies of QA and QC samples will be those specified in the SAP. Table 3-1 defines the number of QA and QC samples to be collected. All QA/QC sampling will follow the requirements and procedures provided in Chapter 6.0 of the SAP.

Accutest Laboratories, Inc. (Accutest) will be utilized as the fixed-base analytical laboratory and will be responsible for conforming to laboratory QA/QC procedures presented in Chapter 7.0 of the SAP (IT, 2000b). This QA program provides the methods and procedures that will assess the precision, accuracy, and completeness of the data. All data collected as part of the RI will be stored in an electronic database for future use. The specifics of the data management plan are provided in Chapter 8.0 of the SAP.

Table 3-1 presents the numbers of samples to be collected and the analytical methods to be performed for all samples collected during the RI of Landfill Areas 1 and 2. Table 3-2 includes sample identification numbers, including QA/QC samples. Sample identification numbers were developed in accordance with procedures established in Section 4.0 of the SAP (IT, 2000b). The rationale for selection of sample analyses and sampling approach, in addition to the sampling procedures that will be used during the RI are discussed in the following sections.

### *3.1.2 Rationale for Selection of Sample Analyses*

In order to determine the presence of contamination at either landfill site, a series of samples is proposed for each. The fixed base laboratory will analyze all samples collected for VOCs, SVOCs, TAL metals, TPH, pesticides, and PCBs. These methods were chosen because they provide the most comprehensive set of constituents for analysis. This is necessary because the types of burials that took place at both landfills are uncertain.

#### *3.1.2.1 Landfill Area 1*

***Groundwater.*** To verify the results of the previous analytical results from the 1996 through 1997 E&E sampling efforts, the four monitoring wells installed in 1996 will be resampled.

***Surface and Subsurface Soil.*** To determine the risk to humans and the environment posed by media to which they are commonly exposed during routine activities, 20 surface soil and a

maximum of 16 (2 at each soil boring location) subsurface soil samples will be collected at the locations shown on Figure 3-1.

#### *3.1.2.2 Landfill Area 2*

***Groundwater.*** To verify the previous analytical results, the five monitoring wells surrounding Landfill Area 2 and installed in 1996 will be resampled and samples will be analyzed as described previously.

***Surface and Subsurface Soil.*** To determine the risk to humans and the environment posed by media to which they are commonly exposed in normal routine activities, 24 surface soil and a maximum of 24 (2 at each soil boring location) subsurface soil samples will be collected at the locations shown on Figure 3-2.

### *3.1.3 Selection of Sampling Locations*

The locations of samples shown on Figures 3-1 and 3-2 were selected so that the probability of collecting media that had come into contact with buried wastes was maximized. Some of these locations may be revised based on the results of possible near-surface geophysical data. The criteria for the present locations of the samples are as follows:

#### *Surface Soil*

- Directly above the disposal areas
- Down-slope of any buried material that has become exposed by erosion
- At or near the bottom of any sloping material covering the buried materials
- In low-lying areas of soil covering the buried materials.

Some of these locations may be revised based upon the location of areas of stained soil.

#### *Subsurface Soil*

- Circumvent disposal areas of both landfills. Maximum of two samples per borehole: one at the highest organic vapor analyzer (OVA) reading; one for vertical delineation.

## *3.2 Sampling and Field Procedures*

The procedures for field activities will be discussed in the following sections. Chapter 5.0 of the SAP (IT, 2000b) provides detailed instructions for sample collection and data acquisition activities that will be used during the RI for Landfill Areas 1 and 2.

### 3.2.1 Surface Soil Sampling Procedures

A total of 44 surface soil samples (0 to 1 foot) will be collected from the landfill areas. At Landfill Area 1, 12 samples will be collected within and 12 outside the landfill boundaries. At Landfill Area 2, a total of 12 samples will be collected within and 8 outside the landfill boundaries. These samples will be collected using spoons, hand augers, or other hand sampling equipment. All sampling equipment that may come in contact with samples or sampling surfaces will be constructed of stainless-steel and will be properly cleaned and decontaminated as described in Section 6.1.7 of the SAP (IT, 2000b) before collecting samples and between sampling locations. The VOC aliquots will be collected directly from the sampling device using the EnCore™ sampler(s) (Method 5035). The remaining soil will be transferred to a stainless-steel mixing bowl and homogenized. The homogenized sample will then be transferred to the appropriate sample jars. After collection, the soil samples will labeled for proper identification (using designations listed in Table 3-2), and packed in an iced cooler pending transport to the site office and shipment. Documentation procedures specified in Section 6.3.3 of the SAP shall be followed for the collection of all soil samples at the former Ramey AFB. Decontamination of sampling equipment will follow Section 6.1.7 of the SAP.

Upon receipt of the samples, the fixed-base laboratory will prepare all samples for analysis. Each sample interval will then be analyzed for the specified suite of analyses, including VOCs, SVOCs, TPH, TAL metals, pesticides, and PCBs. In addition, five of the surface soil samples collected from within and five outside the landfill boundaries will be analyzed for total organic carbon (TOC).

Additional information regarding collection of surface soil samples can be found in Section 6.1.1 of the SAP (IT, 2000b). Investigation-derived waste (IDW) generated during the soil sampling activities will be handled as described in Section 3.4 of this document.

### 3.2.2 Direct-Push Subsurface Soil Sampling Procedures

Sampling for characterization and delineation of soil contamination at the former Ramey AFB may be conducted utilizing direct-push technology at some locations. A total of 20 direct-push soil borings will be drilled at the landfill areas (12 at Landfill Area 1 and 8 at Landfill Area 2). Equipment for obtaining the sample will be provided by a subcontractor, and a variety of equipment ensembles may be employed; however, all will share these basic elements:

- Hydraulic drive unit
- Stainless-steel sampling point
- Drive point

- Teflon™ sampling sleeve
- Sampling rod.

Soil samples will be field-screened using a calibrated flame ionization detector (FID). Soil samples will be collected from a 2-foot interval displaying the highest FID reading, above the water table or bedrock. Two soil samples will be collected from borings where organic vapors are detected by the FID at concentrations greater than 10 parts per million (ppm); one from the zone with the highest FID reading and one from an interval more than 10 feet below the last reading of 10 ppm or greater. If bedrock or groundwater is encountered before readings fall below 10 ppm, then the second sample will be collected from above the water table or bedrock. If all field screening results are less than 10 ppm, then only one soil sample will be collected from above the water table or bedrock at a depth of 10 feet bgs or less. Therefore, a maximum of two soil samples will be collected for laboratory analysis from the landfill areas (maximum total of 16 samples from Landfill Area 1 and 24 samples from Landfill Area 2). Based on the variable depths to bedrock encountered in the landfill areas by E&E in 1997, only one soil sample per boring may be necessary. The maximum boring depth anticipated would be approximately 30 feet bgs, but would be dependent on OVA readings encountered.

When the sample probe has reached the desired depth, the point will be retracted and the soil sampler driven forward to be filled. The sample device is a decontaminated stainless-steel tube with an unused inner Teflon™ sleeve. The Teflon™ sleeve will be removed from the sample tube, split open, and the sample removed.

The soil samples will be visually logged in accordance with American Society for Testing and Materials (ASTM) D-1452-85 using the Unified Soil Classification System and as described in Section 6.1.1 of the SAP (IT, 2000b). Field observations (e.g., presence of fuel-product, discoloration of soil, etc.) shall be recorded in the field notes. After the sampler has been retrieved and inspected, the 2-foot sample interval will be collected for laboratory analysis. Soil collected for volatile analysis shall be collected directly from the sampling device into EnCore™ samplers as soon as possible after the sampler is opened to minimize volatilization. The remaining soil will be transferred to a stainless-steel mixing bowl and homogenized. The homogenized sample will then be transferred to the appropriate sample jars. The soil samples will labeled for proper identification (using designations listed in Table 3-2), and packed in an iced cooler pending transport to the site office and shipment. Documentation procedures specified in Section 6.3.3 of the SAP shall be followed for the collection of all soil samples at the former Ramey AFB. Decontamination of sampling equipment will follow Section 6.1.7 of the SAP.

Upon receipt, the fixed-base laboratory will prepare all samples for analysis. Each sample interval selected will then be analyzed for the specified suite of analyses, including VOCs, SVOCs, TPH, TAL metals, pesticides, and PCBs.

Direct-push sampling points will be abandoned by filling with hydrated bentonite as described in Section 5.1.2 of the SAP (IT, 2000b) with a 3-inch grout cap at the top of the borehole. IDW from the direct-push drilling activities will be handled as described in Section 3.4 of this document.

### *3.2.3 Geotechnical Soil Samples*

Selected soil samples from the vicinity of each landfill area will be analyzed for geotechnical properties. Five surface soil samples collected from within each of the landfill areas and five surface soil samples collected outside each of the landfill boundaries will be analyzed for grain size (collocated with those samples to be analyzed for TOC). In addition, undisturbed subsurface soil samples (less than 10 feet bgs) from five of the soil borings (collocated with the surface geotechnical samples) outside each landfill area will be collected and analyzed for bulk soil density, total soil porosity, air-filled porosity, water-filled porosity, particle density, and fractional organic carbon ($f_{oc}$). The surface and subsurface geotechnical samples collected outside the landfill boundaries will be collocated at the same borings. All geotechnical samples will be sent to IT's Environmental Technology Development Center for analysis.

### *3.2.4 Monitoring Well Sampling Procedures*

Groundwater samples will be collected from the nine existing monitoring wells at Landfill Areas 1 and 2. However, the method of groundwater sampling specified in the SAP (IT, 2000b) will not be used because of the depth to groundwater (approximately 190 feet) and the limitations of peristaltic pumps (maximum lift of 30 feet). Therefore, the method specified herein will take precedence.

The monitoring well purging and sampling will be conducted using a portable, submersible, piston pump. This type of pump uses compressed air to operate a reciprocating motor piston, which pushes the groundwater to the surface. The pumps are designed such that the air does not come in contact with the groundwater. Piston pumps are capable of lifts of up to 1,000 feet. Flow rates can be controlled so that low-flow sampling can be conducted.

Purging procedures will follow those outlined in Appendix D of the SAP, except with the use of a piston pump instead of a peristaltic pump. Air supply and exhaust lines for the pump will

consist of polyethylene tubing. The groundwater discharge line will consist of Teflon™ or Teflon™-lined polyethylene tubing. The air supply line will be connected to a portable air compressor. Since the air does not come in contact with the groundwater, compressed gas such as nitrogen should not be required.

Water quality parameters such as temperature, pH, specific conductivity, salinity, turbidity, dissolved oxygen, and oxidation-reduction potential (redox) will be measured using a Horiba U-23 water quality meter or equivalent.

Once field parameters have stabilized, groundwater samples will be collected by direct discharge from the discharge tubing into the sample containers. Because of the depth to groundwater, the use of bailers for collecting VOC samples is not appropriate. The sample bottles will be labeled, placed in ziplock baggies, and stored in iced-filled coolers until shipment. Sample identification, labeling, packing, shipping, and chain-of-custody will follow procedures outlined in Section 6.0 of the SAP (IT, 2000b).

All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated before use and after each successive use in accordance with decontamination procedures outlined in Chapter 6.0 of the SAP.

### *3.2.5 QA/QC Sampling*

To ensure the reliability of field sampling procedures and materials, field QA/QC samples will be collected or prepared as appropriate for each medium sampled, each sample shipment, and/or each sampling event. The field activities will be considered one event unless the field personnel leave the site for more than 72 hours during the course of the investigation. All water used during field sampling as analyte-free will be deionized water and organic-free water prepared to EPA standards. Chapter 6.0 of the SAP (IT, 2000b) provides specified information regarding QA/QC samples and describes how to identify and document QA/QC samples.

### *3.2.6 Karst Investigation*

The aquifer underlying the former Ramey AFB consists of karst limestone. Because of the nature of karst aquifers, it is recommended that dye tracing be performed at Landfill Areas 1 and 2 to ensure that the existing monitoring wells are hydraulically connected to the sites. Monitoring wells cannot be assumed to intercept drainage from the landfill sites in a karst setting unless a positive connection from the site to the monitoring wells has been demonstrated (ASTM 1995). Dye tracing is the only method of determining if monitoring points have a hydrogeologic connection to a site.

Since the objective of a RI is to determine the extent of contamination, it is also recommended that a karst inventory be conducted to determine the location of springs, sinkholes, pumping wells, and other features in the vicinity of the former Ramey AFB. A background study of the groundwater flow system will also be conducted to determine regional groundwater flow direction and gradients, and tidal influences. As part of the background study, four rounds of groundwater sampling will be performed to check the background fluorescence of the groundwater. The background sampling will begin at the peak of the high flow season and continue at 1-month intervals for 4 months. Each background test will run for 1 week. The background groundwater samples will be analyzed for three different dye tracing agents: Fluorescein (acid yellow 73), Eosine (acid red 87), and Rhodamine WT (acid red 388).

In general, the dye tracing will be performed using fluorescent dyes. The dye will be recovered using charcoal packets supplied by a karst laboratory. The packets will be placed in the same interval or location of wells and springs for comparibility of results. Duplicate sampling will be performed for QA/QC. Used charcoal packets will be submitted to a qualified karst-oriented laboratory (i.e., Western Kentucky University) for analysis. A detailed plan for conducting the dye trace study will be formulated upon completion of the karst inventory.

### *3.2.7 Decontamination Procedures*

***Sampling Equipment.*** Decontamination of data acquisition and sampling equipment will be performed in accordance with Chapter 6.0 of the SAP (IT, 2000b) to maintain the integrity of the soil and water samples collected during the field investigation.

***Nonsampling Equipment.*** All equipment that may contact the interior of a borehole or that may contact other equipment entering the hole shall be thoroughly cleaned using steam or high-pressure hot water. Decontamination will be performed prior to setting up on the first sampling location, between each sampling location, following sampling, and at the last sampling location. No tools or equipment should contact the ground or become contaminated after cleaning until used in sampling. If this occurs, contaminated items shall again be cleaned before use in the manner previously specified. At the sampling location, cleaned equipment shall be kept off the ground by storing on cleaned metal racks (not wooden pallets) or on polyethylene-covered pallets.

### 3.2.8 Sample Custody and Tracking Procedures

Sample custody is a vital aspect of an environmental investigation because it will ensure integrity of samples and eventual defensibility of the data. Proper sample custody procedures will result in a record of sample stewardship from the time it is collected until the analyses have been performed. This means that all steps of the investigation will be repeatable and that all information used to draw conclusions and make recommendations will be as accurate as possible. All sample custody and tracking procedures, including laboratory notification, field custody procedures, identification, and shipping will be performed as specified in Section 6.2 of the SAP (IT, 2000b).

### 3.2.9 Documentation

All field activities shall be documented in an official logbook or Field Activity Daily Log to maintain a record of the progress of the fieldwork and to allow the reconstruction of events that occur during the RI of Landfill Areas 1 and 2. Field documentation forms for use during the RI of Landfill Areas 1 and 2, in addition to the official logbook, include: Field Activity Daily Logs, Sample Collection Logs, HTRW Drilling Log, Groundwater Sample Collection Logs, and Analysis Request/Chain of Custody Records. The procedures for identifying and documenting samples collected during the RI at Landfill Areas 1 and 2 are presented in Section 6.3 of the SAP (IT, 2000b). Examples of these forms are provided in Appendix A.

### 3.2.10 Field Instrument Calibration

Field testing and monitoring equipment will be inspected and calibrated before use. Testing and monitoring equipment includes hand-held organic vapor monitors (e.g., organic vapor analyzer) used for health and safety air monitoring and for screening soil vapors, combination pH/temperature/specific conductivity meters, redox, dissolved oxygen meters, salinity, and turbidity meters. Calibration standards for these instruments will be kept on site and in good condition. Each day an instrument is used, its calibration will be compared against one of these certified standards. Additional information regarding instrument calibration procedures and records is presented in Section 6.4 of the SAP (IT, 2000b).

## 3.3 Sample Analysis

A summary of the samples to be submitted for laboratory analysis and analytical methods is presented in Tables 3-1 and 3-2. Off-site analyses will be performed by Accutest using EPA methods and will meet the QA/QC requirements described in the referenced SW846 methods and the SAP (IT, 2000b).

Analytical samples collected for off-site analysis during this investigation will be sent to:

Accutest Laboratories, Inc.
4405 Vineland Road, C-15
Orlando, Florida 32811
Contact: Harry Behzadi or Linda Williams
Phone: (407) 425-6700.

All QA split samples will be sent to:

Accura Analytical Labs
6017 Financial Drive
Norcross, Georgia 30071-5816
Contact: Dave Fuller
Phone: (707) 449-8800.

Prior to sending any QA samples, the IT project chemist will notify the USACE chemist, Dr. Franz Froelicher, at least 3 weeks before sample shipment so that appropriate sample receipt procedures can be verified with the laboratory.

### *3.4 Investigation-Derived Waste*

Investigations will generate purge water, excess sample material and decontamination liquids, and possibly other IDW. IDW will be characterized as hazardous or nonhazardous and will be disposed of accordingly. Materials deemed to be hazardous will be disposed within 90 days as specified in the SAP (IT, 2000b).

The purpose of this section of the WP is to provide a plan that will allow a consistent format for determining the disposition of wastes generated during investigation activities at the former Ramey AFB. Development of this section was guided by the EPA document *Management of Investigation-Derived Wastes During Site Inspections*, EPA/540/G-91-009 (EPA, 1991a).

IDW such as soil and decontamination fluids will be collected separately in 55-gallon drums. Each container will be marked in English and Spanish showing the date of collection, area from which collection was made, and the nature of the waste (e.g., solid or liquid, etc.) and the name and telephone number of the contact person. The drums will be inventoried on an IDW/drum inventory log. The drums will not contain mixtures of soil or water from different well or site locations. All drums will be sealed and the containers covered to prevent leakage of the contents or introduction of contamination from external sources. Drums will be placed on pallets to facilitate handling. Analysis will be performed on composite samples of the solid IDW for

native concentrations as needed. Decontamination fluid IDW will be characterized as needed. The following sections describe in more detail the general sampling and analysis approach for solid and liquid IDW.

### *3.4.1 Technical Rationale*

The IT team members for the Former Ramey AFB effort will consult with the staff regulatory specialist to review the existing data on a waste stream. From the review, the regulatory specialist will determine the following:

- Is the collected data sufficient to characterize the waste as hazardous or nonhazardous?
- Can a hazardous waste profile and hazardous waste manifest be prepared if the waste is hazardous?
- What are the disposal options for the waste for classification as either hazardous or nonhazardous?

After these questions have been addressed, the regulatory specialist will prepare a memorandum to the IT project manager (PM) summarizing the results of his evaluation of the waste stream data. He will also prepare a waste profile and manifest if the waste is determined to be hazardous. The IT PM will evaluate the recommended disposal options and prepare bid packages to solicit proposals from transport/ disposal subcontractors to handle and dispose of the waste. The IT PM will next compile an approval package consisting of the regulatory specialist's memorandum, profile and manifest (if needed), supporting analytical data, subcontractor cost proposal results, and copies of waste handling permits and licenses of the recommended subcontractors. The IT PM will compose a cover letter for the package explaining where the waste was produced, the quantity, the results of analysis, the determination of hazard status, and the recommended disposal option. This package will then be sent to the USACE PM for review and approval. A USACE representative will be responsible for signing any necessary manifests. When approval is received, IT will then contract the selected subcontractors to arrange for pickup and off-site disposal. If the waste is not hazardous, the disposal options are described below.

The following sections discuss the specific IDW characterization steps and disposal options available for use.

### 3.4.2 Solid Investigation-Derived Waste

The first step in determining disposal options for IDW is to determine if the waste is a hazardous waste as defined in Title 40 Code of Federal Regulations (CFR) Part 261, Resource Conservation and Recovery Act (RCRA). This determination can be made either by knowledge of the generating process, or by comparing analytical results to the levels that would be required from the toxicity characteristics leaching procedure (TCLP) test. If analytical results are less than 20 times the action levels required from the TCLP in 40 CFR 261.24, then waste is generally considered to be nonhazardous. On the other hand, if analytical results are greater than 20 times the action levels required from the TCLP, the waste may be considered hazardous. However, the regulatory specialist or the USACE may elect to run the TCLP tests to make the determination with certainty. If the IDW is RCRA-hazardous, it must be disposed of at a Subtitle C RCRA-permitted treatment, storage, and disposal facility. IT will contract the facility to provide disposal. IT employees will prepare manifests for signature by USACE representatives and oversee pickup of the containers by a qualified transporter. The USACE will review the manifests within 3 days of receipt. As per the TERC, a completed Rapid Form 4025 January 1993 (proposed) must accompany the manifests sent to the USACE. The USACE chemist will be contacted for further information as needed. IT will also prepare land disposal restriction notification as applicable.

If an IDW is not RCRA-hazardous, or concentrations of analytes are less than 20 times the TCLP limits, it may be possible to either disposed of it in a subtitle D landfill or municipal landfill. Upon concurrence of the regulatory specialist, the soil IDW may be spread on the ground.

### 3.4.3 Liquid Investigation-Derived Waste

Liquid IDW from the RI of Landfill Areas 1 and 2 will consist of either groundwater from well purging or equipment decontamination fluids. Equipment decontamination fluids will be collected and drummed and a representative composite sample collected from the containers for characterization and analysis. Groundwater from well purging activities will be containerized in segregated drums and labeled with the source area (Landfill Areas 1 or 2), and the well identity. Assuming that the purged groundwater has similar concentration of contaminants as the collected field samples, no additional sampling will be required for characterization. The results of the field samples will be evaluated upon receipt to determine the disposal options for the associated water IDW. One of the following options will be selected based on the field sample results:

- Where analytical results indicate trace level (less than the reporting limit) or no contamination present for the site contaminants of concern, the results will be forwarded to the USACE PM for review, with a recommendation that the corresponding waste be poured onto the ground as nonhazardous material.

- Where analytical results indicate other contaminants are especially high in concentration, the data will be forwarded to the IT regulatory specialist and a determination made on whether or not the IDW is hazardous. The USACE PM will then be contacted for concurrence. The procedures for disposal as hazardous waste previously described will be followed.

### *3.4.4 Other Investigation-Derived Waste*

Other IDW generated during the RI of Landfill Areas 1 and 2 may include such items as personal protective equipment, decontamination pad plastic and sheeting, and consumable supplies. These materials will be considered either hazardous or nonhazardous according to the characteristic of the other forms of waste generated during sampling activities. If the soil and liquid IDW is considered nonhazardous, then the other waste generated during that same sampling activity will also be nonhazardous. If soil and liquid IDW is found to be hazardous, then other waste generated will be hazardous.

# 4.0 Human Health Baseline Risk Assessment

## 4.1 Conceptual Site Exposure Model

A conceptual site exposure model (CSEM) provides the basis for identifying and evaluating the potential risk to human health (Figures 4-1, 4-2). The CSEM includes the receptors appropriate to all plausible scenarios, and the potential exposure pathways. By graphically presenting all possible pathways by which a potential receptor may be exposed, including all sources, release and transport pathways, and exposure routes, the CSEM facilitates consistent and comprehensive evaluation of risk to human health, and helps to ensure that potential pathways are not overlooked. The elements necessary to construct a complete exposure pathway and develop the CSEM include:

- Physical Setting
- Source of contamination potentially released at site
- Source media (i.e., soil)
- Contaminant release mechanisms
- Contaminant transport pathways
- Transport (secondary, tertiary) media
- Exposure media (i.e., surface soil, dust, ingested beef)
- Receptors
- Routes of exposure (ingestion, inhalation, dermal contact).

Contaminant release mechanisms and transport pathways, which result in the transfer of contaminants across media, are not relevant for direct receptor contact with a contaminated source medium (e.g., incidental ingestion of soil).

### 4.1.1 Physical Setting

The former Ramey AFB has two landfill areas that were used for disposal from 1939 until 1973 (E&E, 1997). The types of materials disposed in the landfills are not completely known. However, medical waste has appeared at Landfill Area 1, as described in the following text. It is unknown whether trenches were used at the landfills.

***Landfill Area 1.*** Landfill Area 1 is a 6-acre predominantly open grass area, with a patch of sparse shrub/scrub vegetation on the south central portion of the landfill, and a few deciduous trees on the southeast side (IT, 2000c). The Landfill Area 1 site consists largely of the landfill proper. Although the exact boundaries of the landfill proper are not known, there appears to be a narrow perimeter of land outside the landfill proper. The entire area is fenced with barbed wire and currently used as a pasture for cattle. The landfill slopes from east to west, with a large drainage ditch that terminates in a large sinkhole on the western side. The sinkhole is

approximately 100 to 200 feet in diameter and approximately 30 feet deep. The entire surface of Landfill Area 1 appears to be unstable, rendering it unlikely to be tilled and used for crop production, or developed for any other purpose. Exposed medical waste was observed in the wall of the drainage ditch, in the wall and on the floor of the sinkhole, and in the paths worn in the soil by the cattle, particularly on the western side. This observation indicates that the soil cover may be thinner on the western side of the landfill. The sinkhole is fenced with barbed wire to exclude the cattle.

The drainage ditch, situated along the northwest side of the landfill, is entirely canopied by deciduous trees and thick underbrush. The ditch is approximately 4 to 6 feet wide at the base, and the walls are approximately 10 to 15 feet in height. The bed and walls of the ditch show evidence of large volumes of water rushing through the ditch. Presumably heavy rains create surges of overland runoff, which is channeled through the ditch and into the sinkhole. The ditch appears to be eroding into the sinkhole. It appears to contain water only during storm events. A residential area is located across the road from the landfill. Industrial and commercial buildings are located next to and across a frontage road on the eastern side of the landfill.

***Landfill Area 2.*** The Landfill Area 2 site is approximately 20 acres in area, and includes a large, fenced agricultural field surrounded by other agricultural fields, cow pastures, and abandoned Base housing (IT, 2000c). The exact border of the landfill proper is unknown, but the Landfill Area 2 site includes a substantial perimeter outside of the landfill proper. Only the northwest corner of the site is not presently tilled or planted with commercial/subsistence crops. This corner is vegetated with tall grasses. The landfill terrain can be described as very gently rolling hills, with the highest point in the northeastern corner. Low points of the landfill are along the western boundary, the southeastern corner, and the north central boundary.

A sinkhole is forming to the north of the agricultural field, and may include part of the landfill. Currently, the sinkhole is approximately 40 feet in diameter at ground level, slopes to approximately 20 feet in diameter at the bottom, and is approximately 5 to 6 feet deep. A drainage ditch runs along the western fence line of the site, and if water were present, it would flow in a northerly direction. The ditch begins abruptly, and does not appear to lead to any surface water body, but rather gently spreads out until it blends in with the ground surface. Although this ditch appears to be located within the landfill boundary, no waste was observed in the ditch. There is no evidence of aquatic biota; therefore, the ditch is presumed to contain water only during storm events. It could not be visually determined how much of the landfill is within the tilled area and how much is within the sinkhole and surrounding cow pasture.

A pond is located to the northeast of the historical landfill boundary. It appears to be man-made and is surrounded by a barbed wire fence. Local field workers indicate that the pond is filled with water from a municipal reservoir. The water is used to irrigate crops via gravity feed. Because the pond is located at the highest point of the area and is fed from an off-site source, it is not expected that potential contaminants from the landfill would migrate via groundwater or surface runoff into the pond water and/or sediments.

Residences are located near Landfill Area 2; however, most of the surrounding land is agricultural.

### 4.1.2 Source of Contamination Potentially Released at Site

The source of the contamination potentially released at the landfills is the waste materials dumped or buried at the site.

### 4.1.3 Media of Interest

Potentially contaminated source media are probably limited to surface and subsurface soil. The water table is located approximately 200 feet bgs; therefore, it is unlikely that waste would have been disposed directly into groundwater. Potential exposure media relevant to the former Ramey AFB landfills are limited to surface and subsurface soil, and ambient air. Although groundwater may be contaminated by leaching, the depth to groundwater precludes direct exposure. Furthermore, groundwater in the area is not used as a source of potable water. Also, because of its depth, it is unlikely that groundwater would discharge to the surface. Since exposure is not plausible, groundwater is not sampled or included in the risk assessment. Surface water in the ditches may be contaminated by erosion and runoff, but surface water appears to be present only during storm events. Therefore, it is unlikely that human receptors would be repeatedly and predictably exposed to either surface water or sediment. As previously noted, surface water and sediment in the irrigation pond associated with Landfill Area 2 probably do not reflect contamination from the landfill. Surface water and sediment are not sampled or included in the risk assessment.

### 4.1.4 Release Mechanisms and Transport Pathways

Potential contaminant release mechanisms and transport pathways relevant to risk assessment of the landfills include the release of soil dust and volatilization of VOCs from soil into the air. In addition, vegetation growing on contaminated soil may accumulate contaminants that are ingested by livestock, which provide food for humans, or ingested directly by humans.

### 4.1.5 Receptors and Exposure Pathways

Several receptors may be exposed to surface and subsurface soil at the former Ramey AFB landfills under both current and future site-use assumptions.

#### 4.1.5.1 Landfill Area 1

***Current Site Use.*** Landfill Area 1 is currently used as a cow pasture. The instability of the terrain renders it practically unsuitable for any other use. Although Landfill Area 1 is fenced, the barbed wire fencing used to control cattle would not prevent trespassers from visiting the site. Plausible receptors include an off-site farmer who is a consumer of animal agriculture products (off-site consumer) and a youthful trespasser.

- ***Off-Site Consumer.*** Either dairy or beef cattle may be pastured on Landfill Area 1. However, Landfill Area 1 is relatively remote and is located a considerable distance from the nearest farmstead that might operate a dairy. It is unlikely that currently lactating cattle would be pastured on Landfill Area 1 because of the labor involved in moving them to and from a milking facility twice daily. Therefore, it is assumed that beef cattle or non-lactating dairy cattle (i.e., "dry" cows and preparturient heifers) are pastured on the landfill.

  Cattle may be exposed to contaminants in surface soil at Landfill Area 1 indirectly by grazing pasture grasses that accumulate contaminants from soil, and directly by incidental ingestion of soil while grazing. Humans may be exposed to soil directly while moving cattle to and from the pasture, and indirectly by consumption of milk or beef. Direct exposure during the movement of cattle is expected to be short in duration, and infrequent because of the remote location of the pasture relative to nearby farmsteads. Therefore, it is assumed that direct exposure to the farmer is insignificant compared with the potential for indirect exposure via consumption of animal products, and direct exposure is not evaluated for the off-site consumer.

  Indirect exposure of the off-site consumer could involve consumption of milk and beef. However, as previously noted, the cattle pastured on Landfill Area 1 are unlikely to be lactating. Therefore, it is assumed that the off-site consumer is indirectly exposed to soil at Landfill Area 1 only by ingestion of beef.

- ***Youthful Trespasser.*** A youthful trespasser may readily gain access to Landfill Area 1 for the purpose of hiking or playing, thereby becoming directly exposed to surface soil. Potentially complete direct exposure routes include incidental ingestion, dermal contact, and inhalation of dust and volatiles.

***Future Site Use.*** There are no plans to develop Landfill Area 1 for any future use. As previously noted, the presence of a sinkhole and the unstable nature of the surface of the site

render the site unsuitable for future development. Therefore, it is assumed that future site use would be the same as current site use. The receptor scenarios developed for current site use also apply to future site use.

#### *4.1.5.2 Landfill Area 2*

***Current Site Use.*** Much of Landfill Area 2 is used in the agricultural production of crops for human consumption. Part of Landfill Area 2 appears to be included in a pasture area. The pasture is large, and does not lend itself well to use by currently milking cattle. Therefore, it is assumed that beef cattle or non-lactating dairy cattle are pastured on Landfill Area 2. Plausible receptors include a farm worker and a youthful trespasser.

- ***Farm Worker.*** A farm worker may be directly exposed to soil while tilling the land for crop production. Potentially complete direct exposure routes include incidental ingestion, dermal contact, and inhalation of dust and volatiles. Sources of indirect exposure may include consumption of vegetables and fruits grown on site, and consumption of beef from cattle grazed on site. Consumption of milk is not evaluated as described for the off-site consumer for Landfill Area 1.

- ***Youthful Trespasser.*** A youthful trespasser may readily gain access to Landfill Area 2 for the purpose of hiking or playing, thereby becoming directly exposed to soil. Potentially complete direct exposure routes include incidental ingestion, dermal contact, and inhalation of dust and volatiles.

***Future Site Use.*** There are no plans to develop Landfill Area 2 for any future use. However, the area is large and the surface is gently sloping, but it appears to be much more stable than Landfill Area 1. It is plausible to consider that the site could be developed for alternative purposes such as residential. Plausible receptors under the future site-use scenario include the farm worker and youthful trespasser, assuming that site use does not change. Groundskeeper, resident, and construction worker scenarios are added in the event of a future decision to develop the site for alternative uses.

