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SITE INVESTIGATION FOR LANDFILL AREAS 1 AND 2 FORMER RAMEY AIR FORCE BASE, AGUADILLA, PUERTO RICO

FINAL - VOLUME 1

March 2001

Prepared for:

Savannah District,
United States Army Corps of Engineers

ecology and environment, inc.
International Specialists in the Environment

200.1e
I02PR087902_03.10_0001

ROUTING AND TRANSMITTAL SLIP

Date 23 March 2001

TO: (Name, office, symbol, room number, building, Agency/Post)	Initials	Date
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3. CESAJ-DP-S / HERNANDEZ		
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5.		

	Action		File		Note and Return
	Approval		For Clearance		Per Conversation
	As Requested		For Correction		Prepare Reply
	Circulate	X	For Your Information		See Me
	Comment		Investigate		Signature
	Coordination		Justify		

REMARKS

John:

Attached for your information and review is one copy of the RAMEY Final E&E Report Submittal (Final Report for Site Investigation) volumes 1 and 2. After you review, please return this copy to DP-S, Mr. Bridgers, as it is our last copy.

I have forwarded copies to the Antilles Office to be provided to EQB.

If you have any questions, please contact Robert at 3085 or me at 3420.

Thanks.

Abby Hernandez
x3420

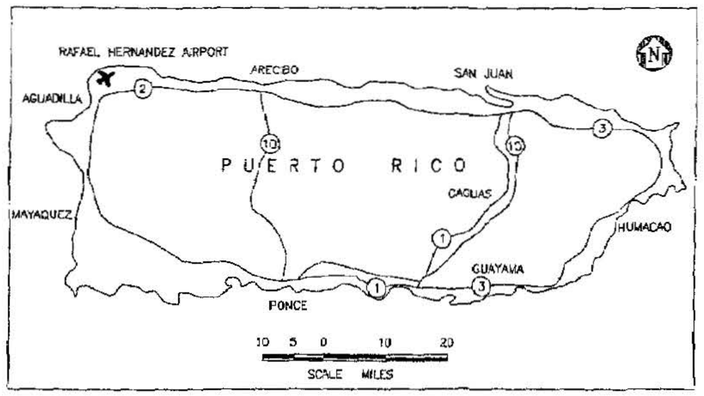
DO NOT use this form as a RECORD of approvals, concurrences, disposals, clearances, and similar actions

FROM: (Name, org-symbol, Agency/Post)	
Matt Gapinski	Room No.-Bldg 381-d
	Phone No. 1365

OPTIONAL FORM 41 (Rev. 7-76)
Prescribed by GSA
FPMR (41 CFR) 101-11.206

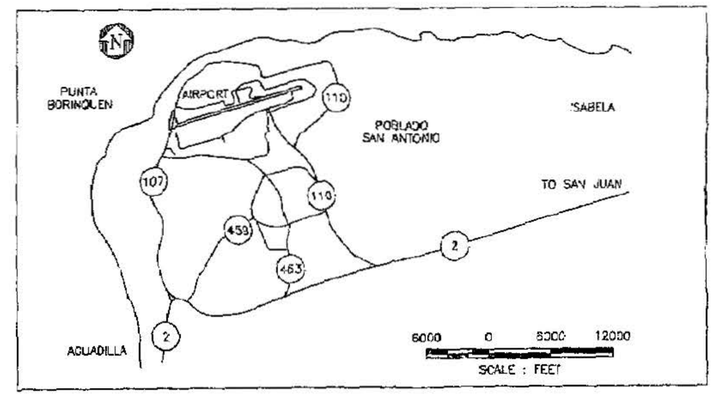
SAFETY ON THIS JOB DEPENDS ON YOU

REVISIONS					
NO	SYM	ZONE	DESCRIPTION	DATE	APPROVED



LOCATION MAP

INDEX OF SHEETS		
SHEET NO.	DRAWING NO.	SHEET TITLE
SHEET 1 OF 7	JD4S001F.DWG	TITLE SHEET
SHEET 2 OF 7	JD4S002F.DWG	SITE LOCATION MAP
SHEET 3 OF 7	JD4S003F.DWG	PIPELINE ABANDONMENT DETAILS
SHEET 4 OF 7	JD4D004F.DWG	VALVE PIT DETAILS
SHEET 5 OF 7	JD4D005F.DWG	MISCELLANEOUS FACILITIES DETAILS
SHEET 6 OF 7	JD4D006F.DWG	UNIVERSITY AREA, PUBLIC WORKS AREA, AND TANK FARM 2 UNDERGROUND STORAGE TANK DETAILS
SHEET 7 OF 7	JD4D007F.DWG	PUBLIC WORKS AREA AND DEFUELING PUMP PIT No. 3 UNDERGROUND STORAGE TANK DETAILS



VICINITY MAP

FORMER RAMEY AIR FORCE BASE FACILITY ABANDONMENT AND DISPOSAL AGUADILLA, PUERTO RICO

ADVANCE COPY
TECHNICAL REVIEW ONLY
SUBJECT TO REVISION. NOT TO BE USED FOR CONSTRUCTION PURPOSES.

This project was designed by the Jacksonville District of the U.S. Army Corps of Engineers. The initials or signatures and registration designations of individuals appear on these project documents within the scope of their employment as required by ER 1110-1-8152

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DEFENSE ENVIRONMENTAL RESTORATION PROGRAM
FORMERLY USED DEFENSE SITES (DERP-FUDS)
FORMER RAMEY AIR FORCE BASE
FACILITY ABANDONMENT AND DISPOSAL
AGUADILLA, PUERTO RICO
TITLE SHEET

DESIGN ENGL. KB
DWN. JMT CHKD. CL
CONTRACT NO.
DATED:
SIZE F
DRAWING NO. 1
SCALE: AS SHOWN DATED 05/18/98 SHEET 1 OF 7

SAFETY ON THIS JOB DEPENDS ON YOU

REVISIONS					
NO.	SYM.	ZONE	DESCRIPTION	DATE	APPROVED

ATLANTIC OCEAN

UNIVERSITY AREA

PUBLIC WORKS AREA

TANK CAR FILLING PITS

VALVE PIT No. 10

VALVE PIT No. 7

VALVE PIT No. 8

VALVE PIT No. 9

VALVE PIT No. 8A

TANK FARM No. 5

TRUCK FILL STAND 4

VALVE PIT No. 7A

TANK FARM No. 4A

VALVE PIT No. 10B

VALVE PIT No. 6A

VALVE PIT No. 26

PUMP PIT

NO GAS FILLING STATION

VALVE PIT No. 6

AQUA PIT TRAP

VALVE PIT No 21

VALVE PIT No. 22

VALVE PIT No. 16

TRUCK FILL STAND 3

VALVE PIT No 14

VALVE PIT No 15

TANK FARM 6

FENCE

GATE

VALVE PIT No 13

TANK FARM 7

TRUCK FILL STAND 2

DEFUELING PUMP PIT No. 3

TRUCK FILL STAND 1

IMMEDIATE STORAGE PUMP STATION 1060

FILTER METER PIT No.3B

IMMEDIATE STORAGE PUMP STATION 1120

VALVE PIT No. 18

FILTER METER PIT No.2A

FILTER METER PIT No.3A

FILTER METER PIT No.2B

FILTER METER PIT No. 3C

FILTER METER PIT No. 3D

FILTER METER PIT No. 2D

FILTER METER PIT No. 2C

FILTER METER PIT No 1B

VALVE PIT No 12

VALVE PIT No. 17

DEFUELING PUMP PIT No 1

IMMEDIATE STORAGE PUMP STATION 1229

DEFUELING PUMP PIT No 2

FILTER METER PIT No.1A

FILTER METER PIT No. 1D

FILTER METER PIT No. 1C

BULK STOR. TANK No. 1214

BULK STOR. TANK No. 1215

BULK STOR. TANK No. 1213

TRANSFER PUMP STA No. 1247

AQUA SEPARATOR PIT

TRUCK FILL STAND 5

FUELS TESTING BUILDING

STORAGE TANK No 1250

STORAGE TANK No 1248

POND

VALVE PIT No. 5

TRANSFER PUMP STA No. 1211

BULK STOR. TANK No 1212

TANK FARM 1

VALVE PIT No 28

TRUCK FILL STAND 1251

TRUCK FILL STAND 1203

TANK FARM 2

VALVE PIT No. 2

VALVE PIT No 1A

VALVE PIT No 1

VALVE PIT No 3B

VALVE PIT No 3

VALVE PIT No 4

SANITARY LANDFILL

SANITARY LANDFILL

AMMO AREA ACCESS ROAD

NOTES

STAGING AREAS SHOULD BE CLOSE TO EACH WORK AREA AND ALL ACCESS ROUTES SHOULD BE CONFIRMED WITH THE PORT AUTHORITY PRIOR TO COMMENCEMENT OF WORK.

LEGEND

- TRUCK FILL STAND
- ELIGIBLE VALVE PIT
- INELIGIBLE VALVE PIT
- MISCELLANEOUS FACILITIES
- USTs
- BLIND FLANGE
- PROPOSED ACCESS ROUTE TO SITES
- PREVIOUSLY ABANDONED ELIGIBLE PIPELINE
- PREVIOUSLY ABANDONED INELIGIBLE PIPELINE
- CURRENTLY IN USE INELIGIBLE AVIATION FUEL PIPELINE
- PUERTO RICAN HAT PALMS

N

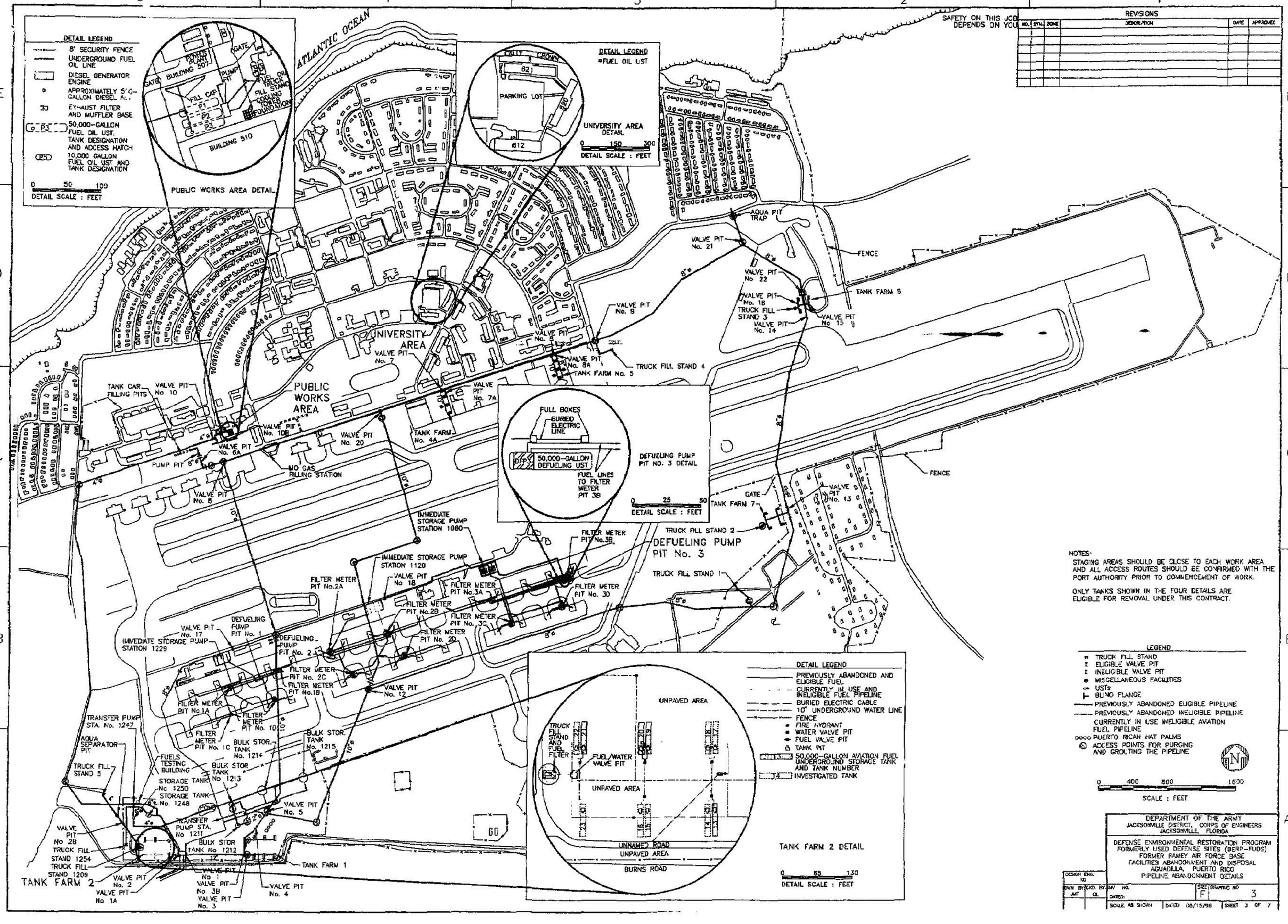
0 400 800 1600

SCALE : FEET

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DEFENSE ENVIRONMENTAL RESTORATION PROGRAM
FORMERLY USED DEFENSE SITES (DERP-FUDS)
FORMER RAMEY AIR FORCE BASE
FACILITY ABANDONMENT AND DISPOSAL
AGUADILLA, PUERTO RICO
SITE LOCATION MAP

DESIGN ENG NO
DWN BY JMT
CKD BY CL
DWNG NO.
DATE
SCALE AS SHOWN
DATED 05/15/96
SIZE F
DWGS NO. NO 2
SHEET 2 OF 7



NOTES:

STAGING AREAS SHOULD BE CLOSE TO EACH WORK AREA AND ALL ACCESS ROUTES SHOULD BE CONFIRMED WITH THE PORT AUTHORITY PRIOR TO COMMENCEMENT OF WORK.

ONLY TANKS SHOWN IN THE FOUR DETAILS ARE ELIGIBLE FOR REMOVAL UNDER THIS CONTRACT.

LEGEND

- TRUCK FILL STAND
- ELIGIBLE VALVE PIT
- INELIGIBLE VALVE PIT
- MISCELLANEOUS FACILITIES
- USTs
- BLIND FLANGE
- PREVIOUSLY ABANDONED ELIGIBLE PIPELINE
- PREVIOUSLY ABANDONED INELIGIBLE PIPELINE
- CURRENTLY IN USE INELIGIBLE AVIATION FUEL PIPELINE
- PUERTO RICAN HAT PALMS
- ACCESS POINTS FOR PURGING AND GROUTING THE PIPELINE

0 400 800 1600

SCALE : FEET

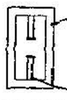
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DEFENSE ENVIRONMENTAL RESTORATION PROGRAM
FORMERLY USED DEFENSE SITES (DERP-FUDS)
FORMER RAMEY AIR FORCE BASE
FACILITIES ABANDONMENT AND DISPOSAL
AGUADILLA, PUERTO RICO
PIPELINE ABANDONMENT DETAILS

DESIGN ENG. KD
DWN BY MF CKD. BY CL
DWG. NO.
DATED:
SIZE F
DRAWING NO. 3
SCALE AS SHOWN DATED 06/15/98 SHEET 3 OF 7

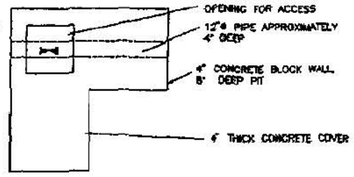
SAFETY ON THIS JOB DEPENDS ON YOU

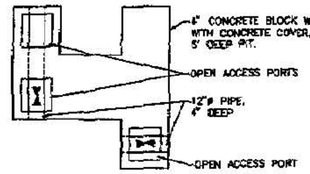
REVISIONS					
NO.	SYM.	ZONE	DESCRIPTION	DATE	APPROVED



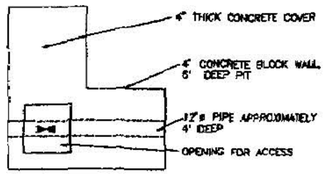
(TOP VIEW)
VALVE PIT NO. 2

(TOP VIEW)
VALVE PIT NO. 2B

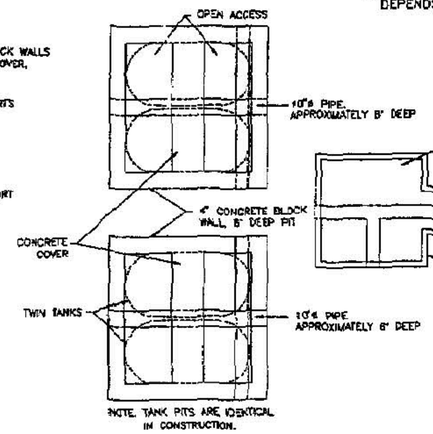


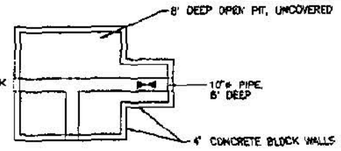


(TOP VIEW)
VALVE PIT NO. 4

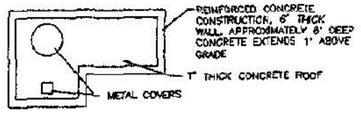


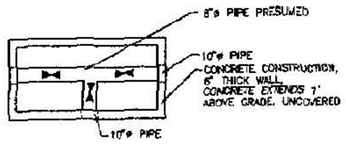
(TOP VIEW)
VALVE PITS NO 3B AND 3



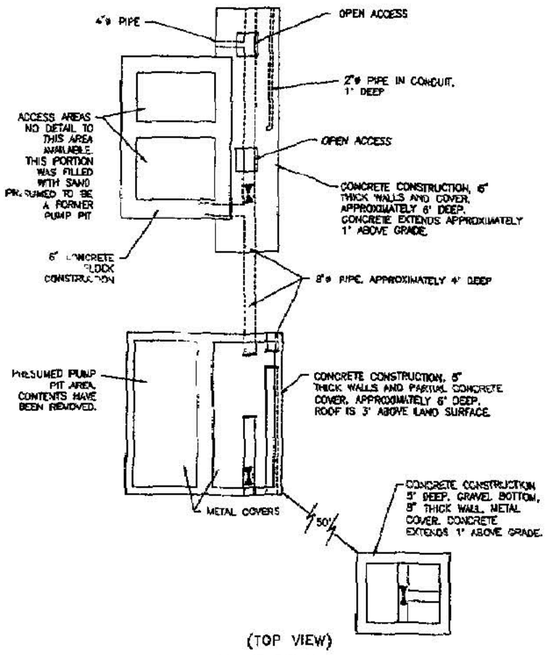


(TOP VIEW)
VALVE PIT NO 5
AND TWIN TANK PITS AREA

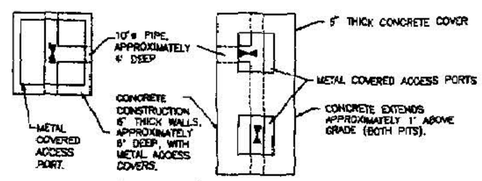




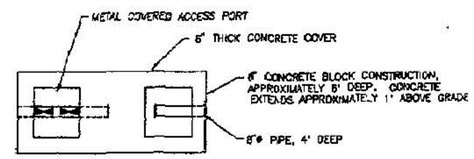
(TOP VIEW)
VALVE PIT NO. 6



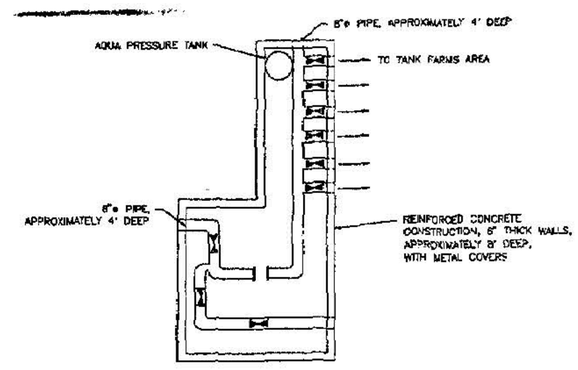
(TOP VIEW)
VALVE PIT NO. 6A
AND PUMP PIT



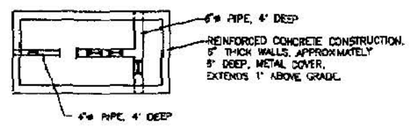
(TOP VIEW)
VALVE PIT NOS. 8 AND 8A



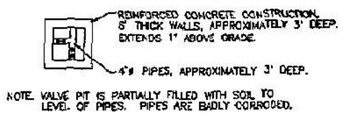
(TOP VIEW)
VALVE PIT NO. 9



(TOP VIEW)
AQUA PRESSURE SYSTEM VALVE PIT
LOCATED WEST SIDE OF TANK FARM NO. 5.

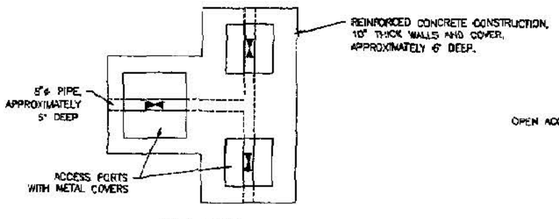


(TOP VIEW)
VALVE PIT NO 10

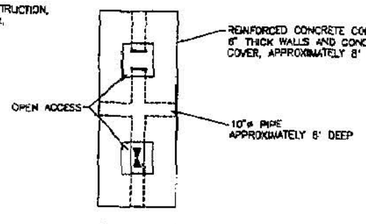


NOTE. VALVE PIT IS PARTIALLY FILLED WITH SOIL TO LEVEL OF PIPES. PIPES ARE BADLY CORRODED.

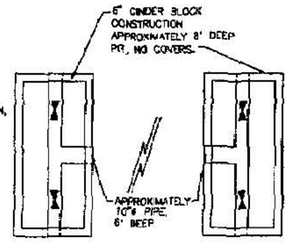
(TOP VIEW)
VALVE PIT 10B



(TOP VIEW)
VALVE PIT NO. 13
AT TANK FARM NO. 7

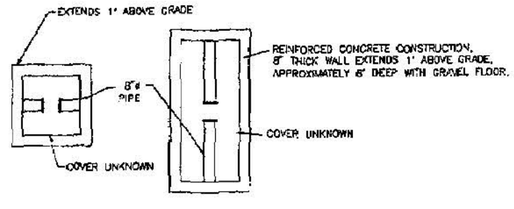


(TOP VIEW)
VALVE PIT NO. 14



(TOP VIEW)
VALVE PIT NO. 16

(TOP VIEW)
VALVE PIT NO. 15



(TOP VIEW)
TYPICAL VALVE PITS NO. 20, 21, AND 22

KEY.
VALVE
BLIND FLANGE

0 4 8 12
SCALE : FEET

NOTES:
DIMENSIONS ARE ESTIMATED BASED ON FIELD INVESTIGATION PARAMETERS

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DEFENSE ENVIRONMENTAL RESTORATION PROGRAM
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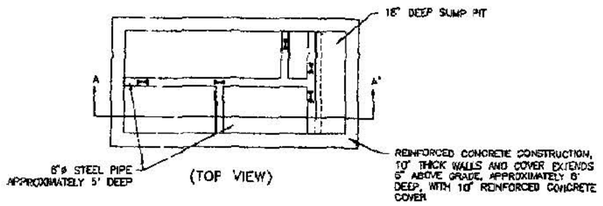
FORMER RAMEY AIR FORCE BASE
FACILITY ABANDONMENT AND DISPOSAL
AGUADILLA, PUERTO RICO
VALVE PIT DETAILS

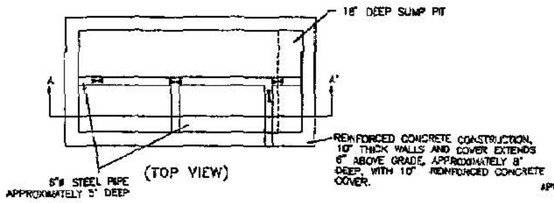
DESIGN ENG. KD
DWN BY JMT CHKD BY CL
DRAWING NO. 4

SAFETY ON THIS JOB DEPENDS ON YOU

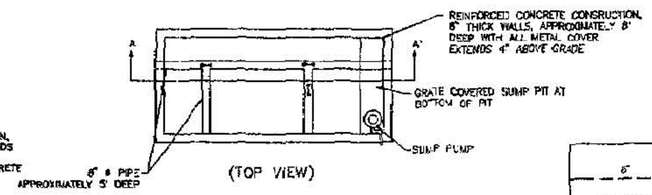
REVISIONS					
NO.	SYM.	ZONE	DESCRIPTION	DATE	APPROVED



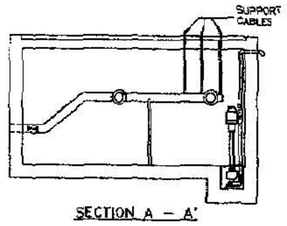
(TOP VIEW)



(TOP VIEW)

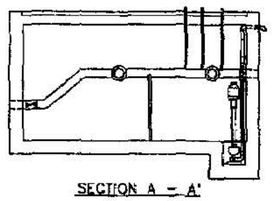


(TOP VIEW)



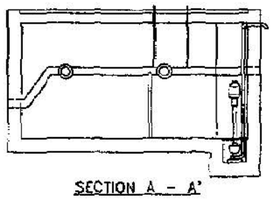
SECTION A – A'

TYPICAL FILTER METER PITS NO. 2D, 3A, AND 3B.



SECTION A – A'

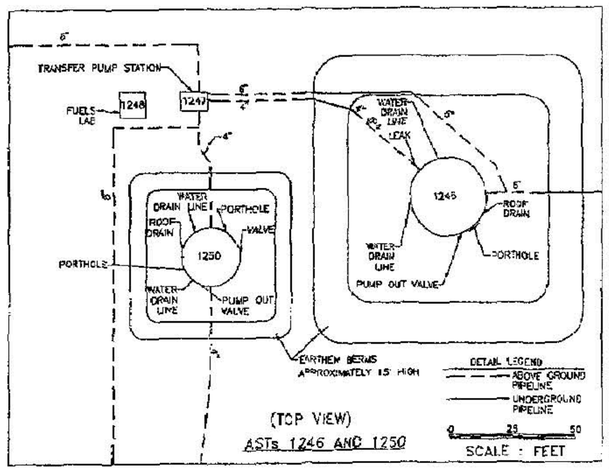
TYPICAL FILTER METER PITS NO. 2A, 2C, AND 3D



SECTION A – A'

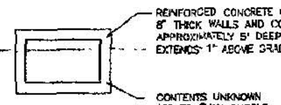
FILTER METER PIT NO. 3C

FORMER B-52 FUELING AREA



(TOP VIEW)

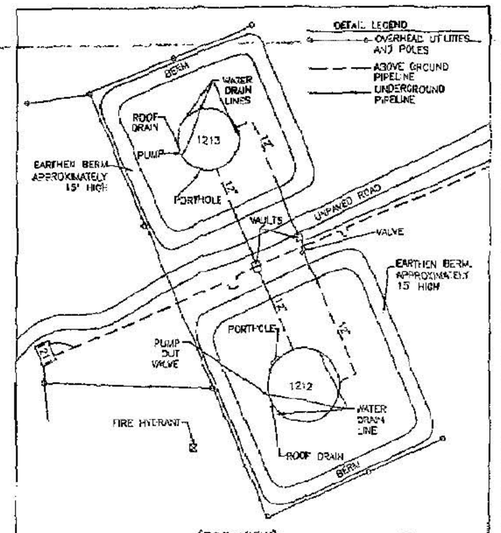
ASTs 1246 AND 1250



(TOP VIEW)

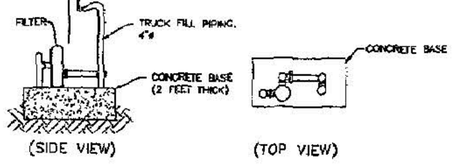
AQUA SEPARATOR PIT

(WEST OF AST 1250)



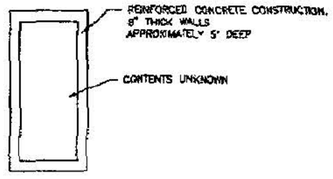
(TOP VIEW)

ASTs 1212 AND 1213



(SIDE VIEW) (TOP VIEW)

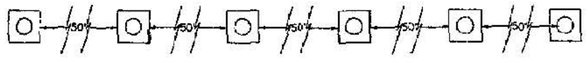
TYPICAL TRUCK FILL STANDS 1, 2, 3, 4, 5, 1254, AND PUBLIC WORKS AREA



(TOP VIEW)

AQUA TRAP PIT

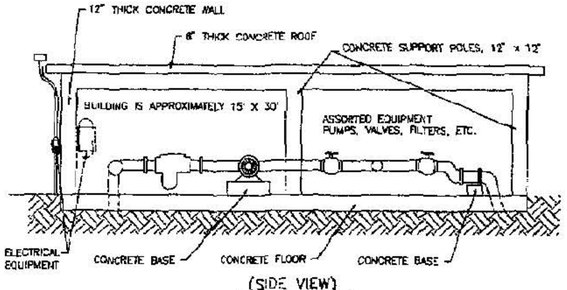
(NORTHEAST OF RUNWAY)



6 CONCRETE PITS, 6" THICK WALLS, APPROXIMATELY 5' DEEP, FLUSH MOUNTED WITH 12" DIAMETER COVER PLATES

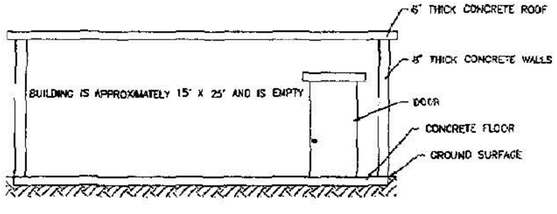
(TOP VIEW)

TANK CAR FILLING PITS



(SIDE VIEW)
(NOT TO SCALE)

TRANSFER PUMP STATION 1247



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FUELS TESTING BUILDING

NOTES

ALL DIMENSIONS ARE ESTIMATED BASED ON INVESTIGATIVE PARAMETERS

KEY

VALVE

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SCALE : FEET

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DEFENSE ENVIRONMENTAL RESTORATION PROGRAM
FORMERLY USED DEFENSE SITES (DERP-FUDS)
FORMER RANEY AIR FORCE BASE
FACILITY ABANDONMENT AND DISPOSAL
AGUADILLA, PUERTO RICO
MISCELLANEOUS FACILITIES DETAILS

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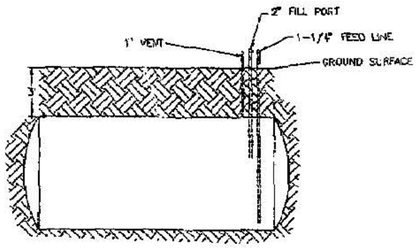

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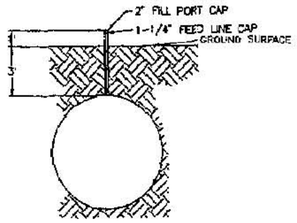
TYPICAL DETAIL OF 5,000 GALLON UNDERGROUND STORAGE TANKS IN UNIVERSITY AREA



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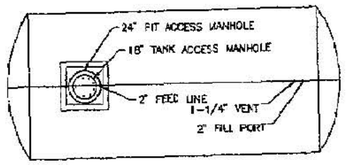

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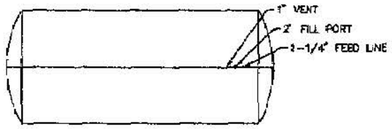
TYPICAL DETAIL OF 10,000 GALLON UNDERGROUND STORAGE TANKS IN PUBLIC WORKS AREA



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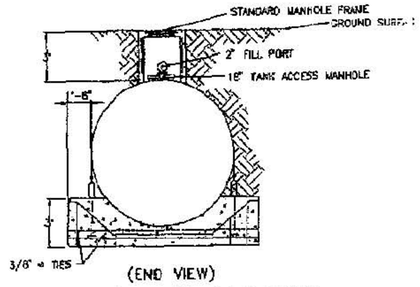
TYPICAL DETAIL OF 5,000 GALLON UNDERGROUND STORAGE TANKS IN UNIVERSITY AREA



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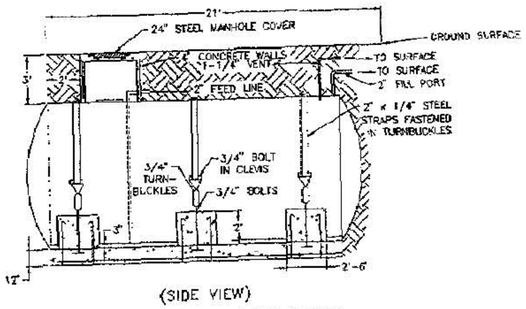

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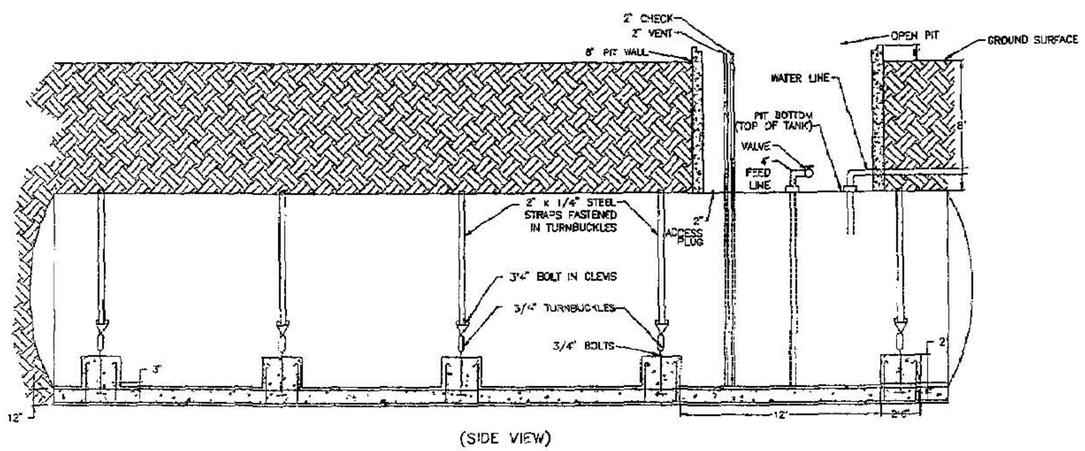
TYPICAL DETAIL OF 10,000 GALLON UNDERGROUND STORAGE TANKS IN PUBLIC WORKS AREA



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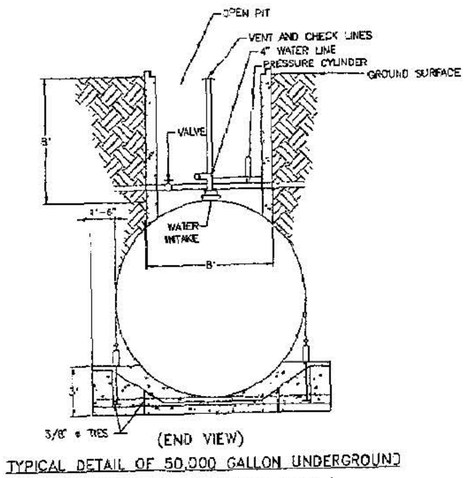
TYPICAL DETAIL OF 50,000 GALLON UNDERGROUND STORAGE TANKS IN TANK FARM 2



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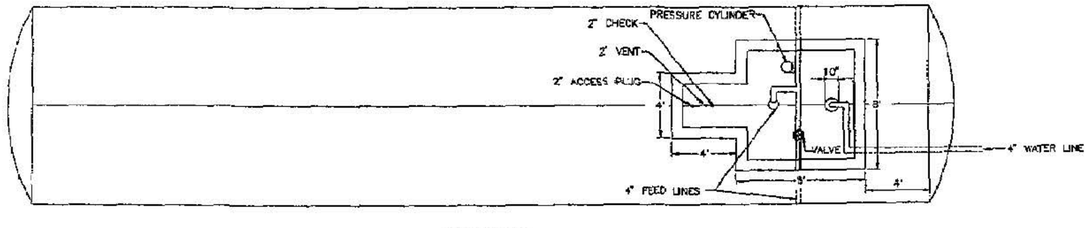

(TOP VIEW)

TYPICAL DETAIL OF 50,000 GALLON UNDERGROUND STORAGE TANKS IN TANK FARM 2

NOTES

ALL DIMENSIONS ARE ESTIMATED BASED ON INVESTIGATIVE PARAMETERS

0 4 8 12

SCALE : FEET

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DEFENSE ENVIRONMENTAL RESTORATION PROGRAM
FORMERLY USED DEFENSE SITES (DERP-FUDS)
FORMER RAMEY AIR FORCE BASE
FACILITY ABANDONMENT AND DISPOSAL
AGUADILLA, PUERTO RICO
UNIVERSITY AREA, PUBLIC WORKS AREA, AND TANK FARM 2 UNDERGROUND STORAGE TANK DETAILS

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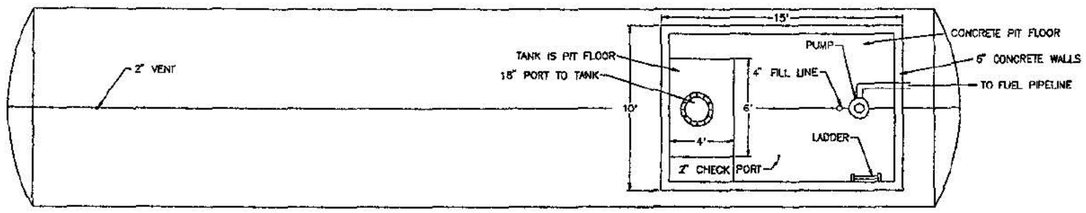
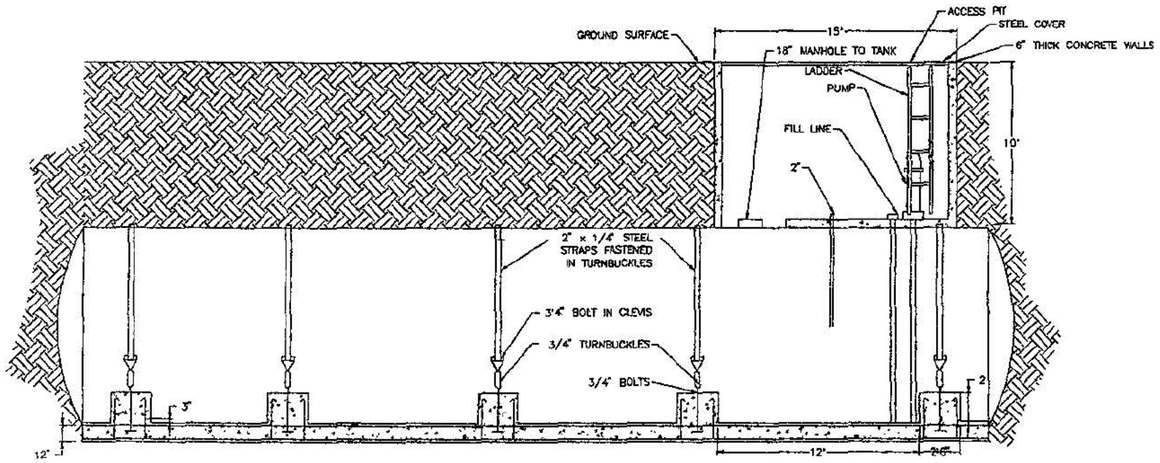


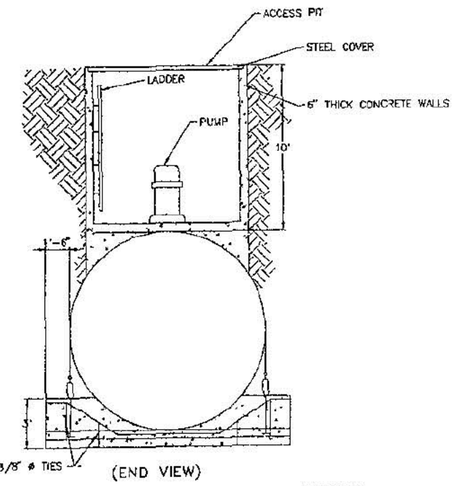
(TOP VIEW)

TYPICAL DETAIL OF 50,000 GALLON UNDERGROUND STORAGE TANKS IN DEFUELING PUMP PIT No. 3



(SIDE VIEW)

TYPICAL DETAIL OF 50,000 GALLON UNDERGROUND STORAGE TANKS AT DEFUELING PUMP PIT No. 3



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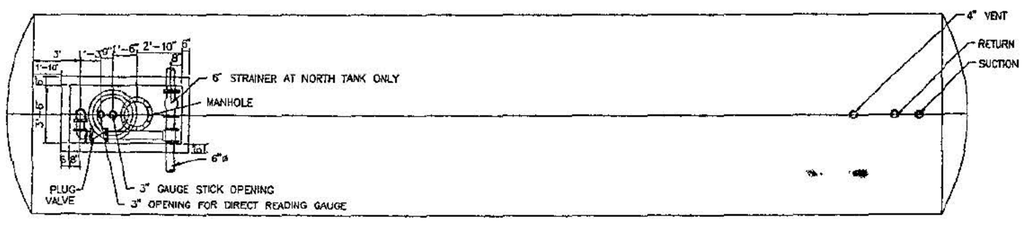
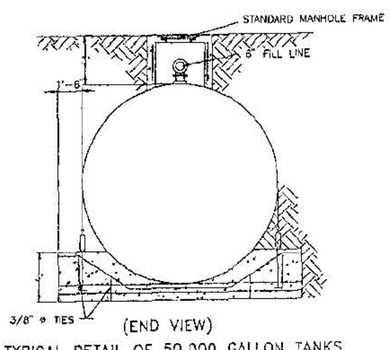


(TOP VIEW)

TYPICAL DETAIL OF 50,000 GALLON UNDERGROUND STORAGE TANKS IN PUBLIC WORKS AREA



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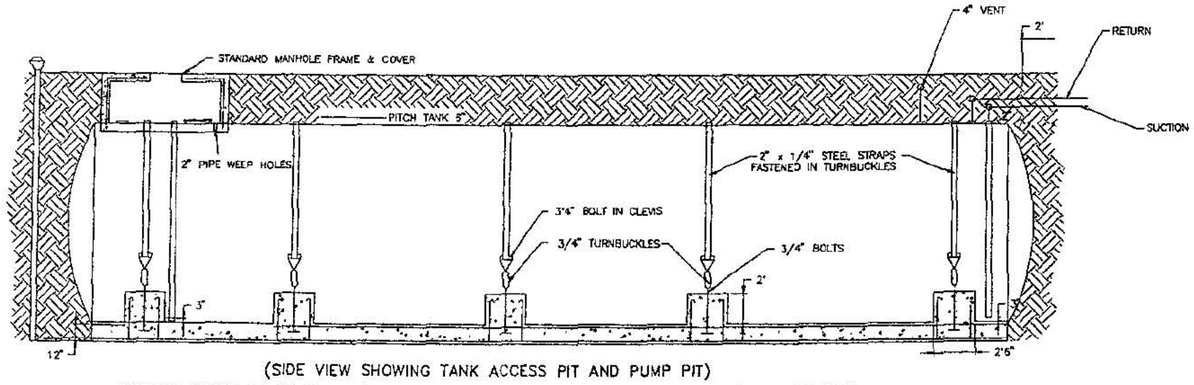
TYPICAL DETAIL OF 50,000 GALLON TANKS UNDERGROUND STORAGE TANKS IN PUBLIC WORKS AREA



(SIDE VIEW SHOWING TANK ACCESS PIT AND PUMP PIT)

TYPICAL DETAIL OF 50,000 GALLON UNDERGROUND STORAGE TANKS IN PUBLIC WORKS AREA

NOTES

ALL DIMENSIONS ARE ESTIMATED BASED ON INVESTIGATIVE PARAMETERS

0 4 8 12

SCALE . FEET

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE FLORIDA

DEFENSE ENVIRONMENTAL RESTORATION PROGRAM
FORMERLY USED DEFENSE SITES (DERP-FUDS)
FORMER RAMEY AIR FORCE BASE
FACILITY ABANDONMENT AND DISPOSAL
AGUADILLA, PUERTO RICO
PUBLIC WORKS AREA AND DEFUELING PUMP PIT
PIT No 3 UNDERGROUND STORAGE TANK DETAILS

DESIGN ENG NO			
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		SCALE AS SHOWN	DATED 05/15/96
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FINAL

Site Investigation Report For Landfill Areas 1 and 2 Former Ramey Air Force Base Aguadilla, Puerto Rico

Contract Number: DACA21-93-D-0034
Delivery Order Number 0020

Volume 1

March 2001

Prepared for:

DEPARTMENT OF THE ARMY
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Table of Contents

Section		Page
	Executive Summary	1
1	Introduction	1-1
2	Site Background and Setting	2-1
	2.1 Description and History	2-1
	2.1.1 Former Ramey Air Force Base	2-1
	2.2 Regional Geology/Hydrogeology	2-4
	2.2.1 Hydrogeology	2-4
	2.2.2 Aquifer Description	2-4
	2.2.3 Aquifer Characteristics	2-5
	2.2.4 Aquifer Use	2-5
3	Investigation Methodology	3-1
	3.1 Geophysical Survey	3-1
	3.2 Soil Sampling	3-1
	3.3 Monitoring Well Installation, Construction, and Development	3-3
	3.4 Groundwater, Surface Water, and Sediment Sampling	3-4
	3.5 Sample Numbering System	3-5
	3.6 Data Validation and Evaluation	3-5
	3.7 Surveying of Sample Locations	3-5
	3.8 Water Level Measurements	3-6
	3.9 Decontamination and Investigation-Derived Waste (IDW)	3-6
4	Results of Investigation	4-1
	4.1 Geophysical Survey	4-1
	4.2 Site Geology/Hydrogeology	4-2
	4.3 Laboratory Analytical Results	4-3
	4.3.1 Surface Soil Results	4-3
	4.3.2 Subsurface Soil Results	4-5
	4.3.3 Groundwater Results	4-7
	4.3.4 Surface Water/Sediment Results	4-10
	4.3.5 Quality Assurance/Quality Control and Data Validation Results	4-11
	4.4 Pathway Evaluation	4-11
	4.5 Discussion of Results	4-12
5	Conclusions and Recommendations	5-1

Table of Contents (Cont.)