- ***Farm Worker.*** The exposure scenario described for the farm worker under the current site-use scenario would apply as well to the future site-use scenario.

- ***Youthful Trespasser.*** The exposure scenario described for the youthful trespasser under the current site-use scenario would apply as well to the future site-use scenario.

- ***Groundskeeper.*** A groundskeeper scenario is added to the future site-use scenario to address the receptor most highly exposed to soil should the site be

developed for commercial or industrial uses. Potentially complete direct exposure routes include incidental soil ingestion, dermal contact with soil, and inhalation of dust and volatiles.

- ***Resident.*** A residential scenario is added as generally the most stringent evaluation for unrestricted use. Potentially complete direct exposure routes include incidental soil ingestion, dermal contact with soil, and inhalation of dust and volatiles. Indirect exposure includes consumption of fruits and vegetables grown on site.

- ***Construction Worker.*** A construction worker is added as a plausible short-term scenario involving exposure to surface and subsurface soil. Potentially complete direct exposure routes include incidental ingestion, dermal contact, and inhalation of dust and volatiles.

### *4.1.6 Evaluating Exposure to Soil*

***Landfill Area 1.*** Samples to be collected at the Landfill Area 1 Site include surface soil (0 to 1 foot bgs) from the area of the landfill proper, and surface soil (0 to 1 foot bgs), plus subsurface soil (1 to 3 feet bgs) from the remainder of the site that consists of a narrow perimeter around the landfill proper. Subsurface soil samples are taken to determine whether contamination has migrated outside of the landfill proper. Subsurface soil samples are not taken from greater depths because human exposure to greater depths is not plausible. Human receptors to be evaluated at Landfill Area 1 are an off-site consumer (indirectly exposed to soil via grazing cattle) and a youthful trespasser. Exposure to soil at Landfill Area 1 is expected to be random across the site, because cattle graze randomly and a trespasser is likely to roam in random fashion across the entire area. Therefore, all analytical data (surface soil from the landfill proper, and surface and subsurface soil from the area outside the landfill proper) will be combined to yield a single data set for exposure assessment for both the current and future site-use evaluations. Data from the surface soil from outside the area of the landfill proper will be visually compared with data from the subsurface soil to identify any obvious or significant differences in the extent of contamination. The implications of these differences will be discussed in the Summary and Conclusions section of the risk assessment.

***Landfill Area 2.*** Samples to be collected at the Landfill Area 2 Site include surface soil (0 to 1 foot bgs) from the area of the landfill proper, and surface soil (0 to 1 foot bgs), plus subsurface soil (1 to 10 feet bgs) from the remainder of the site located outside of the landfill proper. Human receptors to be evaluated at Landfill Area 2 include a farm worker and a youthful trespasser. The farm worker could raise crops or pasture cattle on any part of the site; therefore,

it is assumed that the farm worker is exposed directly and indirectly to surface soil randomly across the entire site. Similarly, a trespasser is likely to roam randomly across the entire site. Therefore, a single data set comprising analytical data from surface soil across the entire site (the landfill proper and the area around the landfill proper) will be used for the exposure assessment for the farm worker and youthful trespasser for both the current and future site-use evaluations.

Other receptors evaluated for future site use include the groundskeeper, resident, and construction worker. Under the future site-use scenario, the area of the landfill itself could be developed as a lawn or garden area, and the groundskeeper could be exposed randomly to surface soil over the landfill as well as the area around the landfill. Therefore, the groundskeeper evaluation under the future site-use scenario will use a data set that combines the analytical data from surface soil from the landfill proper with analytical data from surface soil from the area around the landfill (same surface soil data set as used for the farm worker and youthful trespasser).

It is assumed that homes may be placed on the area around the landfill, but not on the landfill proper. Residential exposure, therefore, is limited to the soil in the area around the landfill. Two soil exposure evaluations will be performed for the resident. The first assumes that the resident is exposed only to surface soil, and uses analytical data from surface soil from the area around the landfill. The second assumes that the construction of homes at the sites may redistribute subsurface soil to the surface, and will use data from surface soil from the area around the landfill combined with data from subsurface soil from the area around the landfill.

Two kinds of construction projects are plausible at Landfill Area 2. The first could involve activities such as surface grading, landscaping, or paving, in which case the construction worker would be exposed only to surface soil. The second type of project could include building or installing utilities in the area around the landfill proper, in which case deeper excavation (i.e., to a depth of 10 feet bgs) could be involved and the construction worker would be exposed to both surface and subsurface soil. Therefore, two construction worker evaluations will be performed. The first will use the data set that combines the analytical data from surface soil from the landfill proper with analytical data from surface soil from the area around the landfill, as described for the groundskeeper evaluation. The second will use data from surface soil from the area around the landfill combined with data from subsurface soil from the area around the landfill.

### *4.2 Baseline Risk Assessment Tasks*

The human health risk assessment for the two landfills at the former Ramey AFB will be performed in two phases. Phase One is a screening procedure designed to list all the chemicals

identified in all of the media sampled. The list is then narrowed to identify site-related chemicals, and then further reduced to identify chemicals of potential concern (COPC). COPC are carried forward to Phase Two, which is a site-specific baseline human health risk assessment (BHHRA). If COPC are identified, then a BHHRA will be conducted.

### *4.2.1 Phase One: Screening Human Health Risk Assessment*

Phase One, or the screening human health risk assessment, consists of several steps that determine if COPC are present at the two landfills. The first step is to compile a list of site chemicals. Any chemical detected at least once in a given medium is considered a site chemical for that medium. Duplicate analytical results will be averaged with the original analytical result for analysis in the screening human health risk assessment and the BHHRA.

All analytical data will be validated, and major validation qualifier codes will be defined. Some of the more common qualifiers and their meanings are (EPA 1989a):

- U: Chemical was analyzed for but not detected; the associated value is the sample quantitation limit.
- J: Value is estimated, probably below the contract-required quantitation limit.
- R: QC indicates that the data are unusable (chemical may or may not be present).
- B: Concentration of chemical in sample is not sufficiently higher than concentration in the blank (using five-times, ten-times rule, as follows).

Organic chemicals are omitted from consideration if they are common laboratory contaminants (acetone, 2-butanone, methylene chloride, toluene, phthalate esters) and if all sample concentrations are less than ten times the highest blank concentration. Other organic chemicals are omitted if all analytical results are less than five times the highest concentration detected in any blank.

"J" qualified data are used in the risk assessment; "R" and "B" qualified data are not. The handling of "U" qualified data (nondetects) in the human health risk assessment is described in Section 4.2.1.5.

#### *4.2.1.1 Selecting Chemicals of Potential Concern*

The following approach is used to select COPC. The process of elimination proceeds in the order of the listed screening criteria.

#### 4.2.1.2 Background Screening

The first step in the human health risk assessment screening will be to compare the site-specific maximum detected concentrations (MDC) of inorganics and polynuclear aromatic hydrocarbons (PAH) with the background levels at the former Ramey AFB (to be determined during the background study). These data will help to determine which chemicals are site-related and which may be present at naturally occurring concentrations, or represent anthropogenic background. Initially, the MDCs will be compared to two times the mean of the background. Two times the mean concentration for background screening is believed to capture the variation in sampling and analysis, but is unlikely to exceed the upper limit of detected concentrations. Thus, two times the mean provides a conservative criterion with which to begin the background screening.

If the MDC is found to be greater than two times the mean concentration, then the MDC is compared with the 95 percent upper tolerance limit (UTL) estimated from background data for metals and PAHs. If the MDC does not exceed two times the mean or the UTL of background, the chemical is considered to be present at concentrations equivalent to background. The chemical is not identified as a site-related chemical and is not carried further in the Phase One evaluation. All chemicals whose MDCs are either below their respective two times mean or 95 percent UTL will be eliminated as potential COPC. If the MDC is greater than the UTL, then that chemical, in that medium, is considered to be site-related and is carried forward to the next screening step.

#### 4.2.1.3 Exclusion of Essential Element

Major nutritional essential elements (calcium, sodium, potassium, and magnesium) are excluded from consideration in the BHHRA. The nutritional element iron is carried through the COPC selection process; however, due to concerns with the oral reference dose (RfD) for iron, this chemical is evaluated qualitatively if it is chosen as a COPC, not quantitatively. If iron is chosen as a COPC, further discussion regarding the concern over the RfD will be included in the BHHRA.

#### 4.2.1.4 Risk-Based Screening

This step of the human health risk assessment screening consists of comparing the MDCs with risk-based screening levels (RBSL). The RBSLs are based upon RBCs derived by EPA Region III (EPA, 2000a). The most current RBCs were issued by Region III in April 2000. The RBCs will be utilized as a screening tool since Puerto Rico has not established soil standards. The Region III RBC values are widely accepted as initial human health risk and hazard screening values. The RBCs are not region-specific, but are based on chemical-specific human health

effects and, therefore, are appropriate as initial, conservative screening criteria when other regulatory guidance is not available.

RBSLs are RBCs from the latest version of the EPA Region III RBC Tables (EPA, 2000a), adjusted, if necessary, to reflect an incremental lifetime cancer risk (ILCR) of 1E-6 and a hazard index (HI) of 0.1 (to provide additional protection for simultaneous exposure to multiple chemicals). RBCs are not presented for inorganic lead. To account for total lead in soil, a screening value of 400 milligrams per kilogram (mg/kg) will be used, as per EPA (1994).

Chemicals whose MDCs are less than their RBSLs are not considered further in the risk assessment because it is very unlikely that they would contribute significant risk. If no chemical within a medium exceeds its RBSL, then that medium and its exposure pathways are eliminated from the risk assessment process. If the MDC exceeds the RBSL, the chemical is selected as a COPC for that medium. Chemical concentrations in surface soil and subsurface soil are compared with "residential soil" RBSLs.

#### *4.2.1.5 Chemicals Not Detected*

It is not uncommon to have several chemicals in a given medium for which all analytical results are reported as "not detected." This is no cause for alarm when their detection limits are below their RBSLs, because it is unlikely that the chemicals, if present at their detection limits, would contribute significantly to site risk. It is possible, however, that undetected chemicals with detection limits greater than their RBSLs could be present at concentrations associated with significant risk. Such chemicals will be addressed qualitatively in the screening level risk assessment and during the BHHRA, if it is possible that their presence could be associated with unacceptable risks.

### *4.3 Phase Two: Baseline Human Health Risk Assessment*

***Baseline Risk Assessment Tasks.*** This section presents the methodology and assumptions that will be used to conduct Phase Two, a BHHRA (if necessary) for the two landfills at the former Ramey AFB. The BHHRA will be conducted only if COPC are selected during Phase One of the initial screening. The following approach is based on federal EPA guidance documents.

A human health BHHRA consists of the following:

- ***Data Evaluation.*** Describes the statistical summarization of the analytical data, selection of COPC for each site and each medium of interest, and the estimation of source-term concentrations for each COPC in each medium.

- ***Exposure Assessment.*** Further develops the exposure scenarios identified in the CSEM, the pathways by which they may be exposed, the exposure-point concentrations of COPC, and the estimated dose or contact rates for each of the COPC.

- ***Toxicity Assessment.*** Describes the hazard evaluation, i.e., the adverse health effects associated with each of the COPC, and the dose-response evaluation, i.e., the relationship between dose or contact rate and the magnitude of the adverse effect.

- ***Risk Characterization.*** Combines the output of the exposure assessment and the toxicity assessment to quantify the risk to each receptor.

- ***Uncertainty Analysis.*** Describes the uncertainty associated with this quantification.

- ***Summary and Conclusions.*** Summarizes the evaluation and interprets the results in terms of site management.

### *4.3.1 Data Evaluation*

During Phase One, COPC will be selected for surface and subsurface soil at the former Ramey AFB. If COPC are selected during Phase One, the analytical results for those COPC will be subjected to a statistical summarization that will permit the calculation of source-term concentrations, which are conservative estimates of average. The process of evaluating analytical results and selecting COPC is described in Section 4.2. The processes of statistical summarization and the development of source-term concentrations are described in the following subsections.

***Data Sets for Soil.*** Receptors for Landfill Area 1 include an off-site consumer and a youthful trespasser. A single data set for Landfill Area 1 will consist of surface soil data from the landfill proper, surface soil data from the perimeter around the landfill proper, and subsurface soil data from the perimeter. All receptors are assumed to be randomly exposed across the site; therefore, statistical methods will be used to estimate a source-term concentration that represents a conservative estimate of average as described in the following text.

Receptors for Landfill Area 2 include a farm worker, trespassing youth, resident, and groundskeeper. The surface soil data set combines data from the landfill proper with data from the area around the landfill. Statistical methods will be used to estimate a source-term concentration that represents a conservative estimate of average as described in the following paragraphs. The other receptor for Landfill Area 2 is a construction worker. As previously noted, two data sets will be developed for the construction worker: one comprising surface soil data from the landfill proper and the area around the landfill proper, and one comprising surface plus subsurface soil from the area around the landfill proper. A similar approach is taken for the resident. As previously noted, two data sets will be developed for the resident: one comprising surface soil data from the area around the landfill proper and one comprising surface plus subsurface soil from the area around the landfill.

Once the data sets are compiled, statistical methods are used to evaluate the analytical results in order to estimate source-term concentrations. The statistical methods to be used in data evaluation reflect EPA (1989a, 1992a) guidance. The following information is tabulated for each detected chemical in each medium:

- Chemical name
- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Arithmetic mean
- Upper confidence limit (UCL) on the mean of the concentration (if appropriate)
- Two times the arithmetic mean of background (background screening)
- UTL on the mean of the background concentration (background screening)
- Appropriate RBSL
- COPC selection
- Source-term concentration.

Because of the uncertainty associated with characterizing contamination in environmental media, both the mean and the UCL on the mean for either a normal or any other type of distribution are reported for each medium of interest, provided the data are sufficient (i.e., there are at least five sample points). UCLs and source-term concentrations are not estimated for chemicals not selected as COPC, because these chemicals are not addressed in the BHHRA. The MDC is selected as the source-term concentration for data sets consisting of fewer than five samples.

The upper 95 percent confidence limit on the mean is generally referred to as the UCL. In general, outliers are included in the calculation of the UCL because high values seldom appear as outliers for a lognormal distribution, and environmental data are frequently lognormally

distributed (EPA, 1992a). Inclusion of outliers increases the overall conservatism of the risk estimate.

The first step in UCL estimation is to determine the statistical distribution of the data set. Data sets with five samples, or greater, are tested for normality by the Shapiro-Wilks Test (EPA, 1992b). The UCL is calculated for data sets that display a normal distribution by an adaptation of the Student t-Test as described below. The UCL is calculated for all other data sets by the Chebychev method. Distribution testing is performed only for those chemicals selected as COPC in Phase One.

The UCL is calculated for data sets displaying a normal distribution as follows (EPA, 1992a):

$$UCL = \bar{x} + t_{1-\alpha,n-1} * (s/\sqrt{n})$$

where:

| | | |
|---|---|---|
| $\bar{x}$ | = | sample arithmetic mean |
| $t_1$ | = | critical value for student's plus distribution |
| $\alpha$ | = | 0.05 (95 percent confidence limit for a one-tailed test) |
| n | = | number of samples in the set |
| s | = | sample standard deviation. |

The UCL is calculated for data sets identified as lognormal and those determined to fit neither a normal nor a lognormal distribution by an adaptation of the Chebychev theorem as developed by (EPA, 1997a). The Chebychev method tends to yield conservative, and probably less accurate UCL estimates than more computationally intensive methods such as jackknifing or bootstrapping (EPA, 1997a). Therefore, bootstrap or jackknife methods may be applied to refine the UCL estimates if risk drivers are identified.

The Chebychev equation for calculating UCLs on the mean is as follows:

$$UCL = \bar{x} + ks/n^{0.5}$$

where:

| | | |
|---|---|---|
| $\bar{x}$ | = | sample arithmetic mean |
| s | = | sample standard deviation |
| n | = | number of samples in the data set. |

It is noted that $k$ should be set equal to 3.16, for a 95 percent one-tail UCL on the mean. This value is obtained by setting $1-1/k^2$ (EPA, 1997a, Equation 28) equal to 0.90. The $k$ value given by EPA (1997a) (4.47) should be used as a 95 percent UCL on the mean only if both the upper and lower tails are of interest (Singh, 2000), which is seldom the case for the calculation of environmental concentration terms.

The UCL or the MDC, whichever is lower, is selected as the source-term concentration (EPA, 1992a), which is interpreted as a conservative estimate of average.

Analytical results are presented as "nondetects" whenever chemical concentrations in samples do not exceed the detection limits for the analytical procedures for those samples. Generally, the reporting limit is the lowest concentration of a chemical that can be "seen" above the normal, random noise of an analytical instrument or method. To apply the previously mentioned statistical procedures to a data set with nondetects, a concentration value must be assigned to the nondetects. Nondetects will be assumed to be present at one-half the detection limit (EPA, 1989a).

### 4.3.2 Exposure Assessment

Exposure is the contact of a receptor with a chemical or physical agent. An exposure assessment estimates the type and magnitude of potential exposure of receptors to COPC found at, or migrating from, a site (EPA, 1989a). An exposure assessment includes the following steps:

- Characterize the physical setting.
- Identify the contaminant sources, release mechanisms, and migration pathways.
- Identify the potentially exposed populations or receptors.
- Identify the potential exposure pathways.
- Estimate exposure concentrations.
- Estimate chemical intakes or contact rates.

Several of these steps, through identifying the potentially exposed receptors and exposure pathways, were described in Section 4.1. This section will more fully develop the receptor scenarios identified in the CSEM. It will also develop the protocol for estimating exposure concentrations and for estimating chemical intake rates or contact rates.

### 4.3.3 Receptor Scenarios

The receptor scenarios identified in Section 4.1 are more fully developed in this section. The exposure pathways are summarized in Table 4-1; the exposure variable values are summarized in Table 4-2.

Most BHHRAs are based on a reasonable maximum exposure (RME) assumption. The intent of the RME assumption is to estimate the highest exposure level that could reasonably be expected to occur, but not necessarily the worst possible case (EPA, 1989a, 1991b). It is interpreted as reflecting the 90 to 95th percentile on exposure. In keeping with EPA (1991b) guidance, variables chosen for the RME evaluation for intake or contact rate, exposure frequency (EF) and exposure duration (ED) are generally upper-bounds. Other variables, e.g., body weight (BW) and exposed skin surface area (SA), are generally central or average values. In the case of contact rates consisting of multiple components, e.g., dermal contact with soil, which consists of a dermal absorption factor (ABS) and soil-to-skin adherence factor (AF), only one variable, i.e., ABS, needs to be an upper-bound. The conservatism built into the individual variables ensures that the entire estimate for contact rate is more than sufficiently conservative.

The averaging time (AT) for noncancer evaluation is computed as the product of ED (years) times 365 days per year, to estimate an average daily dose over the entire exposure period (EPA, 1989a). For cancer evaluation, AT is computed as the product of 70 years, the assumed human lifetime, times 365 days per year, to estimate an average daily dose prorated over a lifetime, regardless of the frequency or duration of exposure. This methodology assumes that the risk from short-term exposure to a high dose of a given carcinogen is equivalent to long-term exposure to a correspondingly lower dose, provided that the total lifetime doses are equivalent. This approach is consistent with current EPA (1986) policy of carcinogen evaluation, although it introduces considerable uncertainty into the cancer risk assessment.

A fractional term (FI) is introduced into the chemical intake equations to account for scenarios in which exposure to a potentially contaminated medium associated with the site is less than total daily exposure to that medium. For example, the youthful trespasser is expected to spend not more than half of a waking day on site potentially exposed to contaminated soil. This is reflected in an FI of 0.5, which is introduced to adjust exposure via incidental ingestion of soil and dermal contact with soil. The default value of FI is 1.

Reference is made in the off-site consumer and farm worker receptor scenarios to consumption of "homegrown" beef, fruits, and vegetables. The term "homegrown" is enclosed in quotes because these receptors do not actually live on the site; they do not maintain their residences on the site, but they use the land for production of crops for their own personal use. The resident, however, may also grow fruits and vegetables for his personal use, but since he also maintains his residence on the site, the term homegrown is not enclosed in quotes.

#### 4.3.3.1 Off-Site Consumer of Animal Agriculture Products

The off-site consumer is a plausible receptor scenario for current and future site-use of Landfill Area 1. It is assumed that the off-site consumer is a nearby resident who ingests "homegrown" beef from cattle that are pastured on the landfill and the narrow perimeter that surrounds the landfill. Data on beef consumption are available for the United States population (EPA, 1997b), but were not located for the Puerto Rican population. Lacking data for Puerto Rico, the 90$^{th}$ percentile on consumption of homegrown beef for young children (0 through 6 years old) and adults from United States data are adapted for this evaluation. EPA (1997b) provides 90$^{th}$ percentile homegrown beef consumption rates for 12- to 69-year-old adults of 3.53 to 4.10 grams per kilogram (g/kg) BW per day (fresh weight). Assuming pre- and post-cooking food preparation losses of 51 percent (EPA, 1997b) and an adult BW of 70 kg (EPA, 1991b), a time-weighted 90$^{th}$ percentile beef consumption rate for adults of 147 grams per day (g/day) is estimated, which is rounded to 150 g/day. Data regarding beef consumption by children were not located. However, EPA (1997b) provides 90$^{th}$ percentile home-produced meat consumption rates ranging from 7.84 to 8.68 g/kg BW per day (fresh weight). It is assumed that the majority of ingested meat is beef. Assuming pre- and post-cooking food preparation losses of 51 percent (EPA, 1997b), and that a young (0 through 6 years old) child weighs an average of 15 kg (EPA, 1991b) a time-weighted 90$^{th}$ percentile beef consumption rate for children of 60.1 g/day is estimated, which is rounded to 60 g/day. It is conservatively assumed that 100 percent of beef consumption comes from "homegrown" sources.

It is assumed that the off-site consumer spends 6 years as a child and an additional 24 years as an adult (EPA, 1991b). He is exposed 350 day per year, i.e., each day that he spends at home. The beef consumption rate, when expressed on a BW basis, is higher for the child than the adult. Therefore, the noncancer hazard estimates are based only on childhood exposure. The cancer risk estimates are calculated as the sum of the risks associated with childhood and adult exposures.

#### 4.3.3.2 Youthful Trespasser

The youthful trespasser is identified as a plausible receptor for both landfills. Potential exposure routes include incidental ingestion of soil, dermal contact with soil, and inhalation of airborne dust and volatiles. The youthful trespasser is assumed to be a nearby resident who makes regular visits to the landfills for recreational purposes. It is assumed that the youthful trespasser makes one visit per week (52 days per year), and spends 8 hours per day on site.

The youthful trespasser is assumed to be a 7 to 16-year-old youth with an average BW of 45 kg exposed for 10 years. An incidental soil ingestion rate of 100 milligrams per day (mg/day) is

assumed for persons over 6 years old (EPA, 1991b). The inhalation rate is assumed to be 13.5 cubic meters per day ($m^3$/day) (0.56 cubic meters per hour [$m^3$/hour]) (EPA, 1997b).

EPA (1997b) identifies a 45-kg youth as being approximately 13 years old. A 13-year-old youth has a total body SA of about 14,700 centimeters ($cm^2$) (EPA, 1992c). Clothing provides partial protection against dermal contact with soil, restricting potential contact to approximately 25 percent of the body, or approximately 3,700 $cm^2$ (EPA, 1992c). EPA (1992c) recommends a default value of 0.2 mg/$cm^2$, the lower end of the range of 0.2 to 1.0 milligrams per $cm^2$ (mg/$cm^2$), as an average coefficient for the AF.

EPA (1989a) permits the development of a fraction term (FI) to reflect the proportion of his total daily exposure to soil that a receptor obtains from the contaminated medium. It is assumed that the 8 hours per day that the youthful trespasser spends in contact with surface soil represents 50 percent of his daily exposure to soil (potential exposure to soil throughout his waking hours, assumed to be 16 hours per day). Therefore, an FI of 0.5 is used for the soil exposure pathways to reflect the portion of exposure to soil that may involve contaminated soil on site.

#### *4.3.3.3 Farm Worker*

The farm worker is identified as a plausible receptor for Landfill Area 2, because the area is currently used for crop production. Potential exposure routes include incidental ingestion of soil, dermal contact with soil, and inhalation of airborne dust and volatiles. The farm worker is assumed to be a 70-kg adult nearby resident (EPA, 1991b) with a soil ingestion rate of 100 mg/day, and an inhalation rate of 2.5 $m^3$/hour, based on heavy activity level (EPA, 1997b). He is assumed to work on the site 8 hours/day on 5 days/week for 250 days/year for 30 years (EPA, 1991b). Clothing provides partial protection against dermal contact with soil, restricting potential contact to approximately 25 percent of the body, or approximately 5,000 $cm^2$ (EPA, 1992c). EPA (1992c) recommends a default value of 0.2 mg/$cm^2$, the lower end of the range of 0.2 to 1.0 mg/$cm^2$, as an average coefficient for AF.

It is assumed that the farm worker also consumes "homegrown" beef from the site. Young children in the family would consume the same dietary items. Therefore, the adult and child beef consumption scenarios previously described for the off-site consumer apply to the farm worker and the farm worker child.

In addition, the farm worker and the farm worker child may consume "homegrown" fruits and vegetables. Data on fruit and vegetable consumption are available for the United States population (EPA, 1997b), but were not located for the Puerto Rican population. Nonetheless, the

90th percentile on consumption of homegrown fruits and vegetables for young children (0 to 6 years old) and adults from United States data are adapted for this evaluation. EPA (1997b) provides 90th percentile homegrown fruit consumption rates for 12- to 69-year-old adults of 4.17 to 6.76 g/kg BW per day (fresh weight). Assuming paring and preparation losses of 21 percent (average for five fruits), moisture content of approximately 85 percent (EPA, 1997b), and an adult BW of 70 kg (EPA, 1991b), a time-weighted 90th percentile fruit consumption rate for adults of 45 g dry weight per day is estimated. EPA (1997b) provides 90th percentile homegrown fruit consumption rates ranging from 6.02 to 19.3 g/kg BW per day (fresh weight) for young children. Assuming preparation losses of 21 percent, moisture content of approximately 85 percent (EPA, 1997b), and a young child BW of 15 kg (EPA, 1991b), a time-weighted 90th percentile fruit consumption rate for children of 20 g dry weight per day is estimated. Cooking losses were not included in these estimations; it is assumed fruits are eaten raw.

EPA (1997b) provides 90th percentile homegrown vegetable consumption rates for 12- to 69-year-old adults of 3.44 to 5.12 g/kg BW per day (fresh weight). Assuming preparation losses of 17 percent (average of 11 vegetables that may contribute substantially to total vegetable intake), moisture content of approximately 81 percent (same 11 vegetables) (EPA, 1997b), and an adult BW of 70 kg (EPA, 1991b), a time-weighted 90th percentile vegetable consumption rate for adults of 48 g dry weight per day is estimated. EPA (1997b) provides 90th percentile homegrown vegetable consumption rates ranging from 6.35 to 13.1 g/kg BW per day (fresh weight) for young children. Assuming preparation losses of 17 percent (see previous reference), moisture content of approximately 81 percent (EPA, 1997a), and a young child BW of 15 kg (EPA, 1991b), a time-weighted 90th percentile fruit consumption rate for children of 21 g dry weight per day is estimated.

It is conservatively assumed that 100 percent of fruit and vegetable consumption comes from "homegrown" sources.

The adult farm worker is assumed to be directly exposed to soil while working on the Landfill Area 2 site for 30 years, which is the upper-bound for residential location in one place in the United States (EPA, 1991b). In addition, it is assumed that he consumes "homegrown" beef, fruits, and vegetables on each of the 350 days the resident is expected to spend at home. The farm worker child, on the other hand, is not directly exposed to soil at the Landfill Area 2 site. He does, however, consume "homegrown" beef, fruits, and vegetables 350 days per year for 6 years. Separate cancer risk and noncancer hazard estimates are calculated for the adult farm worker and the child farm worker. The estimates for the child and adult farm workers are not summed because the direct exposure pathways pertain only to the adult.

#### 4.3.3.4 Groundskeeper

The groundskeeper is a plausible receptor for Landfill Area 2 under a future land-use scenario. The groundskeeper is a site worker who spends the majority of his time outdoors tending yards and gardens, trimming shrubs, and performing other general outdoor duties. Potential exposure routes include incidental ingestion of soil, dermal contact with soil, and inhalation of airborne dust and volatiles. The groundskeeper is assumed to be a 70-kg adult (EPA, 1991b) with a soil ingestion rate of 100 mg/day, and an inhalation rate of 2.5 $m^3$/hour, based on heavy activity level (EPA, 1997b). He is assumed to work on the site 8 hours/day on 5 days/week for 250 days/year for 25 years (EPA, 1991b). Clothing provides partial protection against dermal contact with soil, restricting potential contact to approximately 25 percent of the body, or approximately 5,000 $cm^2$ (EPA, 1992c). EPA (1992c) recommends a default value of 0.2 mg/$cm^2$, the lower end of the range of 0.2 to 1.0 mg/$cm^2$, as an average coefficient for soil-to-skin adherence.

#### 4.3.3.5 Resident

The resident is a plausible receptor for Landfill Area 2 under a future land-use scenario. Potential direct exposure routes include incidental ingestion of soil, dermal contact with soil, and inhalation of airborne dust and volatiles. In addition, the resident may maintain some fruit trees and plant a vegetable garden. Therefore, the fruit and vegetable ingestion scenarios developed for the farm worker adult and child apply also to the resident.

Assessment of residential exposure involves evaluating both an adult and a child. The adult evaluation captures the conservatism associated with a longer ED, because an individual resident spends more time as adult than child. The child evaluation, however, captures the conservatism associated with greater ingestion and inhalation rates, at least when normalized for BW. The cancer risk estimates are calculated as the sum of the risk associated with childhood and adult exposures.

The adult resident is assumed to weigh 70 kg (EPA, 1991b), have a soil incidental ingestion rate of 100 mg/day, and have an inhalation rate of 20 $m^3$/day (0.83 $m^3$/hour). The EF and ED for the adult resident are assumed to be 350 days/year and 24 years, respectively (EPA, 1991b). Clothing provides partial protection against dermal contact with soil, restricting potential contact to approximately 25 percent of the body, or approximately 5,000 $cm^2$ (EPA, 1992c). EPA (1992c) recommends a default value of 0.2 mg/$cm^2$, the lower end of the range of 0.2 to 1.0 mg/$cm^2$, as an average coefficient for AF.

The child resident is assumed to be 0 through 6 years of age, weigh 15 kg, have a soil incidental ingestion rate of 200 mg/day (EPA, 1991b), and have an inhalation rate of 7.7 $m^3$/day (0.32 $m^3$/hour) (EPA, 1997b). The EF and ED for the child resident are assumed to be 350 days/year and 6 years, respectively (EPA, 1991b). The total dermal SA of a 15-kg child is approximately 6,240 $cm^2$ (EPA, 1997b). Clothing provides partial protection against dermal contact with soil, restricting potential contact to approximately 25 percent of the body (EPA, 1992c), or approximately 1,560 $cm^2$ (EPA, 1992c). EPA (1992c) recommends a default value of 0.2 mg/$cm^2$, the lower end of the range of 0.2 to 1.0 mg/$cm^2$, as an average coefficient for AF.

#### *4.3.3.6 Construction Worker*

The construction worker is introduced as a plausible scenario for direct exposure to surface soil at Landfill Area 2, and for exposure to surface and subsurface soil in the area around the perimeter of Landfill Area 2. Potential exposure routes include incidental ingestion of soil, dermal contact with soil, and inhalation of airborne dust and volatiles. In a future site-use scenario, the construction worker is involved in a short-term (hypothetical 6-month) construction project that includes excavation and grading of soil. The groundskeeper is assumed to be a 70-kg adult (EPA, 1991b) with a soil ingestion rate of 100 mg/day, and an inhalation rate of 2.5 $m^3$/hour, based on heavy activity level (EPA, 1997b). He is assumed to work on the site 8 hours/day on 5 days/week for 250 days/year (EPA, 1991b) for one-half year (i.e., total of 125 days). Clothing provides partial protection against dermal contact with soil, restricting potential contact to approximately 25 percent of the body SA, or approximately 5,000 $cm^2$ (EPA, 1992c). EPA (1992c) recommends a default value of 0.2 mg/$cm^2$, the lower end of the range of 0.2 to 1.0 mg/$cm^2$, as an average coefficient for AF.

### *4.3.4 Quantification of Exposure-Point Concentrations*

The exposure-point concentrations of chemicals in soil for the different receptors will be the source-term concentrations estimated as described in Section 4.3.1.

#### *4.3.4.1 Exposure-Point Concentrations in Ambient Air*

Exposure to airborne dust and VOCs from soil is a potential exposure pathway for the youthful trespasser, farm worker, groundskeeper, resident, and construction worker. Two phenomena give rise to dust in the air to which a receptor might be exposed:

- Receptor activity on the site
- Action of the wind.