Section **Page**

6 References 6-1

7 Puerto Rico Registered Professional Engineer Certification 7-1

Appendix

A Photographic Log A-1

B USACE Memorandum B-1

C Drilling Logs and Well Construction Diagrams C-1

D Well Development Records D-1

E Quality Control Summary Reports E-1

F Investigation Derived Waste Summary F-1

G Analytical Data G-1

List of Tables

Table		Page
3-1	Laboratory Analytical Sample Designations Former Ramey Air Force Base, Aguadilla, Puerto Rico	3-7
3-2	Sample Analytical Summary Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico	3-14
3-3	Sample Analytical Summary Landfill Area 2, Former Ramey Air Force Base, Aquadilla, Puerto Rico	3-16
4-1	Monitoring Well Construction and Groundwater Elevation Data, Landfill Areas 1 and 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico, July 1997 and December 1998	4-15
4-2	Surface Soil Analytical Results - Inorganics Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico, June 1997	4-17
4-3	Surface Soil Analytical Results - Organics Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico, June 1997	4-19
4-4	Surface Soil Analytical Results - Inorganics Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico, June 1997	4-20
4-5	Surface Soil Analytical Results - Organics Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico, June 1997	4-22
4-6	Subsurface Soil Analytical Results - Inorganics Monitoring Well RMW1-1, Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico, June 1997	4-23

List of Tables (Cont.)

Table **Page**

4-7 Subsurface Soil Analytical Results - Organics
Monitoring Well RMW1-1,
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-25

4-8 Subsurface Soil Analytical Results - Inorganics
Monitoring Well RMW1-4,
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-26

4-9 Subsurface Soil Analytical Results - Organics
Monitoring Well RMW1-4,
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-28

4-10 Subsurface Soil Analytical Results - Inorganics
Monitoring Well RMW2-1,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-29

4-11 Subsurface Soil Analytical Results - Organics
Monitoring Well RMW2-1,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-32

4-12 Subsurface Soil Analytical Results - Inorganics
Monitoring Well RMW2-2,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-34

4-13 Subsurface Soil Analytical Results - Organics
Monitoring Well RMW2-2,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-37

4-14 Subsurface Soil Analytical Results - Inorganics
Monitoring Well RMW2-3,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-39

4-15 Subsurface Soil Analytical Results - Organics
Monitoring Well RMW2-3,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-41

List of Tables (Cont.)

Table **Page**

4-16 Subsurface Soil Analytical Results - Inorganics
Monitoring Well RMW2-4,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-42

4-17 Subsurface Soil Analytical Results - Organics
Monitoring Well RMW2-4,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-44

4-18 Subsurface Soil Analytical Results - Inorganics
Monitoring Well RMW2-5,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-45

4-19 Subsurface Soil Analytical Results - Organics
Monitoring Well RMW2-5,
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-47

4-20 Groundwater Analytical Results - Inorganics
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-48

4-21 Groundwater Analytical Results - Organics
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-50

4-22 Groundwater Analytical Results - Inorganics
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-52

4-23 Groundwater Analytical Results - Organics
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-54

4-24 Surface Water Analytical Results - Inorganics
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-56

4-25 Surface Water Analytical Results - Organics
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-57

List of Tables (Cont.)

Table **Page**

4-26 Sediment Analytical Results - Inorganics
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-58

4-27 Sediment Analytical Results - Organics
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-60

4-28 Groundwater Analytical Results - Inorganics
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, December 1998 4-62

4-29 Groundwater Analytical Results - Organics
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, December 1998 4-64

4-30 Groundwater Analytical Results - Inorganics
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, December 1998 4-66

4-31 Groundwater Analytical Results - Organics
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, December 1998 4-68

4-32 Trip Blank and Rinsate Blank Analytical Results
Landfill Areas 1 and 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, June 1997 4-70

4-33 Trip Blank and Rinsate Blank Analytical Results
Landfill Areas 1 and 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico, December 1998 4-71

F-1 Investigation Derived Wastes
Landfill Area 1, Former Ramey Air Force Base,
Aguadilla, Puerto Rico F-3

F-2 Investigation Derived Wastes
Landfill Area 2, Former Ramey Air Force Base,
Aguadilla, Puerto Rico F-4

List of Illustrations

Figure		Page
2-1	Former Ramey Air Force Base, Aguadilla, Puerto Rico	2-7
2-2	Landill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico	2-8
2-3	Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico	2-9
3-1	Sample Locations Map, Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico	3-18
3-2	Sample Location Map, Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico	3-19
4-1	Geophysical Grid Overlay Map, Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico	4-72
4-2	Geophysical Grid Location Map, Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico	4-73
4-3	Average Terrain Conductivity Map, Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico	4-74
4-4	Geologic Cross Section A-A', (SW to NE) Landfill Areas 1 and 2 Former Ramey Air Force Base, Aguadilla, Puerto Rico	4-75
4-5	Geologic Cross Section B-B' (NW to SE) Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico	4-76
4-6	Geologic Cross Section C-C' (N to S) Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico	4-77
4-7	Groundwater Elevation Isopleth Map, Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico	4-78

List of Illustrations (Cont.)

Figure **Page**

4-8 Groundwater Elevation Isopleth Map, Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico 4-79

4-9 Surface Soil Sample Locations Exceeding Residential RBCs and/or SSLs Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico 4-80

4-10 Surface Soil Sample Locations Exceeding Residential RBCs and/or SSLs Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico 4-81

4-11 Subsurface Soil Sample Locations Exceeding Industrial RBCs and/or SSLs Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico 4-82

4-12 Subsurface Soil Sample Locations Exceeding Industrial RBCs and/or SSLs Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico 4-83

4-13 Exceedances of Regulatory Standards/Guidances 1998 Groundwater Sample Results, Landfill Area 1, Former Ramey Air Force Base, Aguadilla, Puerto Rico 4-84

4-14 Exceedances of Regulatory Standards/Guidance 1998 Groundwater Sample Results, Landfill Area 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico 4-85

List of Acronyms

AFB	Air Force Base
ASC	Analytical Services Center
BGS	Below Ground Surface
BN	Base/Neutral Extractable Organic Compound
CDAP	Chemical Data Acquisition Plan
DAF	Dilution Attenuation Factor
DOD	Department of Defense
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
EQB	Environmental Quality Board
GDAP	Geologic Data Acquisition Plan
IDW	Investigation-Derived Waste
MCL	Maximum Contaminant Level
mg/kg	Milligrams per Kilogram
μg/L	Micrograms per Liter
NGVD	National Geodetic Vertical Datum
OVA	Organic Vapor Analyzer
PCB	Polychlorinated Biphenyl
PRASA	Puerto Rico Aqueduct and Sewer Authority
PRWQS	Puerto Rico Water Quality Standards
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
QCSR	Quality Control Summary Report
RBC	Risk-Based Concentration
SADL	South Atlantic Division Laboratory
SI	Site Investigation
SSL	Soil Screening Level
TAL	Target Analyte List
TCE	Trichloroethylene
TOC	Top of Casing
TOV	Total Organic Vapor
TPH	Total Petroleum Hydrocarbon
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VOC	Volatile Organic Compound

Executive Summary

The former Ramey Air Force Base (AFB) occupies approximately 4,357 acres north of the city of Aguadilla, on the extreme northwestern tip of the island of Puerto Rico. The United States government acquired the property between 1939 and 1963 and used the site as a fully operational Air Force base until its deactivation in 1973. Except for approximately 125 acres that are still used by the United States Government as a United States Coast Guard installation, this area is now operated by the Puerto Rico Port Authority as a municipal airport and as an industrial park, and portions of the property are leased to local farmers for agricultural purposes and cattle grazing.

Landfill Area 1 is comprised of an approximately 18-acre area located south of the municipal airport runway complex. During the period that the Department of Defense (DOD) maintained operations at the former Ramey AFB, landfilling activities appear to have been conducted across an approximately 6-acre portion of the site. The Landfill Area 1 site area is currently leased by the Port Authority to a local farmer, who uses the site (including the former landfill) to graze cattle. Landfill Area 2 is comprised of an approximately 65-acre area east of Landfill Area 1. During DOD operation of the former Ramey AFB, landfilling activities appear to have been conducted across an approximately 20-acre portion of the site. The Landfill Area 2 site area is also currently leased by the Port Authority to a local farmer who uses the site (including the former landfill) to graze cattle and grow agricultural crops.

Ecology and Environment, Inc., (E & E) completed a Site Investigation (SI) at Landfill Areas 1 and 2 for the United States Army Corps of Engineers (USACE), Savannah District, under Contract Number DACA21-93-D-0034, Delivery Order Number 0020. The purpose of the investigation was to identify the presence of soil, sediment, surface water, or groundwater contamination at the sites that is attributable to DOD landfilling activities. This SI report summarizes the results of the investigation activities which were conducted from April 16 to July 14, 1997.

Site features at Landfill Area 1 include a sinkhole approximately 5 acres in area and up to 35 feet deep; a 30-foot high, 3-acre hill northeast of the sinkhole; and a broad, fenced area of high grass and trees. An aircraft apron currently used to store inoperable and scrap aircraft, is located north of the site. Topographic relief in the immediate vicinity of the former landfill is approximately 70 feet

and generally slopes toward the sinkhole. Evidence that a portion of the site was used as a landfill includes abundant construction debris and scrap metal observed inside the sinkhole. Various medical wastes have also been observed inside the sinkhole, including intravenous bags and tubing, latex surgical gloves, and syringes. Medical wastes appear to have been contained in fabric bags buried in the landfill with other debris. Following storm events, runoff from the southern portion of the municipal airport runway complex and industrial park flows into the sinkhole through several drainage channels. One of these drainage channels is eroding landfill material from the landfill. Ponding inside the sinkhole can be up to 12 feet deep and last for one week or more following a storm event.

Site features at Landfill Area 2 include several concrete building foundations, a recently-constructed watering pond for cattle, and a shallow drainage ditch running along the western margin of the site. The concrete building foundations are overgrown and appear to be of an age and design consistent with former DOD activity at the former Ramey AFB. The site vicinity is generally flat-lying, grass-covered, and sectioned with barb-wire fencing to prevent cattle from disturbing crops. It appears that the tenant farmer periodically rotates cattle-grazing and agricultural cultivation areas. It is reported that the landfilled portion of the site received municipal, household garbage from a former adjacent Air Force housing development called "Tropical Acres." Evidence that a portion of the site was used as a landfill includes garbage and debris observed in the eroded sides of the northern portion of the drainage ditch.

During the field investigation, E & E installed four monitoring wells at Landfill Area 1 and five monitoring wells at Landfill Area 2. Soil samples were collected from the monitoring well boreholes, and groundwater samples were collected from the nine monitoring wells. In addition, one surface water and one sediment sample were collected from the sinkhole at Landfill Area 1 shortly following a storm event. All of the samples were sent to E & E's Analytical Services Center (ASC) for chemical analysis.

Analytes detected in samples collected at the site were compared to United States Environmental Protection Agency (EPA) Region 3 Risk-Based Concentrations (RBCs) for industrial and residential soils, EPA Generic Soil Screening Levels (SSLs), Puerto Rico Water Quality Standards (PRWQS) for surface water and groundwater, EPA RBCs for tapwater, and EPA Maximum Contaminant Levels (MCLs) for drinking water. A limited number of constituents, including several metals, a few base/neutral extractable organic compounds (BNs), and one volatile organic compound (VOC), exceeded the regulatory standards or guidance levels in surface soils, sediment, subsurface soils, and/or groundwater. Analytes detected in surface soil, subsurface soils, and groundwater may not be attributable to former DOD landfilling activities at Landfill Areas 1 and

2. Analytes detected in the sediment sample may or may not be attributable to former DOD landfilling activities. However, further assessment is needed to determine whether the constituents present are reflective of site contamination, are representative of background levels, or are from non-DOD sources of contamination.

E & E recommends the collection of background surface and subsurface soil samples, the collection of filtered groundwater samples from three of the existing wells at Landfill Area 2, and the collection of groundwater samples from the U.S. Customs office well located near the landfill areas. A risk assessment may also be required if it is determined that the detected constituents are site related contaminants. E & E also recommends that the landfills be stabilized (at a minimum), and engineered erosional controls be established to prevent the further exposure of landfill material.

1 Introduction

This Site Investigation (SI) Report for Landfill Areas 1 and 2 at the former Ramey Air Force Base (AFB) in Aguadilla, Puerto Rico, was prepared by Ecology and Environment, Inc., (E & E) for the Department of the Army, Savannah District, United States Army Corps of Engineers (USACE), under Contract Number DACA21-93-D-0034, Delivery Order Number 0020. This report presents the results of the assessment fieldwork performed by E & E and its subcontractors between March 24 and July 14, 1997 and December 9, 1998 to December 18, 1998, in accordance with the SI Work Plan prepared by E & E and approved by the USACE in February 1997 (E & E 1997a). Due to site conditions, fieldwork was completed with some USACE-approved deviations from the project work plan. Deviations from the work plan are discussed in Section 3.

The purpose of the SI at Landfill Areas 1 and 2 was to identify the presence of soil, sediment, surface water, and/or groundwater contamination that may be attributed to former Department of Defense (DOD) activities at these locations. Laboratory analytical results for samples collected at both landfills indicate a few analytes are present in soil, sediment, and groundwater in exceedance of regulatory guidance. The SI was conducted in accordance with all applicable USACE, federal, Commonwealth of Puerto Rico, and local regulations and guidelines.

Appendix A presents a photographic log of the field investigation. Appendix B presents the USACE memorandum detailing the results of a geophysical survey performed at the site to define site boundaries. Appendix C presents the drilling logs and well construction details of groundwater monitoring wells completed at the site during the investigation. Appendix D presents the groundwater monitoring well development records. Appendix E presents the Quality Control Summary Reports (QCSR) for the investigation. Appendix F presents a summary of containerized investigation-derived waste (IDW) at the site. Appendix G presents the laboratory analytical data for the site.

2 Site Background and Setting

2.1 Description and History

2.1.1 Former Ramey Air Force Base

The former Ramey AFB occupies approximately 4,357 acres north of the city of Aguadilla, on the extreme northwestern tip of the island of Puerto Rico (see Figure 2-1). The United States Government acquired the property between 1939 and 1963 and utilized the site as a fully operational Air Force base until its deactivation in 1973. On March 1, 1974, ownership of most of the property was transferred to the Puerto Rico Industrial Development Company. Since March 1974, numerous land parcel transfers have occurred between United States government agencies, the United States government and private companies, and the United States government and local government agencies. Except for approximately 125 acres that are still utilized by the United States Government as a United States Coast Guard Installation, this area is now operated by the Puerto Rico Port Authority as a municipal airport and as an industrial park, and portions of the property are leased to local farmers for agricultural purposes (USACE 1992).

Landfill Area 1

Landfill Area 1 is comprised of an approximately 18-acre area located south of the airfield runway complex (see Figure 2-2). During the period that DOD maintained operations at the former Ramey AFB, actual landfilling activities appear to have been conducted across an approximately 6-acre portion of the site. A 1970 aerial photograph depicts the landfill during its operation, but E & E was not able to determine from file information the duration or exact period that landfilling activities occurred.

An aircraft apron, currently used to store inoperable and scrap aircraft, is located north of the site. Site features include a large sinkhole approximately 5 acres in area and up to 35 feet deep, a 30-foot high, 3-acre hill northeast of the sinkhole, and a broad, fenced area of high grass and trees. The 3-acre hill is located adjacent to and north of the area of landfilling. Topographic relief in the immediate vicinity of the former landfill is approximately 70 feet and generally slopes toward the sinkhole.

The sinkhole receives storm water runoff from the southern portion of the runway complex via several well-developed drainage channels that lead into the sinkhole from the north. These channels are up to 30 feet deep and have scoured the soil away to expose bedrock along much of their course. Large tree trunks and some scrap metal debris have been transported into and along these channels. The easternmost channel is eroding landfill material from its eastern cutwall where it contacts the landfill area (see Figure 2-2) and storm water has transported landfill material into the sinkhole. Storm water collects in a ponding area in the southern portion of the sinkhole. Fine-grained sediments in the sinkhole allow for slow, steady infiltration of storm water to the aquifer below. Several swallows occur along the course of the drainage channels that feed the sinkhole. These swallows allow for the direct transmission of stormwater to the aquifer below. The sinkhole and drainage channels remain dry except during storm events, which generate very high energy runoff, and result in ponding in the sinkhole for up to a week.

The site area is currently leased by the Port Authority to a local farmer, who uses the site (including the former landfill) to graze cattle. Some evidence of recent public dumping was observed to the south and east of the site. Evidence that a portion of the site (the landfilled area) was used as a landfill includes abundant construction debris observed at and near the ground surface, and construction debris and scrap metal observed inside the sinkhole. Various medical wastes have also been observed inside the sinkhole, including intravenous bags and tubing, latex surgical gloves, and syringes. The observed medical wastes appear to have been contained in fabric bags buried in the landfill with other debris. As mentioned above, landfill material is actively being eroded from the landfill by a storm water drainage channel. E & E was not able to determine the original source of medical wastes deposited at the landfill. The southwestern portion of the bottom of the sinkhole is covered by soil and undergrowth. The sides of the sinkhole are comprised of exposed, heavily weathered limestone. Evidence of debris caught in tree branches indicate the water depth inside the sinkhole has exceeded 8 feet. E & E observed a storm event at the site that resulted in ponding up to 12 feet deep in the sinkhole, and USACE reported standing water in the sinkhole during a December 1995 site visit.

USACE conducted a geophysical survey of Landfill Area 1 in February 1996. The survey identified subsurface anomalies which are expected to indicate areas where landfill material is buried (see Appendix B). The anomalies detected by the USACE survey, however, appear to include recently deposited material from public dumping not associated with DOD use of the site, and which extends beyond the limits of the USACE survey. Based on observations made on-site, along with the 1970 aerial photograph, it appears that the bulk of DOD landfilling activities were confined to the area depicted on Figure 2-2.

USACE accompanied E & E during a site visit on April 16, 1996, to observe site conditions and discuss project objectives. E & E also conducted a file review of available site information in Puerto Rico during April 1996. During the file review, E & E could find no evidence of past investigations at Landfill Area 1.

Landfill Area 2

Landfill Area 2 is comprised of an approximately 65-acre area (see Figure 2-3). During the period that DOD maintained operations at the former Ramey AFB, actual landfilling activities appear to have been conducted across an approximately 20-acre portion of the site. The site is currently leased by the Port Authority to a local farmer, who uses the site (including the former landfill) to graze cattle and grow agricultural crops. The site vicinity is generally flat-lying, grass-covered, and sectioned with barb-wire fencing to prevent cattle from disturbing crops. The position of the barb-wire fencing has been changed recently by the tenant farmer; fencelines described by USACE personnel during the geophysical survey activities, and those observed by E & E during later site visits, differ slightly. It appears that the tenant farmer periodically rotates cattle-grazing and agricultural cultivation areas. Site features include several concrete building foundations, a recently-constructed watering pond for cattle, and a shallow drainage ditch running along the western margin of the site (see Figure 2-3). The concrete building foundations are overgrown and appear to be of an age and design consistent with former DOD activity at the former Ramey AFB. The watering pond was constructed during the USACE geophysical survey, and its shape has subsequently been slightly altered. Barb-wire fencing has recently been installed around the pond. Evidence that a portion of the site was used as a landfill includes garbage and debris observed along the eroded sides in the northern portion of the drainage ditch. It is reported that the landfill received municipal, household garbage from a former adjacent Air Force housing development called "Tropical Acres."

USACE conducted a geophysical survey of Landfill Area 2 in February 1996. The survey identified subsurface anomalies which are expected to indicate areas where landfill material is buried. Upon completing the survey and evaluating the data, USACE concluded that the limits of landfilling activity extended beyond the north and west boundary of the survey. E & E completed additional geophysical survey activities to establish the extent of the landfill boundaries. During the survey, a buried road and an underground sewer system along the northwest and western margins of the site was discovered. These features appear to have been associated with DOD activities, and landfilling does not appear to have occurred to the north and west of them. Geophysical survey results are discussed in Section 4.

A broad, shallow sinkhole is located approximately 200 feet north of the area of landfilling (see Figure 2-3). The sinkhole is generally dry, but could retain storm water for some period following heavy precipitation. The site generally slopes to the south; however, a small area along the northeastern margin of the site appears to contribute surface drainage to the sinkhole.

USACE accompanied E & E during a site visit on April 16, 1996 to observe site conditions and discuss project objectives. E & E also conducted a file review of available site information in Puerto Rico during April 1996. During the file review, E & E could find no evidence of past investigations at Landfill Area 2.

2.2 Regional Geology/Hydrogeology

2.2.1 Hydrogeology

Landfill Areas 1 and 2 occur within the Northern Coastal physiographic region of the island of Puerto Rico. The Northern Coast slopes gently from the foothills, which mark the Cordillera Central Mountain region, to the Atlantic Ocean. Surficial deposits consist of sand, silt and limestone clays, overlying a dissected paleo surface, the remnants of which stand above the lowlands as isolated *mogotes*, or limestone hills (Rodriquez - Martinez 1995; Tucci/Martinez 1995).

The sites and vicinity are underlain by Quaternary-age sand deposits. These deposits are 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 (USGS, 1969).

The surficial deposits are underlain by the Micocene-age Aymamon Limestone, which outcrops at Landfill Area 1. The Aymamon is typified by tropical karstic topography, including sinkholes and *mogotes*, both of which occur at Landfill Area 1. Dissolutioning of the Aymamon is generally very active in the intermogotal areas in the vicinity of the site. The Aymamon is characterized as a very dense, conchoidally fracturing limestone of white, light gray, buff and rose colors. The formation is estimated to be up to 1,000 feet thick beneath the site (Rodriquez-Martinez 1995; Tucci/Martinez 1995).

The Miocene-age Aquada Limestone underlies the Aymamon Limestone. The Aquada is characterized as a hard, thick-bedded to massive calcarenite and dense limestone interbedded with chalky limestone and marl, commonly containing some quartz grains. The formation is estimated to be up to 1,000 feet thick beneath the site (Rodriquez-Martinez 1995).

2.2.2 Aquifer Description

Most groundwater in the site vicinity occurs within the water table aquifer that extends throughout the North Coast Province. An underlying artesian aquifer, which is an important source

of water in North-Central Puerto Rico, becomes fragmented and unproductive in the site vicinity (Tucci/Martinez 1995).

The water table aquifer extends from the water table surface to the top of the freshwater/saline-water interface. This is not a sharp interface, but rather a gradational zone 75 to 115 feet thick. The water table aquifer is composed of the Aymamon and Aquada limestones, although some alluvial deposits are present in the uppermost portion of the aquifer in some coastal areas. The Aymamon is the most important part of the aquifer beneath the site because the Aquada lies below the freshwater/saline-water interface (Tucci/Martinez 1995).

2.2.3 Aquifer Characteristics

Estimated hydraulic conductivities within the Aymamon Limestone range from 57 to 570 feet per day and diminish with depth. This diminishing is likely related to the maximum effective depth to which karstification will occur within the aquifer. Estimates of transmissivity in the site vicinity are sparse because no rigorous aquifer tests have been conducted in the area. Continuous streamflow and groundwater-level data were not obtained until 1985. Available transmissivity estimates for the freshwater zone of the water table aquifer range from 200 to more than 280,000 square feet per day. Transmissivity values this high probably reflect cavernous porosity and enhanced dissolutioning along bedding planes, joints, and fractures. The Aymamon in the site vicinity is also mostly a grainstone-packstone and coral boundstone with as much as 25 percent total porosity (Rodriquez-Martinez 1995; Tucci/Martinez 1995).

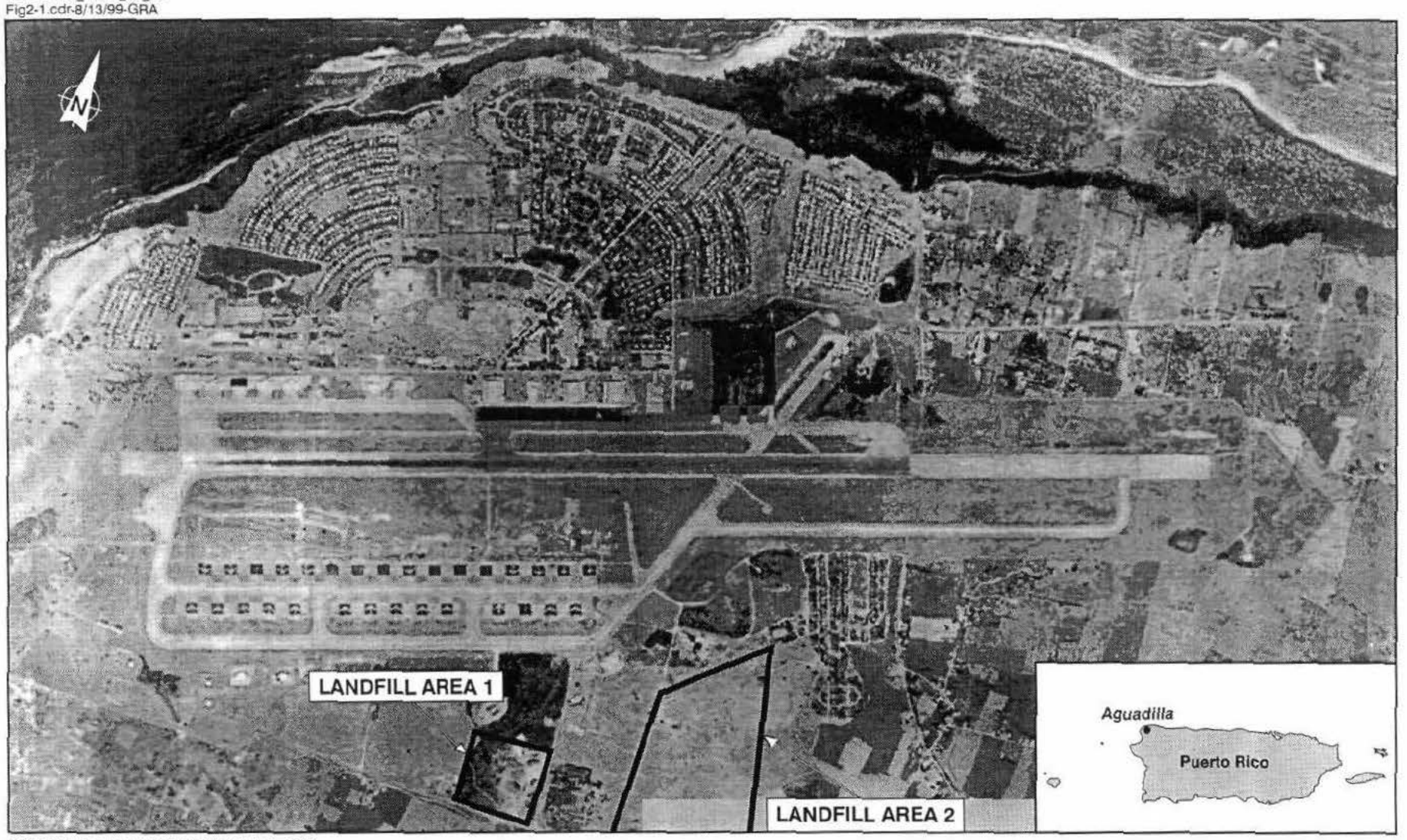
Groundwater was encountered from 200 to 230 feet below ground surface (BGS) at Landfill Areas 1 and 2. The flow direction in the water table aquifer was expected to be generally to the northwest, toward the Atlantic Ocean coastline. However, site-specific data suggests that the karst topography may be causing localized flow direction changes (see Section 4.2).

2.2.4 Aquifer Use

The Puerto Rico Aqueduct and Sewer Authority (PRASA) reports that domestic water supply in the vicinity of the site is obtained from several surface water reservoirs located between 5 and 10 miles south and southeast, and upgradient of the site. All of the former Ramey AFB is supplied by PRASA, and no indication of private supply wells for domestic use could be found during the 1996 site visit or file review (PRASA 1983; E & E 1996f). However, during E & E's 1998 field effort, a potable well was found to have been recently installed at the U.S. Customs office which is located approximately 4,000 feet from the landfill areas. Also, based upon USACE and E & E conversations with local farmers, it is possible that a well may be installed in the vicinity of

Landfill Area 2 at some time in the future for livestock watering and irrigation. 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.

02: 000438_VN03_00_05
Fig2-1.cdr-8/13/99-GRA

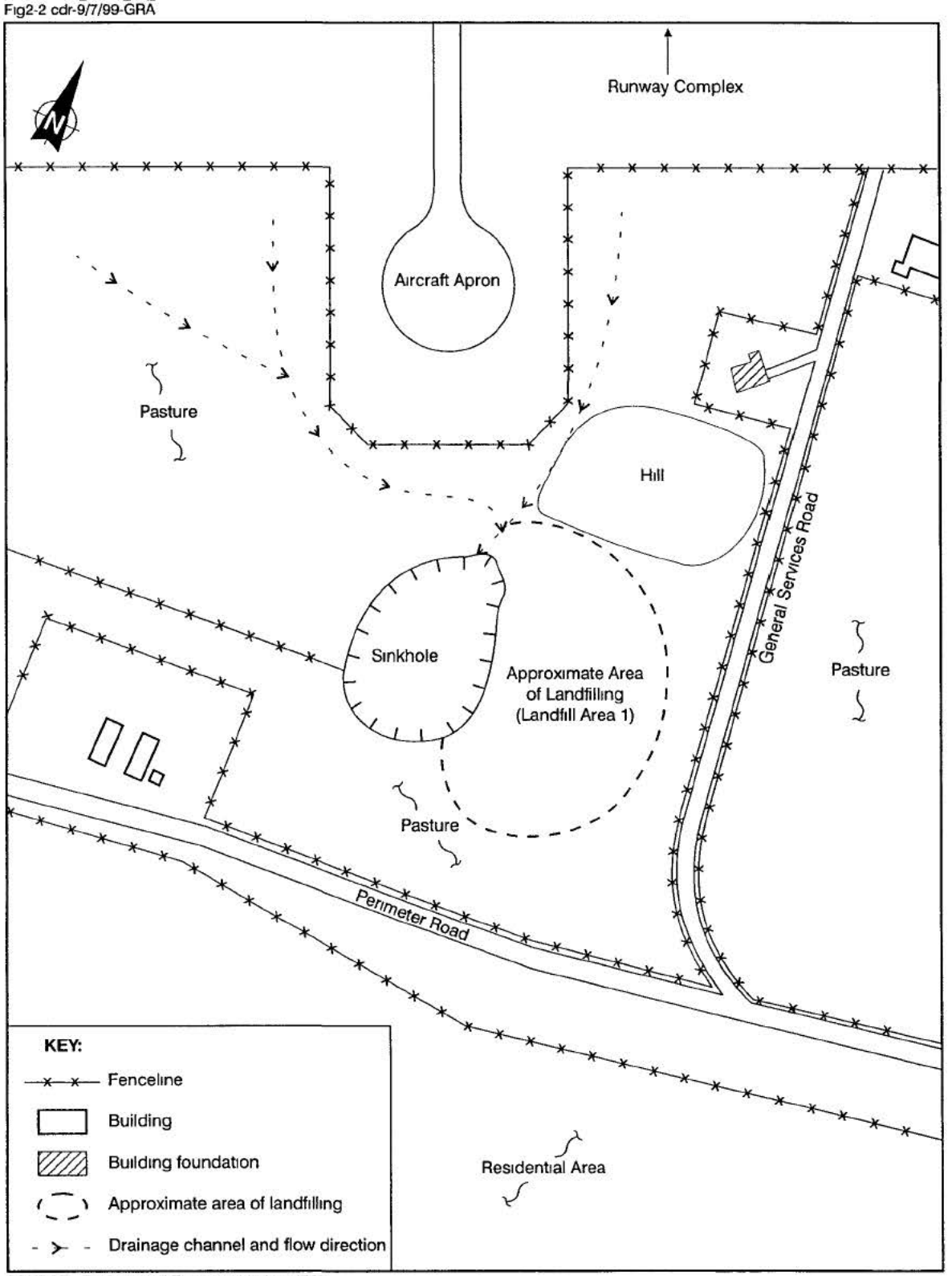


SOURCE: Ecology and Environment, Inc., 1997

SCALE
0 1/2 1 Mile

Figure 2-1 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

02 000438_VN03_00_05
Fig2-2 cdr-9/7/99-GRA

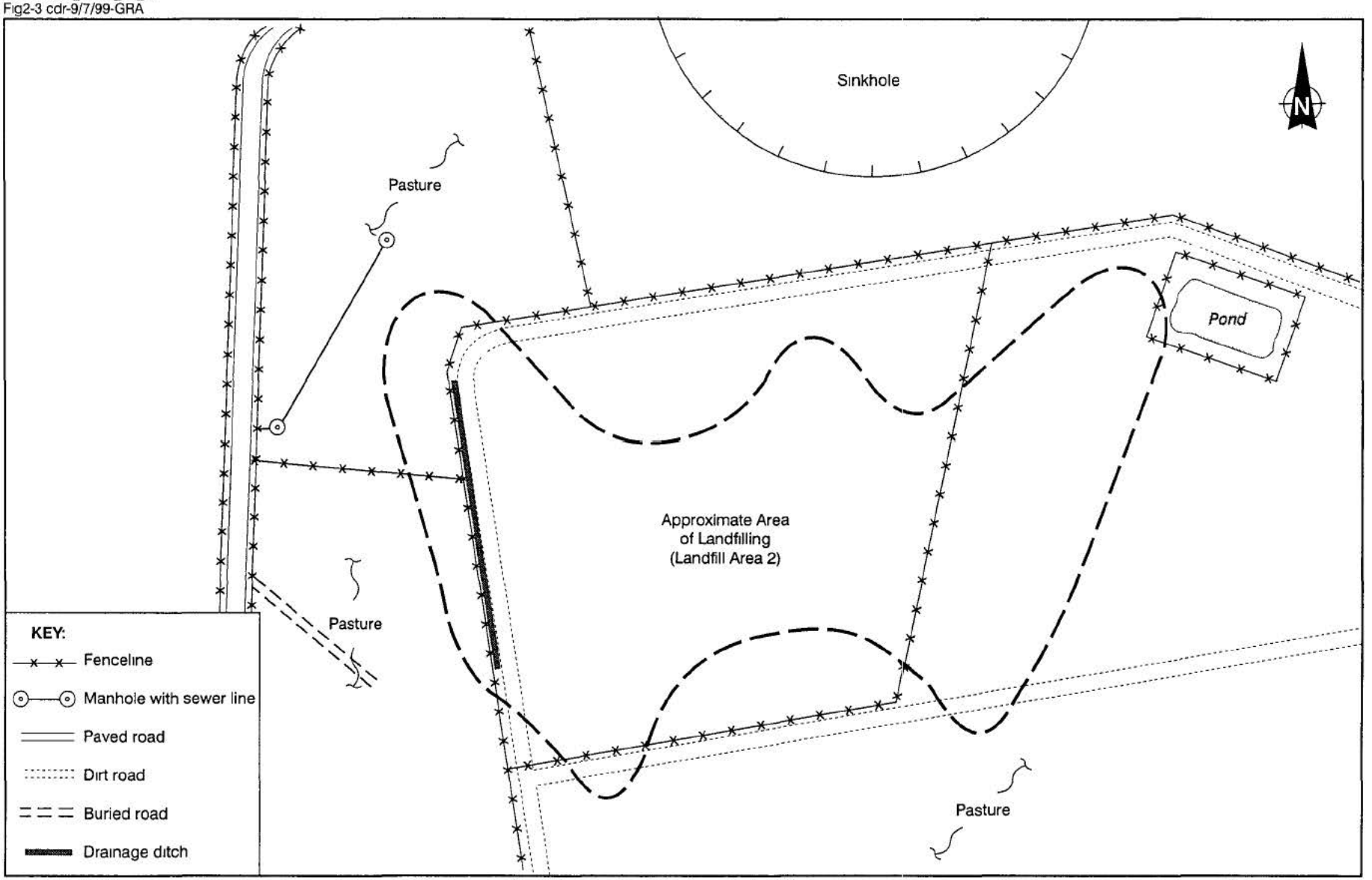


SOURCE Ecology and Environment, Inc. 1997

APPROXIMATE SCALE
0 250 500 Feet

Figure 2-2 LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

02· 000438_VN03_00_05
Fig2-3 cdr-9/7/99-GRA



SOURCE Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 330 660 Feet

Figure 2-3 LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

3 Investigation Methodology

3.1 Geophysical Survey

Geophysical surveys were conducted by the USACE at both landfills. E & E was to supplement the USACE data by conducting additional geophysical surveys at both Landfill Area 1 and Landfill Area 2 in order to establish the limits of landfilling activities at each site. However, during the file review, E & E discovered a 1970 aerial photograph which sufficiently depicted DOD landfilling activities at Landfill Area 1. Based on discussion with USACE, a geophysical survey by E & E at Landfill Area 1 was determined to be unnecessary. The 1970 aerial photograph did not depict Landfill Area 2 during an active period, and the limits of DOD landfilling activities could not be readily established. Therefore, a geophysical survey was performed at Landfill Area 2 in accordance with Section 4.1.2 of the work plan, and Section 5.1 of the Geologic Data Acquisition Plan (GDAP).

The electromagnetic survey was performed using a Geonics, Ltd. EM-31 to record bulk terrain conductivity in millimhos per meter. Readings were recorded in the field logbook and included in-phase and conductivity in the north-south and east-west instrument orientations. The data was contoured as independent data sets, averaged values, and using the difference between north-south and east-west readings. Surfer and CorelDraw software was used to graphically represent the data. The survey grid was established in accordance with Section 4.1.2 of the work plan and included 250 data points.

3.2 Soil Sampling

Soil samples were collected from four groundwater monitoring well boreholes at Landfill Area 1 (RMW1-1 through RMW1-4) and from five groundwater monitoring well boreholes at Landfill Area 2 (RMW2-1 through RMW2-5).

The monitoring well borehole locations (see Figures 3-1 and 3-2) were chosen outside of the fill areas to avoid encountering buried materials. The actual monitoring well locations differ slightly

from the proposed locations shown in the work plan due to site conditions discovered during field activities. In accordance with Section 4.3.1 of the work plan, the number of monitoring wells installed at the site was reduced due to the depth of groundwater beneath the site. The final locations were selected to provide information from upgradient, cross gradient and downgradient areas. Lithologic soil samples were proposed to be collected from the monitoring well boreholes with a split-spoon sampler at 5-foot intervals from ground surface to a depth of 35 feet BGS. Bedrock, however, was encountered at or near the surface in some of the monitoring well boreholes, and thus, fewer samples were collected. In other borings, bedrock was encountered at depths greater than 35 feet BGS. As discussed with USACE, soil samples for analytical analysis were not collected from depths greater than 34 to 36 feet BGS because landfilling activities are not expected to have affected soils greater than this depth.

A lithologic log for each borehole, containing a lithologic description, Unified Soil Classification, and total organic vapor (TOV) readings, was prepared and maintained in the field to characterize the site-specific subsurface geologic conditions. These logs are presented in Appendix C.

Depending on the depth to bedrock, soil samples were collected from each boring for chemical analysis and included samples from the following: 0 to 2 feet BGS, 4 to 6 feet BGS, 9 to 11 feet BGS, 14 to 16 feet BGS, 19 to 21 feet BGS, 24 to 26 feet BGS, 29 to 31 feet BGS, and/or 34 to 36 feet BGS. No organic vapor analyzer (OVA) readings above background were detected in the boreholes, the split-spoons, or the breathing zone during drilling activities.

The soil samples were sent to E & E's Analytical Services Center (ASC) to be analyzed for volatile organic compounds (VOCs; United States Environmental Protection Agency [EPA] Method 8260 plus naphthalene and methyl tert butyl ether), base/neutral extractable organic compounds (BNs; EPA Method 8270B), pesticides and polychlorinated biphenyls (PCBs; EPA Method 8081), Target Analyte List (TAL) metals: silver; aluminum; arsenic; barium; beryllium; calcium; cadmium; chromium; copper; iron; mercury; potassium; magnesium; manganese; sodium; nickel; lead; antimony; selenium; titanium; vanadium; and zinc (EPA Methods 6010, 7060, 7421, 7740, 7841, 7470, and 7471), total petroleum hydrocarbons (TPH) in the gasoline and diesel ranges (EPA Method 8015M), and explosives (EPA Method 8330).

Soil lithology at the site was characterized based on visual inspection of split-spoon samples, and soil and rock cuttings collected during drilling activities in accordance with Section 3.3.3 of the GDAP and Section 4.3 of the work plan.

Tables 3-1, 3-2, and 3-3 present summarized sample analysis, location, depth interval, and numbering system information.

3.3 Monitoring Well Installation, Construction, and Development

Nine 2-inch inside diameter, Schedule 40 polyvinyl chloride (PVC), monitoring wells were installed with 0.010-inch factory slotted screen using hollow-stem auger, mud rotary, and air rotary techniques. Four monitoring wells were installed at Landfill Area 1 and five monitoring wells were installed at Landfill Area 2. The number of monitoring wells installed at each site was determined in accordance with Section 4.3.1 of the workplan, based on a depth to groundwater of greater than 175 feet BGS. Monitoring well locations are shown on Figures 3-1 and 3-2 and were chosen to allow for groundwater data collection from points upgradient, downgradient, and crossgradient to the landfills.

Monitoring well construction deviated slightly from the work plan due to difficult drilling conditions and the depth of groundwater, and were generally constructed as follows: hollow-stem auger techniques were used to make an 11-inch borehole until bedrock was encountered. A 6-inch, inside diameter PVC surface casing was installed to a depth of 4 feet BGS at the RMW1-4, and RMW2-1 through RMW2-5 monitoring well locations to prevent unconsolidated soils from falling into the borehole during drilling activities. This procedure was not required at every location. Split-spoon samples were collected as described above for the purposes of lithologic characterization and chemical analysis of soil samples. Upon reaching bedrock, air rotary techniques were used to complete a 6.5-inch borehole to a depth of approximately 100 to 120 feet BGS. At this depth, a more permeable zone was encountered which dramatically reduced the volume of cuttings recovered. From this depth to the bottom of each borehole (between 237 and 277 feet BGS), air rotary techniques were used to make a 4-inch borehole. This allowed for greater recovery of cuttings while still providing sufficient annulus for the well material. Mud rotary techniques were employed at the RMW1-1 monitoring well location in an attempt to remove cuttings from the borehole, but this method was not successful. Boreholes were overdrilled to provide a trap for cuttings that could not be circulated out of the hole. The monitoring well screen was placed in the borehole to bracket the water table, and centralizers were used to ensure plumb installation. Fifteen feet of 0.010-inch factory slotted screen was used at all locations except for monitoring well RMW1-1, where 35 feet of screen was installed to enable the field geologist to determine the depth of the water table for subsequent well installations. Because the wells were completed in bedrock, no filter media was emplaced around the well screen. At the RMW1-1 and RMW2-1 monitoring well locations, a one-way washout valve was placed at the bottom of the screened interval to allow rock cuttings to be washed out of the borehole using potable water during well installation. This procedure was not required at every location. Shale traps (manufactured conical rubber traps that slip over the outside of the well to prevent well material from passing between the well and the formation) were attached to the well casing and placed at the top of the more permeable zone to prevent the loss of grout to the

formation. A 2-foot thick bentonite seal was emplaced above the shale trap, and the boreholes were then grouted to ground surface. Surface protection was installed at each monitoring well in accordance with the work plan, except at the RMW1-4 location. The Puerto Rico Port Authority requested that RMW1-4 be completed with flush-mount surface protection to allow for mowing. Drilling logs and well construction diagrams are presented in Appendix C.

Following construction, the wells were developed by surging and over-pumping. Water levels, specific conductance, temperature, turbidity, and pH were measured before, during, and after development. Development was continued until parameters stabilized, as described in the work plan. Well development records are included in Appendix D.

3.4 Groundwater, Surface Water, and Sediment Sampling

After development and stabilization, the monitoring wells were purged and sampled in June 1997. Measurements of specific conductance, temperature, turbidity, and pH were again recorded during purging, and purging continued until these parameters stabilized. The groundwater samples were collected and sent to E & E's ASC for analysis of VOCs (EPA Method 8260 plus naphthalene and methyl tert butyl ether), BNs (EPA Method 8270B), pesticides and PCBs (EPA Method 8081), TAL metals (EPA Methods 6010, 7060, 7421, 7470, and 7471), and TPH in the gasoline and diesel ranges (EPA Method 8015M). The wells were purged and resampled in December 1998 for the same parameters to verify the presence of several detected constituents.

One surface water and one sediment sample were collected immediately following a storm event from the southeastern edge of the sinkhole at Landfill Area 1, nearest the landfill material exposed at the surface (see Figure 3-1). The sediment sample was collected from 0 to 0.5 foot BGS. Both samples were analyzed by E & E's ASC for VOCs (EPA Method 8260 plus naphthalene and methy tert butyl ether), BNs (EPA Method 8270B), pesticides and PCBs (EPA Method 8081), TAL metals (EPA Methods 6010, 7060, 7421, 7470, and 7471), and TPH in the gasoline and diesel ranges (EPA Method 8015M). Tables 3-1 and 3-2 present summarized sample analysis, location, depth interval, and numbering system information.

Per E & E's CDAP and Work Plan, all VOC water samples were preserved with acid. No effervescence was noted in the samples in the field and no headspace was noted at the laboratory prior to analysis.

3.5 Sample Numbering System

In accordance with the work plan and the Chemical Data Acquisition Plan (CDAP), an alphanumeric code was used to identify and track all samples collected at the site. The samples were identified using the format:

R-S/W-YYY-A-D

- R - Identifies the sample as originating from a specific installation (i.e., R for the former Ramey AFB site);
- S/W - An "S" indicates a soil/sediment sample; "W" identifies it as a surface water/groundwater sample;
- YYY - Indicates the sample location number (001-999);
- A - Indicates the sample depth interval for a multiple depth sample collected at a single location; and
- D - Designates the sample as a duplicate.

Table 3-1 presents a sample numbering matrix which correlates the field identification number assigned to a sample location with the alphanumeric code assigned to the sample.

3.6 Data Validation and Evaluation

To satisfy quality control (QC) requirements, duplicate, equipment rinsate, and trip blank samples were collected and sent to E & E's ASC for analysis. To satisfy quality assurance (QA) requirements, a split of each duplicate, equipment rinsate, and trip blank sample was collected and sent to the USACE South Atlantic Division Laboratory (SADL) for analysis.

All samples were collected, preserved, packaged, transported, and analyzed in accordance with the work plan (E & E 1997a). Further discussion of this and other data validation issues is presented in the QCSRs included in Appendix E. One complete data package of the analytical results was provided to Caribbean Bioresearch, Inc., to satisfy requirements for data validation by a Puerto Rico certified chemist.