Airborne dust to which the farm worker, groundskeeper, and construction worker would be exposed is more likely to be raised by the nature of their activities rather than the action of the

wind, because these receptors would operate equipment that raises dust. The youthful trespasser and resident, on the other hand, are more likely to be exposed to dust raised by wind erosion.

Therefore, the most appropriate approach to estimating chemical concentrations in ambient air for the farm worker, groundskeeper, and construction worker is to use an activity-based dust loading equation (U.S. Department of Energy [DOE], 1989):

$$C_a = (D)(C_s)(CF_1)$$

where:

| | | |
|---|---|---|
| $C_a$ | = | contaminant concentration in air (milligrams per cubic meter [mg/m$^3$], calculated) |
| D | = | dust loading factor (grams [g] of soil/m$^3$ of air) |
| $C_s$ | = | chemical concentration in soil (mg/kg) |
| $CF_1$ | = | conversion factor (1E-3 kilograms per gram). |

Plausible values for D include 2E-4 g/m$^3$ for agricultural activity (DOE, 1989), 6E-4 g/m$^3$ for construction work (DOE, 1983), and 1E-4 g/m$^3$ for other activity (National Council on Radiation Protection and Measurements, 1984). The value for D of 2E-4 g/m$^3$ for agricultural activity will be used for the farm worker. It is assumed that groundskeeping activities are most appropriately reflected by the value for D of 1E-4 g/m$^3$ for other activity, which will be used in this evaluation. The value for D of 6E-4 g/m$^3$ will be used for the construction worker.

The youthful trespasser and resident are more likely to be exposed to dust that arises from wind erosion rather than from dust-raising activities on the site. EPA (1996) derived a model for estimating a dust particulate emission factor (PEF) based on an "unlimited reservoir" model and the assumption that the source area is square:

$$PEF = Q/C \times \frac{3600}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)}$$

where:

| | | |
|---|---|---|
| PEF | = | particulate emission factor (m$^3$/kg, calculated) |
| Q/C | = | inverse of the mean concentration at center of square source (43.74g/m$^2$-second per kg/m$^3$, site-specific value from Table 3 in EPA, 1996) (Zone IX, Miami, FL, 30 acre site) |
| 3600 | = | seconds/hour |
| V | = | fraction of surface covered with vegetation (0.5, unitless, default) |

$U_m$ = mean annual wind speed (site-specific or default, 4.69 m/s)
$U_t$ = equivalent threshold value of wind speed at 7 m (site-specific or default, 11.32 m/s)
F(x) = function dependent on $U_m/U_t$ (default 0.194).

Q/C is estimated as a site-specific variable using the guidance and data compiled by EPA (1996). The former Ramey AFB is placed in climatic Zone IX, and Miami, Florida is selected as most closely approximating meteorological conditions at the Base because of its coastal location. A Q/C value of 43.74 $g/m^2$-second per $kg/m^3$ (based on a 30-acre site) appears to be the most defensible and conservative, and is applicable to the former Ramey AFB landfills.

The concentration of COPC in air is calculated as follows:

$$C_a = \frac{C_s}{PEF}$$

where:

$C_a$ = contaminant concentration in air ($mg/m^3$, calculated)
$C_s$ = contaminant concentration in soil (mg/kg)
PEF = particulate emission factor ($m^3/kg$).

Exposure to VOCs released from soil is a plausible exposure scenario for any of the receptors directly exposed to surface or subsurface soil. Unless surface soil is recently contaminated, concentrations of VOCs in the first few inches of undisturbed surface soil generally are low, having dissipated with time, so that airborne concentrations of VOCs from ongoing volatilization are negligible. The levels of VOCs in soil more than a few inches deep, however, can be substantial, so that airborne concentrations could be significant.

Exposure-point concentrations of VOCs in ambient air due to volatilization from soil are estimated with a chemical-specific soil volatilization factor calculated from the following equations and defaults provided by EPA (1996):

$$VF_s = Q/C \bullet CF_2 \bullet \left( \frac{[\,3.14 \bullet D_A \bullet T\,]^{1/2}}{2 \bullet \rho_b \bullet D_A} \right)$$

and

$$D_A = \frac{(\theta_a^{10/3} \bullet D_i \bullet H' + \theta_w^{10/3} \bullet D_W)/n^2}{\rho_b \bullet K_d + \theta_w + \theta_a \bullet H'}$$

where:

| | | |
|---|---|---|
| $VF_s$ | = | chemical-from-soil volatilization factor ($m^3$/kg, chemical-specific, calculated) |
| Q/C | = | inverse of the mean concentration at the center of the source (43.74 g/$m^2$-second per kg/$m^3$, see above |
| $CF_2$ | = | conversion factor ($10^{-4}$ square meters ($m^2$) per square centimeter [$cm^2$]) |
| $D_A$ | = | apparent diffusivity ($cm^2$ per second, calculated) |
| T | = | exposure interval (seconds, estimated as ED 3.15E7 seconds per year) |
| ED | = | exposure duration (years, receptor-specific) |
| $\rho_b$ | = | dry soil bulk density (site-specific or default 1.5 g/$cm^3$) |
| $\theta_a$ | = | air-filled soil porosity (site-specific estimated as n - $\theta_w$ or default 0.28 unitless) |
| n | = | total soil porosity (site-specific estimated as 1-[$\rho_b/\rho_s$] or default 0.43 unitless) |
| $\rho_s$ | = | true soil or particle density (site-specific or default 2.65 g/$cm^3$) |
| $\theta_w$ | = | water-filled soil porosity (site-specific or default 0.15 $L_{water}/L_{soil}$) |
| $D_i$ | = | diffusivity in air ($cm^2$/second, chemical specific) |
| H' | = | dimensionless Henry's law constant (chemical-specific, may be estimated as H x 41) |
| H | = | Henry's law constant (atmosphere-$m^3$/mole, chemical-specific) |
| $D_W$ | = | diffusivity in water ($cm^2$/second, chemical-specific) |
| $K_d$ | = | soil-water partition coefficient (cubic centimeters per gram [$cm^3$/g], chemical-specific, may be estimated as $K_{oc}$ x $f_{oc}$) |
| $K_{oc}$ | = | soil organic carbon-water partition coefficient ($cm^3$/g, chemical-specific) |
| $f_{oc}$ | = | organic carbon content of soil (site-specific or default 0.006 g/g). |

The concentration of chemical in the air is calculated as follows:

$$C_a = \frac{C_s}{VF_s}$$

where:

| | | |
|---|---|---|
| $C_a$ | = | chemical concentration in air (mg/$m^3$, calculated) |
| $C_s$ | = | chemical concentration in soil (mg/kg) |
| $VF_s$ | = | chemical-from-soil volatilization factor ($m^3$/kg). |

Site-specific data will be used for as many variables as possible; defaults from various EPA guidance documents will be used where site-specific data are not available.

#### 4.3.4.2 Exposure-Point Concentrations in Fruits and Vegetables

The potential for fruit and vegetable items to accumulate COPC is considered for metals and SVOCs; VOCs are generally too mobile and labile to contribute significantly to food-chain pathways. COPC concentrations in fruits and vegetables are estimated from the following equation:

$$C_p = (C_s)(B_p)$$

where:

| | | |
|---|---|---|
| $C_p$ | = | concentration of contaminant in vegetable or fruit dry matter (mg/kg, calculated) |
| $C_s$ | = | concentration of contaminant in soil (mg/kg) |
| $B_p$ | = | soil-to-plant biotransfer factor (mg of chemical per kg of dry plant/mg of chemical per kg of dry soil). |

$C_p$ will be expressed $C_{pv}$ for vegetables and $C_{pr}$ for fruit. Values of $B_p$ for metals will be taken from Baes, et al. (1984); values for the vegetative parts of plants (Bpv) will be used for vegetables and values for the reproductive parts of plants (Bpr) will be used for fruits. Values of $B_p$ for SVOCs will be calculated using the following equation (Travis and Arms, 1988):

$$\log B_p = 1.588 - 0.578 \log K_{ow}$$

where:

| | | |
|---|---|---|
| $\log B_p$ | = | soil-to-plant biotransfer factor (mg of chemical per kg of dry plant/mg of chemical per kg of dry soil, calculated) |
| $K_{ow}$ | = | octanol-water partition coefficient. |

#### 4.3.4.3 Exposure-Point Concentrations in Beef

The potential for beef to accumulate COPC is considered for metals and SVOCs; VOCs are generally too mobile and labile to contribute significantly to food-chain pathways. It is assumed that beef cattle graze on pasture growing on potentially contaminated soil, and that pasture provides 100 percent of forage intake, which is equivalent to 8.8 kg forage dry matter per day (EPA, 1998). During grazing, cattle are assumed to ingest 0.5 kg of soil per day (EPA, 1998). Estimation of COPC concentrations in beef is a two-step process. The first step, estimation of COPC concentrations in forage, is accomplished by the following equation:

$$C_f = (C_s)(B_p)$$

where:

| | | |
|---|---|---|
| $C_f$ | = | concentration of contaminant in forage (pasture grasses) dry matter (mg/kg, calculated) |
| $C_s$ | = | concentration of contaminant in soil (mg/kg) |
| $B_p$ | = | soil-to-plant biotransfer factor (mg of chemical per kg of dry plant/mg of chemical per kg of dry soil). |

Values of $B_p$ for metals will be taken from, Baes, et al. (1984); values for the vegetative parts of plants (Bpv) will be used for pasture grasses. Values of $B_p$ for SVOCs will be calculated using the previous equation from Travis and Arms (1988).

The second step, estimating COPC concentrations in beef, is accomplished by the following equation:

$$C_b = [(C_f)(Qf) + (Qs)(C_s)]\ (Bb)$$

where:

| | | |
|---|---|---|
| $C_b$ | = | concentration of contaminant in edible beef tissue (mg/kg, calculated) |
| $C_f$ | = | concentration of contaminant in forage (pasture grasses) dry matter (mg/kg) |
| Qf | = | beef cattle forage dry matter ingestion rate (8.8 kg/day) |
| Qs | = | beef cattle soil ingestion rate (0.5 kg/day) |
| $C_s$ | = | concentration of contaminant in soil (mg/kg) |
| Bb | = | beef biotransfer factor (mg of chemical per kg of edible beef tissue). |

### *4.3.5 Quantification of Chemical Intake Rates*

This section describes the models used to quantify doses or intakes of the COPC by the receptors and exposure pathways previously identified. The intake model variables generally reflect 50th or 95th percentile values, which, when applied to the exposure-point concentrations derived as described previously, ensure that the estimated intake rates represent the RME.

Models were taken or modified from EPA (1989a) unless otherwise indicated.

#### 4.3.5.1 Inhalation of COPC in Air

All receptors except the off-site consumer and the farm worker child may be exposed to airborne dust and VOCs from soil. The inhaled dose of COPC in air is estimated as follows:

$$I_a = \frac{(C_a)(IR_a)(FI_a)(ET_a)(EF)(ED)}{(BW)(AT)}$$

where:

| | | |
|---|---|---|
| $I_a$ | = | inhaled dose of COPC (mg/kg-day, calculated) |
| $C_a$ | = | concentration of COPC in air (mg/m$^3$) |
| $IR_a$ | = | inhalation rate (m$^3$/hour) |
| $ET_a$ | = | exposure time (hours/day) |
| EF | = | exposure frequency (days/year) |
| ED | = | exposure duration (years) |
| BW | = | body weight (kg) |
| AT | = | averaging time (days). |

#### 4.3.5.2 Incidental Ingestion of COPC in Soil

All receptors except the off-site consumer and the farm worker child may be exposed to soil by incidental ingestion. The ingested dose of COPC in soil is estimated from the equation:

$$I_s = \frac{(C_s)(IR_s)(FI_s)(EF)(ED)(CF_3)}{(BW)(AT)}$$

where:

| | | |
|---|---|---|
| $I_s$ | = | ingested dose of COPC in soil (mg/kg-day, calculated) |
| $C_s$ | = | concentration of COPC in soil (mg/kg) |
| $IR_s$ | = | soil incidental ingestion rate (mg/day) |
| $FI_s$ | = | fraction of daily soil exposure attributed to site (unitless) |
| EF | = | exposure frequency (days/year) |
| ED | = | exposure duration (years) |
| $CF_3$ | = | conversion factor (1E-6 kg/mg) |
| BW | = | body weight (kg) |
| AT | = | averaging time (days). |

#### 4.3.5.3 Dermal Contact with COPC in Soil

All receptors except the off-site consumer and the farm worker child may be exposed to soil by dermal contact. Unlike the methodologies for estimating inhaled or ingested dose of COPC, which quantify the dose presented to the barrier membrane (the pulmonary or gastrointestinal mucosa, respectively), dermal dose is estimated as the dose that crosses the skin and is

systemically absorbed. For this reason, dermal toxicity values are also based on absorbed dose. The absorbed dose of COPC is estimated as follows (EPA, 1992c):

$$DAD = \frac{(DA)(SA)(FI_d)(EF)(ED)}{(BW)(AT)}$$

where:

| | | |
|---|---|---|
| DAD | = | average dermally absorbed dose of COPC (mg/kg-day, calculated) |
| DA | = | dose absorbed per unit body surface area per day (mg/cm$^2$) |
| SA | = | body surface area exposed to soil (cm$^2$/day) |
| $FI_d$ | = | fraction of daily soil exposure attributed to site (unitless) |
| EF | = | exposure frequency (days/year) |
| ED | = | exposure duration (years) |
| BW | = | body weight (kg) |
| AT | = | averaging time (days). |

It is assumed that one exposure event occurs each exposure day to maintain the dimensional integrity of the equation.

Dermal uptake of COPC from soil assumes that absorption is a function of the fraction of a dermally applied dose that is absorbed. It is calculated from the following equation (EPA, 1992c):

$$DA = (C_s)(CF_3)(AF)(ABS)$$

where:

| | | |
|---|---|---|
| DA | = | dose absorbed per unit body surface area per day (mg/cm$^2$, calculated) |
| $C_s$ | = | concentration of COPC in soil or sediment (mg/kg) |
| $CF_3$ | = | conversion factor (1E-6 kg/mg) |
| AF | = | soil-to-skin adherence factor (mg/cm$^2$) |
| ABS | = | dermal absorption fraction (unitless, chemical-specific value). |
| AT | = | averaging time (days). |

#### *4.3.5.4 Ingestion of COPC in Beef*

The off-site consumer and the farm worker may be indirectly exposed to soil by consumption of "homegrown" beef. The ingested dose of COPC in beef is estimated from the equation:

$$I_b = \frac{(C_b)(IR_b)(FI_b)(EF)(ED)(CF_4)}{(BW)(AT)}$$

where:

| | | |
|---|---|---|
| $I_b$ | = | ingested dose of COPC in beef (mg/kg-day, calculated) |
| $C_b$ | = | concentration of contaminant in edible beef tissue (mg/kg) |
| $IR_b$ | = | beef ingestion rate (g/day) |
| $FI_b$ | = | fraction of beef "homegrown" (unitless) |
| EF | = | exposure frequency (days/year) |
| ED | = | exposure duration (years) |
| $CF_4$ | = | conversion factor (1E-3 kg/g) |
| BW | = | body weight (kg) |
| AT | = | averaging time (days). |

#### *4.3.5.5 Ingestion of COPC in Fruits and Vegetables*

The off-site consumer and the farm worker may be indirectly exposed to soil by consumption of "homegrown" fruits and vegetables. The ingested dose of COPC in fruits and vegetables is estimated from the equation:

$$I_p = \frac{\left[(C_{pv})(IR_v)+(C_{pr})IRr\right](FI_p)(EF)(ED)(CF_4)}{(BW)(AT)}$$

where:

| | | |
|---|---|---|
| $I_p$ | = | ingested dose of COPC in plants (fruits and vegetables) (mg/kg-day, calculated) |
| $C_{pv}$ | = | concentration of contaminant in vegetable dry matter (mg/kg) |
| $IR_v$ | = | vegetable dry matter ingestion rate (g/day) |
| $C_{pr}$ | = | concentration of contaminant in fruit dry matter (mg/kg) |
| $IR_r$ | = | fruit dry matter ingestion rate (g/day) |
| $FI_p$ | = | fraction of fruits and vegetables "homegrown" (unitless) |
| EF | = | exposure frequency (days/year) |
| ED | = | exposure duration (years) |
| $CF_4$ | = | conversion factor (1E-3 kg/g) |
| BW | = | body weight (kg) |
| AT | = | averaging time (days). |

### *4.3.6 Toxicity Assessment*

Toxicity is defined as the ability of a chemical to induce adverse effects in biological systems. The purpose of the toxicity assessment is two-fold:

- Identify the cancer and noncancer effects that may arise from exposure of humans to the COPC (hazard assessment).

- Provide an estimate of the quantitative relationship between the magnitude and duration of exposure and the probability or severity of adverse effects (dose-response assessment).

The latter is accomplished by the derivation of cancer and noncancer toxicity values, as described in the following subsection.

#### *4.3.6.1 Evaluation of Carcinogenic Effects*

A few chemicals are known to be human carcinogens, and many more are suspected to be human carcinogens. The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA, 1986). The qualitative aspect is a weight-of-evidence evaluation of the likelihood that a chemical might induce cancer in humans. EPA (1986) recognizes six weight-of-evidence group classifications for carcinogenicity:

- ***Group A - Human Carcinogen.*** Human data are sufficient to identify the chemical as a human carcinogen.

- ***Group B1 - Probable Human Carcinogen.*** Human data indicate that a causal association is credible, but alternative explanations cannot be dismissed.

- ***Group B2 - Probable Human Carcinogen.*** Human data are insufficient to support a causal association, but testing data in animals support a causal association.

- ***Group C - Possible Human Carcinogen.*** Human data are inadequate or lacking, but animal data suggest a causal association, although the studies have deficiencies that limit interpretation.

- ***Group D - Not Classifiable as to Human Carcinogenicity.*** Human and animal data are lacking or inadequate.

- ***Group E - Evidence of Noncarcinogenicity to Humans.*** Human data are negative or lacking, and adequate animal data indicate no association with cancer.

The toxicity value for carcinogenicity, called a cancer slope factor (SF) or cancer unit risk factor (URF), is an estimate of potency. Potency estimates are developed only for chemicals in Groups A, B1, B2, and C, and only if the data are sufficient. The potency estimates are statistically derived from the dose-response curve from the best human or animal study or studies of the chemical. Although human data are often considered to be more reliable than animal data

because there is no need to extrapolate the results obtained in one species to another, most human studies have one or more of the following limitations:

- The duration of exposure is usually considerably less than lifetime.
- The concentration or dose of chemical to which the humans were exposed can be only crudely approximated, usually from historical data.
- Concurrent exposure to other chemicals frequently confounds interpretation.
- Data regarding other factors (tobacco, alcohol, illicit or medicinal drug use, nutritional factors and dietary habits, heredity) are usually insufficient to eliminate confounding or quantify its effect on the results.
- Most epidemiologic studies are occupational investigations of workers, which may not accurately reflect the range of sensitivities of the general population.
- Most epidemiologic studies lack the statistical power (i.e., sample size) to detect a low, but chemical-related increased incidence of tumors.

Most potency estimates are derived from animal data, which present different limitations:

- It is necessary to extrapolate from results in animals to predict results in humans, usually done by estimating an equivalent human dose from the animal dose.
- The range of sensitivities arising from genotypic and phenotypic diversity in the human population is not reflected in the animal models ordinarily used in cancer studies.
- Usually very high doses of chemical are used, which may alter normal biology, creating a physiologically artificial state and introducing substantial uncertainty regarding the extrapolation to the low-dose range expected with environmental exposure.
- Individual studies vary in quality (e.g., duration of exposure, group size, scope of evaluation, adequacy of control groups, appropriateness of dose range, absence of concurrent disease, sufficient long-term survival to detect tumors with long induction or latency periods).

The SF or URF is usually expressed as "extra risk" per unit dose, i.e., the additional risk above background in a population corrected for background incidence. It is calculated by the expression:

$$(p_{(d)} - p_{(0)})/(1 - p_{(0)})$$

where:

$p_{(d)}$ = the probability of cancer associated with dose = 1 mg/kg-day
$p_{(0)}$ = the background probability of developing cancer at dose = 0 mg/kg-day.

The SF is expressed as risk per milligrams per kilogram per day (mg/kg-day). To be appropriately conservative, the SF is usually the 95 percent upper-bound on the slope of the dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios. EPA (1986) assumes that there are no thresholds for carcinogenic expression; therefore, any exposure represents some quantifiable risk.

The oral SF is usually derived directly from the experimental dose data, because oral dose is usually expressed as mg/kg-day. When the test chemical is administered in the diet or drinking water, oral dose first must be estimated from data for the concentration of the test chemical in the food or water, food or water intake data, and body weight data.

The EPA (2000b) Integrated Risk Information System (IRIS) expresses inhalation cancer potency (URF) as a unit risk-based on concentration, or risk per microgram of chemical/$m^3$ in ambient air. Because cancer risk characterization requires a potency expressed as risk per mg/kg-day, the unit risk must be converted to the mathematical equivalent of an inhalation cancer SF, or risk per unit dose. Since the inhalation unit risk is based on continuous lifetime exposure of an adult human (assumed to inhale 20 $m^3$ of air per day and to weigh 70 kg) the mathematical conversion consists of multiplying the unit risk (per micrograms per cubic meter [$\mu g/m^3$]) by 70 kg and by 1,000 $\mu$g/mg, and dividing the result by 20 $m^3$/day.

#### *4.3.6.2 Evaluation of Noncancer Effects*

Most chemicals, whether or not associated with carcinogenicity, are associated with noncancer effects. The evaluation of noncancer effects (EPA, 1989b) involves:

- Qualitative identification of the adverse effect(s) associated with the chemical; these may differ depending on the duration (acute or chronic) or route (oral or inhalation) of exposure

- Identification of the critical effect for each duration of exposure (i.e., the first adverse effect that occurs as dose is increased)

- Estimation of the threshold dose for the critical effect for each duration of exposure

- Development of an uncertainty factor, i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect and slope of the dose-response curve, and deficiencies in the database, in regard to developing a RfD for human exposure

- Identification of the target organ for the critical effect for each route of exposure.

These information points are used to derive an exposure route- and duration-specific toxicity value called an RfD, expressed as mg/kg-day, which is considered to be the dose for humans, with uncertainty of an order of magnitude or greater, at which adverse effects are not expected to occur. Mathematically, it is estimated as the ratio of the threshold dose to the uncertainty factor.

IRIS (EPA, 2000b) and the Health Effects Assessment Summary Tables (HEAST) (EPA, 1997c) express the inhalation noncancer reference value as a reference concentration (RfC) in units of $mg/m^3$. Because noncancer risk characterization requires a reference value expressed as mg/kg-day, the RfC must be converted to an inhalation RfD. Since the inhalation RfC is based on continuous exposure of an adult human (assumed to inhale 20 $m^3$ of air per day and to weigh 70 kg), the mathematical conversion consists of multiplying the RfC ($mg/m^3$) by 20 $m^3$/day and dividing the result by 70 kg.

For purposes of risk assessment, chronic exposure is defined as equal to or greater than 7 years, i.e., at least 10 percent of expected lifespan; subchronic exposure is defined as 2 weeks to 7 years. According to this definition, construction worker exposures should be evaluated with subchronic rather than chronic RfDs and RfCs. As a practical matter, subchronic RfDs and RfCs are available for relatively few chemicals. The subchronic RfDs and RfCs are never smaller (more restrictive) than their corresponding chronic values. Therefore, to simplify matters, chronic RfDs and RfCs will be used for the construction worker, because they are at least as protective as the subchronic values. Should COPC be identified as risk drivers based on noncancer hazard, the COPC will be evaluated to determine whether a subchronic RfD or RfC is available (or can be derived relatively easily) and whether it would make a difference to the outcome.

#### *4.3.6.3 Target Organ Toxicity*

As a matter of science policy, EPA (1989a) assumes dose- and effect-additivity for noncancer effects. This assumption provides the justification for adding the hazard quotients (HQ) or HIs in the risk characterization for noncancer effects resulting from exposure to multiple chemicals, pathways, or media. EPA (1989a), however, acknowledges that adding all HQ or HI values may

overestimate risk, because the assumption of additivity is probably appropriate only for those chemicals that exert their toxicity by the same mechanism.

Mechanism of toxicity data sufficient for predicting additivity with a high level of confidence are available for very few chemicals. In the absence of such data, EPA (1989a) assumes that chemicals that act on the same target organ may do so by the same mechanism of toxicity, i.e., the target organ serves as a surrogate for mechanism of toxicity. When total HI for all media for a receptor exceeds 1 due to the contributions of several chemicals, it may be appropriate to segregate the chemicals by route of exposure and mechanism of toxicity (i.e., target organ) and estimate separate HI values for each.

Human environmental exposures are likely to involve near- or sub-threshold doses; therefore, the target organs chosen for a given chemical are the ones associated with the critical effect or effects occurring near the threshold. The target organ is also selected on the basis of duration of exposure (i.e., the target organ for chronic or subchronic exposure to low or moderate doses is selected rather than the target organ for acute exposure to high doses) and route of exposure (i.e., ingestion and inhalation). Because dermal RfD values are derived from oral RfD values, the oral target organ is adopted as the dermal target organ. For some chemicals, no target organ is identified. This may arise when no adverse effects are observed or when adverse effects such as reduced longevity or growth rate are not accompanied by recognized organ- or system-specific functional or morphologic alteration.

#### *4.3.6.4 Dermal Toxicity Values*

Dermal RfD values and SFs are derived from the corresponding oral values, provided there is no evidence to suggest that dermal exposure induces exposure route-specific effects that are not appropriately modeled by oral exposure data. In the derivation of a dermal RfD, the oral RfD is multiplied by the gastrointestinal absorption factor (GAF), expressed as a decimal fraction. The resulting dermal RfD, therefore, is based on absorbed dose. The RfD based on absorbed dose is the appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed rather than exposure doses. The dermal SF is derived by dividing the oral SF by the GAF. The oral SF is divided, rather than multiplied, by the GAF because SFs are expressed as reciprocal dose.

#### *4.3.6.5 Sources of Toxicity Information Used in the Risk Assessment*

Toxicity values are chosen using the following hierarchy:

- The EPA's on-line IRIS database (EPA, 2000b) containing toxicity values that have undergone the most rigorous Agency review
- The latest version of the annual HEAST, including all supplements (EPA, 1997c)
- Other EPA documents, memoranda, or National Center for Environmental Assessment (NCEA) derivations for the Superfund Technical Support Center.

All toxicity values, regardless of their source, are evaluated for appropriateness for use in risk assessment.

When toxicity values are not located, the primary literature may be surveyed to determine whether sufficient data exist that would permit derivation of a toxicity value. The use of surrogate chemicals is also considered, if the chemical structure, adverse effects, and toxic potency of the surrogate and chemical of interest are judged to be sufficiently similar. EPA toxicologists are consulted in all such cases.

#### *4.3.6.6 Gastrointestinal Absorption Factors*

GAFs, used to derive dermal RfD values and SFs from the corresponding oral toxicity values, are obtained from the following sources:

- Empirical data
- NCEA position papers
- Federal agency reviews of the empirical data, such as Agency for Toxic Substances and Disease Registry Toxicological Profiles and various EPA criteria documents
- Other published reviews of the empirical data.

GAFs obtained from reviews are compared to empirical (especially more recent) data, when possible, and are evaluated for suitability for use for deriving dermal toxicity values from oral toxicity values. The suitability of the GAF increases when the following similarities are present in the oral toxicokinetic study from which the GAF is derived and in the key toxicity study from which the oral toxicity value is derived:

- The same strain, sex, age, and species of test animal was used.
- The same chemical form (e.g., the same salt or complex of an inorganic element or organic compound) was used.

- The same mode of administration (e.g., diet, drinking water, or gavage vehicle) was used.
- Similar dose rates were used.

The most defensible GAF for each chemical, described in detail within the toxicological profiles, is used in the risk assessment.

#### *4.3.6.7 Toxicological Profiles*

Toxicological profiles will be developed for all chemicals selected as COPC. The profile will include data such as the general use of the chemical, synonyms, Chemical Abstracts Services number, chemical-specific physical characteristics, and current and available toxicological and toxicokinetic information (RfDs/RfCs, SFs/URFs, and GAFs).

### *4.3.7 Risk Characterization*

Risk characterization is the combination of the results of the exposure assessment and toxicity assessment to yield a quantitative expression of risk for the exposed receptors. This quantitative expression is the probability of developing cancer, or a nonprobabilistic comparison of estimated dose with an RfD for noncancer effects. Quantitative estimates are developed for individual chemicals, exposure pathways, and exposure media for each receptor. Although some chemicals induce both cancer and noncancer effects, the risks for each type of effect are calculated separately. The risk characterization is used to guide risk management decisions.

Generally, the risk characterization follows the methodology prescribed by EPA (1989a). The EPA methods are, appropriately, designed to be health-protective, and tend to overestimate, rather than underestimate, risk.

#### *4.3.7.1 Carcinogenic Effects of Chemicals*

The risk of exposure to potential chemical carcinogens is estimated as the probability of an individual developing cancer over a lifetime. In the low-dose range, which would be expected for most environmental exposures, cancer risk is estimated from the following linear equation (EPA, 1989a):

$$ILCR = (I)(SF)$$

where:

| | | |
|---|---|---|
| ILCR | = | incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence, calculated |
| I | = | chronic daily intake, averaged over the expected human lifetime (70 years) (mg/kg-day) |
| SF | = | cancer slope factor (per mg/kg-day). |

The use of this equation assumes that chemical carcinogenesis does not exhibit a threshold, and that the dose-response relationship is linear in the low dose range. This equation could generate theoretical cancer risks greater than 1 for high dose levels; therefore, it is considered to be inaccurate at cancer risks greater than 1E-2. In these cases, cancer risk is estimated by the one-hit model (EPA, 1989a):

$$ILCR = 1 - e^{[(-I)(SF)]}$$

where:

| | | |
|---|---|---|
| ILCR | = | incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence, calculated |
| $e^{(-I)(SF)}$ | = | the exponential of the negative of the risk calculated using previous equation. |

As a matter of policy, EPA (1986) considers the carcinogenic potency of simultaneous exposure to low doses of carcinogenic chemicals to be additive, regardless of the chemical's mechanisms of toxicity or sites (organs of the body) of action. Cancer risk arising from simultaneous exposure by a given pathway to multiple chemicals is estimated from the equation (EPA, 1989a):

$$Risk_p = ILCR_{(chem\ 1)} + ILCR_{(chem\ 2)} + \ldots ILCR_{(chem\ i)}$$

where:

| | | |
|---|---|---|
| $Risk_p$ | = | total pathway risk of cancer incidence, calculated |
| $ILCR(chem_i)$ | = | individual chemical cancer risk. |

Cancer risk for a given receptor across pathways and across media is summed in the same manner.

#### 4.3.7.2 Noncancer Effects of Chemicals

The risk associated with the noncancer effects of a chemical is more appropriately termed "hazard" (to distinguish it from cancer risk, which is expressed as a numerical probability), and is evaluated by comparing an exposure level or intake with a RfD. The HQ, defined as the ratio of intake to RfD, is defined as follows (EPA, 1989a):

$$HQ = I / RfD$$

where:

| | | |
|---|---|---|
| HQ | = | hazard quotient (unitless, calculated) |
| I | = | intake of chemical (mg/kg-day) |
| RfD | = | reference dose (mg/kg-day). |

This approach is different from the probabilistic approach used to evaluate carcinogenic effects. An HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates that the estimated intake is 100 times lower than the RfD. An HQ of unity indicates that the estimated intake equals the RfD. If the HQ is greater than unity, there may be concern for potential adverse health effects.

In the case of simultaneous exposure of a receptor to several chemicals, an HI is calculated as the sum of the HQs by:

$$HI = I_1 / RfD_1 + I_2 / RfD_2 + \ldots I_i / RfD_i$$

where:

| | | |
|---|---|---|
| HI | = | hazard index (unitless, calculated) |
| $I_i$ | = | intake for the $i^{th}$ toxicant |
| $RfD_i$ | = | reference dose for the $i^{th}$ toxicant. |

If the HI for a given receptor, across all applicable exposure pathways, exceeds 1.0, individual HI values are calculated for each target organ.

### 4.3.8 Uncertainty Analysis

This section will briefly introduce the evaluation of uncertainties inherent in the risk assessment process. Uncertainty is a factor in each step of the exposure and toxicity assessments presented

in the preceding sections. Uncertainties associated with earlier stages of the process become magnified when they are concatenated with other uncertainties in the latter stages of the process. Such uncertainty includes variations in sample analytical results, the values of variables used as input to a given model, the accuracy with which the model itself represents actual environmental processes, the manner in which the exposure scenarios are developed, and the high-to-low dose and interspecies extrapolations for dose-response relationships. It is not possible to eliminate all uncertainty; however, a recognition of the uncertainties is fundamental to the understanding and reasonable use of risk assessment results.