3.7 Surveying of Sample Locations

The location and elevation of the surface water/sediment sample location and the nine monitoring wells installed at the site were surveyed by a registered land surveyor and referenced to a

permanent survey marker. The elevations of each monitoring well were surveyed to the nearest 0.01 foot and referenced to the National Geodetic Vertical Datum (NGVD).

3.8 Water Level Measurements

Water level measurements for the nine newly installed monitoring wells were determined to the nearest 0.01 foot using an electronic water level indicator, in accordance with the work plan. Water level measurements were referenced to the surveyed top of casing (TOC) elevations. Water levels were measured on July 13, 1997, and the data are presented on Table 4-1. Water levels were collected again on December 10, 1998 to verify the groundwater flow at the site (see Table 4-1).

3.9 Decontamination and Investigation-Derived Waste (IDW)

Decontamination of drilling and sampling equipment was performed in accordance with the work plan. All IDW was containerized, sealed, labeled, and stored on site pending disposal. Appropriate disposal methods will be determined based on sample analytical results and input from the Commonwealth of Puerto Rico Environmental Quality Board (EQB). Appendix F contains a summary of the containers of IDW awaiting disposal.

Table 3-1

LABORATORY ANALYTICAL SAMPLE DESIGNATIONS
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

SI Report Designation	Depth Interval (Ft BGS)	Laboratory Analyses	Field/Laboratory Designation
LANDFILL NO. 1			
RMW1-1	0 - 2	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-1-S-001-A
RMW1-1	4 - 6	VOCs, BNs; Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel; explosives	R-1-S-001-B
RMW1-1	9 - 11	VOCs, BNs, Pesticides/PCBs, TAL metals; TPH as gasoline, TPH as diesel, explosives	R-1-S-001-C
RMW1-1	15 - 17	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-1-S-001-D
RMW1-2	0 - 2	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-1-S-002-A
RMW1-2	0 - 2	VOCs, BNs; Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-1-S-002-A-D
RMW1-3	0 - 2	VOCs, BNs; Pesticides/PCBs; TAL metals, TPH as gasoline, TPH as diesel, explosives	R-1-S-003-A
RMW1-4	0 - 2	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-1-S-004-A
RMW1-4	4 - 6	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline. TPH as diesel, explosives	R-1-S-004-B
RMW1-4	9 - 11	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-1-S-004-C
RMW1-4	14 - 16	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-1-S-004-D
RSW-1	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel	R-1-SW-001

Key at end of table

Table 3-1

LABORATORY ANALYTICAL SAMPLE DESIGNATIONS
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

SI Report Designation	Depth Interval (Ft BGS)	Laboratory Analyses	Field/Laboratory Designation
LANDFILL NO. 1			
RSW-1	NA	VOCs, BNs, Pesticides/PCBs; TAL metals, TPH as gasoline, TPH as diesel	R-1-SW-001-D
RSD-1	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel	R-1-SD-001
RSD-1	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline; TPH as diesel	R-1-SD-001-D
RMW1-1	NA	VOCs; BNs, Pesticides/PCBs, TAL metals; TPH as gasoline, TPH as diesel.	R-1-GW-001 RMW1-1 (1998)
RMW1-2	NA	VOCs; BNs; Pesticides/PCBs, TAL metals, TPH as gasoline; TPH as diesel	R-1-GW-002 RMW1-2 (1998)
RMW1-3	NA	VOCs; BNs, Pesticides/PCBs, TAL metals; TPH as gasoline, TPH as diesel.	R-1-GW-003 RMW1-3 (1998)
RMW1-4	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel.	R-1-GW-004 RMW1-4 (1998)
RMW1-4	NA	VOCs, BNs; Pesticides/PCBs; TAL metals, TPH as gasoline, TPH as diesel	R-1-GW-004-D RMW1-4-D (1998)
Trip Blank	NA	VOCs	R-1-SW-001-T
Trip Blank	NA	VOCs	R-1-W-001-T
Trip Blank	NA	VOCs	R-1-S-001-T
Trip Blank	NA	VOCs	R-1-S-004-T
Trip Blank	NA	VOCs	R1-TB-2 (1998)
Rinsate	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel	R-1-R

Key at end of table

Table 3-1

LABORATORY ANALYTICAL SAMPLE DESIGNATIONS
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

SI Report Designation	Depth Interval (Ft BGS)	Laboratory Analyses	Field/Laboratory Designation
LANDFILL NO. 1			
R1-RS-1	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel.	R1-RS-1 (1998)
R2-RS-2	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel	R2-RS-2 (1998)
LANDFILL NO. 2			
RMW2-1	0 - 2	VOCs; BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives.	R-2-S-001-A
RMW2-1	4 - 6	VOCs, BNs, Pesticides/PCBs, TAL metals; TPH as gasoline, TPH as diesel, explosives	R-2-S-001-B
RMW2-1	9 - 11	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-001-C
RMW2-1	14 - 16	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-001-D
RMW2-1	19 - 21	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-001-E
RMW2-1	24 - 26	VOCs, BNs, Pesticides/PCBs; TAL metals, TPH as gasoline; TPH as diesel, explosives	R-2-S-001-F
RMW2-1	29 - 31	VOCs, BNs; Pesticides/PCBs; TAL metals, TPH as gasoline; TPH as diesel, explosives	R-2-S-001-G
RMW2-1	34 - 36	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-001-H
RMW2-2	0 - 2	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel; explosives.	R-2-S-002-A

Key at end of table

Table 3-1

LABORATORY ANALYTICAL SAMPLE DESIGNATIONS
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

SI Report Designation	Depth Interval (Ft BGS)	Laboratory Analyses	Field/Laboratory Designation
RMW2-2	4 - 6	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives.	R-2-S-002-B
LANDFILL NO. 2			
RMW2-2	4 - 6	VOCs; BNs, Pesticides/PCBs; TAL metals; TPH as gasoline, TPH as diesel; explosives	R-2-S-002-B-D
RMW2-2	9 - 11	VOCs, BNs; Pesticides/PCBs; TAL metals, TPH as gasoline, TPH as diesel; explosives	R-2-S-002-C
RMW2-2	14 - 16	VOCs; BNs; Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel; explosives	R-2-S-002-D
RMW2-2	19 - 21	VOCs, BNs, Pesticides/PCBs; TAL metals; TPH as gasoline, TPH as diesel, explosives	R-2-S-002-E
RMW2-2	24 - 26	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-002-F
RMW2-2	29 - 31	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel; explosives	R-2-S-002-G
RMW2-2	34 - 36	VOCs, BNs, Pesticides/PCBs; TAL metals; TPH as gasoline, TPH as diesel, explosives.	R-2-S-002-H
RMW2-3	0 - 2	VOCs, BNs, Pesticides/PCBs; TAL metals, TPH as gasoline, TPH as diesel; explosives.	R-2-S-003-A
RMW2-3	0 - 2	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline; TPH as diesel; explosives	R-2-S-003-A-D
RMW2-3	4 - 6	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-004-B
RMW2-3	9 - 11	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel; explosives.	R-2-S-004-C

Key at end of table

Table 3-1

LABORATORY ANALYTICAL SAMPLE DESIGNATIONS
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

SI Report Designation	Depth Interval (Ft BGS)	Laboratory Analyses	Field/Laboratory Designation
RMW2-3	14 - 16	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives.	R-2-S-004-D
LANDFILL NO. 2			
RMW2-3	19 - 21	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-004-E
RMW2-3	24 - 25	VOCs, BNs, Pesticides/PCBs, TAL metals; TPH as gasoline, TPH as diesel, explosives	R-2-S-004-F
RMW2-3	29 - 31	VOCs, BNs, Pesticides/PCBs, TAL metals; TPH as gasoline, TPH as diesel, explosives	R-2-S-004-G
RMW2-3	34 - 36	VOCs, BNs, Pesticides/PCBs; TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-004-H
RMW2-4	0 - 2	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-004-A
RMW2-4	4 - 6	VOCs; BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel; explosives	R-2-S-004-B
RMW2-4	4 - 6	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel; explosives	R-2-S-004-B-D
RMW2-5	0 - 2	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-005-A
RMW2-5	4 - 6	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel; explosives	R-2-S-005-B
RMW2-5	9 - 11	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives	R-2-S-005-C
RMW2-5	14 - 16	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel, explosives.	R-2-S-005-D

Key at end of table

Table 3-1

LABORATORY ANALYTICAL SAMPLE DESIGNATIONS
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

SI Report Designation	Depth Interval (Ft BGS)	Laboratory Analyses	Field/Laboratory Designation
RMW2-1	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel	R-2-GW-001 RMW2-1 (1998)
LANDFILL NO. 2			
RMW2-1	NA	VOCs, BNs; Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel.	RMW2-1-D (1998)
RMW2-2	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel	R-2-GW-002 RMW2-2 (1998)
RMW2-3	NA	VOCs; BNs, Pesticides/PCBs; TAL metals, TPH as gasoline; TPH as diesel	R-2-GW-003 RMW2-3 (1998)
RMW2-4	NA	VOCs, BNs, Pesticides/PCBs, TAL metals; TPH as gasoline, TPH as diesel	R-2-GW-004 RMW2-4 (1998)
RMW2-5	NA	VOCs, BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel	R-2-GW-005 RMW2-5 (1998)
RMW2-5	NA	VOCs; BNs, Pesticides/PCBs, TAL metals; TPH as gasoline; TPH as diesel	R-2-GW-005-D
Trip Blank	NA	VOCs	R-2-S-001-T
Trip Blank	NA	VOCs	R-2-S-002-T
Trip Blank	NA	VOCs	R-2-S-003-T
Trip Blank	NA	VOCs	R-2-S-004-T
Trip Blank	NA	VOCs	R-2-S-005-T
Trip Blank	NA	VOCs	R-2-W-002-T
Trip Blank	NA	VOCs	R2-TB-2 (1998)
Trip Blank	NA	VOCs	R2-TB-3 (1998)
Rinsate	NA	VOCs; BNs, Pesticides/PCBs, TAL metals, TPH as gasoline, TPH as diesel	R-2-R

Key at end of table

Table 3-1

LABORATORY ANALYTICAL SAMPLE DESIGNATIONS
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

Note All samples were collected in 1997 unless otherwise noted in parenthesis (i e RMW2-1 [1998])

Key

BN	=	Base/neutral extractable organic compound
Ft BGS	=	Feet Below Ground Surface
NA	=	Not applicable
PCB	=	Polychlorinated biphenyl
TAL	=	Target analyte list
TPH	=	Total petroleum hydrocarbon
VOC	=	Volatile organic compound

Key at end of table

Table 3-2

SAMPLE ANALYTICAL SUMMARY
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

Sample Type/Matrix	Analytical Parameter (Method Number)	Number of Samples	Field QC Samples				Field QA Samples[a]		
			Duplicate	Equipment Rinsates	Trip Blanks[3]	Total Field and QC Samples	Duplicates	Trip Blanks[3]	Total QA Samples
Soil	VOC (8260[1])	10	1	0	2	13	1	1	2
	BN (8270B)	10	1	0	0	11	1	0	1
	Pesticides/PCBs (8081)	10	1	0	0	11	1	0	1
	TAL Metals (Various[2])	10	1	0	0	11	1	0	1
	TPH as gasoline (8015M)	10	1	0	0	11	1	0	1
	TPH as diesel (8015M)	10	1	0	0	11	1	0	1
	Explosives (8330)	10	1	0	0	11	1	0	1
Groundwater (Sampling and Resampling of 4 wells)	VOC (8260[1])	8	2	2	2	14	2	2	4
	BN (8270B)	8	2	2	0	12	2	0	2
	Pesticides/PCBs (8081)	8	2	2	0	12	2	0	2
	TAL Metals (Various[2])	8	2	2	0	12	2	0	2
	TPH as gasoline (8015M)	8	2	2	0	12	2	0	2
	TPH as diesel (8015M)	8	2	2	0	12	2	0	2
Surface Water	VOC (8260[1])	1	1	0	1	3	1	1	2
	BN (8270B)	1	1	0	0	2	1	0	1
	Pesticides/PCBs (8081)	1	1	0	0	2	1	0	1
	TAL Metals (Various[2])	1	1	0	0	2	1	0	1
	TPH as gasoline (8015M)	1	1	0	0	2	1	0	1
	TPH as diesel (8015M)	1	1	0	0	2	1	0	1

Key at end of table.

Table 3-2

SAMPLE ANALYTICAL SUMMARY
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

Sample Type/Matrix	Analytical Parameter (Method Number)	Number of Samples	Field QC Samples				Field QA Samples[a]		
			Duplicate	Equipment Rinsates	Trip Blanks[3]	Total Field and QC Samples	Duplicates	Trip Blanks[3]	Total QA Samples
Sediment	VOC (8260[1])	1	1	0	1	3	1	0	1
	BN (8270B)	1	1	0	0	2	1	0	1
	Pesticides/PCBs (8081)	1	1	0	0	2	1	0	1
	TAL Metals (Various[2])	1	1	0	0	2	1	0	1
	TPH as gasoline (8015M)	1	1	0	0	2	1	0	1
	TPH as diesel (8015M)	1	1	0	0	2	1	0	1

1 Including MTBE and Napthalene

2 TAL metals silver, aluminum, barium, beryllium, calcium, cadmium, chromium, cobalt, iron, potassium, magnesium, manganese, sodium, nickel, antimony, titanium, vanadium, zinc (6010), arsenic (7060), mercury (7470/7471), lead (7421)

3 One trip blank was included with every VOC-containing sample shipment cooler

a To satisfy QA requirements, a split of each field QC sample was sent to the USACE QA laboratory

Key

BN = Base/neutral extractable organic compound
PCB = Polychlorinated biphenyl
QA = Quality assurance
QC = Quality control
TAL = Target analyte list
TPH = Total petroleum hydrocarbon
VOC = Volatile organic compound

Table 3-3

SAMPLE ANALYTICAL SUMMARY
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

Sample Type/Matrix	Analytical Parameter (Method Number)	Number of Samples	Field QC Samples				Field QA Samples[a]		
			Duplicate	Equipment Rinsates	Trip Blanks[3]	Total Field and QC Samples	Duplicates	Trip Blank[3]	Total QA Samples
Soil	VOC (8260[1])	30	3	0	5	38	3	3	6
	BN (8270B)	30	3	0	0	33	3	0	3
	Pesticides/PCBs (8081)	30	3	0	0	33	3	0	3
	TAL Metals[2] (Various)	30	3	0	0	33	3	0	3
	TPH as diesel (8015M)	30	3	0	0	33	3	0	3
	TPH as gasoline (8015M)	30	3	0	0	33	3	0	3
	Explosives (8330)	30	3	0	0	33	3	0	3
Groundwater (Sampling and Resampling 5 wells)	VOC (8260[1])	10	2	2	3	17	2	3	5
	BN (8270B)	10	2	2	0	14	2	0	3
	Pesticides/PCBs (8081)	10	2	2	0	14	2	0	3
	TAL Metals[2] (Various)	10	2	2	0	14	2	0	3
	TPH as diesel (8015M)	10	2	2	0	14	2	0	3
	TPH as gasoline (8015M)	10	2	2	0	14	2	0	3

Key at end of table

Table 3-3

SAMPLE ANALYTICAL SUMMARY
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

[1] Including MTBE and napthalene
[2] TAL metals silver, aluminum, barium, beryllium, calcium, cadmium, chromium, cobalt, iron, potassium, magnesium, manganese, sodium, nickel, antimony, titanium, vanadium, zinc (6010), arsenic (7060), mercury (7470/7471), lead (7421)
[3] One trip blank was included with every VOC-containing sample shipment cooler

[a] To satisfy QA requirements, a split of each field QC sample was sent to the USACE QA laboratory.

Key

BN = Base/neutral extractable organic compound
PCB = Polychlorinated biphenyl
QA = Quality assurance
QC = Quality control
TAL = Target analyte list
TPH = Total petroleum hydrocarbon
VOC = Volatile organic compound

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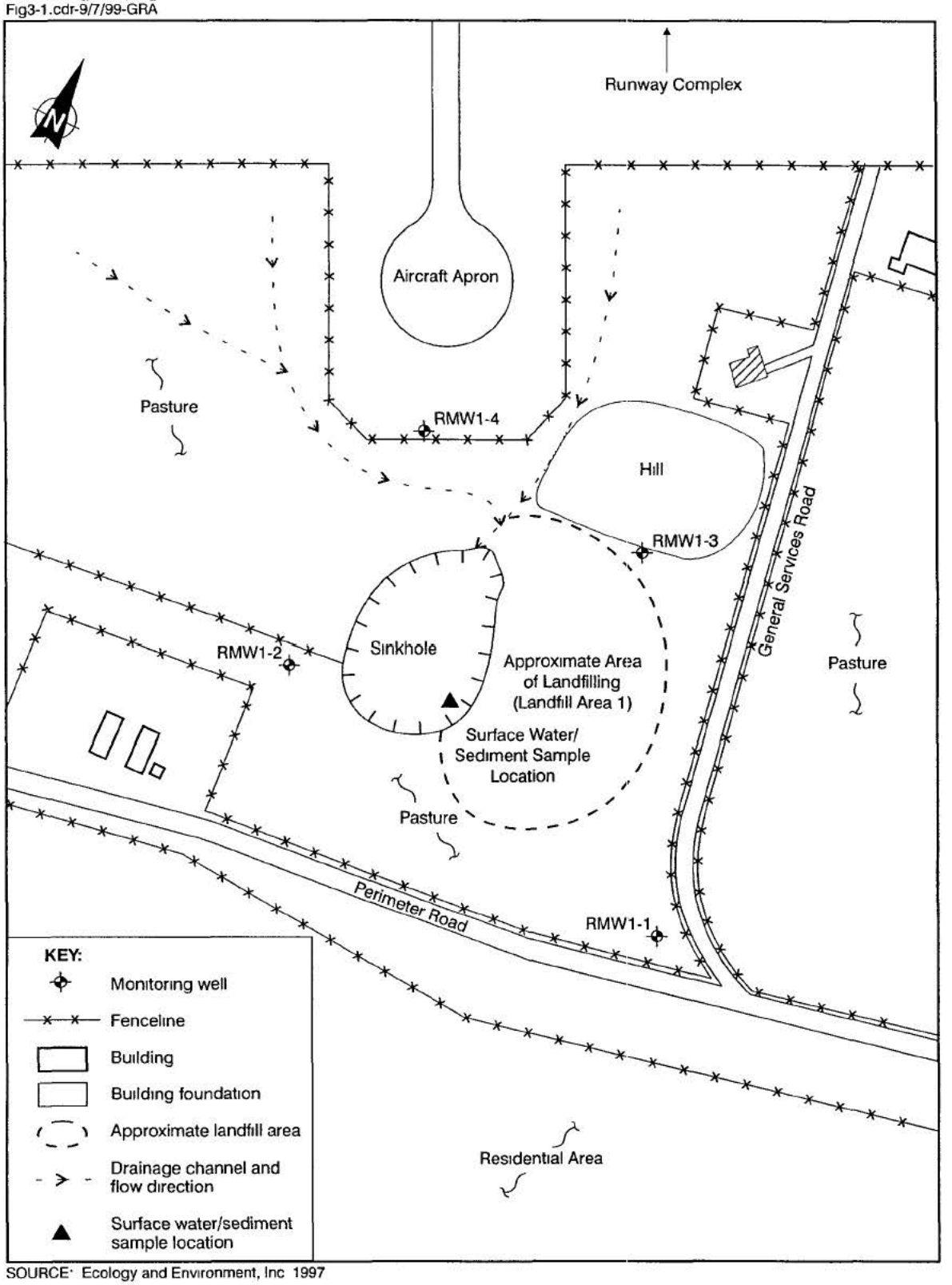
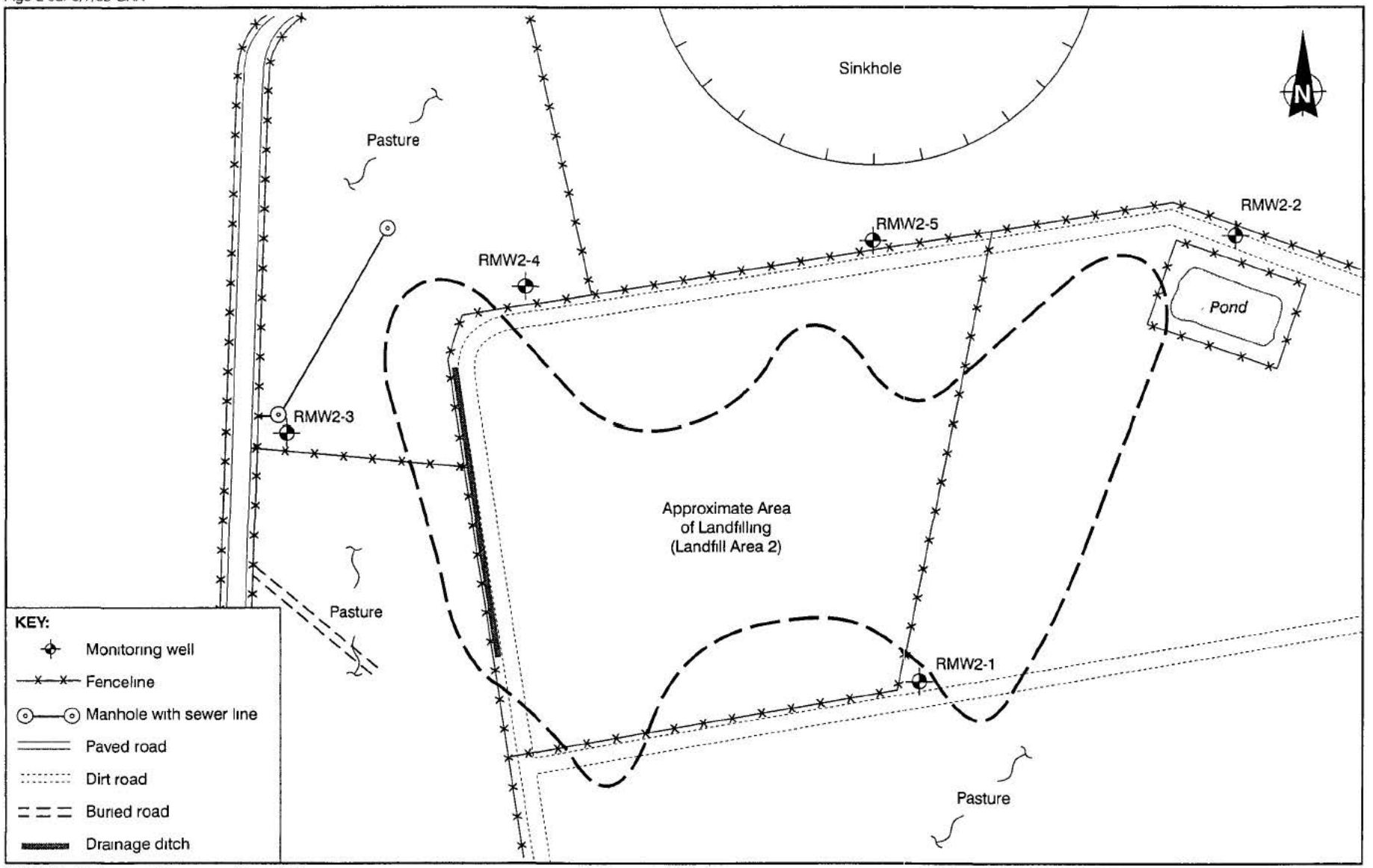


SOURCE: Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 250 500 Feet

Figure 3-1 SAMPLE LOCATIONS MAP
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

02 000438_VN03_00_05
Fig3-2 cdr-9/7/99-GRA



SOURCE Ecology and Environment, Inc. 1997

APPROXIMATE SCALE
0 330 660 Feet

Figure 3-2 SAMPLE LOCATION MAP
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

4 Results of Investigation

4.1 Geophysical Survey

A geophysical survey was performed at Landfill Area 2 using a Geonics, Ltd. EM-31 to record bulk terrain conductivity in millimhos per meter. The survey grid was established on 50-foot centers and overlapped the USACE survey by approximately 150 feet (see Figure 4-1). E & E's survey grid (see Figure 4-2) extended north and west of the USACE survey, and several surface features were identified that aided in the interpretation of field data and the determination of the probable location of the landfill boundaries.

As the survey was conducted and data evaluated, E & E determined that the survey grid needed to be extended 100 feet to the north and west beyond the dimensions proposed in the work plan. E & E extended the grid to confirm the approximate limits of former landfilling activities. As the survey was conducted, linear features that were not readily visible at or near the surface became apparent once the EM-31 data was evaluated. A shallow sewer line of a design and age consistent with DOD activity at the former Ramey AFB was discovered in the northwest corner of the survey grid. E & E also discovered a 10-foot by 10-foot concrete pad 75 feet north of the sewer line with low curbing, a sloped floor, and a floor drain. The data suggests that the floor drain is connected to the shallow sewer and/or a fire hydrant approximately 100 feet to the west. Building foundations and an overgrown parking area were found approximately 100 feet north and northwest of these features. Based on the presence of these features and data collected during the geophysical survey, E & E concluded that landfill activities did not occur in this area.

In the southern portion of E & E's survey grid, an overgrown road, of a design and age consistent with DOD activity at the former Ramey AFB, was discovered. This road terminated in the general area of three building foundations. A concrete culvert is still in place beneath the road, and evidence of the road bed is visible in the sides of the shallow north-south drainage ditch in which landfill material was first discovered. Based on the presence of the road bed, the building foundations, visible landfill material only present in the northern portion of the drainage ditch, and the geophysical survey data, E & E concluded that landfill activities did not occur south of the overgrown road.

Figure 4-3 illustrates averaged terrain conductivity readings collected with the EM-31 in the north-south and east-west orientations. Anomalies detected in the northwestern portion of the survey grid are associated with the shallow sewer line, fire hydrant, and other surface features discussed above. E & E used the USACE geophysical data in conjunction with E & E's additional data to determine the approximated landfill boundary as shown on Figure 4-3. The Surfer and CorelDraw electronic files were submitted to USACE as a separate deliverable.

4.2 Site Geology/Hydrogeology

Unconsolidated soils encountered during the drilling activities at Landfill Areas 1 and 2 were visually characterized, and consisted primarily of brown to orange-brown silty sandy clay and sandy clay (CL). At Landfill Area 2, where agricultural crops are currently being grown, a thin (1- to 2-foot thick) veneer of brown silty loam overlies the orange-brown silty sandy clays and sandy clays. Unconsolidated sediments in the area are between 0 and 70 feet thick. These unconsolidated sediments are underlain by the Aymamon Limestone (Miocene). The Aymamon is present beneath the site as a buff to yellow-tan, soft, moderately to heavily weathered, porous and pitted limestone with some iron staining evident. Hardness and color varies slightly with depth. Some travertine and clear calcite crystals were observed in rock cuttings at approximately 135 feet BGS at Landfill Area 1. Cuttings from various depths were also observed to contain fossils. A loss of air circulation during drilling activities, likely due to increased secondary porosity and void space, was generally noted between 150 and 200 feet BGS. Because the monitoring wells were completed in bedrock, no geotechnical samples were collected. Figures 4-4, 4-5, and 4-6 present cross sections of site lithology.

Groundwater was encountered between approximately 214 and 240 feet BGS at Landfill Area 1, and between approximately 211 and 223 feet BGS at Landfill Area 2. The groundwater flow direction in the vicinity of both sites was expected to be to the north and northwest toward the ocean. However, as shown in Figure 4-7, the groundwater collected in 1997 indicates that the groundwater flow direction at Landfill Area 1 is toward the east. In order to confirm the unexpected flow direction, E & E did a field check of the monitoring well elevations and collected an additional round of groundwater elevation data from Landfill Area 1 in December 1998. The majority or the well elevations were confirmed by E & E's field team, but there was a minor discrepancy in the elevation for RMW1-2. Given the fact that RMW1-2 was initially surveyed by a registered surveyor, E & E must rely on the elevation data provided by the surveyor. The groundwater data collected by E & E in December 1998 confirms that the groundwater flow appears to be to the east. It is not known what could be causing this unexpected flow direction, however it may be related to a localized preferential

flow pattern in the karst bedrock, as will be discussed below. The hydraulic gradient at Landfill Area 1 is approximately 0.0002. This is very flat and is what would be expected in a highly permeable aquifer near the coast. As shown in Figure 4-8, the groundwater flow direction at Landfill Area 2 appears to be to generally to the north toward the coast. However, the water level in monitoring well RMW2-5 is considerably lower than the other four wells at the site and distorts the water level elevation isopleths. This anomalously low water level may also be related to karst features and preferential flow zones as was discussed for Landfill Area 1. The groundwater flow and water level at RMW2-3 were confirmed during the additional field efforts in 1998. The hydraulic gradient at Landfill Area 2 is approximately 0.0030, which is much steeper than at Landfill Area 1. However, this steeper gradient is created by the anomalously lower water level at well RMW2-5 and may not be indicative of the general vicinity. It should also be noted that there could be seasonal variations in the groundwater flow direction and conditions. Table 4-1 presents well and groundwater depth and elevation data, and Figures 4-7 and 4-8 illustrate the groundwater surface elevation across the site.

Preferential flow paths and karst solutioning of the Aymamon Limestone, as well as the proximity of the sites to the coast, may result in a complicated groundwater flow scenario which may not be fully represented in Figures 4-7 and 4-8. It is possible that some of the sinkholes near the landfills are hydraulically connected to off-shore upwellings of fresh water. An on-going United States Geological Survey (USGS) investigation has identified such upwellings using infrared aerial photography and has traced (using geophysics) subsurface anomalies from the coast to the sinkholes that are consistent with fractures or solution channels. One of the upwellings identified by the USGS study is located approximately 2,500 feet northwest of the sites at the base of a cliff. This freshwater spring is in less than 10 feet of water in an area frequently used for recreational surfing, swimming, and snorkeling. (Richards, 1997).

4.3 Laboratory Analytical Results

4.3.1 Surface Soil Results

Nine surface soil samples, plus QA/QC samples, were collected for laboratory analysis at Landfill Areas 1 and 2 (four at Landfill Area 1 and five at Landfill Area 2). Only the analytes present above detection limits are detailed on the summary tables described below. Puerto Rico has not established soil standards, therefore soil sample analytical results were compared to EPA Region 3 Risk-Based Concentrations (RBCs) for residential soils as a conservative, initial screening criteria. Other EPA regions have not developed RBCs and the Region 3 values are widely accepted as screening values. The RBCs developed by Region 3 are based on compound-specific human health effects and, therefore, are appropriate as initial conservative screening criteria when other regulatory

guidance is unavailable. In addition, site data were compared to EPA Soil Screening Level (SSL) values for the migration to groundwater pathway. The SSL values used were developed using a dilution attenuation factor (DAF) of 20 to account for natural processes that reduce contaminant concentration in the subsurface. The complete laboratory analytical data is presented in Appendix G.

Landfill Area 1

Summary analytical results for surface soil samples collected at Landfill Area 1 are presented on Tables 4-2 and 4-3. The depth for each sample is shown on the summary analytical tables. Figure 4-9 presents an illustration of surface soil sample locations at Landfill Area 1 with data that exceeded the EPA RBC screening levels.

With regard to inorganic constituents, all four surface soil samples exceeded the residential RBC of 0.43 milligrams per kilogram (mg/kg) for arsenic: RMW1-1 (14 mg/kg); RMW1-2 (38 mg/kg); RMW1-3 (27 mg/kg); and RMW1-4 (39 mg/kg). Samples RMW1-2 and RMW1-4 also exceeded the SSL for arsenic of 29 mg/kg. One surface soil sample exceeded the SSL of 5 mg/kg for antimony: RMW1-1 (6.8 mg/kg). Three surface soil samples exceeded the SSL of 0.7 mg/kg for thallium: RMW1-2 (1.2 mg/kg); RMW1-3 (0.93 mg/kg); and RMW1-4 (2.4 mg/kg). Four surface soil samples exceeded the SSL of 38 mg/kg for total chromium: RMW1-1 (73 mg/kg); RMW1-2 (180 mg/kg); RMW1-3 (120 mg/kg); and RMW1-4 (140 mg/kg). RBCs for antimony, thallium and chromium were not exceeded in any of the samples. Three surface soil samples exceeded the residential RBC of 23,000 mg/kg for iron: RMW1-2 (46,000 mg/kg); RMW1-3 (30,000 mg/kg); and RMW1-4 (45,000 mg/kg). No other surface soil samples at Landfill Area 1 exceeded residential RBCs or SSLs for inorganic constituents. It is possible that some of the above inorganic constituents may be naturally occurring above the conservative RBCs or SSLs and do not represent contamination. Since background samples were not collected as part of this investigation, this data must be collected in a subsequent phase of investigation. See Section 4.5 for further discussion.

No organic compounds exceeded residential RBCs or SSLs in surface soil samples, and no TPHs in the diesel or gasoline ranges were detected.

Landfill Area 2

Summary analytical results for surface soil samples collected at Landfill Area 2 are presented on Tables 4-4 and 4-5. The depth for each sample is shown on the summary analytical tables. Figure 4-10 presents an illustration of surface soil sample locations at Landfill Area 2 with data that exceeded the EPA RBC screening levels.

Each of the five surface soil samples exceeded the residential RBC of 0.43 mg/kg and the SSL of 29 mg/kg for arsenic: RMW2-1 (38 mg/kg); RMW2-2 (38 mg/kg); RMW2-3 (43 mg/kg); RMW2-4 (43 mg/kg); and RMW2-5 (33 mg/kg). Four surface soil samples exceeded the SSL of 0.7 mg/kg for thallium: RMW2-1 (2.4 mg/kg); RMW2-2 (1.9 mg/kg); RMW2-3 (2.2 mg/kg); and RMW2-4 (1.8 mg/kg). The samples did not exceed the RBC of 5.5 mg/kg for thallium. All five samples exceeded the SSL for chromium: RMW2-1 (130 J mg/kg); RMW2-2 (150 mg/kg); RMW2-3 (160 J mg/kg); RMW2-4 (180 mg/kg); and RMW2-5 (140 mg/kg). None of these samples exceeded the RBC of 230 mg/kg for chromium. Each of the five soil samples exceeded the residential RBC of 23,000 mg/kg for iron: RMW2-1 (41,000 mg/kg); RMW2-2 (41,000 mg/kg); RMW2-3 (47,000 mg/kg); RMW2-4 (47,000 mg/kg); and RMW2-5 (39,000 mg/kg). One sample exceeded the RBC of 1,600 mg/kg for manganese: RMW2-3 (1,800 mg/kg). No other surface soil samples at Landfill Area 2 exceeded residential RBCs or SSLs for inorganic constituents. It is possible that some of the above inorganic constituents may be naturally occurring above the conservative RBCs or SSLs and do not represent contamination. Since background samples were not collected as part of this investigation, this data must be collected in a subsequent phase of investigation. See Section 4.5 for further discussion.

No organic compounds exceeded residential RBCs or SSLs in surface soil samples, and no TPHs in the diesel or gasoline ranges were detected.

4.3.2 Subsurface Soil Results

Thirty-one subsurface soil samples, plus QA/QC samples, were collected at Landfill Areas 1 and 2. Six of the subsurface soil samples were collected at Landfill Area 1, and the remaining 25 subsurface samples were collected at Landfill Area 2. The depth for each subsurface soil sample is shown on the summary analytical tables. Only analytes present above detection limits are detailed in the tables. Puerto Rico has not established soil standards, therefore soil sample analytical results were compared to EPA Region 3 RBCs for industrial soils and to EPA SSLs. According to EPA guidance, subsurface soils are likely only encountered under an industrial scenario, where ground-intrusive activities are taking place. Therefore, industrial RBCs are more appropriate when comparing subsurface soil analytical data to screening levels. The complete laboratory analytical data is presented in Appendix G.

Landfill Area 1

The depth of subsurface soil samples was controlled by the thickness of unconsolidated material at the site. Bedrock was encountered at 20 feet BGS in RMW1-1, 4.5 feet BGS in RMW1-2, 5 feet BGS in RMW1-3, and 16 feet BGS in RMW1-4. Subsurface soil samples were collected from unconsolidated soils only. Summary analytical results are presented on Tables 4-6 through 4-9. Figure 4-11 presents an illustration of subsurface soil sample locations with data that exceeded regulatory screening levels.

Each of the subsurface soil samples collected from RMW1-1 and RMW1-4 exceeded the RBC of 3.8 mg/kg for arsenic: RMW1-1, 4 to 6 feet BGS (19 mg/kg); 9 to 11 feet BGS (36 mg/kg); 15 to 17 feet BGS (29 mg/kg); RMW1-4, 4 to 6 feet BGS (66 mg/kg); 9 to 11 feet BGS (42 mg/kg); and 15 to 17 feet BGS (48 mg/kg). With the exception of the 4 to 6 feet and 15 to 17 feet intervals at RMW1-1, these samples also exceeded the SSL of 29 mg/kg for arsenic. Two subsurface soil samples from RMW1-1 and two from RMW1-4 exceeded the SSL of 0.7 mg/kg for thallium; RMW1-1, 4 to 6 feet BGS (1.2 mg/kg); 15 to 17 feet BGS (1.1 mg/kg); RMW1-4, 4 to 6 feet BGS (2.3 mg/kg); and 9 to 11 feet BGS (2.9 mg/kg). The thallium concentrations were well below the industrial RBC of 140 mg/kg. Two subsurface soil samples from RMW1-1 and three subsurface soil samples from RMW1-4 exceeded the SSL of 38 mg/kg for total chromium: RMW1-1, 4 to 6 feet BGS (150 mg/kg) ; and 9 to 11 feet BGS (140 mg/kg); RMW1-4, 4 to 6 feet BGS (230 mg/kg); 9 to 11 feet BGS (280 mg/kg); and 9 to 11 feet BGS (190 mg/kg). None of the samples exceeded the RBC for chromium of 6,100 mg/kg for industrial soils. No other subsurface soil samples at Landfill Area 1 exceeded industrial RBCs or SSLs for inorganic constituents. It is possible that some of the above inorganic constituents may be naturally occurring above the conservative RBCs or SSLs and do not represent contamination. Since background samples were not collected as part of this investigation, this data must be collected in a subsequent phase of investigation. See Section 4.5 for further discussion.

No subsurface soil samples exceeded industrial RBCs or SSLs for organic compounds, and no TPH in the diesel and gasoline ranges was detected at Landfill Area 1.

Landfill Area 2

The depth of subsurface soil samples was controlled by the thickness of unconsolidated material at the site. Bedrock was encountered at 66 feet BGS in RMW2-1, 10.5 feet BGS in RMW2-2, 57 feet BGS in RMW2-3, 8 feet BGS in RMW2-4, and 15 feet BGS in RMW2-5. In accordance with the workplan, subsurface soil samples were collected to a maximum depth of 36 feet BGS where possible. Landfill activities are not expected to have affected soils below 36 feet BGS.

Subsurface soil samples were collected from unconsolidated soils only. Summary analytical results for subsurface soil samples collected at Landfill Area 2 are presented on Tables 4-10 through 4-19. Figure 4-12 presents an illustration of subsurface soil sample locations with data that exceeded regulatory guidance.

All of the subsurface soil samples collected from RMW2-1, RMW2-2, RMW2-3, RMW2-4, and RMW2-5 exceeded the RBC for arsenic of 3.8 mg/kg. In addition, with the exception of the samples collected from the 19 to 21, 24 to 26, 29 to 31, and 34 to 36 feet intervals at RMW2-2, all samples exceeded the SSL of 29 mg/kg for arsenic. With the exception of the samples collected from the 19 to 21, 24 to 26, 29 to 31, and 34 to 36 feet intervals at RMW2-2, and all depth intervals at RMW2-5, all samples exceeded the SSL of 0.7 mg/kg for thallium. None of the samples exceeded the industrial RBC of 140 mg/kg for thallium. In addition, all samples with the exception of those collected from the 19 to 21, 24 to 26, 29 to 31, and 34 to 36 foot intervals at RMW2-2, exceeded the SSL of 38 mg/kg for total chromium. No other subsurface soil samples at Landfill Area 2 exceeded industrial RBCs or generic SSLs for inorganic constituents. It is possible that some of the above inorganic constituents may be naturally occurring above the conservative RBCs or SSLs and do not represent contamination. Since background samples were not collected as part of this investigation, this data must be collected in a subsequent phase of investigation. See Section 4.5 for further discussion.

No organic compounds exceeded industrial RBCs or generic SSLs in subsurface soil samples, and no TPH in the diesel and gasoline ranges was detected at Landfill Area 2.

4.3.3 Groundwater Results

Nine groundwater samples, plus QA/QC samples, were collected at Landfill Areas 1 and 2 in June of 1997. Four of the groundwater samples were collected at Landfill Area 1, and five groundwater samples were collected at Landfill Area 2. The wells were resampled in December 1998 to verify the presence and concentration of constituents previously detected. Only analytes present above detection limits are detailed in the tables. Groundwater analytical results were compared to EPA Region 3 RBCs for tapwater, the Commonwealth of Puerto Rico EQB Water Quality Standards (PRWQS) Regulation, as amended, and the October 1996 EPA Maximum Contaminant Levels (MCLs). The iron concentrations reported here are estimated because the field duplicate indicated high variability. The duplicate sample, however, is higher than the original result; therefore, the evaluation of the results is not affected. The complete analytical data is presented in Appendix G.

Landfill Area 1

Summary analytical results for groundwater samples collected in June 1997 at Landfill Area 1 are presented on Tables 4-20 and 4-21. Summary analytical results for groundwater samples collected in December 1998 at Landfill Area 1 are presented in Tables 4-28 and 4-29. Figure 4-13 presents an illustration of monitoring wells with data from the most recent sampling event which exceeded regulatory guidance.

One of the groundwater samples collected in June 1997 at Landfill Area 1 (RMW1-1) exceeded the EPA MCL secondary standard of 300 micrograms per liter (μg/L) for iron at a concentration of 450 μg/L. No other groundwater samples collected at Landfill Area 1 exceeded regulatory guidance for inorganic constituents. It is possible that iron may be naturally occurring above the MCL and does not represent contamination. Since background samples were not collected as part of this investigation, this data must be collected in a subsequent phase of investigation. See Section 4.5 for further discussion.

One of the groundwater samples collected in June 1997 at Landfill Area 1 (RMW1-4) exceeded the EPA RBC of 0.15 μg/L for chloroform at a concentration of 3.4 μg/L. Puerto Rico has not established a water quality standard for chloroform, and the EPA MCL is 100 μg/L. Chloroform is often associated with potable water used during well installation. Three of the groundwater samples collected in June 1997 exceeded the EPA MCL of 5.0 μg/L, the PRWQS of 5.0 μg/L, and/or the EPA RBC of 1.60 μg/L for trichloroethene (TCE): RMW1-2 (2.2 J μg/L); RMW1-3 (4.8 J μg/L); and RMW1-4 (7.8 μg/L). TCE was also present in RMW1-1, but at a level below the guidance concentrations. The majority of detected chloroform and TCE concentrations are estimated because the results are detected less than the quantitation limit. The quantitation limits are above the EPA RBC but not above the EPA MCL. No other groundwater samples collected in June 1997 at Landfill Area 1 exceeded regulatory guidance for organic constituents, and no TPH in the gasoline or diesel ranges was detected.

The December 1998 groundwater results confirmed the presence of TCE in all four wells. Three of the wells had TCE levels in excess of the guidance concentrations: RMW1-2 (2.3 J μg/L); RMW1-3 (8.9 μg/L); and RMW1-4 (8.4 μg/L). No chloroform was detected. No other constituents exceeded guidance concentrations.

Landfill Area 2

Summary analytical results for groundwater samples collected at Landfill Area 2 are presented on Tables 4-22 and 4-23. Summary analytical results for groundwater samples collected in December 1998 at Landfill Area 2 are presented in Tables 4-30 and 4-31. Figure 4-14 presents an

illustration of monitoring wells with data from the most recent sampling event which exceeded regulatory guidance.

One of the groundwater samples collected in June 1997 at Landfill Area 2 (RMW2-1) exceeded the EPA MCL secondary standards of 50 μg/L for manganese and 200 μg/L for aluminum, at concentrations of 97 μg/L and 420 μg/L, respectively. Three of the groundwater samples collected in June 1997 at Landfill Area 2 exceeded the EPA MCL secondary standard of 300 μg/L for iron: RMW2-1 (540 μg/L); RMW2-2 (330 μg/L); and RMW2-3 (490 μg/L). The iron concentrations are estimated because the laboratory duplicates indicated slightly high variability, but the evaluation of the results are not affected or bias. No other groundwater samples exceeded regulatory guidance for inorganic constituents. It is possible that some of the above inorganic constituents may be naturally occurring above the MCL and do not represent contamination. Since background samples were not collected as part of this investigation, this data must be collected in a subsequent phase of investigation. See Section 4.5 for further discussion.

Two of the groundwater samples collected in June 1997 at Landfill Area 2 exceeded the EPA RBC of 0.15 μg/L for chloroform: RMW2-1 (4.7 μg/L); and RMW2-3 (3.1 μg/L). One of the June 1997 groundwater samples (RMW2-1) exceeded the EPA RBC of 0.17 μg/L for bromodichloromethane at a concentration of 1.2 μg/L. Puerto Rico has not established groundwater standards for chloroform or bromodichloromethane, but the EPA MCL for both constituents is 100 μg/L total trihalomethanes. The chloroform and bromodichloromethane concentrations are estimated because the results are detected less than the quantitation limit. The quantitation limits for these compounds are above the EPA RBC but not above the EPA MCL. The chloroform and bromodichloromethane is often associated with potable water used during well installation. No other groundwater samples collected in June 1997 at Landfill Area 2 exceeded regulatory guidance, and no TPH in the gasoline or diesel ranges was detected. TCE was detected in all wells except for RMW2-2; however, all concentrations were below guidance levels.

The December 1998 groundwater results confirmed the presence of elevated levels of iron (EPA secondary MCL) in wells RMW2-1 (780 μg/L), RMW2-2 (530 μg/L), and RMW2-3 (390 μg/L). Aluminum was also in excess of the EPA secondary MCL at RMW2-1 (630 μg/L), RMW2-2 (480 μg/L), and RMW2-3 (290 μg/L). No other groundwater samples exceeded regulatory guidance for inorganic or organic constituents at Landfill Area 2. Chloroform and bromodichloromethane were not detected. TCE was still present in the same wells as before and at levels below guidance concentrations.