Generally, risk assessments carry two types of uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements, e.g., instrument uncertainty (accuracy and precision) associated with contaminant concentrations. The results of the risk assessment reflect the accumulated variances of the individual measured values used to develop it. A different kind of uncertainty stems from data gaps, i.e., additional information needed to complete the database for the assessment. Often, the data gap is significant, such as the absence of information on the effects of human exposure to a chemical or on the biological mechanism of action of an agent (EPA, 1992d). Many of the data gaps are filled with default values from various EPA guidance efforts.

EPA (1992d) guidance urges risk assessors to address or provide descriptions of individual risk to include the "high end" portions and "CT" of the risk distribution. One way of fulfilling this request, if either cancer or noncancer risk exceed generally acceptable limits, is to re-compute the cancer risks or HIs using CT values for as many intake model variables as possible. In contrast to the RME evaluation, which prevails in BHHRAs and uses upper-end values for intake or contact rates, EF, and ED, the CT evaluation chooses average or mid-range values for these variables (EPA, 1991b). The intent is to present a quantified risk/hazard estimate more typical for the receptor of interest. The CT exposure evaluation, however, falls short of its stated intent for several reasons. First, the same source-term concentration is usually used for the CT evaluation as is used for the RME evaluation. EPA (1993) considers that the UCL or MDC selected as a conservative estimate of average for the RME is appropriate for the CT estimates. Second, there is little information available as to what constitutes a reliable CT estimate for most exposure variables (EPA, 1993), with the possible exception of a simple on-site residential scenario. Hence, RME values are still used. Third, no CT toxicity values are available (except for the cancer SF for PCBs), so the uncertainty about the toxicity assessment is not included. A CT evaluation, therefore, usually provides little perspective on uncertainty, particularly for exposure scenarios such as the off-site consumer, youthful trespasser, farm worker, and construction worker, for which no reliable estimation of most exposure variable values can be

made. It should be stated that management decisions are generally based on RME rather than CT evaluations.

Another method of quantifying uncertainty, called Monte Carlo simulation, provides a more graphic illustration of the uncertainty about a risk/hazard estimate, because it presents the risk as a range with probability densities. To be meaningful, however, Monte Carlo simulation requires that the nature of the distributions of the variables that drive the risk assessment should be well-characterized. However, well-characterized distributions are available for few exposure or toxicological variables, in which case the Monte Carlo simulation provides an incomplete or misleading illustration of the magnitude or the distribution of the uncertainty. Because of the deficiencies of the CT analysis and the Monte Carlo simulation, the uncertainty evaluation will be limited to a qualitative discussion of the impact of the major sources of uncertainty on the outcome of the risk assessment.

One important source of uncertainty to this risk assessment is the application of exposure variables based on continental United States demographics and human behavior to receptors living in Puerto Rico. In particular, variables such as BW, length of time at one job or living in one residence, work and hygiene habits that affect incidental soil ingestion, and consumption rates for beef, fruits, and vegetables have not been studied in the Puerto Rican culture. In the absence of site-specific data, 90$^{th}$ percentile values from United States data were chosen for these variables to intentionally impart a conservative and protective bias.

### *4.3.9 Summary and Conclusions*

This section will synthesize the results of the risk assessment and the uncertainty section to identify the implications of the BHHRA on site management.

# 5.0 Screening Level Ecological Risk Assessment

Screening level ecological risk assessments (SLERA) will be conducted for landfills at the former Ramey AFB. The SLERAs are designed to evaluate potential unacceptable risks to ecological receptors posed by site-related contamination potentially present at two landfills. The SLERAs will be conducted in accordance with the EPA *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1997d), known as the "Process Document." The SLERA corresponds to Steps 1 and 2 of the 7-Step (formerly the 8-Step) ecological risk assessment process for Superfund (Figure 5-1).

The goal of screening-level problem formulation is to develop an ecological site conceptual model for the site that addresses the following:

- The environmental setting
- The contaminants known or suspect of being present at the site
- The presence or absence of contaminant fate or transport mechanisms
- The presence or absence of viable exposure pathways and receptors.

The two landfills will be evaluated separately.

## 5.1 Summary of Historical Sampling Results

Historical surface soil, surface water, and sediment samples were collected by E&E in 1997. At Landfill Area 1, all three matrices were analyzed for inorganic analytes, VOCs, SVOCs, and pesticides/PCBs. Additionally, surface soil was analyzed for explosive compounds. Surface soil was the only matrix sampled at Landfill Area 2, and was analyzed for inorganic analytes, VOCs, SVOCs, pesticides/PCBs, and explosive compounds.

### 5.1.1 Landfill Area 1

Four surface soil samples, one surface water sample, and one sediment sample were analyzed for a suite of chemical compounds.

A total of 21 inorganic analytes were detected in Landfill Area 1 surface soil (see Table 2-7 for detected analytes and concentrations). Four VOCs were detected, including acetone, ethyl benzene, total xylene, and toluene (see Table 2-8 for detected concentrations); however, it should be noted that all for compounds were detected in only one of four samples, and toluene was the only compound that was not qualified as an estimated concentration. No SVOCs, pesticides/PCBs, or explosive compounds were detected in surface soil (Table 2-8).

Nine inorganic analytes were detected in Landfill Area 1 surface water (see Table 2-11 for detected analytes and concentrations). No VOCs, SVOCs, or pesticides/PCBs were detected in surface water (Table 2-12).

Nineteen inorganic analytes were detected in Landfill Area 1 sediment (see Table 2-13 for analytes and concentrations). Toluene and total xylene were the only two VOCs detected in sediment; however, both duplicate samples were J qualified and both original samples were qualified as nondetect (Table 2-14). Twelve SVOCs were detected. However, only four were not J qualified (see Table 2-14 for compounds and concentrations). All four pesticides detected in Landfill Area 1 sediment were reported as estimated concentrations (Table 2-14).

### 5.1.2 Landfill Area 2

Five surface soil samples were analyzed for a suite of chemical compounds. Twenty-one inorganic analytes were detected in Landfill Area 2 surface soil (see Table 2-9 for detected analytes and their respective concentrations). Both acetone and toluene (VOCs) were detected in one of five samples at estimated concentrations (Table 2-10). No SVOCs were detected in Landfill Area 2 surface soil, and only three pesticides were detected in one of five samples (Table 2-10).

No surface water or sediment samples were collected at Landfill Area 2.

## 5.2 Site Description

A description of each landfill will be compiled from existing site reports, maps (e.g., U.S. Geological Survey, National Wetlands Inventory), available aerial photographs, communication with appropriate agencies (e.g., U.S. Fish and Wildlife Service, National Heritage Program), and a site visit.

### 5.2.1 Site History

For each landfill, the site history will include information about the events that have lead to the current investigation.

### 5.2.2 Site Setting

The site setting of each landfill will include geographical location, accessibility, and its surroundings. Land use (e.g., industrial, business, residential, military, agricultural, and undeveloped) upstream and downstream of the sites will be described, with special note to natural areas such as parks, wildlife refuges, and wetlands. A general description of topography, including a description of whether the site is open or wooded, flat or hilly, marshy or dry, will be

completed. The setting will describe surface water associated with each site. A description of the aquifer, overlaying strata, and groundwater discharge area will also be included.

### 5.2.3 Ecological Description

For each landfill, ecological descriptions of site habitat (e.g., wetlands, woodlands, grasslands, open fields, ponds, streams) will be provided. Information regarding site-related plants and animals will be provided, including migratory species of animals and species that use the area during only part of their life cycle. Species of special interest, such as game species, Federal- or State-listed endangered or threatened species, and species protected under other statutes will be described. Other relevant information includes geological information such as hydrology, sediment types, and soil types.

## 5.3 Screening Level Ecological Risk Assessment

This activity constitutes an evaluation of ecological risks for each site. The analytical data to be used will consist of samples collected by IT for the RI sampling effort. For these SLERAs, results of surface soil (0.0 to 1.0 foot), surface water, and sediment samples (0 to 0.5 foot) will be used. Chapter 3.0 presents details of environmental samples to be collected at each landfill. The SLERA methodology will generally follow the Seven-Step risk assessment process presented in the Process Document, but with Steps 1 and 2 collapsed and Step 3 modified to reflect anticipated changes in the guidance (Figure 5-1).

### 5.3.1 Ecological Conceptual Site Model

In order to better understand the two landfills with respect to potential contaminant pathways and generic ecological receptors, Figures 5-2 and 5-3 present ecological conceptual site models for Landfill Aeas 1 and 2, respectively.

#### 5.3.1.1 Landfill Area 1

Landfill Area 1 is predominantly an open grass area, with a patch of sparse shrub/scrub vegetation on the south central portion of the landfill, and a few deciduous trees on the southeast side. The landfill appears to slope from east to west towards the sinkhole. During the site walk performed by IT in January 2000, exposed medical waste was observed on the western side, indicating that soil cover may be thinner on that side of the landfill. It was also noted that medical waste was predominantly exposed along cattle trails.

The sinkhole, immediately west of the landfill, is ringed by deciduous vegetation and somewhat dense underbrush. Vegetation at the bottom of the sinkhole is composed of forbes and terrestrial grasses. Medical refuse exists near the bottom of the sinkhole along the eastern side. It is

presumed this was buried waste that has been exposed through erosional processes, as there is also medical waste in the wall of the sinkhole near the top. Larger pieces of metallic waste may have been simply pushed over the side of the sinkhole. There is no evidence of any type of aquatic habitat within the sinkhole.

A steeply sloped ditch leading to the sinkhole, situated along the northwest side of the landfill, is entirely canopied by deciduous trees and thick underbrush. The ditch is approximately 4 to 6 feet wide at the base, and the walls are approximately 10 to 15 feet in height. The bed and walls of the ditch show evidence of large volumes of water passing through the ditch. Presumably heavy rains create surges of overland runoff, which is channeled through the ditch and into the sinkhole. The ditch appears to be eroding into the landfill, as medical waste is exposed on the east wall of the ditch. There are no signs of aquatic habitat within the ditch.

The ecological risk assessment for Landfill Area 1 will focus on terrestrial receptors, as there is no evidence of any type of viable aquatic habitat. It is believed that the western ditch and the sink hole may become inundated with overland runoff due to heavy rain events; however, due to the geological characteristics of the area, this water would seep to ground water in a short period of time. Therefore, there would not be enough time for any type of permanent aquatic habitat to be established.

#### *5.3.1.2 Landfill Area 2*

Landfill Area 2 is presently used in an agricultural capacity. Prior to this, it was used for grazing cattle. Only the northwest corner of the site is not presently tilled or planted with commercial/subsistence crops. This corner is vegetated with tall grasses. The landfill terrain can be described as very gently rolling hills with the highest point in the northeastern corner. Low points of the landfill are along the western boundary, the southeastern corner, and the north central boundary.

A drainage ditch runs along the western fence line of the site and, if water were present, it would flow in a northerly direction. The ditch begins abruptly, and does not appear to lead to any surface water body, but rather gently spreads out until it blends in with flat earth. Although this ditch appears to be located within the landfill boundary, no refuse material was observed in the ditch. There is no evidence of aquatic biota; therefore, it is presumed only to contain water during storm events.

A pond is located to the northeast of the historical landfill boundary. It appears to be man-made and is surrounded by a barbed wire fence. Through interviews with local field workers during

the IT site walk in January 2000, it was learned that the pond is filled by pumping water from a water distribution pipe that runs from a municipal reservoir past the landfill area and into the former Ramey AFB. The water is used to irrigate crops via gravity feed. Because the pond is located at the highest point of the area and is fed by an off-site source, it is not expected that potential contaminants from the landfill could migrate via groundwater or surface runoff into the pond water and/or sediments.

The ecological risk assessment for Landfill Area 2 will focus on terrestrial receptors, as the western ditch could only be considered an aquatic habitat during heavy rain events, and the pond and its associated surface water and sediment are upgradient of the landfill.

### *5.3.2 Step 1, Preliminary Screen and Abiotic Hazard Quotients*

This section describes the initial screening step, which is intended to determine if there is a need for further examination of potential ecological impacts at the sites. Contaminants that can not be eliminated from further consideration through screening will be carried forward as chemicals of potential ecological concern (COPEC).

MDCs for each matrix contaminant will be compared individually to the latest version of Biological Technical Advisory Group screening values (SV) for EPA Region III. In cases for which no Region III SV is available, other source values (e.g., EPA Region V, EPA Region IV, Florida Department of Environmental Conservation, etc.) will be used. The comparisons will be presented as a ratio described by the following formula:

$$AHQ = MDC / SV$$

where:

| | | |
|---|---|---|
| AHQ | = | abiotic hazard quotient |
| MDC | = | maximum detected concentration |
| SV | = | screening value. |

Chemicals with an abiotic hazard quotient (AHQ) less than or equal to 1 will be regarded as having insignificant risk potential to ecological receptors, and will be recommended for elimination from further evaluation. In contrast, chemicals with an AHQ greater than 1 will be defined as COPEC and retained for further evaluation in Step 2.

***Scientific Management Decision Point One.*** The initial screening step can conclude with a scientific management decision point. At this point, risk managers will examine the information generated from Step 1 (e.g., the AHQs and the site and ecological descriptions) and

declare a necessity to proceed to the next step in the assessment. If, however, the managers conclude that further evaluation is not required, the decision and details of such action will constitute the ecological risk section for the investigative report.

Because ecological benchmark SVs are quite conservative, it is anticipated that several chemicals will almost certainly produce AHQs greater than 1, thus requiring additional examination in the next step.

### *5.3.3 Step 2, Problem Formulation*

At the beginning of this activity, COPEC carried from Step 1 will undergo additional comparisons to ensure that subsequent examination focuses on those contaminants from site-related activities that are capable of posing ecological risk. Some naturally occurring analytes such as calcium, magnesium, potassium, and sodium are nutritionally essential to most organisms and should be excluded from further consideration. Those analytes that can be shown to be less than accepted background values or not statistically different than background will not be considered further. Chemicals that are detected infrequently may be artifacts in the data that may not reflect site-related activity. Generally, those chemicals that are detected in low concentrations in less than 5 percent of the samples from a given medium will not be considered further, unless their presence is expected based on historical information regarding the site. Chemicals detected infrequently at high concentrations may identify the existence of "hot spots" and will be retained.

Those contaminants that remain following this second screening step require a more detailed evaluation that considers actual site conditions. The latter component of Step 2 will involve the problem formulation for the site. Details of the exposure setting is the context within which contamination levels are evaluated and appropriate ecological receptors are evaluated and selected. The overall quality of the habitat at each site will be examined and hypothetical contaminant fate and transport (exposure) pathways will be evaluated for actual site conditions. General toxicity mechanisms for chemical classes (e.g., organochlorine pesticides, PCBs, PAHs, etc.) of site contaminants will be presented. The goal of this step will be to provide the risk managers with:

- A list of site-related contaminants that truly have the potential to damage ecological systems at the site.
- A detailed description of site characteristics as a framework for evaluating contaminant impact.

***Scientific Management Decision Point Two.*** The risk managers may conclude that there is no unacceptable threat to local biotic communities at any of these steps. Therefore, there would be no need for further evaluation, in which case details of the basis for that action will constitute the ecological risk section for the investigative report.

Follow-on steps (EPA, 1997d) should be performed for the site if results indicate that:

- Viable ecological habitat exists for supporting valuable ecological communities of terrestrial and aquatic species, and valuable ecosystems.
- One or more potential chemical stressors are present at the site.
- One or more ecological receptors (i.e., ecological entities of significance and interest, such as species, habitats, populations, communities, and/or ecosystems) are present at the site.

### *5.4 Baseline Ecological Risk Assessment*

Should the risk managers decide that there are significant ecological threats at any of the landfills, a baseline ecological risk assessment (BERA) will be conducted for that/those site(s). Details of those procedures are provided in the process document (EPA, 1997d), and include Steps 3 through 7 as presented in Figure 5-1. Details on how this portion of such a study would be conducted are not provided at this time because new analytical data are not yet available, and the screening-level steps necessary to support the selection of appropriate ecological receptors are not complete. The selection of specific stressors, valid ecological receptors, and clearly identified habitat types will require input from the risk managers.

The outcome of the BERA will be a report(s) on the data, results, professional judgment, and conclusions concerning the potential for ecological impacts at the site. From an ecological point of view, risk management actions, which may include proceeding with remedial activities, implementing biological monitoring, or a decision for no further action, are beyond the scope of risk assessment. Risk managers and stakeholders will select the final decision(s) with input from the risk assessors and results of the BERA.

# 6.0 Project Organization

The primary participants involved in executing this investigation include the USACE-Savannah District, IT, and IT's approved subcontractors. A project organization chart is presented in Figure 6-1.

## 6.1 USACE Personnel

***Project Manager.*** The USACE PM is responsible for programming and securing funding for environmental restoration activities while ensuring the work to be performed is formerly used defense site-eligible. The PM is fiscally responsible for the project and is therefore consulted on matters involving funding issues.

***Contracting Officer.*** The contracting officer (CO) is the contractual authority between USACE and IT. The CO is the only person with contractual authority to negotiate, enter into contracts, obligate funds, order changes, and negotiate resultant increases or decreases in the estimated contract cost, fee, and performance schedule. The CO is responsible for award and administration of binding contractual documents. Other CO responsibilities include task order award, change notification, and negotiation, cost overruns, small and small-disadvantaged business subcontracting, subcontract consent, government property tracking, reporting and dispositions, and project closeout.

***Contracting Officer Representative.*** The contracting officer representative (COR) is responsible for providing technical direction to IT throughout project execution, approving in-scope changes, advising the CO of changes that may affect cost and/or schedule, and issuing technical direction. For this RI of Landfill Areas 1 and 2, a COR is appointed by the USACE-Savannah District. The COR's authority is limited to technical direction within the general scope of work stated in the contract. The COR may not direct work to be done that is outside the contract scope, request a subcontract change, or otherwise cause an increase or decrease in estimated subcontract cost, fee, or performance schedule without written concurrence from the CO.

***Technical Manager.*** The USACE technical manager (TM) serves as the primary focal point for all project issues relative to the work at the former Ramey AFB. The USACE TM facilitates the implementation of the terms and conditions of the delivery orders, including interpreting specifications, drawings, or other technical portions of the work description; coordinating responses to technical questions; and reviewing and recommending approval of technical reports

and other deliverable submitted by IT. The USACE TM provides the QA for the RI of Landfill Areas 1 and 2.

### 6.2 IT Personnel

IT management and technical personnel for this project include the following:

- ***Project Manager, Glenn Quarles.*** The PM is IT's representative responsible for the effective execution of this project and serves as IT's primary focal point for all environmental restoration activities at the former Ramey AFB, both with USACE and within IT. The PM takes direction from the USACE COR in executing the RI work plan.

- ***Health and Safety Manager, Mike Henderson, CIH.*** The health and safety manager for this project developed the SSHP referenced in this work plan. This plan complies with 29 CFR Part 1910.120 and 29 CFR 1926.65 in all aspects and includes medical surveillance and training requirements, hazard assessment, personal protective equipment specifications, field implementation procedures, and audits. The health and safety manager is the contact for regulatory agencies on matters of safety and health.

- ***Task Leader, Ken Cunningham, PG.*** The task leader coordinates the effective execution of the field activities, including preparing work plans, conducting the field activities, and preparing the final construction report. The task leader will coordinate closely with the site manager and data management group during execution of the field activities to ensure completion in accordance with the work plans.

- ***Project Chemist, Joyce Dishner.*** The project chemist will work with the project management team in formulating plans and approaches. The project chemist will assess sampling, analytical, and QA/QC requirements for each project task and assist in the interpretation and use of sampling and QA/QC data. The project chemist will review field analytical, and QA/QC data and prepare a QC summary report before those data are transferred to permanent storage or reported to other project participants.

- ***Project Geologist, John Hofer, PG.*** The project geologist will formulate the technical direction of the investigation and prepare the work plan. The project engineer will also prepare the final RI report.

- ***Site Manager, Chris Patrick.*** The site manager provides management and technical direction of tasks. The site manager assigns and directs all on-site activities, ensures adherence to project plans, and prepares status reports for the PM. The site manager also manages subcontractor activities and implements the health and safety program.

- ***Human Health Risk Assessor, Michelle Shipp.*** The human health risk assessor will formulate the work scope of the human health portion of the risk assessment. This will ensure that all potential current and future exposure scenarios are considered. The human health risk assessor will also review pertinent data as they are received and help prepare the risk assessment report.

- ***Ecological Risk Assessor, Greg Sylwester.*** The ecological risk assessor will determine the work scope of the ecological portion of the risk assessment. The ecological risk assessor will review field data as they are received and help prepare the risk assessment report.

# 7.0 Schedule

To manage all phases of the project effectively, the PM will utilize the IT project management system. The integrated project planning, tracking, and control system is composed of two primary concepts:

- Versatile, Integrated System for IT's Operational Needs is used to track and maintain information on project expenses on a weekly basis.
- Schedule and budget controls: IT uses Primavera Project Planner as a planning system to integrate schedule, resource allocation, and budget.

The schedule for preparing the RI work plan and performing the investigation at Landfill Areas 1 and 2 is presented in Figure 7-1. The PM will actively manage the schedule and internal checks will determine the problems early, thus eliminating costly delays and rework that could impact critical schedule milestones.

# 8.0 Site Safety and Health Plan

All work at the site performed by IT or its subcontractors will be performed in accordance with the SSHP presented in Appendix B of this work plan.

This SSHP complies with applicable Occupational Safety and health Administration (OSHA), EPA, and USACE regulations. This plan follows the guidelines established in the following:

- Standard Operating Safety Guidelines (EPA, November 1984)
- Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (National Institute of Occupational Safety and Health 86-116)
- 29 CFR 1910.120, U.S. Department of Labor/Occupational Safety and Health Administration (OSHA)
- 29 CFR 1926.65, U.S. Department of Labor/OSHA
- Safety and Health Elements for Hazardous Toxic and Radiologic Waste and OWE Documents (USACE CER 385-1-92, Appendix B [18 March 1994]).

The contents of the SSHP are also consistent with IT health and safety policies and procedures.

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# TABLES

## Table 2-1

## Monitoring Well Construction Details for Landfill Area 1
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Well Number | Total Depth in Feet (bgs) | Screened Interval in Feet (bgs) | Top of Casing Elevation (above msl) | July 1997 Results | | | December 1998 Results | | | Well Diameter and Surface Protection |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Depth to Water Below Top of Casing (in feet) | Water Table Elevation (above msl) | Depth to Water in Feet (bgs) | Depth to Water Below Top of Casing (in feet) | Water Table Elevation (above msl) | Depth to Water in Feet (bgs) | |
| RMW1-1 | 277 | 238 - 273 | 247.14 | 242.01 | 5.13 | 239.36 | 241.80 | 5.34 | 239.15 | 2-inch ID, locking metal outer case, locking cap, concrete pad, bumper guards |
| RMW1-2 | 257 | 229 - 244 | 241.50 | 236.18 | 5.32 | 233.39 | 236.01 | 5.49 | 233.22 | 2-inch ID, locking cap, flush-mounted metal cover, concrete pad |
| RMW1-3 | 247 | 210 - 225 | 222.59 | 217.38 | 5.21 | 214.69 | 217.20 | 5.39 | 214.51 | 2-inch ID, locking metal outer case, locking cap, concrete pad, bumper guards |
| RMW1-4 | 257 | 222 - 237 | 231.43 | 226.16 | 5.27 | 226.40 | 226.01 | 5.42 | 226.25 | 2-inch ID, flush-mounted, locking metal outer case, locking cap, concrete pad |

bgs - Below ground surface.
ID - Inside diameter.
msl - Mean sea level.

## Table 2-2

## Monitoring Well Construction Details for Landfill Area 2
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Well Number | Total Depth in Feet (bgs) | Screened Interval in Feet (bgs) | Top of Casing Elevation (above msl) | July 1997 Results | | | December 1998 Results | | | Well Diameter and Surface Protection |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Depth to Water Below Top of Casing (in feet) | Water Table Elevation (above msl) | Depth to Water in Feet (bgs) | Depth to Water Below Top of Casing (in feet) | Water Table Elevation (above msl) | Depth to Water in Feet (bgs) | |
| RMW2-1 | 247 | 220 - 235 | 231.74 | 225.96 | 5.78 | 223.49 | 225.68 | 6.06 | 223.21 | 2-inch ID, locking metal outer case, locking cap, concrete pad, bumper guards |
| RMW2-2 | 247 | 205 - 220 | 219.36 | 213.70 | 5.66 | 210.84 | 213.49 | 5.90 | 210.63 | 2-inch ID, locking metal outer case, locking cap, concrete pad, bumper guards |
| RMW2-3 | 247 | 215 - 230 | 227.25 | 221.69 | 5.56 | 219.11 | 221.44 | 5.81 | 218.86 | 2-inch ID, locking metal outer case, locking cap, concrete pad, bumper guards |
| RMW2-4 | 257 | 216 - 231 | 228.46 | 223.34 | 5.12 | 221.34 | 223.13 | 5.37 | 221.13 | 2-inch ID, locking metal outer case, locking cap, concrete pad, bumper guards |
| RMW2-5 | 247 | 211 - 226 | 221.93 | 218.86 | 3.07 | 215.91 | 218.56 | 3.34 | 215.61 | 2-inch ID, locking metal outer case, locking cap, concrete pad, bumper guards |

bgs - Below ground surface.
ID - Inside diameter.
msl - Mean sea level.

## Table 2-3

### Inorganic Groundwater Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location | | | | Puerto Rico Groundwater Quality Standards (µg/L) | EPA Region 3 RBCs (Tapwater µg/L) | EPA MCLs (Drinking Water (µg/L) |
|---|---|---|---|---|---|---|---|
| | RMW1-1 (µg/L) | RMW1-2 (µg/L) | RMW1-3 (µg/L) | RMW1-4 (µg/L) | | | |
| **June 1997** | | | | | | | |
| Lead | ND | ND | 5.8 | ND (ND) | 50 | NE | NE |
| Selenium | 5.4 | ND | ND | ND (ND) | NE | 180 | 50 |
| Zinc | 15 | ND | | ND (ND) | NE | 11,000 | 5,000[a] |
| Manganese | 26 | ND | 11 | ND (ND) | NE | 730 | 50[a] |
| Iron | **450** | ND | 79 | 120 (110) | NE | 11,000 | 300[a] |
| Chromium total | 16 | ND | ND | ND (ND) | NE | 110 | 100 |
| Calcium | 100,000 | 94,000 | 100,000 | 100,000 (80,000) | NE | NE | NE |
| Magnesium | 12,000 | 14,000 | 15,000 | 16,000 (13,000) | NE | NE | NE |
| Aluminum | 150 | ND | ND | ND (ND) | NE | 37,000 | 200[a] |
| Sodium | 33,000 | 46,000 | 60,000 | 73,000 (56,000) | NE | NE | NE |
| Potassium | 1,300 | 3,700 | 3,300 | 4,200 (3,200) | NE | NE | NE |
| **December 1998** | | | | | | | |
| Manganese | 17 | ND | ND | ND (ND) | NE | 730 | 50[a] |
| Iron | ND | 180 | 62 | ND | NE | 11,000 | 300[a] |
| Calcium | 140,000 | 100,000 | 100,000 | 110,000 (96,000) | NE | NE | NE |
| Magnesium | 14,000 | 12,000 | 16,000 | 18,000 (16,000) | NE | NE | NE |
| Barium | 74 | ND | ND | ND | NE | 2,600 | 2,000 |
| Aluminum | 160 | ND | ND | ND | NE | 37,000 | 200[a] |
| Sodium | 53,000 | 39,000 | 65,000 | 79,000 (72,000) | NE | NE | NE |
| Potassium | 4,000 | 3,000 | 2,900 | 34,000 (3,000) | NE | NE | NE |

[a] Secondary standard.
EPA - U.S. Environmental Protection Agency.
MCL - Maximum contaminant level.
µg/L - Micrograms per liter.
ESE - Environmental Science and Engineering, Inc.

ND - Not detected.
ND (ND) - Sample result (duplicate sample result).
NE - Not established.
RBC - Risk-based concentration.
**450** - Bolded, shaded value exceeds EPA MCL.

## Table 2-4

## Organic Groundwater Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location | | | | Puerto Rico Water Quality Standards (µg/L) | EPA Region 3 RBCs (Tapwater µg/L) | EPA MCLs Drinking Water (µg/L) |
|---|---|---|---|---|---|---|---|
| | RMW1-1 (µg/L) | RMW1-2 (µg/L) | RMW1-3 (µg/L) | RMW1-4 (µg/L) | | | |
| **June 1997** | | | | | | | |
| **VOCs** | | | | | | | |
| Acetone | 5.0 JB | ND | ND | ND (ND) | NE | 3,700 | NE |
| Carbon disulfide | 11 B | ND | ND | ND (ND) | NE | 1,000 | NE |
| Chloroform | ND | ND | ND | 3.4 J (3.1 J) | NE | 0.150 | 100 |
| Trichloroethylene | 1.2 J | **2.2 J** | 4.8 J | 7.7 (7.8) | 5.0 | 1.60 | 5.0 |
| **BNAs** | ND | ND | ND | ND (ND) | NE | Various | Various |
| **Pesticides/PCBs** | ND | ND | ND | ND (ND) | Various | Various | Various |
| **TPH as diesel** | ND | 120 | ND | ND (ND) | NE | NE | NE |
| **TPH as gasoline** | ND | ND | ND | ND (ND) | NE | NE | NE |
| **December 1998** | | | | | | | |
| **VOCs** | | | | | | | |
| Acetone | 2.0 J | ND | ND | ND (ND) | NE | 3,700 | NE |
| Trichloroethene | 1.6 J | 2.3 J | 8.9 | 8.4 (7.8) | 5.0 | 1.60 | 5.0 |
| **BNAs** | | | | | | | |
| bis(2-Ethylhexyl)phthalate | ND | ND | ND | ND (ND) | NE | 4.8 | NE |
| **Pesticides/PCBs** | | | | | | | |
| Aroclor 1260 | ND | ND | 0.48 J | ND (ND) | NE | 0.033 | 0.0005 |
| **TPH as diesel** | 220 | ND | ND | ND (ND) | NE | NE | NE |
| **TPH as gasoline** | ND | ND | ND | 62 JB (57 JB) | NE | NE | NE |

µg/L - Micrograms per liter.
B - Analyte present in field or lab blank sample.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
MCL - Maximum contaminant level.
ND - Not detected.
NE - Not established.
ESE - Environmental Science and Engineering, Inc.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.
**2.2** - Bolded, shaded value exceeds either the EPA Region III RBC (tapwater), the EPA MCL, or the Puerto Rico water quality standard for drinking water.
7.7 (7.8) - Sample result (duplicate sample result).

## Table 2-5

## Inorganic Groundwater Analytical Results from Landfill Area 2 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location | | | | | Puerto Rico Groundwater Quality Standards (µg/L) | EPA Region 3 RBCs (Tapwater µg/L) | EPA MCLs Drinking Water (µg/L) |
|---|---|---|---|---|---|---|---|---|
| | RMW2-1 (µg/L) | RMW2-2 (µg/L) | RMW2-3 (µg/L) | RMW2-4 (µg/L) | RMW2-5 (µg/L) | | | |
| **June 1997** | | | | | | | | |
| Lead | 8.5 | ND | 9.8 | ND | ND (ND) | 50 | NE | NE |
| Selenium | 6.0 | ND | 6.6 | ND | ND (ND) | NE | 180 | 50 |
| Zinc | 23 | 23 | 16 | ND | ND (ND) | NE | 11,000 | 5,000[a] |
| Manganese | **97** | ND | 10 | ND | ND (ND) | NE | 730 | 50[a] |
| Iron | **540 J** | **330 J** | **490 J** | ND | ND (ND) | NE | 11,000 | 300[a] |
| Calcium | 100,000 | 130,000 | 150,000 | 80,000 | 80,000 (85,000) | NE | NE | NE |
| Magnesium | 13,000 | 9,100 | 18,000 | 17,000 | 16,000 (18,000) | NE | NE | NE |
| Aluminum | **420** | 180 | 160 | ND | ND (ND) | NE | 37,000 | 200[a] |
| Barium | 46 | ND | 24 | ND | ND (ND) | NE | 2,600 | 2,000 |
| Sodium | 99,000 | 24,000 | 87,000 | 83,000 | 75,000 (86,000) | NE | NE | NE |
| Potassium | 3,200 | 1,300 | 4,200 | 3,800 | 3,200 (4,300) | NE | NE | NE |
| **December 1998** | | | | | | | | |
| Lead | ND (10) | ND | ND | ND | ND | 50 | NE | NE |
| Zinc | ND (15) | ND | ND | ND | ND | NE | 11,000 | 5,000[a] |
| Nickel | ND (ND) | ND | 49 | ND | ND | NE | 730 | 100 |
| Manganese | **71** | ND | ND | ND | ND | NE | 730 | 50[a] |
| Iron | 120 **(780)** | **530** | **390** | 74 | ND | NE | 11,000 | 300[a] |
| Calcium | 90,000 (108,000) | 150,000 | 150,000 | 87,000 | 93,000 | NE | NE | NE |
| Magnesium | 18,700 (17,900) | 10,000 | 18,000 | 19,000 | 19,000 | NE | NE | NE |
| Aluminum | ND (21) | ND | ND | ND | ND | NE | 2,600 | 2,000 |
| Barium | ND **(630)** | **480** | **290** | ND | ND | NE | 37,000 | 200[a] |
| Sodium | 89,200 (85,700) | 22,000 | 83,000 | 88,000 | 91,000 | NE | NE | NE |
| Potassium | 3,800 (4,190_) | ND | 3,400 | 4,100 | 3,800 | NE | NE | NE |

[a] Secondary standard.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
ESE - Environmental Science and Engineering, Inc.
µg/L - Micrograms per liter.
MCL - Maximum contaminant level.
ND - Not detected.
ND (ND) - Sample result (duplicate sample result).
NE - Not established.
RBC - Risk-based concentration.
**97** - Bolded, shaded value exceeds EPA MCL.

## Table 2-6

## Organic Groundwater Analytical Results from Landfill Area 2 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location | | | | | Puerto Rico Groundwater Quality Standards (µg/L) | EPA Region 3 RBCs (Tapwater µg/L) | EPA MCLs Drinking Water (µg/L) |
|---|---|---|---|---|---|---|---|---|
| | RMW2-1 (µg/L) | RMW2-2 (µg/L) | RMW2-3 (µg/L) | RMW2-4 (µg/L) | RMW2-5 (µg/L) | | | |
| **VOCs** | | | | | | | | |
| Chloroform | **4.7 J** | ND | **3.1 J** | ND | ND (ND) | NE | 0.150 | 100 |
| Bromodichloromethane | **1.2 J** | ND | ND | ND | ND (ND) | NE | 0.170 | 100 |
| Trichloroethylene | 1.2 J | ND | 1.6 J | 1.1 J | 1.2 J (1.2 J) | 200 | 1.60 | 5.0 |
| **BNAs** | ND | ND | ND | ND | ND (ND) | NE | Various | Various |
| **Pesticides/PCBs** | ND | ND | ND | ND | ND (ND) | Various | Various | Various |
| **TPH as diesel** | ND | ND | ND | ND | ND (ND) | NE | NE | NE |
| **TPH as gasoline** | ND | ND | ND | ND | ND (ND) | NE | NE | NE |
| **December 1998** | | | | | | | | |
| **VOCs** | | | | | | | | |
| Trichloroethene | 1.5 J (1.2 J) | ND | 1.5 J | 1.2 J | 1.4 J | 200 | 1.60 | 5.0 |
| **BNAs** | ND (ND) | ND | ND | ND | ND (ND) | NE | Various | Various |
| **Pesticides/PCBs** | ND (ND) | ND | ND | ND | ND (ND) | Various | Various | Various |
| **TPH as diesel** | ND (ND) | ND | ND | ND | ND (ND) | NE | NE | NE |
| **TPH as gasoline** | ND (ND) | ND | ND | ND | ND (ND) | NE | NE | NE |

BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
µg/L - Micrograms per liter.
MCL - Maximum contaminant level.
ND - Not detected.
ND (ND) - Sample result (duplicate sample result).
ESE - Environmental Science and Engineering, Inc.
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.
**4.7** - Bolded, shaded value exceeds either the EPA Region III RBC (tap water), the EPA MCL, or the Puerto Rico water quality standard for drinking water.

## Table 2-7

## Inorganic Surface Soil Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location | | | | EPA Region 3 Residential RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|
| | RMW1-1 (0-2.0 ft bgs) mg/kg | RMW1-2 (0-2.0 ft bgs) mg/kg | RMW1-3 (0-2.0 ft bgs) mg/kg | RMW1-4 (0-2.0 ft bgs) mg/kg | | |
| Arsenic | **14** [RBC] | **35 (38)** [RBC,SSL] | **27** [RBC] | **39** [RBC,SSL] | 0.43 | 29 |
| Lead | 7.8 | 11 J (11 J) | 26 J | 6.4 | 400 [c] | 400 c |
| Selenium | 0.84 | 1.2 (1.3) | 0.66 | ND | 390 | 5 |
| Thallium | ND | **0.81 (1.2)** [SSL] | **0.93** [SSL] | **2.4** [SSL] | 5.5 | 0.7 |
| Aluminum | 7,300 | 15,000 (15,000) | 11,000 | 9,400 | 78,000 | NE |
| Antimony | **6.8 J** [SSL] | ND (ND) | ND | ND | 31 | 5 |
| Barium | 16 | 35 (30) | 24 | 39 J | 5,500 | 1,600 |
| Beryllium | ND | 1.1 (1.2) | 0.71 | 0.67 | 160 | 63 |
| Calcium | 140,000 | 13,000 (6,400) | 180,000 | 580 | NE | NE |
| Chromium (total) | **73** [SSL] | **160 (180)** [SSL] | **120** [SSL] | **140** [SSL] | 230 [d] | 38 |
| Cobalt | 6.2 | 15 (16) | 7.2 | 11 | 4,700 | NE |
| Copper | 9.8 | 18 (19) | 13 | 19 | 3,100 | NE |
| Iron | 20,000 | **42,000 (46,000)** [RBC] | **30,000** [RBC] | **45,000** [RBC] | 23,000 | NE |
| Magnesium | 830 | 460 (460) | 1,000 | 400 | NE | NE |
| Manganese | 410 | 1,200 (1,100) | 450 | 860 | 1,600 | NE |
| Nickel | 11 | 28 (30) | 17 | 23 | 1,600 | 130 |
| Potassium | 260 | 270 (290) | 300 | 200 | NE | NE |
| Sodium | 150 | ND (ND) | 140 | 140 | NE | NE |
| Vanadium | 46 | 90 (99) | 63 | 100 | 550 | 6,000 |
| Zinc | 17 | 33 (35) | 28 | 25 | 23,000 | 12,000 |
| Mercury | ND | 0.045 (0.035) | 0.069 | ND | 23 [e] | 2 |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

[c] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).

[d] This value is the RBC for Chromium VI.

[e] This value is the RBC for mercuric chloride.

bgs - Below ground surface.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
EPA - U.S. Environmental Protection Agency.
ft - Feet.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
RCRA - Resource Conservation and Recovery Act
NE - Not established.
RBC - Risk-based concentration.
SSL - Soil screening level.
35 (38) - Sample results (duplicate sample result).
**14** [RBC] - Bolded, shaded value exceeds EPA Region 3 RBC.
**39** [SSL] - Bolded, shaded value exceeds EPA Generic SSL.
ESE - Environmental Science and Engineering, Inc.

## Table 2-8

## Organic Surface Soil Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location | | | | EPA Region 3 Residential RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|
| | RMW1-1 (0-2.0 ft bgs) (mg/kg) | RMW1-2 (0-2.0 ft bgs) (mg/kg) | RMW1-3 (0-2.0 ft bgs) (mg/kg) | RMW1-4 (0-2.0 ft bgs) (mg/kg) | | |
| **VOCs** | | | | | | |
| Acetone | ND | ND (ND) | ND | 0.0095 J | 7,800 | 16 |
| Ethyl benzene | ND | ND (ND) | 0.0015 J | ND | 7,800 | 13 |
| Total xylenes | ND | ND (ND) | 0.0014 J | ND | 160,000[c] | 190[c] |
| Toluene | ND | ND (ND) | ND | 0.0076 | 16,000 | 12 |
| **BNAs** | ND | ND (ND) | ND | ND | Various | Various |
| **Pesticides/PCBs** | ND | ND (ND) | ND | ND | Various | Various |
| **TPH as diesel** | ND | ND (ND) | ND | ND | NE | NE |
| **TPH as gasoline** | ND | ND (ND) | ND | ND | NE | NE |
| **Explosives** | ND | ND (ND) | ND | ND | Various | Various |

Note: Puerto Rico has not established soil standards; therefore, soil sample analytical results were compared to EPA Region 3 Risk-Based Concentrations for Residential Soil and EPA Generic Soil Screening Levels as conservative initial screening criteria.

[a] Risk-based concentration from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

[c] These values are the RBC and SSL for ortho-xylene.

bgs - Below ground surface.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
ft - Feet.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
ND (ND) - Sample result (duplicate sample result)
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.
ESE - Environmental Science and Engineering, Inc.

## Table 2-9

## Inorganic Surface Soil Analytical Results from Landfill Area 2 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location | | | | | EPA Region 3 Residential RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|---|
| | RMW2-1 (0-2.0 ft bgs) | RMW2-2 (0-2.0 ft bgs) | RMW2-3 (0-2.0 ft bgs) | RMW2-4 (0-2.0 ft bgs) | RMW-2-5 (0-2.0 ft bgs) | | |
| Arsenic | **38** [RBC,SSL] | **38** [RBC,SSL] | **40 (43)** [RBC,SSL] | **43** [RBC,SSL] | **33** [RBC,SSL] | 0.43 | 29 |
| Lead | 9.6 | 9.9 | 10 (11) | 7.0 | 8.5 | 400 [c] | 400 c |
| Selenium | 2.4 | 1.8 J | 1.1 (2.1) | ND | ND | 390 | 5 |
| Thallium | **2.4** [SSL] | **1.9** [SSL] | **2.2 (2.0)** [SSL] | **1.8** [SSL] | ND | 5.5 | 0.7 |
| Aluminum | 16,000 | 15000 | 16,000 (19,000) | 11,000 | 12,000 | 78,000 | NE |
| Barium | 55 | 32 | 49 (46) | 23 | 26 | 5,500 | 1,600 |
| Beryllium | 0.60 | 0.79 | 0.77 (0.85) | 0.77 | 0.62 | 160 | 63 |
| Cadmium | ND | ND | ND (ND) | ND | 3.3 | 39 | 8 |
| Calcium | 1,600 | 11,000 | 1,200 (960) | 1200 | 1,300 | NE | NE |
| Chromium (total) | **130 J** [SSL] | **150** [SSL] | **150 J (160) J** [SSL] | **180** [SSL] | **140** [SSL] | 230 [d] | 38 |
| Cobalt | 14 | 9.2 | 19 (18) | 14 | 8.5 | 4,700 | NE |
| Copper | 25 | 19 | 23 (25) | 19 | 19 | 3,100 | NE |
| Iron | **41,000** [RBC] | **41,000** [RBC] | **43,000 (47,000)** [RBC] | **47,000** [RBC] | **39,000** [RBC] | 23,000 | NE |
| Magnesium | 600 | 560 | 580 (630) | 480 | ND | NE | NE |
| Manganese | 1,700 | 930 | **1,800 (1,600)** [RBC] | 830 | 420 | 1,600 | NE |
| Nickel | 20 | 21 | 24 (26) | 23 | 19 | 1,600 | 130 |
| Potassium | 520 | 320 | 360 (430) | 240 | 360 | NE | NE |
| Sodium | 270 | ND | ND (ND) | ND | ND | NE | NE |
| Vanadium | 94 | 94 | 97 (100) | 100 | 92 | 550 | 6,000 |
| Zinc | 60 | 46 | 52 (56) | 36 | 36 | 23,000 | 12,000 |
| Mercury | 0.048 | 0.034 | 0.046 (0.059) | 0.070 | ND | 23 [e] | 2 |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

[c] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).

[d] This value is the RBC for Chromium VI.

[e] This value is the RBC for mercuric chloride.

bgs - Below ground surface.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
EPA - U.S. Environmental Protection Agency.
ft - Feet.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
RBC - Risk-based concentration.
RCRA - Resource Conservation and Recovery Act.
SSL - Soil screening level.
40 (43) - Sample result (duplicate sample result).
**38** [RBC] - Bolded, shaded value exceeds EPA Region 3 Residential RBC.
**38** [SSL] - Bolded, shaded value exceeds EPA Generic SSL.
ESE - Environmental Science and Engineering, Inc.

## Table 2-10

## Organic Surface Soil Analytical Results from Landfill Area 2 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location | | | | | EPA Region 3 Residential RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|---|
| | RMW2-1 (0-2.0 ft bgs) (mg/kg) | RMW2-2 (0-2.0 ft bgs) (mg/kg) | RMW2-3 (0-2.0 ft bgs) (mg/kg) | RMW2-4 (0-2.0 ft bgs) (mg/kg) | RMW2-5 (0-2.0 ft bgs) (mg/kg) | | |
| **VOCs** | | | | | | | |
| Acetone | ND | ND | ND (ND) | 0.0058 J | ND | 7,800 | 16 |
| Toluene | ND | 0.0018 J | ND (ND) | ND | ND | 16,000 | 12 |
| **BNAs** | ND | ND | ND (ND) | ND | ND | Various | Various |
| **Pesticides/PCBs** | | | | | | | |
| 4,4'-DDD | ND | 0.0034 | ND (ND) | ND | ND | 2.7 | 16 |
| 4,4'-DDE | ND | 0.010 | ND (ND) | ND | ND | 1.9 | 54 |
| 4,4'-DDT | ND | 0.0063 | ND (ND) | ND | ND | 1.9 | 32 |
| **TPH as diesel** | ND | ND | ND (ND) | ND | ND | NE | NE |
| **TPH as gasoline** | ND | ND | ND (ND) | ND | ND | NE | NE |
| **Explosives** | ND | ND | ND (ND) | ND | ND | Various | Various |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

bgs - Below ground surface.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
ft - Feet.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
ND (ND) - Sample result (duplicate sample result)
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.

## Table 2-11

## Inorganic Surface Water Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample R-1-SW-001 (µg/L) | Puerto Rico Surface Water Quality Standards (µg/L) |
|---|---|---|
| Lead | 6.4 (6.3) | 15 |
| Zinc | 16 (20) | 50 |
| Manganese | 16 (16) | 50 |
| Iron | 1,000 J (1,100 J) | NE |
| Calcium | 8,400 (7,900) | NE |
| Magnesium | 1,000 (960) | NE |
| Aluminum | 580 (620) | NE |
| Sodium | 1,000 (ND) | NE |
| Potassium | 2,400 (2,200) | NE |

J - Estimated concentration.
µg/L - Micrograms per liter.
ND - Not detected.
ND (ND) - Sample result (duplicate sample result).
NE - Not established.
ESE - Environmental Science and Engineering, Inc.

## Table 2-12

## Organic Surface Water Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample<br>R-1-SW-001<br>(µg/L) | Puerto Rico Surface Water Quality Standards (µg/L) |
|---|---|---|
| VOCs | ND (ND) | Various |
| BNAs | ND (ND) | NE |
| Pesticides/PCBs | ND (ND) | Various |
| TPH as diesel | ND (ND) | NE |
| TPH as gasoline. | ND (ND) | NE |

BNA - Base neutral acid/extractable organic compound.
µg/L - Micrograms per liter.
ND - Not detected.
ND (ND) - Sample result (duplicate sample result).
NE - Not established.
PCB - Polychlorinated biphenyl.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.
ESE - Environmental Science and Engineering, Inc.

## Table 2-13

## Inorganic Sediment Sample Analytical Results from Landfill Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location R-1-SD-001 (mg/kg) | EPA Region 3 RBC[a] (Residential; mg/kg) |
|---|---|---|
| Arsenic | **19 (30)** | 0.43 |
| Lead | 72 J (140 J) | 400[b] |
| Selenium | 0.72 (ND) | 390 |
| Thallium | ND (1.0) | 5.5 |
| Aluminum | 11,000 (14,000) | 78,000 |
| Barium | 27 J (220 J) | 5,500 |
| Calcium | 200,000 (140,000) | NE |
| Chromium total | 81 (120) | 230[c] |
| Cobalt | 4.8 (9.1) | 4,700 |
| Copper | 28 (52) | 3,100 |
| Iron | 23,000 J **(57,000 J)** | 23,000 |
| Magnesium | 1,300 (1,600) | NE |
| Manganese | 320 (510) | 1,600 |
| Nickel | 15 (24) | 1,600 |
| Potassium | 540 (1,100) | NE |
| Sodium | 210 (240) | NE |
| Vanadium | 45 (63) | 550 |
| Zinc | 190 (310) | 23,000 |
| Mercury | 0.37 (0.41) | 23[d] |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.
[b] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).
[c] This value is the RBC for Chromium VI.
[d] This value is the RBC for mercuric oxide.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
RBC - Risk-based concentration.
NE - Not established.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act.
RCRA - Resource Conservation and Recovery Act.
11,000 (14,000) - Sample result (duplicate sample result).
**19 (30)** = Bolded, shaded value exceeds Region III Residential RBC.
ESE - Environmental Science and Engineering, Inc.

## Table 2-14

## Organic Sediment Sample Analytical Results from Landfilll Area 1 from Site Investigation Performed by ESE, Inc. in June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Location<br>R-1-SD-001<br>(mg/kg) | EPA Region 3<br>RBC[a]<br>(Residential; mg/kg) |
|---|---|---|
| **VOCs** | | |
| Toluene | ND (0.0017 J) | 16,000 |
| Total xylenes | ND (0.0067 J) | 160,000 |
| **BNAs** | | |
| Phenanthrene | 0.23 J (16 J) | NE |
| Anthracene | 0.045 J (ND) | 23,000 |
| Fluroanthene | 0.56 (0.53) | 3,100 |
| Pyrene | 0.45 (0.48) | 2,300 |
| Benzo(a)anthracene | 0.42 J (0.42) | 0.87 |
| Chrysene | 0.44 (0.47) | 870 |
| Benzo(b)fluoranthene | 0.64 **(0.94)** | 0.87 |
| Benzo(k)fluoranthene | 0.32 J (ND) | 8.7 |
| Benzo(a)pyrene | 0.40 J (0.41 J) | 0.087 |
| Indeno(1,2,3-cd)pyrene | 0.25 J (0.27 J) | 0.87 |
| Dibenzo(a,h)anthracene | 0.13 J (0.13 J) | 0.087 |
| Benzo(g,h,i)perylene | 0.28 J (0.29 J) | NE |
| **Pesticides/PCBs** | | |
| Gamma-chlordane | 0.0072 J (0.0074 J) | 0.49 |
| 4,4'-DDD | 0.0089 J (ND) | 2.70 |
| 4,4'-DDE | 0.034 (0.027 J) | 1.90 |
| 4,4-'DDT | 0.039 J (ND) | 1.90 |
| **TPH as diesel** | 42 (68) | NE |
| **TPH as gasoline** | ND (ND) | NE |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.
0.0018J (0.0027J) - Sample result (duplicate sample) result.
**0.94** - Bolded, shaded value exceeds EPA Region III Residential RBC.
ESE - Environmental Science and Engineering, Inc.

## Table 2-15

## Inorganics Subsurface Soil Analytical Results, Monitoring Well RMW1-1, Landfill Area 1, June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 15 - 17 (mg/kg) | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|
| Arsenic | **19** RBC | **36** RBC SSL | **29** RBC | 3.8 | 29 |
| Lead | 5.7 | 8.5 | 10 | 1,545[c] | 400[d] |
| Selenium | ND | 1.0 | ND | 10,000 | 5 |
| Thallium | **1.2** SSL | 0.63 | **1.1** SSL | 140 | 0.7 |
| Aluminum | 8,800 | 11,000 | 14,000 | 2,000,000 | NE |
| Barium | 30 | 230 | 33 | 140,000 | 1,600 |
| Beryllium | 1.8 | 1.5 | 1.7 | 4,100 | 63 |
| Calcium | 36,000 | 800 | 4,200 | NE | NE |
| Chromium total | **150** SSL | **140** SSL | 23 | 610[e] | 38 |
| Cobalt | 16 | 21 | 11 | 120,000 | NE |
| Copper | 17 | 17 | 27 | 82,000 | NE |
| Iron | 50,000 | 47,000 | 56,000 | 610,000 | NE |
| Magnesium | 560 | 460 | 1,400 | NE | NE |
| Manganese | 280 | 1,600 | 600 | 41,000 | NE |
| Nickel | 17 | 25 | 58 | 41,000 | 130 |
| Potassium | 170 | 280 | 460 | NE | NE |
| Vanadium | 110 | 110 | 110 | 14,000 | 6,000 |
| Zinc | 23 | 24 | 42 | 610,000 | 12,000 |
| Mercury | ND | ND | 0.038 | 610[f] | 2 |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

[c] Adult industrial lead screening level based on *Recommendations of the Technical Review Workgroup for an Interim Appraoch to Assessing Risk Associated with Adult Exposures to Lead in Soil*, (EPA, 1996).

[d] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).

[e] This value is the RBC for Chromium VI.

[f] This value is the RBC for mercuric chloride.

bgs - Below ground surface.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
EPA - U.S. Environmental Protection Agency.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
RCRA - Resource Conservation and Recovery Act
RBC - Risk-based concentration.
SSL - Soil screening level.
**19** RBC - Bolded, shaded value exceeds EPA Region 3 RBC.
**36** SSL - Bolded, shaded value exceeds EPA Generic SSL.

## Table 2-16

## Organic Subsurface Soil Analytical Results, Monitoring Well RMW1-1, Landfill Area 1, June 1997 Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) | | | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|
| | 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 15 - 17 (mg/kg) | | |
| **VOCs** | ND | ND | ND | Various | Various |
| **BNAs** | ND | ND | ND | Various | Various |
| **Pesticides/PCBs** | ND | ND | ND | Various | Various |
| **TPH as diesel** | ND | ND | ND | NE | NE |
| **TPH as gasoline** | ND | ND | ND | NE | NE |
| **Explosives** | ND | ND | ND | Various | Various |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

bgs - Below ground surface.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.

## Table 2-17

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW1-4, Landfill Area 1, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 15 - 17 (mg/kg) | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|
| Arsenic | **66** RBC,SSL | **42** RBC,SSL | **48** RBC,SSL | 3.8 | 29 |
| Lead | 8.8 | 11 | 15 | 1,545[c] | 400[d] |
| Selenium | 1.0 | 1.1 | ND | 10,000 | 5 |
| Thallium | **2.3** SSL | **2.9** SSL | ND | 140 | 0.7 |
| Aluminum | 13,600 | 15,000 | 17,000 | 2,000,000 | NE |
| Barium | 33 J | 350 J | 24 J | 140,000 | 1,600 |
| Beryllium | 0.91 | 1.7 | 1.7 | 4,100 | 63 |
| Calcium | 1,050 | 210 | 2,300 | NE | NE |
| Chromium (total) | **230** SSL | **280** SSL | **190** SSL | 610[e] | 38 |
| Cobalt | 7.6 | 120 | 9.3 | 120,000 | NE |
| Copper | 20 | 27 | 41 | 82,000 | NE |
| Iron | 76,000 | 75,000 | 58,000 | 610,000 | NE |
| Magnesium | 720 | 1,400 | 1,800 | NE | NE |
| Manganese | 550 | 3,000 | 520 | 41,000 | NE |
| Nickel | 28 | 55 | 50 | 41,000 | 130 |
| Potassium | 220 | 230 | 650 | NE | NE |
| Sodium | 1,080 | ND | ND | NE | NE |
| Vanadium | 160 | 160 | 120 | 14,000 | 6,000 |
| Zinc | 23 | 35 | 48 | 610,000 | 12,000 |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

[c] Adult industrial lead screening level based on *Recommendations of the Technical Review Workshop for Lead for an Interim Appraoch to Assessing Risk Associated with Adult Exposures to Lead in Soil*, (EPA, 1996).

[d] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).

[e] This value is the RBC for Chromium VI.

bgs - Below ground surface.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
EPA - U.S. Environmental Protection Agency.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
RBC - Risk-based concentration.
RCRA - Resource Conservation and Recovery Act
SSL - Soil screening level.
**66** RBC - Bolded, shaded value exceeds EPA Region 3 RBC.
**66** SSL - Bolded, shaded value exceeds EPA Generic SSL.

## Table 2-18

## Organic Subsurface Soil Analytical Results
## Monitoring Well RMW1-4, Landfill Area 1, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) | | | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|
| | 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 15 - 17 (mg/kg) | | |
| **VOCs** | | | | | |
| Acetone | 0.010 J | ND | 0.0083 J | 200,000 | 16 |
| Toluene | 0.019 | 0.013 | 0.0089 | 410,000 | 12 |
| **BNAs** | ND | ND | ND | Various | Various |
| **Pesticides/PCBs** | ND | ND | ND | Various | Various |
| **TPH as diesel** | ND | ND | ND | NE | NE |
| **TPH as gasoline** | ND | ND | ND | NE | NE |
| **Explosives** | ND | ND | ND | Various | Various |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

bgs - Below ground surface.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.

## Table 2-19

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW2-1, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

(Page 1 of 2)

| Parameter | Sample Depth Interval (feet bgs) 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 14 - 16 (mg/kg) | 19 - 21 (mg/kg) | 24 - 26 (mg/kg) | 29 - 31 (mg/kg) | 34 - 36 (mg/kg) | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 70 RBC,SSL | 70 RBC,SSL | 90 RBC,SSL | 84 RBC,SSL | 54 RBC,SSL | 57 RBC,SSL | 34 RBC,SSL | 3.8 | 29 |
| Lead | 9.1 | 9.2 | 10 | 9.6 | 11 | 7.9 | 7.8 | 1,545[c] | 400[d] |
| Selenium | ND | 0.71 | 0.79 | ND | ND | ND | ND | 10,000 | 5 |
| Thallium | 2.2 SSL | 2.1 SSL | 2.2 SSL | 1.7 SSL | 2.0 SSL | 1.9 SSL | 1.4 SSL | 140 | 0.7 |
| Aluminum | 20,000 | 22,000 | 28,000 | 22,000 | 19,000 | 16,000 | 12,000 | 2,000,000 | NE |
| Barium | 15 | 17 | 18 | 23 | 28 | 17 | 20 | 140,000 | 1,600 |
| Beryllium | 0.73 | 0.85 | 1.2 | 1.5 | 1.5 | 1.7 | 0.94 | 4,100 | 63 |
| Calcium | 760 | 540 | 660 | 590 | 530 | 540 | 380 | NE | NE |
| Chromium total | 270 J SSL | 250 J SSL | 310 J SSL | 260 J SSL | 190 J SSL | 200 J SSL | 120 J SSL | 610[c] | 38 |
| Cobalt | 4.4 | 4.4 | 6.2 | 6.4 | 5.5 | 6.4 | 4.2 | 120,000 | NE |
| Copper | 30 | 19 | 21 | 24 | 28 | 32 | 18 | 82,000 | NE |
| Iron | 79,000 | 74,000 | 91,000 | 82,000 | 64,000 | 69,000 | 38,000 | 610,000 | NE |
| Magnesium | 580 | 840 | 1,100 | 930 | 750 | 730 | 500 | NE | NE |
| Manganese | 150 | 130 | 160 | 140 | 130 | 130 | 100 | 41,000 | NE |
| Nickel | 26 | 25 | 35 | 28 | 23 | 27 | 18 | 41,000 | 130 |
| Potassium | 400 | 350 | 400 | 300 | 310 | 250 | 270 | NE | NE |
| Sodium | 210 | 250 | 150 | ND | ND | 130 | ND | NE | NE |
| Vanadium | 180 | 170 | 210 | 190 | 140 | 150 | 87 | 14,000 | 6,000 |
| Zinc | 52 | 38 | 49 | 42 | 39 | 46 | 29 | 610,000 | 12,000 |

## Table 2-19

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW2-1, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.
[c] Adult industrial lead screening level based on *Recommendations of the Technical Review Workshop for Lead for an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil*, (EPA, 1996).
[d] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).
[e] This value is the RBC for Chromium VI.

bgs - Below ground surface.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
RBC - Risk-based concentration.
RCRA - Resource Conservation and Recovery Act
SSL - Soil screening level.
**70** [RBC] - Bolded, shaded value exceeds EPA Region III Industrial RBC.
**70** [SSL] - Bolded, shaded value exceeds EPA Generic SSL.

## Table 2-20

## Organic Subsurface Soil Analytical Results
## Monitoring Well RMW2-1, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) | | | | | | | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 14 - 16 (mg/kg) | 19 - 21 (mg/kg) | 24 - 26 (mg/kg) | 29 - 31 (mg/kg) | 34 - 36 (mg/kg) | | |
| **VOCs** | | | | | | | | | |
| Toluene | 0.0013 J | ND | ND | ND | ND | ND | ND | 410,000 | 12 |
| Carbon disulfide | ND | 0.011 | ND | ND | ND | ND | ND | 200,000 | 32 |
| **BNs** | ND | ND | ND | ND | ND | ND | ND | Various | Various |
| **Pesticides/PCBs** | ND | ND | ND | ND | ND | ND | ND | Various | Various |
| **TPH as diesel** | ND | ND | ND | ND | ND | ND | ND | NE | NE |
| **TPH as gasoline** | ND | ND | ND | ND | ND | ND | ND | NE | NE |
| **Explosives** | ND | ND | ND | ND | ND | ND | ND | Various | Various |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

bgs - Below ground surface.
BN - Base/neutral extractable organic compound.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.

## Table 2-21

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW2-2, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

(Page 1 of 2)

| Parameter | Sample Depth Interval (feet bgs) | | | | | | | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 14 - 16 (mg/kg) | 19 - 21 (mg/kg) | 24 - 26 (mg/kg) | 29 - 31 (mg/kg) | 34 - 36 (mg/kg) | | |
| Arsenic | 52 (53) RBC SSL | 78 RBC SSL | 46 RBC SSL | 9.6 RBC | 4.6 RBC | 6.2 RBC | 5.0 RBC | 3.8 | 29 |
| Lead | 11 (11) | 9.6 | 3.0 | 2.2 | 1.9 | 2.2 | 1.9 | 1,545[c] | 400[d] |
| Selenium | ND (0.82 J) | ND | 1.9 J | 2.9 J | 1.3 J | 1.8 J | 1.5 J | 10,000 | 5 |
| Thallium | 1.8 (2.0) SSL | 1.9 SSL | 2.2 SSL | 1.7 SSL | 2.0 SSL | 1.9 SSL | 1.4 SSL | 140 | 0.7 |
| Aluminum | 20,000 (22,000) | 17,000 | 9,000 | 4,400 | 2,660 | 2,600 | 2,100 | 2,000,000 | NE |
| Barium | 28 (37) | 27 | 9.9 | ND | ND | 3.2 | ND | 140,000 | 1,600 |
| Beryllium | 0.94 (1.0) | 3.1 | ND | ND | ND | ND | ND | 4,100 | 63 |
| Calcium | 3,200 (2,200) | 12,000 | 320,000 | 330,000 | 347,000 | 330,000 | 320,000 | NE | NE |
| Chromium total | 180 (200) SSL | 200 SSL | 71 SSL | 37 | 21 | 24 | 21 | 610[e] | 38 |
| Cobalt | 8.5 (10) | 17 | ND | ND | ND | ND | ND | 120,000 | NE |
| Copper | 25 (30) | 26 | 6.6 | 3.5 | ND | 3.3 | ND | 82,000 | NE |
| Iron | 54,000 (57,000) | 73,000 | 22,000 | 13,000 | 6,550 | 8,200 | 5,000 | 610,000 | NE |
| Magnesium | 630 (630) | 1,700 | 3,600 | 2,200 | 1,690 | 1,500 | 1,400 | NE | NE |
| Manganese | 650 (1,000) | 590 | 54 | 33 | 25 | 32 | 31 | 41,000 | NE |
| Nickel | 27 (25) | 71 | 13 | 5.2 | ND | 4.2 | 2.7 | 41,000 | 130 |
| Potassium | 420 (530) | 330 | 610 | 210 | ND | 170 | 140 | NE | NE |
| Silver | ND (ND) | ND | ND | 1.4 | 1.3 | 1.2 | 1.4 | 14,000 | 34 |
| Sodium | 200 (180) | 140 | ND | ND | ND | ND | ND | NE | NE |
| Vanadium | 120 (130) | 160 | 47 | 32 | 13 | 19 | 13 | 14,000 | 6,000 |
| Zinc | 42 (47) | 42 | 32 | 14 | 8.2 | 7.6 | 5.6 | 610,000 | 12,000 |
| Mercury | 0.093 (0.094) | ND | 0.041 | ND | ND | ND | ND | 610[f] | 2 |

# Table 2-21

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW2-2, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.
[c] Adult industrial lead screening level based on *Recommendations of the Technical Review Workshop for lead for an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil*, (EPA, 1996).
[d] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).
[e] This value is the RBC for Chromium VI.
[f] This value is the RBC for mercuric oxide.

bgs - Below ground surface.
CERCLA - Comprehensive Environmental Response, Conservation, and Liability Act.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
RBC - Risk-based concentration.
RCRA - Resource Conservation and Recovery Act.
SSL - Soil screening level.
**52** [RBC] - Bolded, shaded value exceeds EPA Region III RBC.
**52** [SSL] - Bolded, shaded value exceeds EPA Generic SSL.