4.3.4 Surface Water/Sediment Results

Summary results for the surface water sample collected at Landfill Area 1 are presented on tables 4-24 and 4-25. Only the analytes present above detection limits are detailed on the summary Tables. Surface water analytical results were compared to PRWQS for surface waters. Summary results for the sediment sample collected at Landfill Area 1 are presented on Tables 4-26 and 4-27. Sediment analytical results were compared to EPA Region 3 RBCs for residential soils as a conservative, initial screening criteria. These criteria are used only for guidance to highlight potential problem areas. The EPA RBC criteria are not a regulatory requirement and not a specific project objective. In some cases, the laboratory detection limits specified in the CDAP exceed the EPA RBC particularly for carcinogenic compounds with low RBC values. The low RBC values are not typically achievable by standard analytical methods. Because the sinkhole is dry throughout much of the year, it appears that a comparison of data to sediment criteria would be inappropriate. The sinkhole is not an aquatic habitat, therefore the biologic effects that most sediment criteria are based on are not applicable. Exposure to these sediments occurs in the same way that surface soil does (i.e., surface soil contact to tenant farmers, trespassers, etc.). Puerto Rico has not established soil or sediment standards.

The complete laboratory analytical data for surface water and sediment samples is presented in Appendix G. Surface water and sediment samples were collected at Landfill Area 1 only.

None of the surface water analytical results exceeded the PRWQS for inorganic or organic constituents.

The sediment sample exceeded the residential RBC 0.43 mg/kg for arsenic and 23,000 mg/kg for iron at an estimated concentration of 30 mg/kg and 57,000 mg/kg, respectively. No other sediment analytical results exceeded EPA residential RBCs for inorganic constituents.

With regard to organic constituents, the sediment sample exceeded the residential RBC of 0.87 mg/kg for benzo(b)fluoranthene at a concentration of 0.94 mg/kg. The sediment sample also exceeded the residential RBC of 0.087 mg/kg for benzo(a)pyrene at an estimated concentration of 0.41 mg/kg. In addition, the sediment sample exceeded the residential RBC of 0.087 mg/kg for dibenzo(a,h)anthracene at an estimated concentration of 0.13 mg/kg. The benzo(a)pyrene and dibenzo(a,h)anthracene concentrations are estimated because the results are detected less than the quantitation limit. The quantitation limits for these compounds are above the EPA RBC for residential soils. No other sediment analytical results exceeded EPA Residential RBCs for organic constituents. The sediment sample exhibited a TPH concentration in the diesel range of 68 mg/kg. Neither the EPA nor Puerto Rico have established guidelines for TPH in sediment.

4.3.5 Quality Assurance/Quality Control and Data Validation Results

In accordance with E & E's work plan, field duplicate samples, trip blank samples, and equipment rinsate samples were collected. Table 4-32 presents summary sample results for trip blank and rinsate blank samples for the 1997 sampling efforts. Table 4-33 presents summary sample results for trip blank and rinsate blank samples for the 1998 sampling efforts. Only analytes present above detection limits are included. The analytical results for field duplicate samples are shown next to the original sample results on Tables 4-2 through 4-31. QC sample results indicate that analytical data were not compromised during site activities or simple shipment. Further discussion of the QC data is presented in Appendix E.

Split (QA) samples of all rinsate blank, trip blank, and field duplicate samples were sent to SADL for analysis. USACE will compare E & E's data with QA sample results.

4.4 Pathway Evaluation

An exposure pathway describes the course a chemical takes from its source to a potentially-exposed individual. An exposure pathway analysis consists of four elements:

- A source and mechanism of chemical release to the environment (e.g., volatilization of chemicals in groundwater);
- A relevant environmental transport medium (e.g., air) for the released chemical;
- A relevant point of exposure to the chemicals present in that medium (e.g., chemical inhalation); and
- A route of uptake at the exposure point (e.g., respiratory absorption of airborne chemicals).

A pathway is considered complete if all four elements are present and incomplete if one or more of these elements is not present. It is also assumed that a pathway is complete only if there exists a segment of the human population or ecological community that potentially may contact site chemicals.

Environmental media for which complete exposure pathways potentially exist include surface soil, sediment, subsurface soil, groundwater, and surface water. Surface soil and sediment present the potential for exposure for site workers (farmers) and infrequent site users. It should be noted that exposed landfill material (including medical wastes) also pose a physical hazard for site users. Exposure to subsurface soil would be restricted to those individuals engaged in ground-intrusive activity (e.g., digging), such as a construction worker. Current agricultural activities do not

appear to involve commercial-grade machinery, and the depth of soils disturbed by these activities is believed to be less than 2 feet BGS. Groundwater may be used for livestock watering and irrigation in the future. A potable water well for the U.S. Customs office is located approximately 4,000 feet north of the landfill areas. In addition to ingestion, there is the potential for dermal and inhalation exposure to chemicals in groundwater discharging at off-shore, fresh-water springs located along the coastline. These springs are reported to be in less than 10 feet of water, in areas frequently used for recreational surfing, swimming, and snorkeling. Sediment and surface soil exposure could occur for an individual using the landfills for recreational purposes. Private citizens reported to E & E personnel that recreational horseback trail riding has previously occurred at Landfill Area 1, and possibly at Landfill Area 2. As discussed in Section 2, the fences surrounding the sites appear to have been moved since the original USACE geophysical survey in 1996, and it is likely they will be moved again as tenants change, or the current tenants rotate cattle grazing and agricultural areas. This could result in even less restricted access to one or both landfills. The current fence configuration would likely prevent the use of the sites for recreational purposes, although trespasser access to both sites is generally unrestricted. Due to the leased nature of the property, future land use is impossible to predict. Large-scale, mechanized agriculture would result in additional exposure of site workers (farmers and harvesters) to surface and subsurface soils. The surface and subsurface soil exposure pathways must also be considered from the agricultural land use perspective; constituents detected in site soils could potentially be subject to crop or livestock up-take and subsequent human consumption.

4.5 Discussion of Results

As indicated above, a few constituents were detected in surface and subsurface soils, groundwater, and sediment at levels that exceed selected regulatory guidance levels.

At Landfill Area 1, analytes detected in surface soils that exceeded residential RBCs include arsenic and iron. These inorganic constituents are fairly uniformly distributed across the site and occur at comparable levels where detected. Each of the locations where these analytes exceed the RBCs is topographically upgradient of the area where DOD landfilling activities were conducted. This distribution suggests these constituents are not attributable to DOD landfilling activities at the site, or that the concentrations observed are consistent with natural background conditions. Arsenic compounds are often used as insecticides, herbicides, larvicides, and pesticides in agricultural operations in the United States. It is possible that tenant farming at the site has included broad surficial application of arsenic compounds or use of arsenic compounds in "cattle-dipping" pest control practices. However, it is also possible that the levels of inorganic constituents discussed

above are consistent with background levels in the vicinity of the site. The iron concentrations in surface soils that exceeded the residential RBC of 23,000 mg/kg averaged about 40,000 mg/kg. The uniform distribution of iron across the site implies that these concentrations are consistent with natural background levels. Although the EPA RBC values were used as comparison criteria, it should be noted that less frequent exposure scenarios (e.g., trespasser or industrial) may be more appropriate than the default scenario of residential contact which was used. With the exception of arsenic, which has an industrial RBC of 3.8 mg/kg, none of the analytes detected with concentrations greater than residential RBCs exceed industrial RBCs.

At Landfill Area 2, analytes detected in surface soils that exceeded residential RBCs also included arsenic and iron. As at Landfill Area 1, these constituents are fairly uniformly distributed across the site. Similar concentrations are found topographically upgradient, downgradient, and cross-gradient of the area where DOD landfilling activities occurred. The distribution suggests that these constituents are not related to the landfill. As discussed above, there are other potential sources and mechanisms for the deposition of these constituents that are not attributable to DOD landfilling activities. It may be that these levels are consistent with background concentrations of these inorganic constituents. With the exception of arsenic, concentrations of these analytes did not exceed industrial RBCs.

In surface and subsurface soil samples at both landfills, arsenic, thallium, and chromium were consistently above the SSLs. Also, one surface soil sample at Landfill Area had an antimony level above the SSL. Since these constituents, particularly the arsenic, thallium and chromium, are fairly uniformly distributed across and upgradient of the site, the levels detected may be naturally occurring. These constituents do not appear to be impacting the groundwater since they have not been detected at elevated concentrations in the groundwater.

No constituents detected in the surface water sample collected at Landfill Area 1 exceeded the PRWQS. The sample was collected from the sinkhole shortly following a storm event.

The sediment sample collected from the sinkhole at Landfill Area 1 shortly following a storm event indicates that levels of iron and a few BNs exceeded residential RBCs. As noted above, however, the sinkhole receives stormwater runoff from the Port Authority-operated municipal airport, and the constituents detected may be unrelated to DOD landfilling activities. It appears that the sinkhole is full of water for only a limited time during the year, and does not serve as an aquatic habitat. E & E compared the sediment sample analytical data to EPA Residential RBCs rather than aquatic, biologic-effects-based sediment criteria.

At Landfill Area 1, analytes detected in groundwater samples in 1997 include iron, chloroform, and TCE. The level of iron detected (450 μg/L in RMW1-1) exceeded the EPA MCL secondary standard for drinking water, but did not exceed the PRWQS or EPA RBCs. The secondary

standard for iron is not an enforceable standard, and is based on the aesthetic quality of drinking water rather than a health-risk value. It is possible the elevated level of iron was due to turbidity in the sample. The level of chloroform in one of the monitoring wells (3.4 μg/L in RMW1-4) exceeded the EPA RBC for tapwater, but did not exceed the EPA MCL. Puerto Rico has not established a groundwater standard for chloroform, which is often associated with chlorinated, potable water. It was suspected that the use of potable water during drilling activities influenced the analytical data. TCE concentrations detected in three monitoring wells (RMW1-2 through RMW1-4) exceeded the PRWQS. Two of the samples (from RMW1-3 and RMW1-4) also exceeded the EPA RBC and EPA MCL. Since RMW1-4 appears to be located hydraulically upgradient from the landfill, it raises a question as to whether the TCE is coming from another source upgradient of the landfill. This source may or may not be related to past DOD activity. The monitoring wells of Landfill Area 1 were resampled in December 1998 to confirm that the chloroform was not site related, and to confirm the presence of elevated TCE levels. Based on the most recent sampling event, TCE was the only constituent detected in the monitoring wells above regulatory guidance standards or levels.

At Landfill Area 2, analytes detected in 1997 groundwater samples include aluminum, iron, manganese, bromodichloromethane, and chloroform. The inorganic constituents (aluminum, iron, and manganese) exceeded the EPA MCL secondary standards for drinking water, but did not exceed the PRWQS or EPA RBCs. EPA MCL secondary standards are not enforceable standards and the aquifer beneath the site is not used as a water supply source. These elevated metal levels may be naturally occurring or the result of turbidity in the samples and not site contamination. The highest concentration of these inorganic constituents was detected in a monitoring well upgradient from the landfill. The levels of chloroform detected in two monitoring wells (RMW2-1 and RMW2-3) exceeded the EPA RBC for tapwater, but did not exceed the EPA MCL. The level of bromodichloromethane in RMW2-1 also exceeded the EPA RBC, but did not exceed the EPA MCL. Puerto Rico has not established standards for either constituent, both of which are associated with chlorinated, potable water. It was suspected that the use of potable water during drilling activities influenced the analytical data. The monitoring wells at Landfill Area 2 were resampled in December 1998 to confirm that the chloroform and bromodichloromethane were not site related, and to confirm the elevated metal levels and the presence of TCE. The results showed the presence of elevated levels of iron and aluminum in upgradient and side gradient wells. However, the two downgradient wells (RMW2-4 and RMW2-5) did not have elevated iron or aluminum levels. This distribution suggests that constituents detected in upgradient and side gradient wells that exceed regulatory standards or guidance levels are unrelated to DOD landfilling activities. Low levels of TCE were detected during both groundwater sampling events; however, in both cases the levels were below guidance concentrations.

Table 4-1

MONITORING WELL CONSTRUCTION AND GROUNDWATER ELEVATION DATA
LANDFILL AREAS 1 AND 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JULY 1997 AND DECEMBER 1998

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)	
Landfill Area 1										
RMW1-1	277	238 - 273	247 14	242.01	5 13	239 36	241 80	5 34	239 15	2-inch I D , 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 I D , 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 I D , 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 I D , flush-mounted, locking metal outer case, locking cap, concrete pad.

Table 4-1

MONITORING WELL CONSTRUCTION AND GROUNDWATER ELEVATION DATA
LANDFILL AREAS 1 AND 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JULY 1997 AND DECEMBER 1998

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)	
Landfill Area 2										
RMW2-1	247	220 - 235	231 74	225 96	5 78	223.49	225 68	6 06	223 21	2-inch I D , 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 I D , 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 I D , 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 I D , 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 I D , locking metal outer case, locking cap, concrete pad, bumper guards

Key:

BGS = Below ground surface
I D = Inner Diameter
msl = Mean sea level

Table 4-2

SURFACE SOIL ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Location				EPA Region 3 Residential RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	RMW1-1 (0-2.0 Ft BGS)	RMW1-2 (0-2.0 Ft BGS)	RMW1-3 (0-2.0 Ft BGS)	RMW1-4 (0-2.0 Ft BGS)		
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

Key at end of table

Table 4-2

SURFACE SOIL ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) 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 (USEPA 1994).
[d] This value is the RBC for Chromium VI.
[e] This value is the RBC for mercuric chloride.

Key.

BGS	=	Below ground surface
EPA	=	United States Environmental Protection Agency
Ft	=	Feet
J	=	Estimated concentration
mg/kg	=	Milligrams per kilogram
ND	=	Not detected above method detection limit
NE	=	Not established
RBC	=	Risk-based concentration
SSL	=	Soil screening level
35 (38)	=	Sample result (duplicate sample result)
14[RBC]	=	Bolded, shaded value exceeds EPA Region 3 RBC
39[SSL]	=	Bolded, shaded value exceeds EPA Generic SSL

Table 4-3

SURFACE SOIL ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Location				EPA Region 3 Residential RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	RMW1-1 (0-2.0 Ft BGS)	RMW1-2 (0-2.0 Ft BGS)	RMW1-3 (0-2.0 Ft BGS)	RMW1-4 (0-2.0 Ft BGS)		
VOCs						
Acetone	ND	ND (ND)	ND	0.0095 J	7,800	16
Ethylbenzene	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
BNs	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 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20.
[c] These values are the RBC and SSL for ortho-xylene.

Key

BGS = Below ground surface
BN = Base/neutral extractable organic compound
EPA = United States Environmental Protection Agency
J = Estimated concentration
Ft = Feet
mg/kg = Milligrams per kilogram
ND = Not detected above method detection limit
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 4-4

SURFACE SOIL ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

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)	RMW2-5 (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	15,000	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)	1,200	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

Key at end of table

Table 4-4

SURFACE SOIL ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) 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 (USEPA 1994).
[d] This value is the RBC for Chromium VI
[e] This value is the RBC for mercuric chloride

Key

BGS	=	Below ground surface
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
mg/kg	=	Milligrams per kilograms
ND	=	Not detected above method detection limit
NE	=	Not established
RBC	=	Risk-based concentration
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

Table 4-5

SURFACE SOIL ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

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)	RMW2-5 (0-2.0 Ft BGS)		
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
BNs	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 3 Table 4/12/99
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20

Key:

BGS = Below ground surface
BN = Base/neutral extractable organic compound
EPA = United States Environmental Protection Agency
Ft = Feet
J = Estimated concentration
mg/kg = Milligrams per kilogram
ND = Not detected above method detection limit
NE = Not established
PCB = Polychlorinated biphenyl
RBC = Risk-based concentration
SSL = Soil screening level
TPH = Total petroleum hydrocarbon
VOC = Volatile organic compound

Table 4-6

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW1-1
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameters	Sample Depth Interval (feet BGS)			EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	15 - 17		
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	8800	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	6,100[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

Key at end of table

Table 4-6

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW1-1
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20.
[c] Adult industrial lead screening level based on "Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil," (USEPA 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 Correction Action Facilities (USEPA 1994)
[e] This value is the RBC for Chromium VI.
[f] This value is the RBC for mercuric chloride

Key:

BGS	=	Below ground surface
EPA	=	United States Environmental Protection Agency
mg/kg	=	Milligrams per kilograms
ND	=	Not detected above method detection limit
NE	=	Not established
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 4-7

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW1-1
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)			EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	15 - 17		
VOCs	ND	ND	ND	Various	Various
BNs	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 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20.

Key:

BGS = Below ground surface
BN = Base/neutral extractable organic compound
EPA = United States Environmental Protection Agency
mg/kg = Milligrams per kilogram
ND = Not detected above method detection limit
NE = Not established
PCB = Polychlorinated biphenyl
RBC = Risk-based concentration
SSL = Soil screening level
TPH = Total petroleum hydrocarbon
VOC = Volatile organic compound

Table 4-8

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW1-4
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)			EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	15 - 17		
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]	6,100[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

Key at end of table

Table 4-8

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW1-4
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20
[c] Adult industrial lead screening level based on "Recommendations of the Technical Review Workshop for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil," (USEPA 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 (USEPA 1994).
[e] This value is the RBC for Chromium VI.

Key

BGS	=	Below ground surface
EPA	=	United States Environmental Protection Agency
mg/kg	=	Milligrams per kilograms
ND	=	Not detected above method detection limit
NE	=	Not established
RBC	=	Risk-based concentration
SSL	=	Soil screening level
66[RBC]	=	Bolded, shaded value exceeds EPA Region 3 RBC
66[SSL]	=	Bolded, shaded value exceeds EPA Generic SSL

Table 4-9

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW1-4
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)			EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	15 - 17		
VOCs					
Acetone	0 010 J	ND	0 0083 J	200,000	16
Toluene	0 019	0 013	0.0089	410,000	12
BNs	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 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20

Key

BGS = Below ground surface
BN = Base/neutral extractable organic compound
EPA = United States Environmental Protection Agency
J = Estimated concentration
mg/kg = Milligrams per kilogram
ND = Not detected above method detection limit
NE = Not established
PCB = Polychlorinated biphenyl
RBC = Risk-based concentration
SSL = Soil screening level
TPH = Total petroleum hydrocarbon
VOC = Volatile organic compound

Table 4-10

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-1
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
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]	6,100[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

Key at end of table.

Table 4-10

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-1
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
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

Key at end of table

Table 4-10

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-1
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20
[c] Adult industrial lead screening level based on "Recommendations of the Technical Review Workshop for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil," (USEPA 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 (USEPA 1994)
[e] This value is the RBC for Chromium VI.

Key

BGS	=	Below ground surface
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
mg/kg	=	Milligrams per kilograms
ND	=	Not detected above method detection limit
NE	=	Not established
RBC	=	Risk-based concentration
SSL	=	Soil screening level
70[RBC]	=	Bolded, shaded value exceeds EPA Region 3 Industrial RBC
70[SSL]	=	Bolded, shaded value exceeds EPA Generic SSL

Table 4-11

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW2-1
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
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
BN	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

Key at end of table

S[illegible]N3900_P0087\TABLE 4-11 WPD

Table 4-11

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW2-1
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a DAF (dilution-attenuation factor) of 20.

Key

BGS	=	Below ground surface
BN	=	Base/neutral extractable organic compound
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
mg/kg	=	Milligrams per kilogram
ND	=	Not detected above method detection limit
NE	=	Not established
PCB	=	Polychlorinated biphenyl
RBC	=	Risk-based concentration
SSL	=	Soil Screening Level
TPH	=	Total petroleum hydrocarbon
VOC	=	Volatile organic compound

Table 4-12

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-2
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
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]	1.0[SSL]	ND	ND	ND	ND	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]	220[SSL]	71[SSL]	37	21	24	21	6,100[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

Key at end of table

Table 4-12

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-2
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
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	10,000	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

Key at end of table

S \UZ\VN3900_P0087\TABLE 4-12 WPD

Table 4-12

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-2
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20
[c] Adult industrials lead screening level based on "Recommendations of the Technical Review Workshop for Lead as an Interim Approach to Assessing Risk Associated with Adult Exposures to Lead as in Soil," (USEPA 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 (USEPA 1994).
[e] This value is the RBC for Chromium VI.
[f] This value is the RBC for mercuric oxide

Key:

BGS	=	Below ground surface
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
mg/kg	=	Milligrams per kilograms
ND	=	Not detected above method detection limit
NE	=	Not established
RBC	=	Risk-based concentration
SSL	=	Soil screening level
52^{RBC}	=	Bolded, shaded values exceeds EPA Region 3 RBC
52^{SSL}	=	Bolded, shaded values exceeds EPA Generic SSL

Table 4-13

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW2-2
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
VOCs	ND (ND)	ND	ND	ND	ND	ND	ND	Various	Various
BNs	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

Key at end of table.

Table 4-13

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW2-2
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentration from EPA Region 3 Table 4/12/99
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20.

Key.

BGS	=	Below ground surface
BN	=	Base/neutral extractable organic compound
EPA	=	United States Environmental Protection Agency
mg/kg	=	Milligrams per kilogram
ND	=	Not detected above method detection limit
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 4-14

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-3
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
Arsenic	79[RBC,SSL]	77[RBC,SSL]	35[RBC,SSL]	45[RBC,SSL]	49[RBC,SSL]	52[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]	260 J[SSL]	190 J[SSL]	160 J[SSL]	160 J[SSL]	170 J[SSL]	170 J[SSL]	6,100[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

Key at end of table

S \UZ\VN3900_P0087\TABLE 4-14 WPD

Table 4-14

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-3
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
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

[a] Risk-based concentration from EPA Region 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) 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," (USEPA 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 (USEPA 1994).
[e] This value is the RBC for Chromium VI.

Key

BGS = Below ground surface
EPA = United States Environmental Protection Agency
J = Estimated concentration
mg/kg = Milligrams per kilograms
ND = Not detected above method detection limit
NE = Not established
RBC = Risk-based concentration
79[RBC] = Bolded, shaded value exceeds EPA Region 3 RBC
79[SSL] = Bolded, shaded value exceeds EPA Generic SSL

Table 4-15

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW2-3
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)							EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLS[b] (mg/kg)
	4 - 6	9 - 11	14 - 16	19 - 21	24 - 26	29 - 31	34 - 36		
VOCs	ND	ND	ND	ND	ND	ND	ND	Various	Various
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	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 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20.

Key:

BGS = Below ground surface
BN = Base/neutral extractable organic compound
EPA = United States Environmental Protection Agency
mg/kg = Milligrams per kilogram
ND = Not detected above method detection limit
NE = Not established
PCB = Polychlorinated biphenyl
RBC = Risk-based concentration
SSL = Soil screening level
TPH = Total petroleum hydrocarbon

Table 4-16

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-4
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)	EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6		
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]	6,100[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)	610,00	12,000
Mercury	ND (0 049)	610[f]	2

Key at end of table

Table 4-16

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-4
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99
[b] Generic SSLs (July 1996) for the migration to groundwater pathway using a default DAF (dilution-attenuation factor) of 20
[c] Adult industrial lead screening level based on "Recommendations of the Technical Review Workshop for Lead for and Interim Approach to Assessing Risk Associated with Adult Exposures to Lead in Soil," (USEPA 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 (USEPA 1994)
[e] This value is the RBC for Chromium VI
[f] This value is the RBC for mercuric oxide.