## Table 2-22

## Organic Subsurface Soil Analytical Results
## Monitoring Well RMW2-2, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) | | | | | | | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 14 - 16 (mg/kg) | 19 - 21 (mg/kg) | 24 - 26 (mg/kg) | 29 - 31 (mg/kg) | 34 - 36 (mg/kg) | | |
| **VOCs** | ND (ND) | ND | ND | ND | ND | ND | ND | Various | Various |
| **BNAs** | ND (ND) | ND | ND | ND | ND | ND | ND | Various | Various |
| **Pesticides/PCBs** | ND (ND) | ND | ND | ND | ND | ND | ND | Various | Various |
| **TPH as diesel** | ND (ND) | ND | ND | ND | ND | ND | ND | NE | NE |
| **TPH as gasoline** | ND (ND) | ND | ND | ND | ND | ND | ND | NE | NE |
| **Explosives** | ND (ND) | ND | ND | ND | ND | ND | ND | Various | Various |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

bgs - Below ground surface.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
mg/kg - Milligrams per kilogram.
ND - Not detected.
ND (ND) - Sample result (duplicate sample result).
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.

## Table 2-23

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW2-3, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

(Page 1 of 2)

| Parameter | Sample Depth Interval (feet bgs) | | | | | | | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 14 - 16 (mg/kg) | 19 - 21 (mg/kg) | 24 - 26 (mg/kg) | 29 - 31 (mg/kg) | 34 - 36 (mg/kg) | | |
| Arsenic | 79 RBC,SSL | 77 RBC,SSL | 35 RBC,SSL | 45 RBC,SSL | 49 RBC,SSL | | 51 RBC,SSL | 3.8 | 29 |
| Lead | 14 | 12 | 7.8 | 7.5 | 8.6 | 11 | 13 | 1,545[c] | 400[d] |
| Thallium | 2.5 SSL | 2.1 SSL | 1.8 SSL | 1.6 SSL | 2.0 SSL | 2.2 SSL | 2.0 SSL | 140 | 0.7 |
| Aluminum | 30,000 | 25,000 | 12,100 | 13,000 | 16,000 | 18,000 | 23,000 | 2,000,000 | NE |
| Barium | 27 | 17 | 14 | 28 | 27 | 39 | 31 | 140,000 | 1,600 |
| Beryllium | 1.6 | 1.6 | 1.1 | 0.99 | 0.83 | 0.86 | 0.84 | 4,100 | 63 |
| Calcium | 820 | 650 | 290 | 330 | 380 | 470 | 520 | NE | NE |
| Chromium total | 290 J SSL | 250 J SSL | 190 J SSL | 160 J SSL | 160 J SSL | 170 J SSL | 170 J SSL | 610[e] | 38 |
| Cobalt | 9.9 | 10 | 6.6 | 9.5 | 12 | 12 | 13 | 120,000 | NE |
| Copper | 23 | 25 | 23 | 20 | 25 | 33 | 36 | 82,000 | NE |
| Iron | ND | ND | 51,300 | 54,000 | 55,000 | 62,000 | 59,300 | 610,000 | NE |
| Magnesium | 1,000 | 1,100 | 540 | 640 | 690 | 760 | 790 | NE | NE |
| Manganese | 250 | 180 | 170 | 300 | 810 | 1,700 | 1,500 | 41,000 | NE |
| Nickel | 38 | 37 | 18 | 20 | 24 | 27 | 27 | 41,000 | 130 |
| Potassium | 540 | 380 | 220 | 230 | 280 | 300 | 420 | NE | NE |
| Vanadium | 180 | 180 | 120 | 120 | 120 | 140 | 140 | 14,000 | 6,000 |
| Zinc | 50 | 48 | 34 | 39 | 45 | 52 | 60 | 610,000 | 12,000 |

## Table 2-23

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW2-3, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



[a] Risk-based concentration from EPA Region III Table, April 12, 1999.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.
[c] Adult industrial lead screening level based on *Recommendations of the Technical Review Workshop for Lead for an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil*, (EPA, 1996).
[d] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).
[e] This value is the RBC for Chromium VI.

bgs - Below ground surface.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
RBC - Risk-based concentration.
RCRA - Resource Conservation and Recovery Act.
SSL - Soil screening level.
**79** [RBC] - Bolded, shaded value exceeds EPA Region III Industrial RBC.
**79** [SSL] - Bolded, shaded value exceeds EPA Generic SSL.

## Table 2-24

## Organic Subsurface Soil Analytical Results
## Monitoring Well RMW2-3, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) | | | | | | | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 14 - 16 (mg/kg) | 19 - 21 (mg/kg) | 24 - 26 (mg/kg) | 29 - 31 (mg/kg) | 34 - 36 (mg/kg) | | |
| **VOCs** | ND | ND | ND | ND | ND | ND | ND | Various | Various |
| **BNAs** | ND | ND | ND | ND | ND | ND | ND | Various | Various |
| **Pesticides/PCBs** | ND | ND | ND | ND | ND | ND | ND | Various | Various |
| **TPH as diesel** | ND | ND | ND | ND | ND | ND | ND | NE | Various |
| **TPH as gasoline** | ND | ND | ND | ND | ND | ND | ND | NE | NE |
| **Explosives** | ND | ND | ND | ND | ND | ND | ND | Various | Various |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

bgs - Below ground surface.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.

## Table 2-25

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW2-4, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) 4 - 6 (mg/kg) | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|
| Arsenic | **89 (88)** RBC,SSL | 3.8 | 29 |
| Lead | 10 (15) | 1,545[c] | 400[d] |
| Selenium | 2.3 (ND) | 10,000 | 5 |
| Thallium | **2.7 (3.2)** SSL | 140 | 0.7 |
| Aluminum | 12,000 (33,000) | 2,000,000 | NE |
| Barium | 33 (49) | 140,000 | 1,600 |
| Beryllium | 2.6 (1.9) | 4,100 | 63 |
| Calcium | 2,400 (1,400) | NE | NE |
| Chromium total | **280 (280)** SSL | 610[e] | 38 |
| Cobalt | 13 (9.5) | 120,000 | NE |
| Copper | 21 (21) | 82,000 | NE |
| Iron | 100,000 (100,000) | 610,000 | NE |
| Magnesium | 2,500 (1,300) | NE | NE |
| Manganese | 100 (150) | 41,000 | NE |
| Nickel | 54 (45) | 41,000 | 130 |
| Potassium | 430 (580) | NE | NE |
| Sodium | ND (210) | NE | NE |
| Vanadium | 180 (180) | 14,000 | 6,000 |
| Zinc | 46 (41) | 610,000 | 12,000 |
| Mercury | ND (0.049) | 610[f] | 2 |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

[c] Adult industrial lead screening level based on *Recommendations of the Technical Review Workshop for Lead for an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil*, (EPA, 1996).

[d] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).

[e] This value is the RBC for Chromium VI.

[f] This value is the RBC for mercuric oxide.

bgs - Below ground surface.
EPA - U.S. Environmental Protection Agency.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
RBC - Risk-based concentration.
SSL - Soil screening level.
89 (88) - Sample result (duplicate sample result).
**89** RBC - Bolded, shaded value exceeds Region III Residential RBC.
**89** SSL - Bolded, shaded value exceeds EPA Generic SSL.

## Table 2-26

## Organic Subsurface Soil Analytical Results
## Monitoring Well RMW2-4, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) 4 - 6 (mg/kg) | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|
| **VOCs** | | | |
| Acetone | 0.015 (ND) | 200,000 | 16 |
| Toluene | 0.0054 J (0.0060 J) | 410,000 | 12 |
| **BNAs** | ND (ND) | Various | Various |
| **Pesticides/PCBs** | ND (ND) | Various | Various |
| **TPH as diesel** | ND (ND) | NE | NE |
| **TPH as gasoline** | ND (ND) | NE | NE |
| **Explosives** | ND (ND) | Various | Various |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

bgs - Below ground surface.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.
VOC - Volatile organic compound.
0.015 (ND) - Sample result (duplicate sample result).

## Table 2-27

## Inorganic Subsurface Soil Analytical Results
## Monitoring Well RMW2-5, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 14 - 16 (mg/kg) | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|
| Arsenic | **41** RBC,SSL | **40** RBC,SSL | **73** RBC,SSL | 3.8 | 29 |
| Lead | 7.3 | 6.9 | 11 | 1,545[c] | 400[d] |
| Aluminum | 11,000 | 10,000 | 18,000 | 2,000,000 | NE |
| Barium | 12 | 7.6 | 50 | 140,000 | 1,600 |
| Beryllium | ND | 0.64 | 2.3 | 4,100 | 63 |
| Cadmium | 2.3 | 3.6 | 6.2 | 2,000[e] | 8 |
| Calcium | 450 | 460 | 18,000 | NE | NE |
| Chromium total | **160** SSL | **200** SSL | **280** SSL | 610[f] | 38 |
| Cobalt | 3.8 | 4.0 | 19 | 120,000 | NE |
| Copper | 14 | 16 | 20 | 82,000 | NE |
| Iron | 44,000 | 48,000 | 55,000 | 610,000 | NE |
| Magnesium | 340 | 440 | 3,900 | NE | NE |
| Manganese | 100 | 140 | 990 | 41,000 | NE |
| Nickel | 16 | 19 | 53 | 41,000 | 130 |
| Potassium | 230 | 120 | 630 | NE | NE |
| Vanadium | 100 | 120 | 140 | 14,000 | 6,000 |
| Zinc | 21 | 22 | 44 | 610,000 | 12,000 |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.

[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

[c] Adult industrial lead screening level based on *Recommendations of the Technical Review Workshop for Lead for an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil*, (EPA, 1996).

[d] A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA, 1994).

[e] This value is the RBC for food.

[f] This value is the RBC for Chromium VI.

bgs - Below ground surface.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act.
EPA - U.S. Environmental Protection Agency.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
RBC - Risk-based concentration.
RCRA - Resource Conservation and Recovery Act.
SSL - Soil screening level.
**41** RBC - Bolded, shaded value exceeds EPA Region III RBC.
**41** SSL - Bolded, shaded value exceeds EPA Generic SSL.

## Table 2-28

## Organic Subsurface Soil Analytical Results
## Monitoring Well RMW2-5, Landfill Area 2, June 1997
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

| Parameter | Sample Depth Interval (feet bgs) | | | EPA Region 3 Industrial RBCs[a] (mg/kg) | EPA Generic SSLs[b] (mg/kg) |
|---|---|---|---|---|---|
| | 4 - 6 (mg/kg) | 9 - 11 (mg/kg) | 14 - 16 (mg/kg) | | |
| **VOCs** | | | | | |
| Acetone | ND | ND | 0.0068 J | 200,000 | 16[a] |
| **BNAs** | ND | ND | ND | Various | Various |
| **Pesticides/PCBs** | ND | ND | ND | Various | Various |
| **TPH as diesel** | ND | ND | ND | NE | NE |
| **TPH as gasoline** | ND | ND | ND | NE | NE |
| **Explosives** | ND | ND | ND | Various | Various |

[a] Risk-based concentrations from EPA Region III Table, April 12, 1999.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default dilution-attenuation factor (DAF) of 20.

bgs - Below ground surface.
BNA - Base neutral/acid extractable organic compound.
EPA - U.S. Environmental Protection Agency.
J - Estimated concentration.
mg/kg - Milligrams per kilogram.
ND - Not detected.
NE - Not established.
PCB - Polychlorinated biphenyl.
RBC - Risk-based concentration.
SSL - Soil screening level.
TPH - Total petroleum hydrocarbon.

## Table 3-1

## Landfill Area 1 and Landfill Area 2 Sampling Requirements
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Sample Location | Sample Designation [a] | Sample Depth [b] | QA/QC Sample Designation: Field Duplicates Split Samples | QA/QC Sample Designation: MS/MSD | Analytical Suite[c] |
|---|---|---|---|---|---|
| **Landfill Area 1** | | | | | |
| **Groundwater Samples** | | | | | |
| RMW1-1 | RAFB-RMW1-1-GW-AA3001-REG | | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| RMW1-2 | RAFB-RMW1-2-GW-AA3002-REG | | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| RMW1-3 | RAFB-RMW1-3-GW-AA3003-REG | | RAFB-RMW1-3-GW-AA3004-FD<br>RAFB-RMW1-3-GW-AA3005-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| RMW1-4 | RAFB-RMW1-4-GW-AA3006-REG | | | RAFB-RMW1-4-GW-AA3006MS-MS<br>RAFB-RMW1-4-GW-AA3006MSD-MSD | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| **Surface Soil** | | | | | |
| LF1SS01 | RAFB-LF1SS01-SS-AA0001-REG | 0-1" | RAFB-LF1SS01-SS-AA0002-FD<br>RAFB-LF1SS01-SS-AA0003-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF1SS02 | RAFB-LF1SS02-SS-AA0004-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SS03 | RAFB-LF1SS03-SS-AA0005-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF1SS04 | RAFB-LF1SS04-SS-AA0006-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF1SS05 | RAFB-LF1SS05-SS-AA0007-REG | 0-1" | | RAFB-LF1SS05-SS-AA0007MS-MS<br>RAFB-LF1SS05-SS-AA0007MSD-MSD | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SS06 | RAFB-LF1SS06-SS-AA0008-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SS07 | RAFB-LF1SS07-SS-AA0009-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF1SS08 | RAFB-LF1SS08-SS-AA0010-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SS09 | RAFB-LF1SS09-SS-AA0011-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF1SS010 | RAFB-LF1SS010-SS-AA0012-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SS011 | RAFB-LF1SS011-SS-AA0013-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SS012 | RAFB-LF1SS012-SS-AA0014-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| **Soil Borings** | | | | | |
| LF1SB01 | RAFB-LF1SB01-SS-AA0020-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF1SB01-DS-AA0021-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |

## Table 3-1

## Landfill Area 1 and Landfill Area 2 Sampling Requirements
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Sample Location | Sample Designation [a] | Sample Depth [b] | QA/QC Sample Designation: Field Duplicates Split Samples | QA/QC Sample Designation: MS/MSD | Analytical Suite[c] |
|---|---|---|---|---|---|
| | RAFB-LF1SB01-DS-AA0022-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SB02 | RAFB-LF1SB02-SS-AA0023-REG | 0-1" | | RAFB-LF1SB02-SS-AA0023MS-MS<br>RAFB-LF1SB02-SS-AA0023MD-MSD | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size, TOC |
| | RAFB-LF1SB02-DS-AA0024-REG | TBD | RAFB-LF1SB02-DS-AA0025-FD<br>RAFB-LF1SB02-DS-AA0026-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF1SB02-DS-AA0027-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SB03 | RAFB-LF1SB03-SS-AA0028-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF1SB03-DS-AA0029-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF1SB03-DS-AA0030-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SB04 | RAFB-LF1SB04-SS-AA0031-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size, TOC |
| | RAFB-LF1SB04-DS-AA0032-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF1SB04-DS-AA0033-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SB05 | RAFB-LF1SB05-SS-AA0034-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size,TOC |
| | RAFB-LF1SB05-DS-AA0035-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF1SB05-DS-AA0036-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SB06 | RAFB-LF1SB06-SS-AA0037-REG | 0-1" | RAFB-LF1SB06-SS-AA0038-FD<br>RAFB-LF1SB06-SS-AA0039-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size,TOC |
| | RAFB-LF1SB06-DS-AA0040-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF1SB06-DS-AA0041-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SB07 | RAFB-LF1SB07-SS-AA0042-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF1SB07-DS-AA0043-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF1SB07-DS-AA0044-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF1SB08 | RAFB-LF1SB08-SS-AA0045-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size,TOC |

## Table 3-1

## Landfill Area 1 and Landfill Area 2 Sampling Requirements
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Sample Location | Sample Designation [a] | Sample Depth [b] | QA/QC Sample Designation: Field Duplicates Split Samples | QA/QC Sample Designation: MS/MSD | Analytical Suite[c] |
|---|---|---|---|---|---|
| | RAFB-LF1SB08-DS-AA0046-REG | TBD | RAFB-LF1SB08-DS-AA0047-FD<br>RAFB-LF1SB08-DS-AA0048-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF1SB08-DS-AA0049-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| **Landfill Area 2** | | | | | |
| **Groundwater Samples** | | | | | |
| RMW2-1 | RAFB-RMW2-1-GW-AB3001-REG | | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| RMW2-2 | RAFB-RMW2-2-GW-AB3002-REG | | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| RMW2-3 | RAFB-RMW2-3-GW-AB3003-REG | | RAFB-RMW2-3-GW-AB3004-FD<br>RAFB-RMW2-3-GW-AB3005-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| RMW2-4 | RAFB-RMW2-4-GW-AB3006-REG | | | RAFB-RMW2-4-GW-AB3006MS-MS<br>RAFB-RMW2-4-GW-AB3006MSD-MSD | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| RMW2-5 | RAFB-RMW2-5-GW-AB3007-REG | | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| **Surface Soil** | | | | | |
| LF2SS01 | RAFB-LF2SS01-SS-AB0001-REG | 0-1" | RAFB-LF2SS01-SS-AB0002-FD<br>RAFB-LF2SS01-SS-AB0003-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF2SS02 | RAFB-LF2SS02-SS-AB0004-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SS03 | RAFB-LF2SS03-SS-AB0005-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF2SS04 | RAFB-LF2SS04-SS-AB0006-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SS05 | RAFB-LF2SS05-SS-AB0007-REG | 0-1" | | RAFB-LF2SS05-SS-AB0007MS-MS<br>RAFB-LF2SS05-SS-AB0007MSD-MSD | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF2SS06 | RAFB-LF2SS06-SS-AB0008-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SS07 | RAFB-LF2SS07-SS-AB0009-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SS08 | RAFB-LF2SS08-SS-AB0010-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SS09 | RAFB-LF2SS09-SS-AB0011-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF2SS010 | RAFB-LF2SS010-SS-AB0012-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SS011 | RAFB-LF2SS011-SS-AB0013-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, TOC, Grain Size |
| LF2SS012 | RAFB-LF2SS012-SS-AB0014-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |

## Table 3-1

## Landfill Area 1 and Landfill Area 2 Sampling Requirements
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Sample Location | Sample Designation [a] | Sample Depth [b] | QA/QC Sample Designation: Field Duplicates Split Samples | QA/QC Sample Designation: MS/MSD | Analytical Suite[c] |
|---|---|---|---|---|---|
| **Soil Borings** | | | | | |
| LF2SB01 | RAFB-LF2SB01-SS-AB0020-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size,TOC |
| | RAFB-LF2SB01-DS-AB0021-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF2SB01-DS-AB0022-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB02 | RAFB-LF2SB02-SS-AB0023-REG | 0-1" | | RAFB-LF2SB02-SS-AB0023MS-MS<br>RAFB-LF2SB02-SS-AB0023MSD-MSD | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB02-DS-AB0024-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB02-DS-AB0025-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB03 | RAFB-LF2SB03-SS-AB0026-REG | 0-1" | RAFB-LF2SB03-SS-AB0027-FD<br>RAFB-LF2SB03-SS-AB0028-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size,TOC |
| | RAFB-LF2SB03-DS-AB0029-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF2SB03-DS-AB0030-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB04 | RAFB-LF2SB04-SS-AB0031-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB04-DS-AB0032-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB04-DS-AB0033-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB05 | RAFB-LF2SB05-SS-AB0034-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size,TOC |
| | RAFB-LF2SB05-DS-AB0035-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF2SB05-DS-AB0036-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB06 | RAFB-LF2SB06-SS-AB0037-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB06-DS-AB0038-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB06-DS-AB0039-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB07 | RAFB-LF2SB07-SS-AB0040-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB07-DS-AB0041-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |

## Table 3-1

## Landfill Area 1 and Landfill Area 2 Sampling Requirements
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Sample Location | Sample Designation [a] | Sample Depth [b] | QA/QC Sample Designation: Field Duplicates Split Samples | QA/QC Sample Designation: MS/MSD | Analytical Suite[c] |
|---|---|---|---|---|---|
| | RAFB-LF2SB07-DS-AB0042-REG | TBD | RAFB-LF2SB07-DS-AB0043-FD<br>RAFB-LF2SB07-DS-AB0044-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB08 | RAFB-LF2SB08-SS-AB0045-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB08-DS-AB0046-REG | TBD | | RAFB-LF2SB08-DS-AB0046MS-MS<br>RAFB-LF2SB08-DS-AB0046MSD-MSD | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB08-DS-AB0047-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB09 | RAFB-LF2SB09-SS-AB0048-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size,TOC |
| | RAFB-LF2SB09-DS-AB0049-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF2SB09-DS-AB0050-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB10 | RAFB-LF2SB10-SS-AB0051-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB10-DS-AB0052-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB10-DS-AB0053-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB11 | RAFB-LF2SB11-SS-AB0054-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Grain Size,TOC |
| | RAFB-LF2SB11-DS-AB0055-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs, Geotechnical |
| | RAFB-LF2SB11-DS-AB0056-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| LF2SB12 | RAFB-LF2SB12-SS-AB0057-REG | 0-1" | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB12-DS-AB0058-REG | TBD | RAFB-LF2SB12-DS-AB0059-FD<br>RAFB-LF2SB12-DS-AB0060-SPLT | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |
| | RAFB-LF2SB12-DS-AB0061-REG | TBD | | | VOCs, SVOCs, TPH, metals, pesticides, PCBs |

[a] The sample designation is composed of five segments: (1) the facility name (RAFB); (2) the site designation (RMW); (3) sample location ID (AA3001); (4) sample type (GW); and (5) sample purpose (REG). Please refer to Chapter 6.0 of the SAP for more detail about sample naming.

[b] TBD - to be determined. Depths of these samples will be detrmined based on screening information and depth to bedrock.

[c] Geotechnical analysis consists of : bulk soil density, total soil porosity, air-filled porosity, water-filled porosity, particle density, and fractional organic carbon.

## Table 3-2

## Sampling and Analytical Requirements for Landfill Area 1 and Landfill Area 2 Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Matrix | Parameter | Analytical Method | Total No. of Samples | QC Samples: No. of Dups | QC Samples: No. of Sample Rinsates | QC Samples: No. of Trip Blanks | QC Samples: Total No. of Samples | QA Samples: No. of Splits | QA Samples: No. of Trip Blank | QA Samples: Total No. of QA Samples | Sample Container | Preservation Requirements | Holding Time | Approx. Total No. of Containers |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Landfill Area 1** | | | | | | | | | | | | | | |
| **Surface Soil*** | VOCs | 8260B | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | (3) Encore® | Cool | 48 hr/14 d | 45 |
| | SVOCs | 8270C | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 15 |
| | Pesticides | 8081 | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 15 |
| | PCBs | 8082 | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 15 |
| | TPH-DRO | 8015M | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 14 days | 15 |
| | TPH - GRO | 8015M | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 14 days | 15 |
| | TAL Metals | 6010B/7000 | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 6 months | 15 |
| | TOC | 9060 | 5 | 1 | 1 | 0 | 7 | 1 | 0 | 1 | 4 oz glass | Cool | 28 days | 15 |
| | Grain Size | ASTMD422 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 oz glass | Cool | NA | 5 |
| **Groundwater** | VOCs | 8260B | 4 | 1 | 0 | 1 | 6 | 1 | 0 | 1 | (3) 40 mL VOA vial | Cool, HCL pH<2 | 14 days | 21 |
| | SVOCs | 8270C | 4 | 1 | 0 | 0 | 5 | 1 | 0 | 1 | (2) 1L amber glass | Cool | 7 days ext/40 days analysis | 12 |
| | Pesticides | 8081 | 4 | 1 | 0 | 0 | 5 | 1 | 0 | 1 | (2) 1L amber glass | Cool | 7 days ext/40 days analysis | 12 |
| | PCBs | 8082 | 4 | 1 | 0 | 0 | 5 | 1 | 0 | 1 | (2) 1L amber glass | Cool | 7 days ext/40 days analysis | 12 |
| | TPH-DRO | 8015M | 4 | 1 | 0 | 0 | 5 | 1 | 0 | 1 | (2) 1L amber glass | Cool | 14 days | 12 |
| | TPH - GRO | 8015M | 4 | 1 | 0 | 0 | 5 | 1 | 0 | 1 | (3) 40 mL VOA vial | Cool, HCL pH<2 | 14 days | 18 |
| | TAL Metals | 6010B/7000 | 4 | 1 | 0 | 0 | 5 | 1 | 0 | 1 | (1) 1L Poly | Cool, $HNO_3$ to pH <2 | 6 months | 6 |
| **Soil Borings** | VOCs | 8260B | 24 | 3 | 0 | 0 | 27 | 1 | 0 | 1 | 4 oz glass | Cool | 14 days | 28 |
| **(Surface &** | SVOCs | 8270C | 24 | 3 | 0 | 0 | 27 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 28 |
| **Deep Soils)** | Pesticides | 8081 | 24 | 3 | 0 | 0 | 27 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 28 |
| | PCBs | 8082 | 24 | 3 | 0 | 0 | 27 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 28 |

## Table 3-2

## Sampling and Analytical Requirements for Landfill Area 1 and Landfill Area 2 Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Matrix | Parameter | Analytical Method | Total No. of Samples | QC Samples | | | | QA Samples | | | Sample Container | Preservation Requirements | Holding Time | Approx. Total No. of Containers |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of Dups | No. of Sample Rinsates | No. of Trip Blanks | Total No. of Samples | No. of Splits | No. of Trip Blank | Total No. of QA Samples | | | | |
| | TPH-DRO | 8015M | 24 | 3 | 0 | 0 | 27 | 1 | 0 | 1 | 4 oz glass | Cool | 14 days | 28 |
| | TPH - GRO | 8015M | 24 | 0 | 0 | 0 | 24 | 1 | 0 | 1 | 4 oz glass | Cool | 14 days | 28 |
| | TAL Metals | 6010B/7000 | 24 | 3 | 0 | 0 | 27 | 1 | 0 | 1 | 4 oz glass | Cool | 6 months | 28 |
| | Geotechnical | Various | 5 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | Sample Sleeve | None | ASAP | 10 |
| | TOC | 9060 | 5 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 4 oz glass | Cool | 28 days | 10 |
| | Grain Size | ASTMD422 | 5 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 32 oz glass | Cool | NA | 5 |
| **Landfill Area 2** | | | | | | | | | | | | | | |
| **Surface Soil[a]** | VOCs | 8260B | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | (3) Encore® | Cool | 48 hr/14 d | 45 |
| | SVOCs | 8270C | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 15 |
| | Pesticides | 8081 | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 15 |
| | PCBs | 8082 | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 7 days ext/40 days analysis | 15 |
| | TPH-DRO | 8015M | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 14 days | 15 |
| | TPH - GRO | 8015M | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 14 days | 15 |
| | TAL Metals | 6010B/7000 | 12 | 1 | 1 | 0 | 14 | 1 | 0 | 1 | 4 oz glass | Cool | 6 months | 15 |
| | TOC | 9060 | 5 | 1 | 1 | 0 | 7 | 0 | 0 | 0 | 4 oz glass | Cool | 28 days | 7 |
| | Grain Size | ASTMD422 | 5 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 32 oz glass | Cool | NA | 5 |
| **Groundwater** | VOCs | 8260B | 5 | 1 | 0 | 1 | 7 | 1 | 0 | 1 | (3) 40 mL VOA vial | Cool, HCL pH<2 | 14 days | 24 |
| | SVOCs | 8270C | 5 | 1 | 0 | 0 | 6 | 1 | 0 | 1 | (2) 1L amber glass | Cool | 7 days ext/40 days analysis | 14 |
| | Pesticides | 8081 | 5 | 1 | 0 | 0 | 6 | 1 | 0 | 1 | (2) 1L amber glass | Cool | 7 days ext/40 days analysis | 14 |
| | PCBs | 8082 | 5 | 1 | 0 | 0 | 6 | 1 | 0 | 1 | (2) 1L amber glass | Cool | 7 days ext/40 days analysis | 14 |
| | TPH-DRO | 8015M | 5 | 1 | 0 | 0 | 6 | 1 | 0 | 1 | (2) 1L amber glass | Cool | 14 days | 14 |
| | TPH - GRO | 8015M | 5 | 1 | 0 | 0 | 6 | 1 | 0 | 1 | (3) 40 mL VOA vial | Cool, HCL pH<2 | 14 days | 21 |
| | TAL Metals | 6010B/7000 | 5 | 1 | 0 | 0 | 6 | 1 | 0 | 1 | (1) 1L Poly | Cool, $HNO_3$ to pH <2 | 6 months | 7 |

## Table 3-2

## Sampling and Analytical Requirements for Landfill Area 1 and Landfill Area 2 Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Matrix | Parameter | Analytical Method | Total No. of Samples | QC Samples | | | | QA Samples | | | Sample Container | Preservation Requirements | Holding Time | Approx. Total No. of Containers |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of Dups | No. of Sample Rinsates | No. of Trip Blanks | Total No. of Samples | No. of Splits | No. of Trip Blank | Total No. of QA Samples | | | | |
| Soil Borings | VOCs | 8260B | 36 | 3 | 0 | 0 | 39 | 3 | 0 | 3 | 4 oz glass | Cool | 14 days | 42 |
| (Surface & | SVOCs | 8270C | 36 | 3 | 0 | 0 | 39 | 3 | 0 | 3 | 4 oz glass | Cool | 7 days ext/40 days analysis | 42 |
| Deep Soils) | Pesticides | 8081 | 36 | 3 | 0 | 0 | 39 | 3 | 0 | 3 | 4 oz glass | Cool | 7 days ext/40 days analysis | 42 |
| | PCBs | 8082 | 36 | 3 | 0 | 0 | 39 | 3 | 0 | 3 | 4 oz glass | Cool | 7 days ext/40 days analysis | 42 |
| | TPH-DRO | 8015M | 36 | 3 | 0 | 0 | 39 | 3 | 0 | 3 | 4 oz glass | Cool | 14 days | 42 |
| | TPH - GRO | 8015M | 36 | 3 | 0 | 0 | 39 | 3 | 0 | 3 | 4 oz glass | Cool | 14 days | 42 |
| | TAL Metals | 6010B/7000 | 36 | 3 | 0 | 0 | 39 | 3 | 0 | 3 | 4 oz glass | Cool | 6 months | 42 |
| | Geotechnical | Various | 5 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | Sample Sleeve | None | ASAP | 5 |
| | TOC | 9060 | 5 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 4 oz glass | Cool | 28 days | 5 |
| | Grain Size | ASTMD422 | 5 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 32 oz glass | Cool | NA | 5 |

Note: Number of trip blanks is estimated. One trip blank will be included in each cooler shipment containing aqueous VOC samples.

[a] All quantities are estimated and may change due to field conditions.
DRO - Diesel range organics.
GRO - Gasoline range organics.
Geotechnical - bulk soil density, total soil porosity, air-filled porosity, water-filled porosity, particle density and fractional organic carbon.
PCB - Polychlorinated biphenyl.
QA - Quality assurance.
QC - Quality control.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
VOC - Volatile organic compound.

## Table 4-1

## Human Receptors for the Landfills
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Source Medium | Model | Exposure Medium | Exposure Pathway |
|---|---|---|---|
| **LANDFILL 1** | | | |
| **Off-Site Consumer of Animal Agriculture Products** | | | |
| Soil | Soil-to-beef bioaccumulation | Beef | Ingestion of homegrown beef |
| **Youthful Trespasser** | | | |
| Soil | None | Soil | Incidental ingestion |
| | | | Dermal contact |
| | Airborne dust from wind erosion of soil | Air | Inhalation |
| | Soil-to-air volatilization | Air | Inhalation |
| **LANDFILL 2** | | | |
| **Farm Worker** | | | |
| Soil | None | Soil | Incidental ingestion |
| | | | Dermal contact |
| | Activity-driven dust-loading factor | Air | Inhalation |
| | Soil-to-air volatilization | Air | Inhalation |
| | Soil-to-beef bioaccumulation | Beef | Ingestion of "homegrown" beef |
| | Soil-to-plant bioaccumulation | Fruits & vegetables | Ingestion of "homegrown" fruits & vegetables |

## Table 4-1

## Human Receptors for the Landfills
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Source Medium | Model | Exposure Medium | Exposure Pathway |
|---|---|---|---|
| **Youthful Trespasser** | | | |
| Soil | None | Soil | Incidental ingestion |
| | | | Dermal contact |
| | Airborne dust from wind erosion of soil | Air | Inhalation |
| | Soil-to-air volatilization | Air | Inhalation |
| **Groundskeeper** | | | |
| Soil | None | Soil | Incidental ingestion |
| | | | Dermal contact |
| | Activity-driven dust-loading factor | Air | Inhalation |
| | Soil-to-air volatilization | Air | Inhalation |
| **Resident** | | | |
| Soil | None | Soil | Incidental ingestion |
| | | | Dermal contact |
| | Airborne dust from wind erosion of soil | Air | Inhalation |
| | Soil-to-air volatilization | Air | Inhalation |
| | Soil-to-plant bioaccumulation | Fruits & vegetables | Ingestion of "homegrown" fruits & vegetables |

## Table 4-1

## Human Receptors for the Landfills
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Source Medium | Model | Exposure Medium | Exposure Pathway |
|---|---|---|---|
| **Construction Worker** | | | |
| Soil | None | Soil | Incidental ingestion |
| | | | Dermal contact |
| | Activity-driven dust-loading factor | Air | Inhalation |
| | Soil-to-air volatilization | Air | Inhalation |

## Table 4-2

## Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors[a] Landfill Sites Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Pathway Variable | Off-Site Consumer of Animal Agriculture Products | Youthful Trespasser | Farm Worker | Grounds-keeper | Resident | Construction Worker |
|---|---|---|---|---|---|---|
| **Ingestion of Homegrown Beef** | | | | | | |
| Beef ingestion rate ($IR_b$), g/day | Adult: 150<br>Child: 60 | NA | Adult: 150<br>Child: 60 | NA | NA | NA |
| Fraction of beef homegrown ($FI_b$), unitless | 1 | NA | 1 | NA | NA | NA |
| Exposure frequency (EF), days/year | 350 | NA | 350 | NA | NA | NA |
| Exposure duration (ED), years | Adult: 24<br>Child: 6 | NA | Adult: 24<br>Child: 6 | NA | NA | NA |
| Body weight (BW), kg | Adult: 70<br>Child: 15 | NA | Adult: 70<br>Child: 15 | NA | NA | NA |
| Averaging time, noncancer (AT), days[b] | Child: 2190 | NA | Adult: 8760<br>Child: 2190 | NA | NA | NA |
| Averaging time, cancer (AT), days[c] | 25550 | NA | 25550 | NA | NA | NA |

## Table 4-2

## Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors[a]
## Landfill Sites
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Pathway Variable | Off-Site Consumer of Animal Agriculture Products | Youthful Trespasser | Farm Worker | Grounds-keeper | Resident | Construction Worker |
|---|---|---|---|---|---|---|
| **Incidental Ingestion of Soil** | | | | | | |
| Soil incidental ingestion rate ($IR_s$), mg/day | NA | 100 | 100 | 100 | Adult: 100<br>Child: 200 | 100 |
| Fraction of daily soil exposure attributed to site ($FI_s$), unitless | NA | 0.5 | 1 | 1 | 1 | 1 |
| Exposure frequency (EF), days/year | NA | 52 | 250 | 250 | 350 | 250 |
| Exposure duration (ED), years | NA | 10 | 30 | 25 | Adult: 24<br>Child: 6 | 0.5 |
| Body weight (BW), kg | NA | 45 | 70 | 70 | Adult: 70<br>Child: 15 | 70 |
| Averaging time, noncancer (AT), days[b] | NA | 3650 | Adult: 10,950 | 9,125 | Child: 8760 | 183 |
| Averaging time, cancer (AT), days[c] | NA | 25550 | 25550 | 25550 | 25550 | 25550 |

## Table 4-2

## Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors[a]
## Landfill Sites
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Pathway Variable | Off-Site Consumer of Animal Agriculture Products | Youthful Trespasser | Farm Worker | Grounds-keeper | Resident | Construction Worker |
|---|---|---|---|---|---|---|
| **Inhalation of VOCs and Resuspended Dust from Soil** | | | | | | |
| Inhalation rate ($IR_a$), $m^3$/hour | NA | 0.56 | 2.5 | 2.5 | Adult: 0.83<br>Child: 0.32 | 2.5 |
| Exposure time ($ET_a$), hours/day | NA | 8 | 8 | 8 | 24 | 8 |
| Exposure frequency (EF), days/year | NA | 52 | 250 | 250 | 350 | 250 |
| Exposure duration (ED), years | NA | 10 | 30 | 25 | Adult: 24<br>Child: 6 | 0.5 |
| Body weight (BW), kg | NA | 45 | 70 | 70 | Adult: 70<br>Child: 15 | 70 |
| Averaging time, noncancer (AT), days[b] | NA | 3650 | Adult: 10,950 | 9,125 | Child: 8760 | 183 |
| Averaging time, cancer (AT), days[c] | NA | 25550 | 25550 | 25550 | 25550 | 25550 |

## Table 4-2

## Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors[a] Landfill Sites Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Pathway Variable | Off-Site Consumer of Animal Agriculture Products | Youthful Trespasser | Farm Worker | Grounds-keeper | Resident | Construction Worker |
|---|---|---|---|---|---|---|
| **Dermal Contact with Soil** | | | | | | |
| Fraction of daily soil exposure attributed to site ($FI_d$), unitless | NA | 0.5 | 1 | 1 | 1 | 1 |
| Body surface area exposed to soil (SA), $cm^2$ | NA | 3700 | 5000 | 5000 | Adult: 5000<br>Child: 1560 | 5000 |
| Soil-to-skin adherence factor (AF), $mg/cm^2$ | NA | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Dermal absorption factor (ABS), unitless | NA | csv | csv | csv | csv | csv |
| Exposure frequency (EF), days/year | NA | 52 | 250 | 250 | 350 | 250 |
| Exposure duration (ED), years | NA | 10 | 30 | 25 | Adult: 24<br>Child: 6 | 0.5 |
| Body weight (BW), kg | NA | 45 | 70 | 70 | Adult: 70<br>Child: 15 | 70 |
| Averaging time, noncancer (AT), days[b] | NA | 3650 | Adult: 10,950 | 9,125 | Child: 8760 | 183 |
| Averaging time, cancer (AT), days[c] | NA | 25550 | 25550 | 25550 | 25550 | 25550 |

## Table 4-2

## Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors[a]
## Landfill Sites
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



| Pathway Variable | Off-Site Consumer of Animal Agriculture Products | Youthful Trespasser | Farm Worker | Grounds-keeper | Resident | Construction Worker |
|---|---|---|---|---|---|---|
| **Ingestion of Homegrown Fruits and Vegetables** | | | | | | |
| Fruits ingestion rate ($IR_f$), g dry weight/day | NA | NA | Adult: 45<br>Child: 20 | NA | Adult:45<br>Child: 20 | NA |
| Vegetables ingestion rate ($IR_v$), g dry weight/day | NA | NA | Adult: 48<br>Child: 21 | NA | Adult: 48<br>Child: 21 | NA |
| Fraction of fruits and vegetables homegrown ($FI_p$), unitless | NA | NA | 1 | NA | NA | NA |
| Exposure frequency (EF), days/year | NA | NA | 350 | NA | 350 | NA |
| Exposure duration (ED), years | NA | NA | Adult: 24<br>Child: 6 | NA | Adult: 24<br>Child: 6 | NA |
| Body weight (BW), kg | NA | NA | Adult: 70<br>Child: 15 | NA | Adult: 70<br>Child: 15 | NA |
| Averaging time, noncancer (AT), days[b] | NA | NA | Adult: 8760<br>Child: 2190 | NA | Child: 2190 | NA |
| Averaging time, cancer (AT), days[c] | NA | NA | 25550 | NA | 25550 | NA |

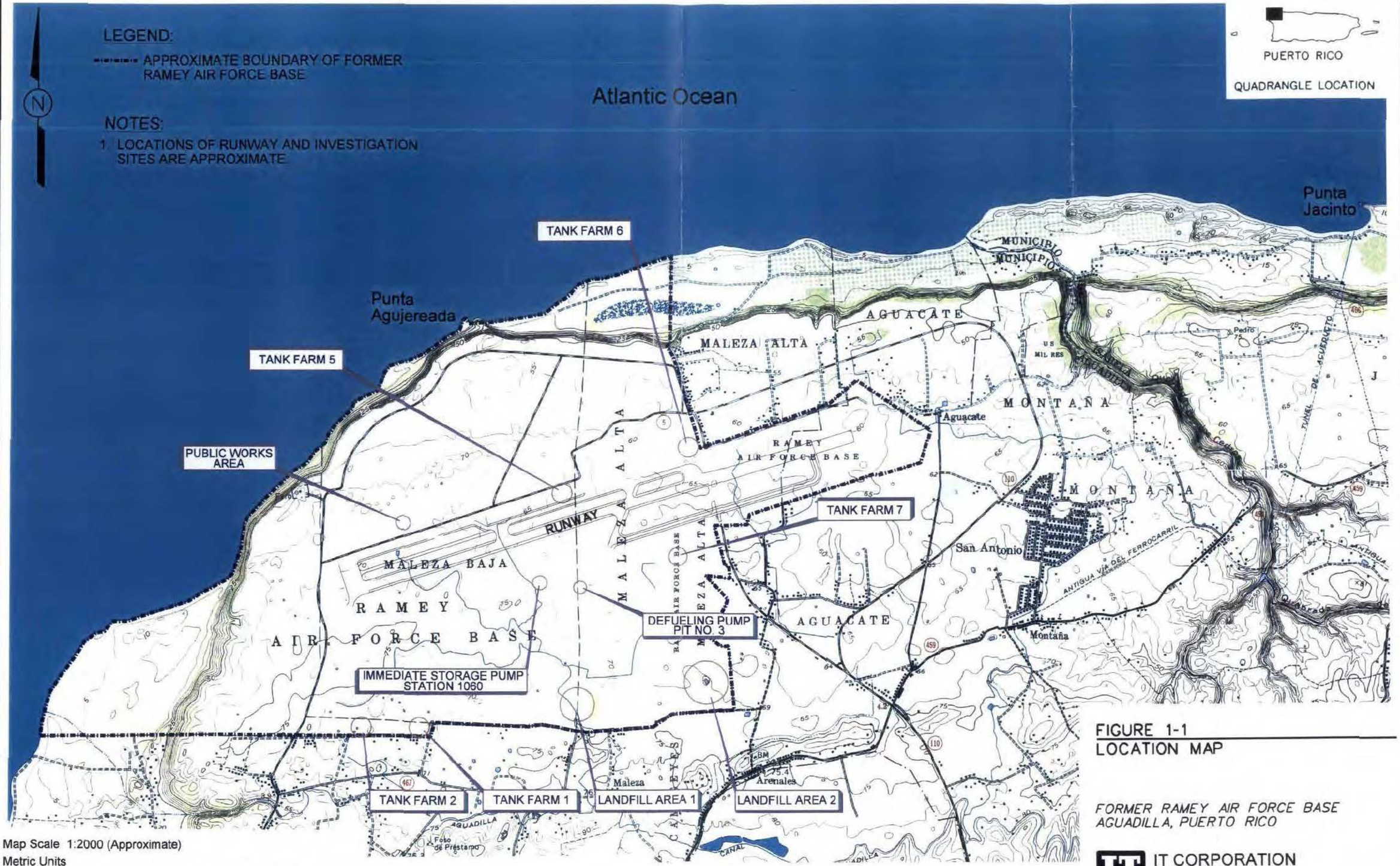
## Table 4-2

## Variables Used to Estimate Potential Chemical Intakes and Contact Rates for Receptors[a]
## Landfill Sites
## Former Ramey Air Force Base, Aguadilla, Puerto Rico



NA = Not applicable to this receptor.
csv = Chemical-specific value.
[a] Please see Section 4.3.1 for justification and documentation of the exposure variable values.
[b] Product of ED x 365 days/year.
[c] Product of assumed lifetime of 70 years (U.S. Environmental Protection Agency, 1991, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors, Interim Final*, Office of Solid Waste and Emergency Response, Washington, DC, OSWER Directive 9285.6-03, 25 March).

# FIGURES




Map Scale 1:2000 (Approximate)
Metric Units
Source: USGS Aguadilla, Isabela, and Moca Quadrangles, 1960

FIGURE 1-1
LOCATION MAP

*FORMER RAMEY AIR FORCE BASE*
*AGUADILLA, PUERTO RICO*

IT CORPORATION
*A Member of The IT Group*

DWG. NO.: \783146es.063 | PROJ. NO.: 783146
INITIATOR: THORBJORNSEN | PROJ. MGR.: C. QUARLES
DRAFT. CHCK. BY: C.E. TUMLIN | ENGR. CHCK. BY: THORBJORNSEN
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 05/16/00 | DRAWN BY: T. BRADSHAW
06/26/2000 01:17:39
c:\cadd\design\783146es.063
tbradsha

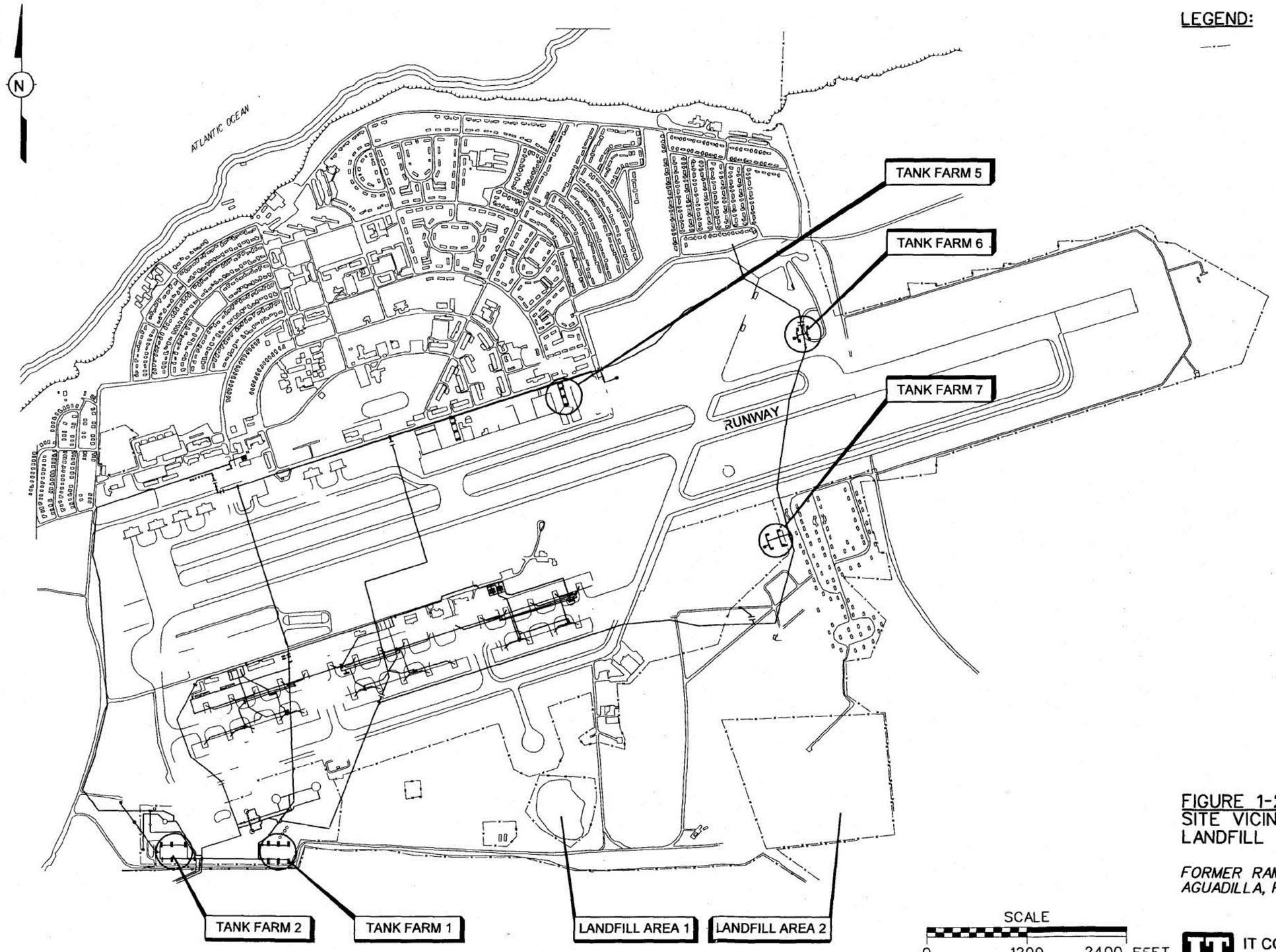



FIGURE 1-2
SITE VICINITY MAP
LANDFILL AREAS 1 AND 2

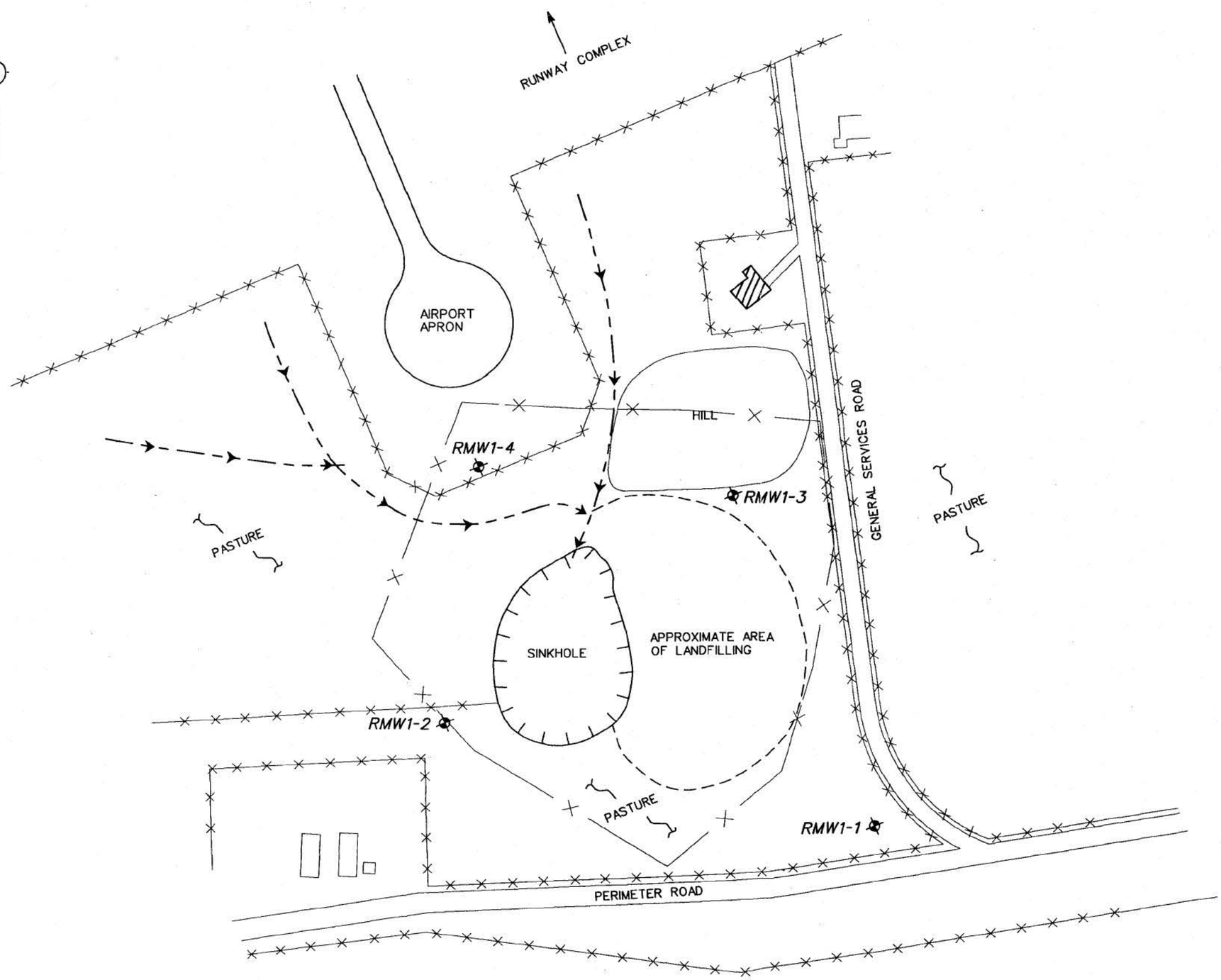
*FORMER RAMEY AIR FORCE BASE*
*AGUADILLA, PUERTO RICO*

IT CORPORATION
*A Member of The IT Group*

| | | | |
|---|---|---|---|
| STARTING DATE: 01/12/00 | DATE LAST REV.: | DRAFT. CHCK. BY: C. TUMLIN | INITIATOR: THORBJORNSEN |
| DRAWN BY: T. BRADSHAW | DRAWN BY: | ENGR. CHCK. BY: THORBJORNSEN | PROJ. MGR.: BOWHOLTZ |

06/15/2000 01:50:28 tbradsha c:\cadd\design\783146es.068

DWG. NO.:...\783146es.068
PROJ. NO.: 783146




## LEGEND:

- FENCELINE
- BUILDING
- BUILDING FOUNDATION
- APPROXIMATE AREA OF LANDFILLING
- DRAINAGE CHANNEL AND FLOW DIRECTION
- *RMW1-1* EXISTING MONITORING WELL

SCALE

0 200 400 FEET

FIGURE 2-1
SITE MAP - LANDFILL 1

*FORMER RAMEY AIR FORCE BASE*
*AGUADILLA, PUERTO RICO*

IT CORPORATION
*A Member of The IT Group*

| | | | |
|---|---|---|---|
| STARTING DATE: 05/23/00 | DATE LAST REV.: | DRAFT. CHCK. BY: C. TUMLIN | INITIATOR: J. HOFER |
| DRAWN BY: T. BRADSHAW | DRAWN BY: | ENGR. CHCK. BY: J. HOFER | PROJ. MGR.: G. QUARLES |

DWG. NO.:...\783146es.069
PROJ. NO.: 774873

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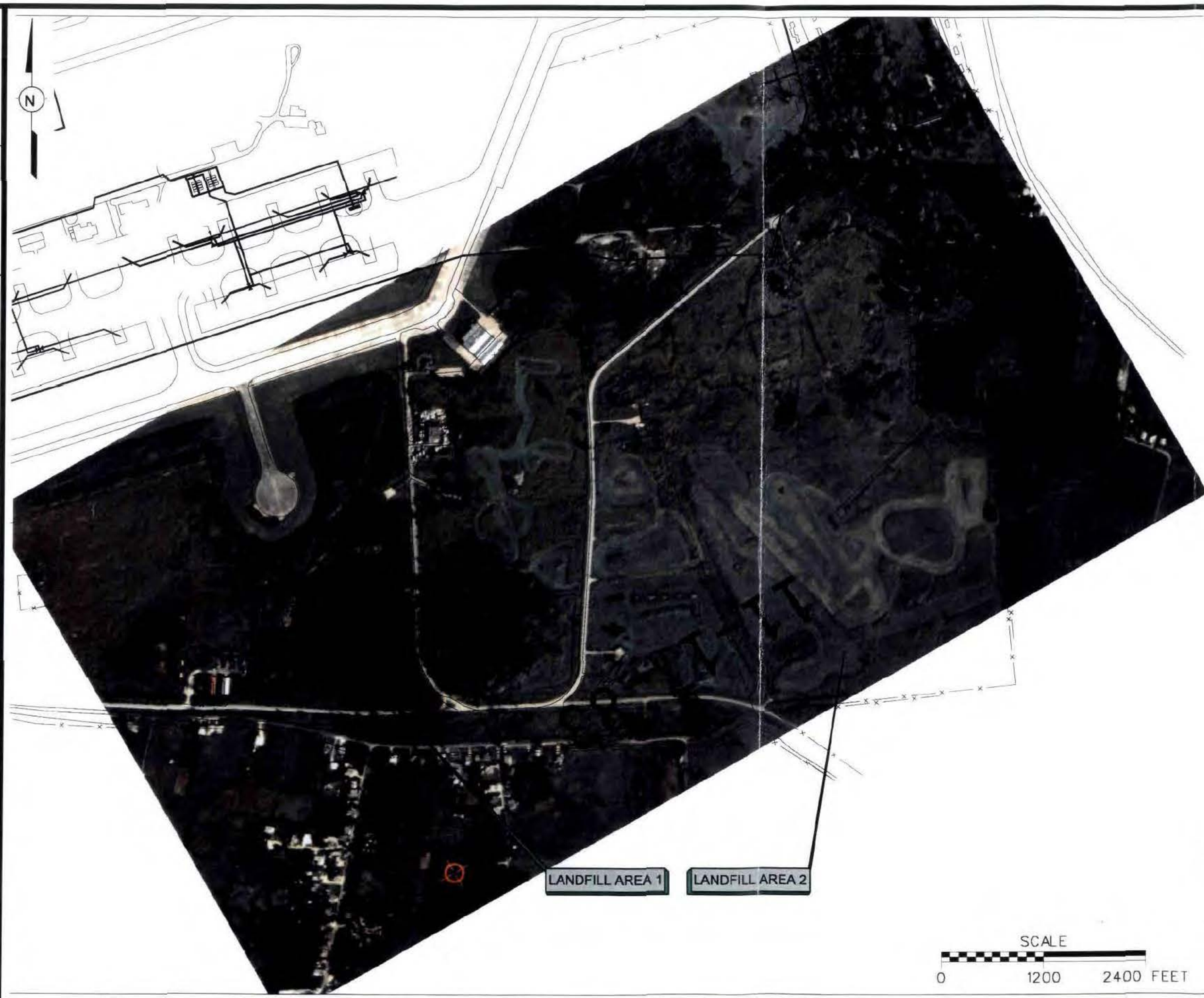


**LEGEND:**

FENCE

SCALE

0 1200 2400 FEET

FIGURE 2-2
SITE MAP
LANDFILLS 1 AND 2

*FORMER RAMEY AIR FORCE BASE*
*AGUADILLA, PUERTO RICO*

IT CORPORATION
*A Member of The IT Group*

| | | | |
|---|---|---|---|
| STARTING DATE: 05/23/00 | DATE LAST REV.: | DRAFT CHCK BY: G. TUMLIN | INITIATOR: J. HOFER | DWG. NO.: \783146es.067 |
| DRAWN BY: T. BRADSHAW | DRAWN BY | ENGR CHCK BY: J. HOFER | PROJ. MGR.: G. QUARLES | PROJ. NO.: 783146 |

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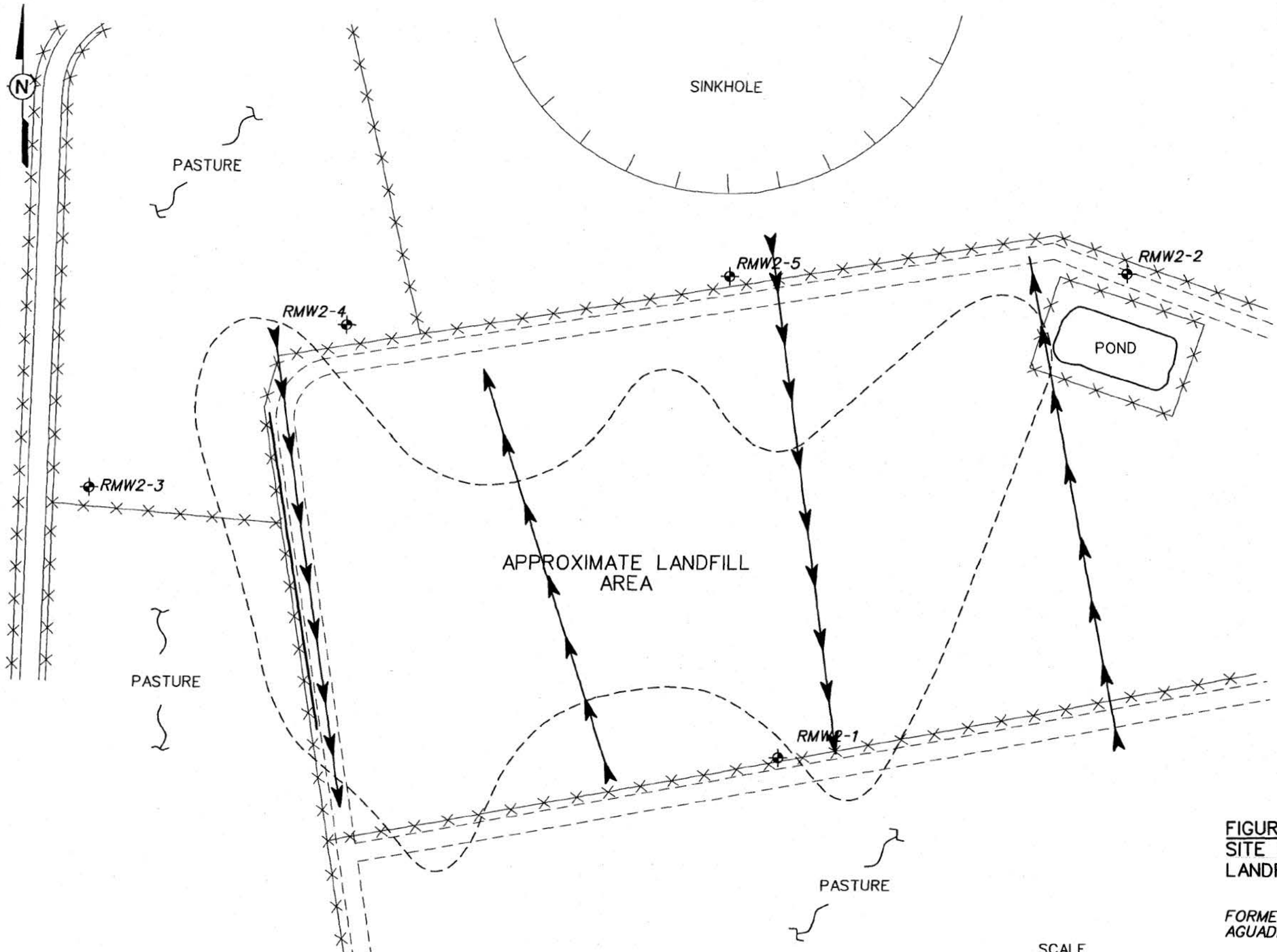



## LEGEND:

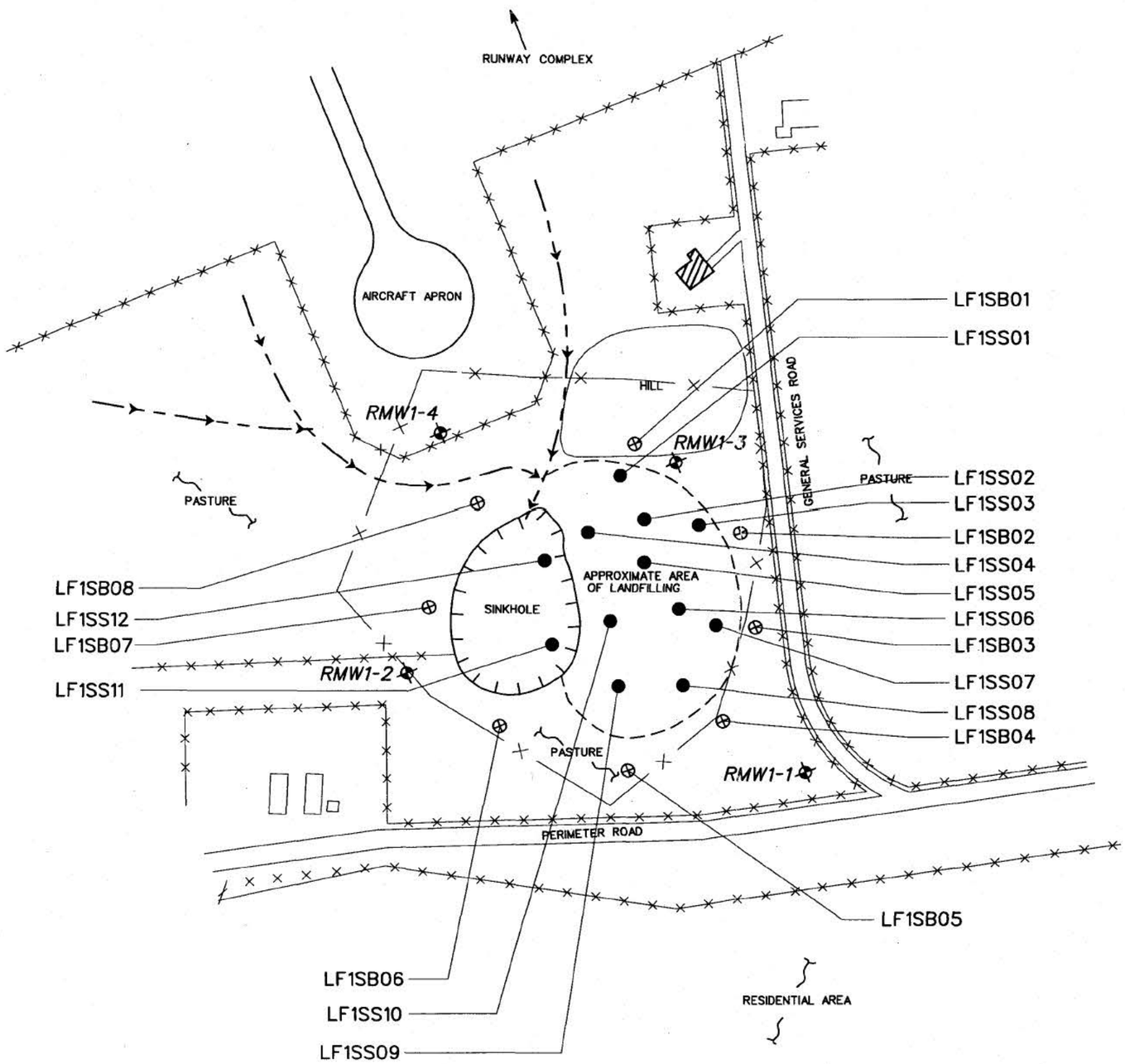
- FENCELINE
- BUILDING
- BUILDING FOUNDATION
- APPROXIMATE AREA OF LANDFILLING
- DRAINAGE CHANNEL AND FLOW DIRECTION
- EXISTING MONITORING WELL
- TOPOGRAPHIC LOW
- TOPOGRAPHIC HIGH

FIGURE 2-3
SITE MAP
LANDFILL AREA 2

*FORMER RAMEY AIR FORCE BASE*
*AGUADILLA, PUERTO RICO*

IT CORPORATION
*A Member of The IT Group*

DWG. NO.:...\783146es.070
PROJ. NO.: 783146
INITIATOR: J. HOFER
PROJ. MGR.: G. QUARLES
DRAFT. CHCK. BY: C. TUMLIN
ENGR. CHCK. BY: J. HOFER
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 05/23/00
DRAWN BY: T. BRADSHAW
06/13/2000
04:36:27
c:\cadd\design\783146es.070
tbradsha




## LEGEND:

- FENCELINE
- BUILDING
- BUILDING FOUNDATION
- APPROXIMATE AREA OF LANDFILLING
- DRAINAGE CHANNEL AND FLOW DIRECTION
- EXISTING MONITORING WELL
- PROPOSED SURFACE SOIL SAMPLING LOCATION
- PROPOSED SOIL BORING LOCATION

SCALE

0 100 200 FEET

FIGURE 3-1
PROPOSED SAMPLE LOCATION MAP
LANDFILL AREA 1

*FORMER RAMEY AIR FORCE BASE*
*AGUADILLA, PUERTO RICO*

IT CORPORATION
*A Member of The IT Group*

| | | | |
|---|---|---|---|
| DRAFT. CHCK. BY: C. TUMLIN | INITIATOR: J. HOFER | DWG. NO.:...\783146es.071 | |
| ENGR. CHCK. BY: J. HOFER | PROJ. MGR.: G. QUARLES | PROJ. NO.: 783146 | |
| STARTING DATE: 05/23/00 | DATE LAST REV.: | | |
| DRAWN BY: T. BRADSHAW | DRAWN BY: | | |

06/20/00 04:37:54 c:\cadd\design\783146es.071 awsmith

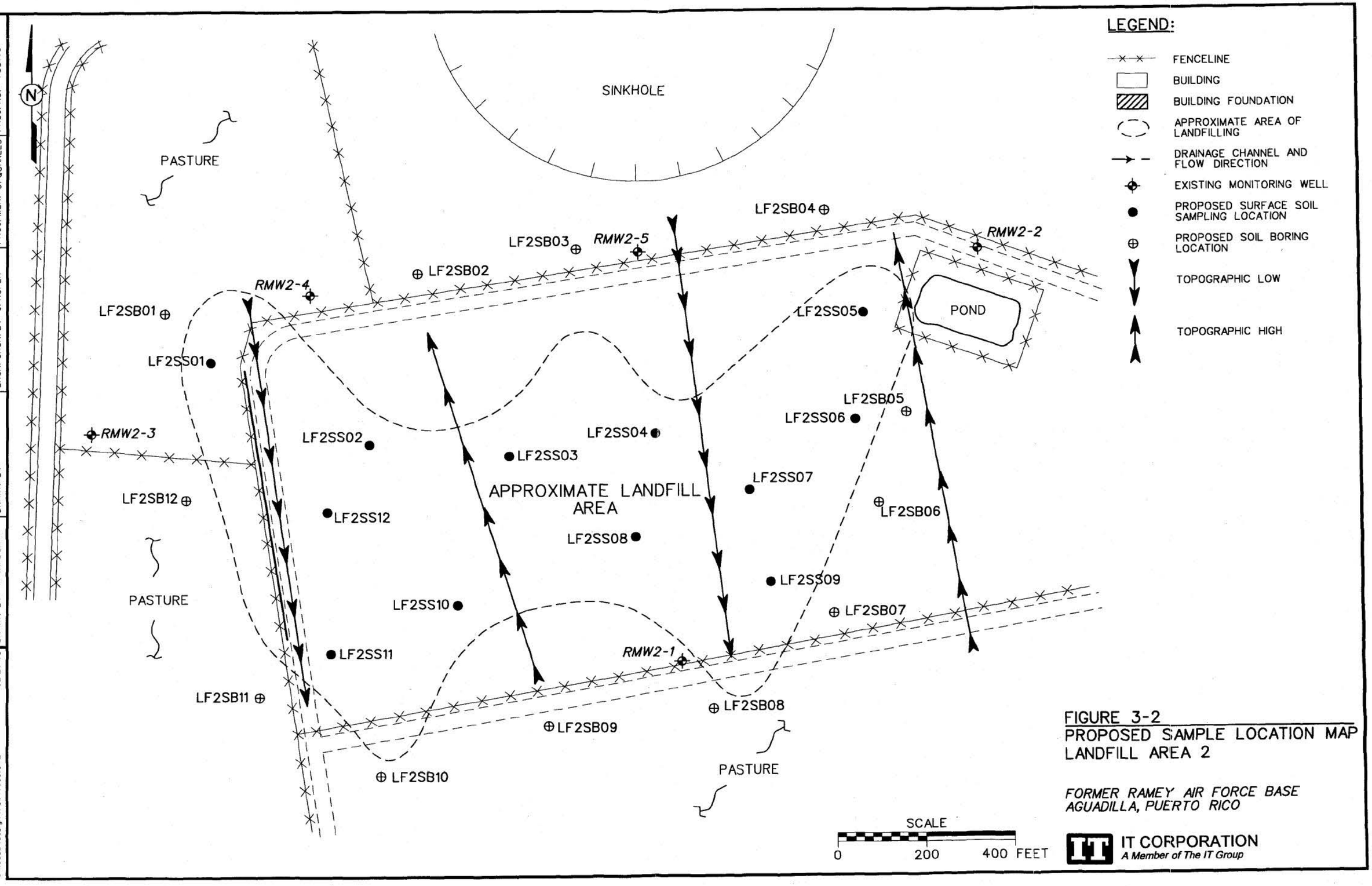
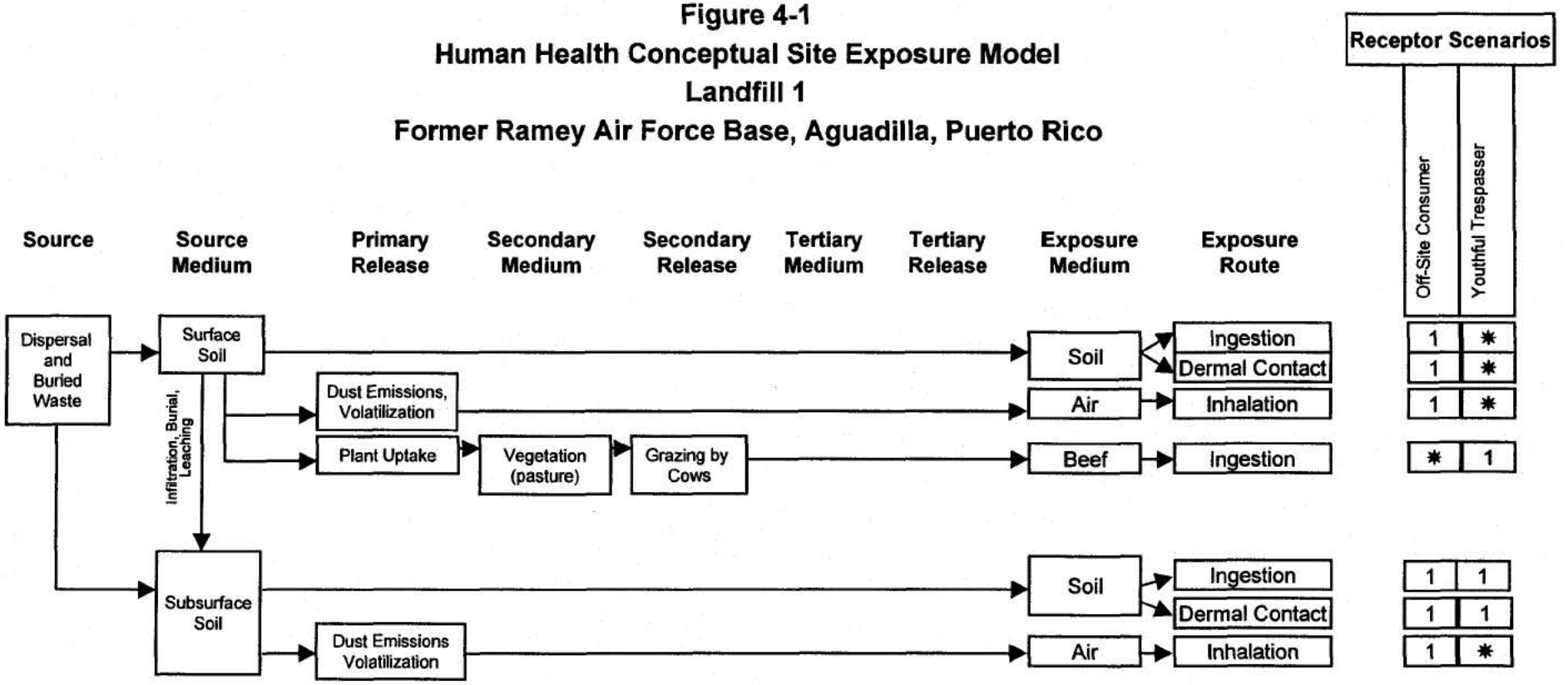



FIGURE 3-2
PROPOSED SAMPLE LOCATION MAP
LANDFILL AREA 2

*FORMER RAMEY AIR FORCE BASE*
*AGUADILLA, PUERTO RICO*

DRAFT. CHCK. BY: C. TUMLIN | INITIATOR: J. HOFER | DWG. NO.: \783146es.072
ENGR. CHCK. BY: J. HOFER | PROJ. MGR.: G. QUARLES | PROJ. NO.: 783146
STARTING DATE: 05/23/00 | DATE LAST REV.:
DRAWN BY: T. BRADSHAW | DRAWN BY:
06/20/00 02:26:40 c:\cadd\design\783146es.072 cwsmith

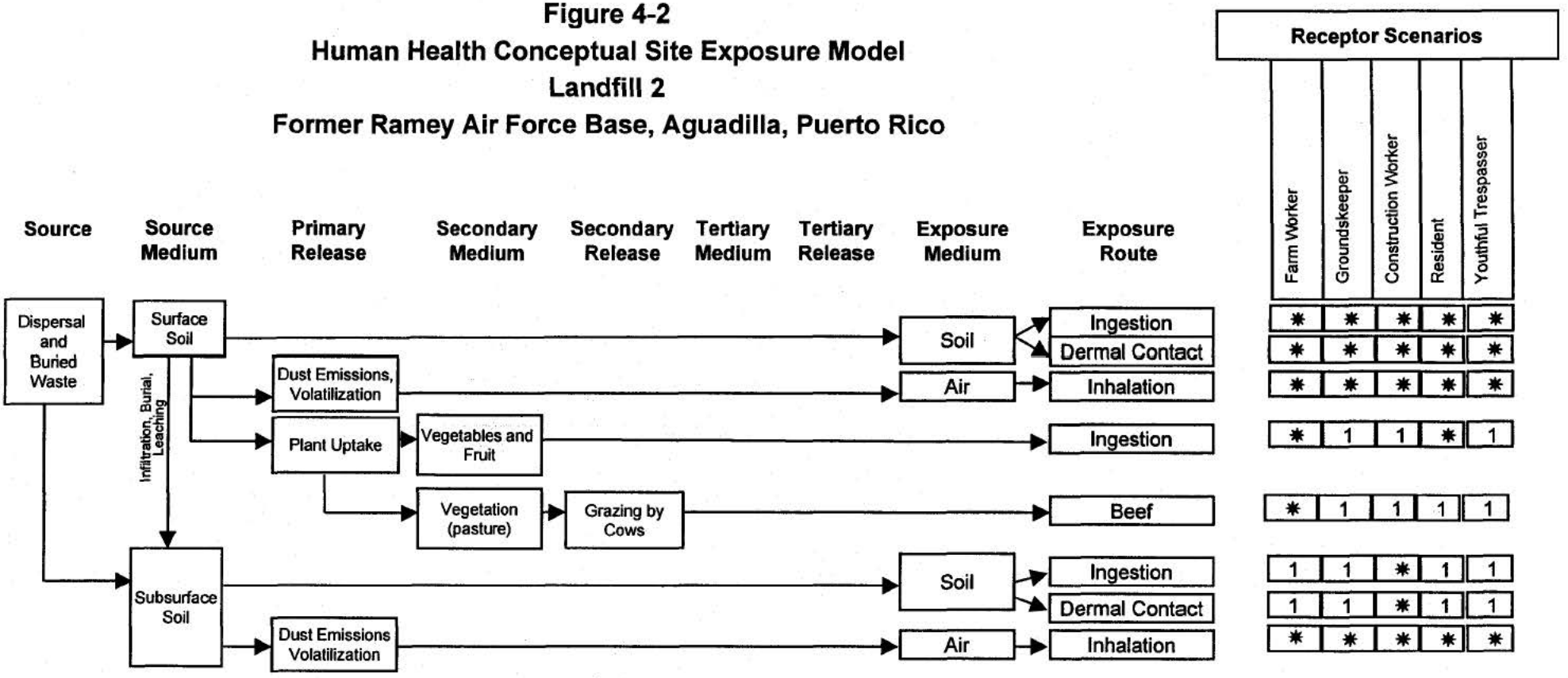
# Figure 4-1
## Human Health Conceptual Site Exposure Model
## Landfill 1
## Former Ramey Air Force Base, Aguadilla, Puerto Rico




✱ = Complete exposure pathway evaluated in the risk assessment.
1 = Incomplete exposure pathway.

KN\4735\Fig4-1&4-2\6/22/00 11:17 AM

# Figure 4-2
## Human Health Conceptual Site Exposure Model
## Landfill 2
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

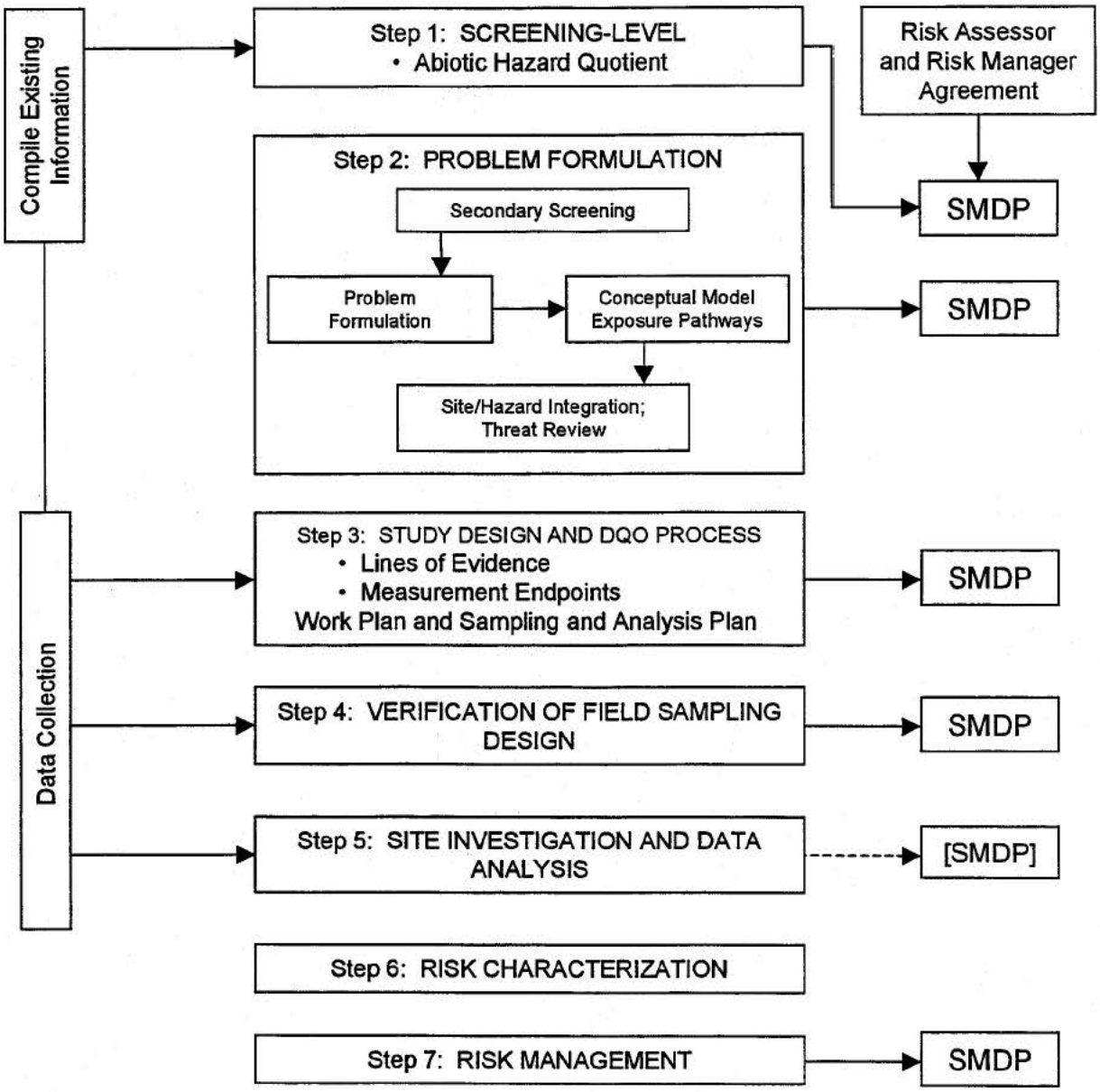



* = Complete exposure pathway evaluated in the risk assessment.
1 = Incomplete exposure pathway.

KN\4735\Fig4-1&4-2\6/22/00 11:17 AM

# Figure 5-1

## Seven-Step (Formerly Eight-Step) Ecological Risk Assessment Process for Superfund
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

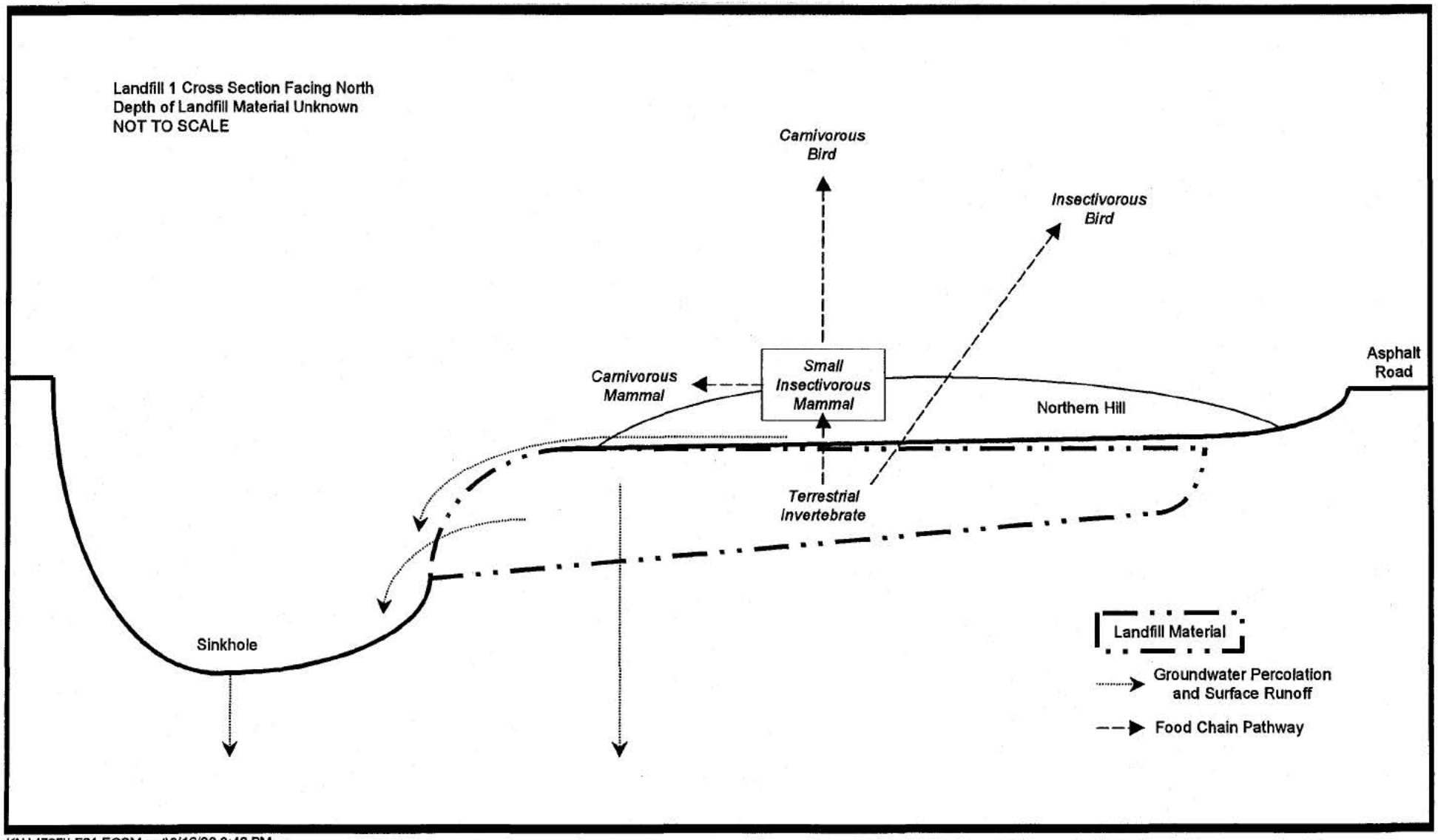



Adapted From:
U.S. Environmental Protection Agency (EPA), 1997, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final, EPA/540/R-97/006.

KN/4735/FIGURE5-1.ppt (1-10-00)2:56pm

## Figure 5-2

## Ecological Conceptual Site Model
## Landfill 1
## Former Ramey Air Force Base, Aguadilla, Puerto Rico




KN:\4735\LF01 ECSM.ppt\6/16/00 2:40 PM

## Figure 5-3

## Ecological Conceptual Site Model
## Landfill 2
## Former Ramey Air Force Base, Aguadilla, Puerto Rico

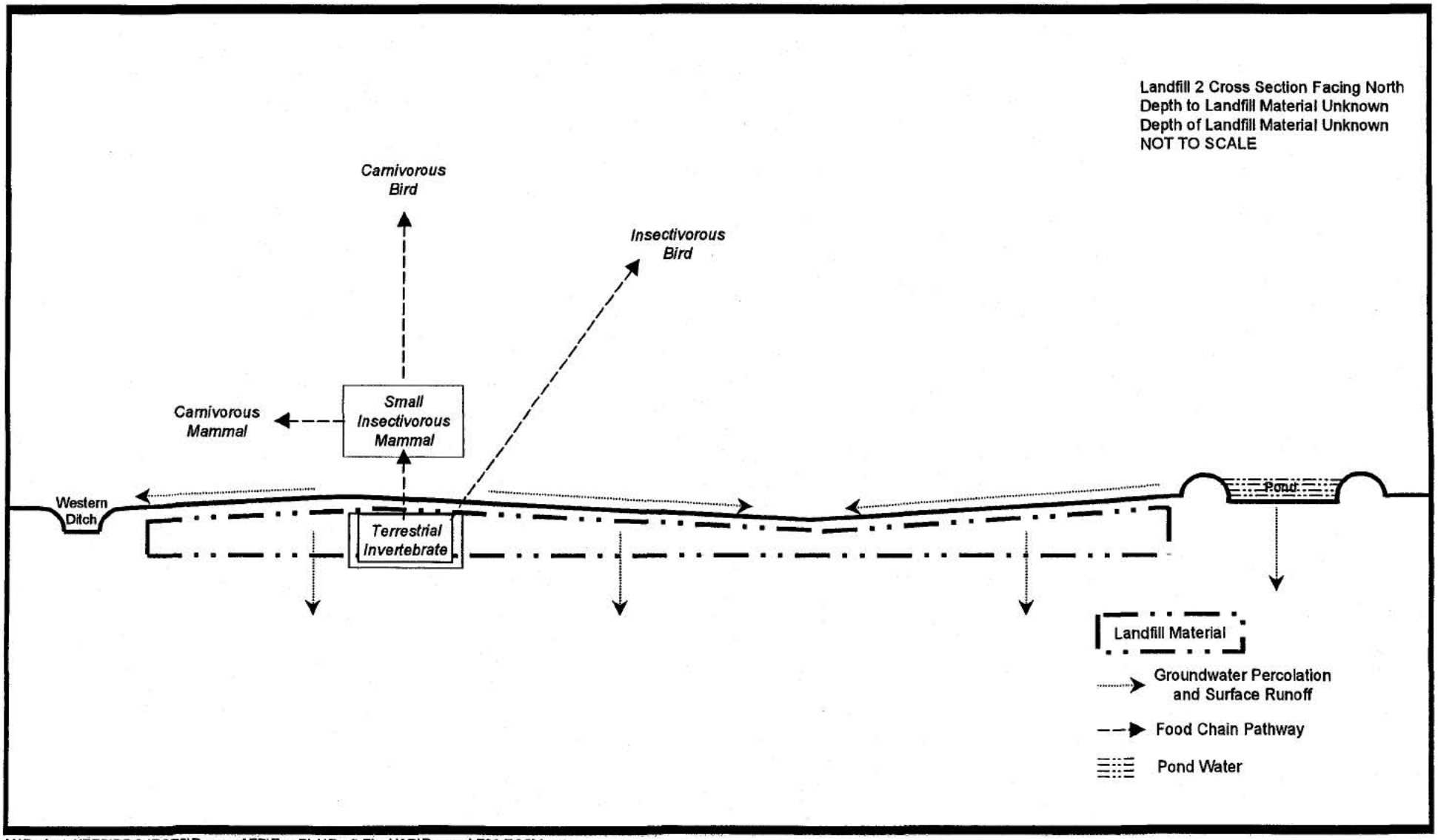



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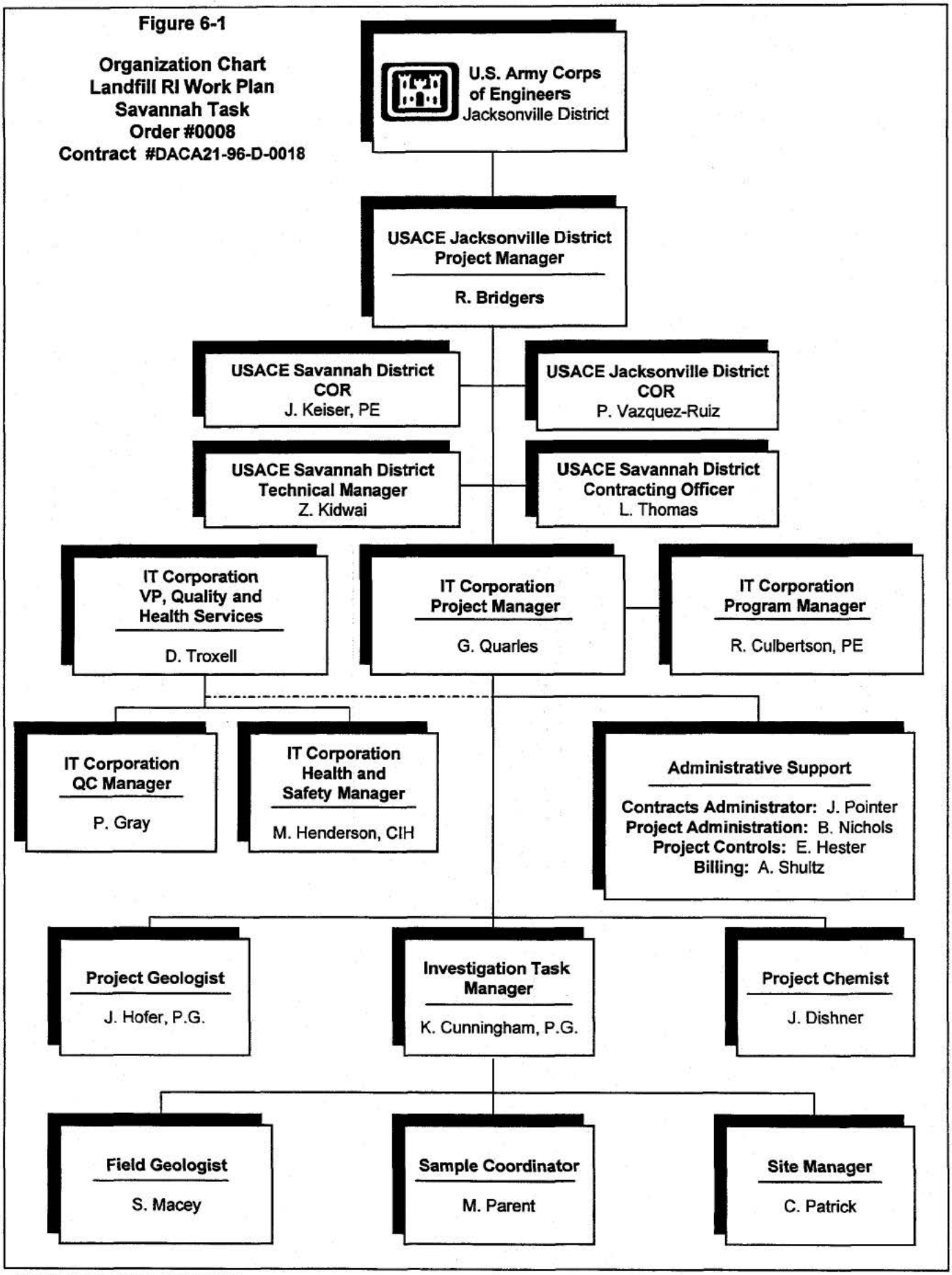
**Figure 6-1**

**Organization Chart**
**Landfill RI Work Plan**
**Savannah Task**
**Order #0008**
**Contract #DACA21-96-D-0018**




KN\4735\FIG-6-1.PPT\6-21-00(10:30AM)

| Activity ID | Early Start | Early Finish | Rem. Dur. |
|---|---|---|---|
| **WAD 3** | | | |
| *Landfill Remedial Investigation* | | | |
| 03080100 | 04OCT99A | 21AUG00 | 77* |
| 03080101 | 04OCT99A | 14JAN00A | 0 |
| 03080105 | 15JAN00A | 16FEB00A | 0 |
| 03080106 | 17FEB00A | 22JUN00 | 17 |
| 03080102 | 23JUN00 | 22JUL00 | 30 |
| 03080103 | 23JUL00 | 06AUG00 | 15 |
| 03080104 | 07AUG00 | 21AUG00 | 15 |
| 03080200 | 22AUG00 | 20OCT00 | 60 |
| 03080300 | 22AUG00 | 27NOV00 | 98 |
| 03080400 | 28NOV00 | 26JAN01 | 60 |
| 03080500 | 28NOV00 | 10JUN01 | 195* |
| 03080501 | 28NOV00 | 26JAN01 | 60 |
| 03080505 | 27JAN01 | 10FEB01 | 15 |
| 03080506 | 11FEB01 | 12MAR01 | 30 |
| 03080502 | 13MAR01 | 11APR01 | 30 |
| 03080503 | 12APR01 | 11MAY01 | 30 |
| 03080504 | 12MAY01 | 10JUN01 | 30 |
| 03080600 | 11JUN01 | 22NOV01 | 165* |
| 03080601 | 11JUN01 | 09AUG01 | 60 |
| 03080605 | 10AUG01 | 24AUG01 | 15 |
| 03080606 | 25AUG01 | 23SEP01 | 30 |
| 03080602 | 24SEP01 | 23OCT01 | 30 |
| 03080603 | 24OCT01 | 22NOV01 | 30 |

| | |
|---|---|
| Start Date | 01MAY99 |
| Finish Date | 22NOV01 |
| Data Date | 06JUN00 |
| Run Date | 21JUN00 11:36 |

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TO08

**Figure 7-1**

**Landfill Schedule**

**Ramey AFB TO #8 (783146)**



Early Bar

Progress Bar