Key:

BGS	=	Below ground surface
EPA	=	United States Environmental Protection Agency
mg/kg	=	Milligrams per kilogram
ND	=	Not detected above method detection limit
NE	=	Not established
RBC	=	Risk-based concentration
SSL	=	Soil screening level
89 (88)	=	Sample result (duplicate sample result)
89[RBC]	=	Bolded, shaded value exceeds EPA Region 3 Residential RBC
89[SSL]	=	Bolded, shaded value exceeds EPA Generic SSL

Table 4-17

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW2-4
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)	EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6		
VOCs			
Acetone	0 015 (ND)	200,000	16
Toluene	0.0054 J (0 0060 J)	410,000	12
BNs	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 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20.

Key:

BGS	=	Below ground surface
BN	=	Base/neutral acid extractable
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
mg/kg	=	Milligrams per kilogram
ND	=	Not detected above method detection limit
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 4-18

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-5
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)			EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16		
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]	6,100[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

Key at end of table

Table 4-18

SUBSURFACE SOIL ANALYTICAL RESULTS - INORGANICS
MONITORING WELL RMW2-5
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-based concentrations from EPA Region 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20.
[c] Adult industrial lead screening level based on "Recommendations of the Technical Review Workshop for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil," (USEPA 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 (USEPA 1994).
[e] This value is the RBC for food
[f] This value is the RBC for Chromium VI.

Key:

BGS	=	Below ground surface
EPA	=	United States Environmental Protection Agency
mg/kg	=	Milligrams per kilograms
ND	=	Not detected above method detection limit
NE	=	Not established
RBC	=	Risk-based concentration
SSL	=	Soil Screening Level
41[RBC]	=	Bolded, shaded value exceeds EPA Region 3 RBC
41[SSL]	=	Bolded, shaded value exceeds EPA Generic SSL

Table 4-19

SUBSURFACE SOIL ANALYTICAL RESULTS - ORGANICS
MONITORING WELL RMW2-5
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Depth Interval (feet BGS)			EPA Region 3 Industrial RBCs[a] (mg/kg)	EPA Generic SSLs[b] (mg/kg)
	4 - 6	9 - 11	14 - 16		
VOCs					
Acetone	ND	ND	0 0068 J	200,000	16[a]
BNs	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 3 Table 4/12/99.
[b] Generic SSLs (July 1996) for the migration to groundwater pathway developed using a default DAF (dilution-attenuation factor) of 20.

Key:

BGS = Below ground surface
BN = Base/neutral extractable organic compound
EPA = United States Environmental Protection Agency
J = Estimated concentration
mg/kg = Milligrams per kilogram
ND = Not detected above method detection limit
NE = Not established
PCB = Polychlorinated biphenyl
RBC = Risk-based concentration
SSL = Soil screening level
TPH = Total petroleum hydrocarbon

Table 4-20

GROUNDWATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in µg/L)

Parameter	Sample Location				Puerto Rico Groundwater Quality Standards (µg/L)	EPA Region 3 Risk-Based Concentration (Tapwater µg/L)	EPA MCLs (Drinking Water µg/L)
	RMW1-1	RMW1-2	RMW1-3	RMW1-4			
Lead	ND	ND	5 8	ND (ND)	50	NE	NE
Selenium	5 4	ND	ND	ND (ND)	NE	180	50
Zinc	15	ND	11	ND (ND)	NE	11,000	5,000[a]
Manganese	26	ND	ND	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

Key at end of table

Table 4-20

GROUNDWATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in μg/L)

[a] Secondary standard.

Key:

EPA	=	United States Environmental Protection Agency
MCL	=	Maximum contaminant level
μg/L	=	Micrograms per liter
ND	=	Not detected above method detection limit
ND (ND)	=	Sample result (duplicate sample result)
NE	=	Not established
450	=	Bolded, shaded value exceeds EPA MCL

Table 4-21

GROUNDWATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in µg/L)

Parameter	Sample Location				Puerto Rico Water Quality Standards (µg/L)	EPA Region 3 Risk-Based Concentration (Tapwater µg/L)	EPA MCLs (Drinking Water µg/L)
	RMW1-1	RMW1-2	RMW1-3	RMW1-4			
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
BNs	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

Key at end of table

Table 4-21

GROUNDWATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in μg/L)

Key

B	=	Analyte present in field or lab blank sample
BN	=	Base/neutral extractable organic compound
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
MCL	=	Maximum contaminant level
μg/L	=	Micrograms per liter
ND	=	Not detected above method detection limit
NE	=	Not established
PCB	=	Polychlorinated biphenyl
RBC	=	Risk-based concentration
TPH	=	Total petroleum hydrocarbon
VOC	=	Volatile organic compound
7 7 (7 8)	=	Sample result (duplicate sample result)
2.2	=	Bolded, shaded value exceeds either the EPA Region 3 RBC (tapwater), the EPA MCL , or the Puerto Rico water quality standard for drinking water

Table 4-22

GROUNDWATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in µg/L)

Parameter	Sample Location					Puerto Rico Groundwater Quality Standards (µg/L)	EPA Region 3 Risk-Based Concentration (Tapwater µg/L)	EPA MCLs (Drinking Water µg/L)
	RMW2-1	RMW2-2	RMW2-3	RMW2-4	RMW2-5			
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

Key at end of table

S \UZ\VN[illegible]0087\TABLE 4-22 WPD

Table 4-22

GROUNDWATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in μg/L)

[a] Secondary standard

Key:

EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
MCL	=	Maximum contaminant level
μg/L	=	Micrograms per liter
ND	=	Not detected above method detection limit
ND (ND)	=	Sample result (duplicate sample result)
NE	=	Not established
97	=	Bolded, shaded value exceeds EPA MCL

Table 4-23

GROUNDWATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in µg/L)

Parameter	Sample Location					Puerto Rico Groundwater Quality Standards (µg/L)	EPA Region 3 Risk-Based Concentration (Tapwater µg/L)	EPA MCLs (Drinking Water µg/L)
	RMW2-1	RMW2-2	RMW2-3	RMW2-4	RMW2-5			
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
BNs	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

Key at end of table

Table 4-23

GROUNDWATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in μg/L)

Key:

BN	=	Base/neutral extractable organic compound
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
MCL	=	Maximum contaminant level
μg/L	=	Micrograms per liter
ND	=	Not detected above method detection limit
ND (ND)	=	Sample result (duplicate sample result)
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 3 RBC (tapwater), the EPA MCL, or the Puerto Rico water quality standard for drinking water

Table 4-24

SURFACE WATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in μg/L)

Parameter	Sample R-1-SW-001	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

Key·

EPA = United States Environmental Protection Agency
J = Estimated concentration
μg/L = Micrograms per liter
ND = Not detected above method detection limit
ND (ND) = Sample result (duplicate sample result)
NE = Not established

Table 4-25

SURFACE WATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in μg/L)

Parameter	Sample R-1-SW-001	Puerto Rico Surface Water Quality Standards (μg/L)
VOCs	ND (ND)	Various
BNs	ND (ND)	NE
Pesticides/PCBs	ND (ND)	Various
TPH as Diesel	ND (ND)	NE
TPH as Gasoline	ND (ND)	NE

Key:

BN = Base/neutral extractable organic compound
EPA = United States Environmental Protection Agency
μg/L = Micrograms per liter
ND = Not detected above method detection limit
ND (ND) = Sample result (duplicate sample result)
NE = Not established
VOC = Volatile organic compound

Table 4-26

SEDIMENT ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Location R-1-SD-001	EPA Region 3 Risk-Based Concentration[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]

Key at end of table.

Table 4-26

SEDIMENT ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

[a] Risk-Based Concentrations from USEPA Region 3 Table 4/12/99
[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 (USEPA 1994)
[c] This value is the RBC for Chromium VI
[d] This value is the RBC for mercuric oxide

Key:

EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
mg/kg	=	Milligrams per kilogram
ND	=	Not detected above method detection limit
NE	=	Not established
RBC	=	Risk-based concentration
19 (30)	=	Sample result (duplicate sample result)
57,000	=	Bolded, shaded value exceeds EPA Region 3 Residential RBC

Table 4-27

SEDIMENT ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Parameter	Sample Location R-1-SD-001	EPA Region 3 Risk-Based Concentration (Residential; mg/kg)
VOCs		
Toluene	ND (0 0017 J)	16,000
Total Xylenes	ND (0 0067 J)	160,000
BNs		
Phenanthrene	0 23 J (16 J)	NE
Anthracene	0 045 J (ND)	23,000
Fluoranthene	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

Key at end of table

Table 4-27

SEDIMENT ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in mg/kg)

Key

BN	=	Base/neutral extractable organic compound
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
mg/kg	=	Milligrams per kilogram
ND	=	Not detected above method detection limit
NE	=	Not established
PCB	=	Polychlorinated biphenyl
RBC	=	Risk-based concentration
TPH	=	Total petroleum hydrocarbon
VOC	=	Volatile organic compound
0 0018JB (0 0027JB)	=	Sample result (duplicate sample result)
0.94	=	Bolded, shaded value exceeds EPA Region 3 Residential RBC

Table 4-28

GROUNDWATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in µg/L)

Parameter	Sample Location				Puerto Rico Groundwater Quality Standards (µg/L)	EPA Region 3 Risk-Based Concentration (Tapwater µg/L)	EPA MCLs (Drinking Water µg/L)
	RMW1-1	RMW1-2	RMW1-3	RMW1-4			
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

Key at end of table

Table 4-28

GROUNDWATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in μg/L)

[a] Secondary standard

Key:

EPA	=	United States Environmental Protection Agency
MCL	=	Maximum contaminant level
μg/L	=	Micrograms per liter
NA	=	Not analyzed
ND	=	Not detected above method detection limit
ND (ND)	=	Sample result (duplicate sample result)
NE	=	Not established

Table 4-29

GROUNDWATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in µg/L)

Parameter	Sample Location				Puerto Rico Water Quality Standards (µg/L)	EPA Region 3 Risk-Based Concentration (Tapwater µg/L)	EPA MCLs (Drinking Water µg/L)
	RMW1-1	RMW1-2	RMW1-3	RMW1-4			
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
BNs							
bis(2-Ethylhexyl)phthalate	ND	ND	ND	ND (ND)	NE	4 8	NE
Pesticides/PCBs							
PCB-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

Key at end of table.

Table 4-29

GROUNDWATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 1
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in μg/L)

Key.

B	=	Analyte present in field or lab blank sample
BN	=	Base/neutral extractable organic compound
EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
MCL	=	Maximum contaminant level
μg/L	=	Micrograms per liter
ND	=	Not detected above method detection limit
NE	=	Not established
PCB	=	Polychlorinated biphenyl
RBC	=	Risk-based concentration
TPH	=	Total petroleum hydrocarbon
VOC	=	Volatile organic compound
7.7 (7.8)	=	Sample result (duplicate sample result)
2.3	=	Bolded, shaded value exceeds either the EPA Region 3 RBC (tapwater), the EPA MCL, or the Puerto Rico water quality standard for drinking water

Table 4-30

GROUNDWATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in µg/L)

Parameter	Sample Location					Puerto Rico Groundwater Quality Standards (µg/L)	EPA Region 3 Risk-Based Concentration (Tapwater µg/L)	EPA MCLs (Drinking Water µg/L)
	RMW2-1	RMW2-2	RMW2-3	RMW2-4	RMW2-5			
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 **(630)**	**480**	**290**	ND	ND	NE	37,000	200[a]
Barium	ND (21)	ND	ND	ND	ND	NE	2,600	2,000
Sodium	89,200 (85,700)	22,000	83,000	88,000	91,000	NE	NE	NE
Potassium	3,800 (41,90)	ND	3,400	4,100	3,800	NE	NE	NE

Key at [illegible] of table.

Table 4-30

GROUNDWATER ANALYTICAL RESULTS - INORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in μg/L)

[a] Secondary standard.

Key:

EPA	=	United States Environmental Protection Agency
J	=	Estimated concentration
MCL	=	Maximum contaminant level
μg/L	=	Micrograms per liter
ND	=	Not detected above method detection limit
ND (ND)	=	Sample result (duplicate sample result)
NE	=	Not established
RBC	=	Risk-based concentration
780	=	Bolded, shaded value exceeds EPA MCL

Table 4-31

GROUNDWATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in µg/L)

Parameter	Sample Location					Puerto Rico Groundwater Quality Standards (µg/L)	EPA Region 3 Risk-Based Concentration (Tapwater µg/L)	EPA MCLs (Drinking Water µg/L)
	RMW2-1	RMW2-2	RMW2-3	RMW2-4	RMW2-5			
VOCs								
Trichloroethene	1.5 J (1 2 J)	ND	1 5 J	1 2 J	1 4 J	200	1 60	5 0
BNs	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

Key at end of table

Table 4-31

GROUNDWATER ANALYTICAL RESULTS - ORGANICS
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in μg/L)

Key:

BN	=	Base/neutral extractable organic compound
EPA	=	United States Environmental Protection Agency
MCL	=	Maximum contaminant level
μg/L	=	Micrograms per liter
ND	=	Not detected above method detection limit
NE	=	Not established
ND (ND)	=	Sample result (duplicate sample result)
PCB	=	Polychlorinated biphenyl
RBC	=	Risk-based concentration
TPH	=	Total petroleum hydrocarbon
VOC	=	Volatile organic compound

Table 4-32

TRIP BLANK AND RINSATE BLANK ANALYTICAL RESULTS
LANDFILL AREAS 1 AND 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
JUNE 1997
(all results in μg/L)

Parameter	Sample											
	R-1-S-001-T Trip Blank	R-1-S-004-T Trip Blank	R-1-SW-001-T Trip Blank	R-1-W-001-T-B Trip Blank	R-2-S-001-T Trip Blank	R-2-S-002-T Trip Blank	R-2-S-003-T Trip Blank	R-2-S-004-T Trip Blank	R-2-S-005-T Trip Blank	R-2-W-002-T Trip Blank	R-1-R Rinsate Blank	R-2-R Rinsate Blank
VOCs												
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND
BNs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
Pesticides/PCBs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
TPH as Diesel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
TPH as Gasoline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
Metals	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND

Key

BGS = Below ground surface
BN = Base/neutral extractable organic compound
μg/L = Micrograms per liter
NA = Not analyzed
ND = Not detected above method detection limit
PCB = Polychlorinated biphenyl
TPH = Total petroleum hydrocarbon
VOC = Volatile organic compound

Table 4-33

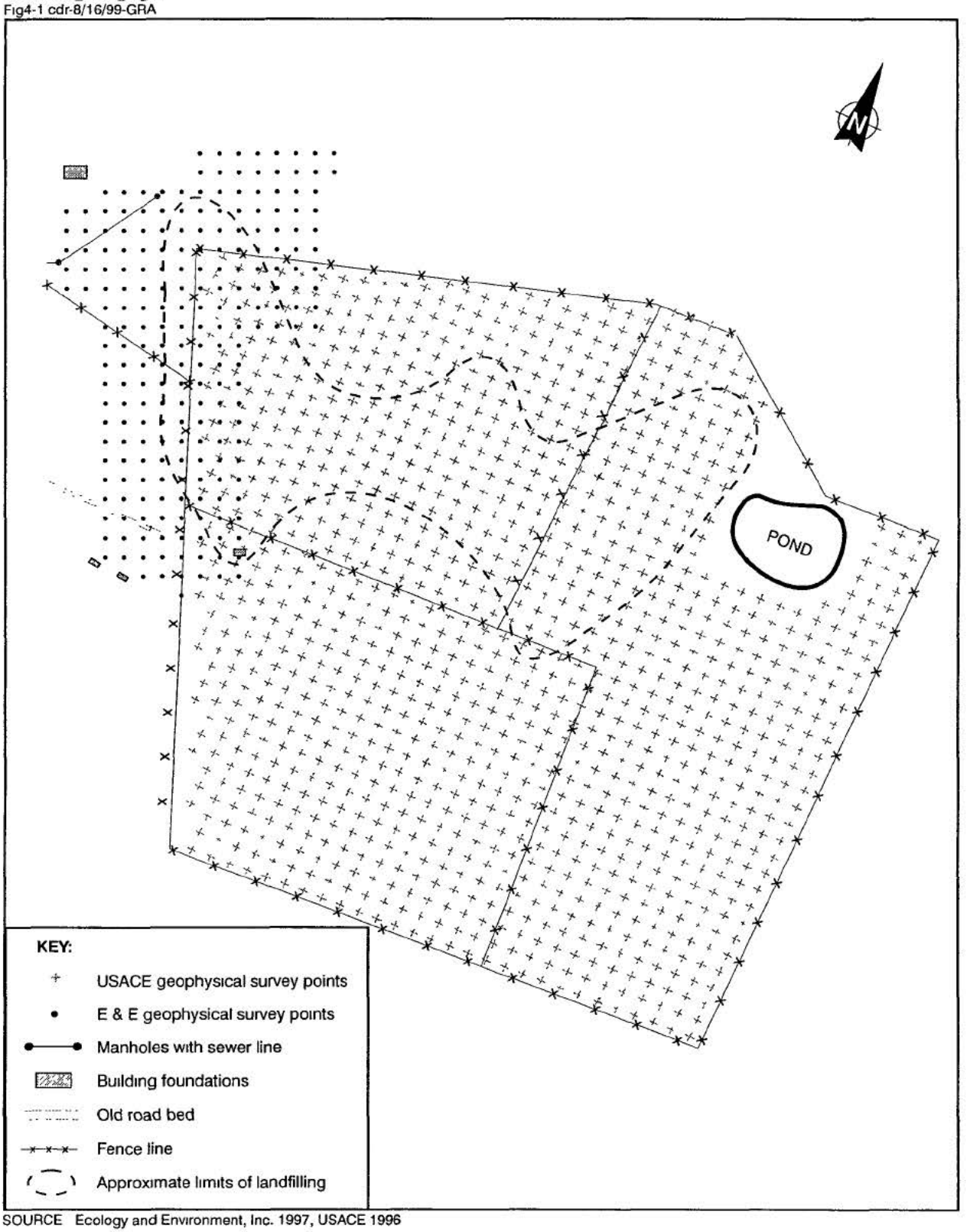
TRIP AND RINSATE BLANK ANALYTICAL RESULTS
LANDFILL AREAS 1 AND 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO
DECEMBER 1998
(all results in μg/L)

Parameter	Sample						
	R1-TB-1 Trip Blank	R1-TB-2 Trip Blank	R2-TB-1 Trip Blank	R2-TB-2 Trip Blank	R2-TB-3 Trip Blank	R1-RS-1 Rinsate Blank	R1-RS-1 Rinsate Blank
VOCs							
Methylene chloride	1 2 J	ND	1.4 J	ND	1.2 J	1 0 J	1 1 J
BNs	NA	NA	NA	NA	NA	ND	ND
Pesticides/PCBs	NA	NA	NA	NA	NA	ND	ND
TPH as Diesel	NA	NA	NA	NA	NA	ND	ND
TPH as Gasoline	NA	NA	NA	NA	NA	ND	ND
Metals	NA	NA	NA	NA	NA	ND	ND

Key

BN = Base/neutral extractable organic compound
J = Estimated value
μg/L = Micrograms per liter
NA = Not analyzed
ND = Not detected above method detection limit
PCB = Polychlorinated biphenyl
TPH = Total petroleum hydrocarbon
VOC = Volatile organic compound

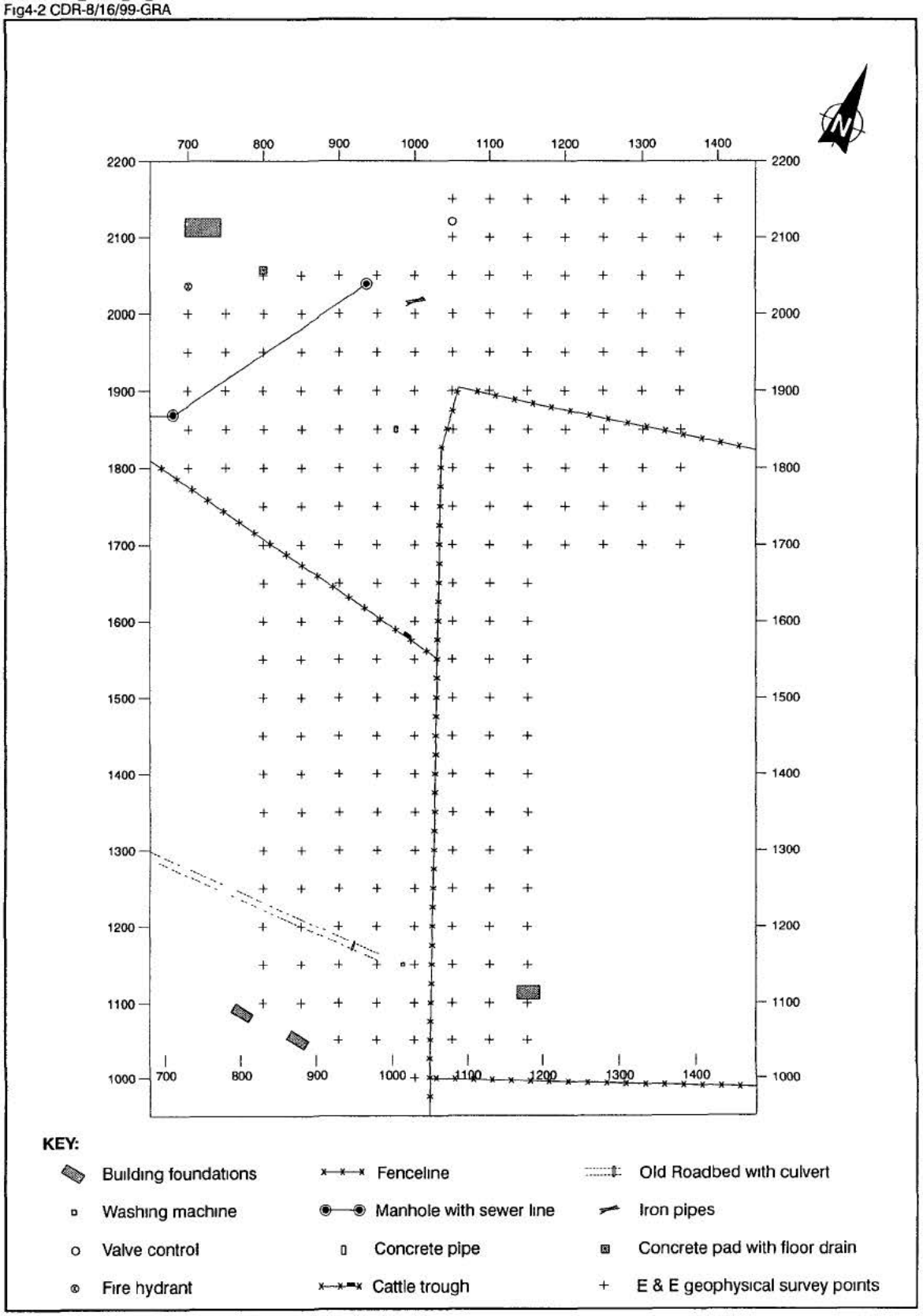
02 000438_VN03_00_05
Fig4-1 cdr-8/16/99-GRA



SOURCE Ecology and Environment, Inc. 1997, USACE 1996

SCALE
0 400 800 Feet

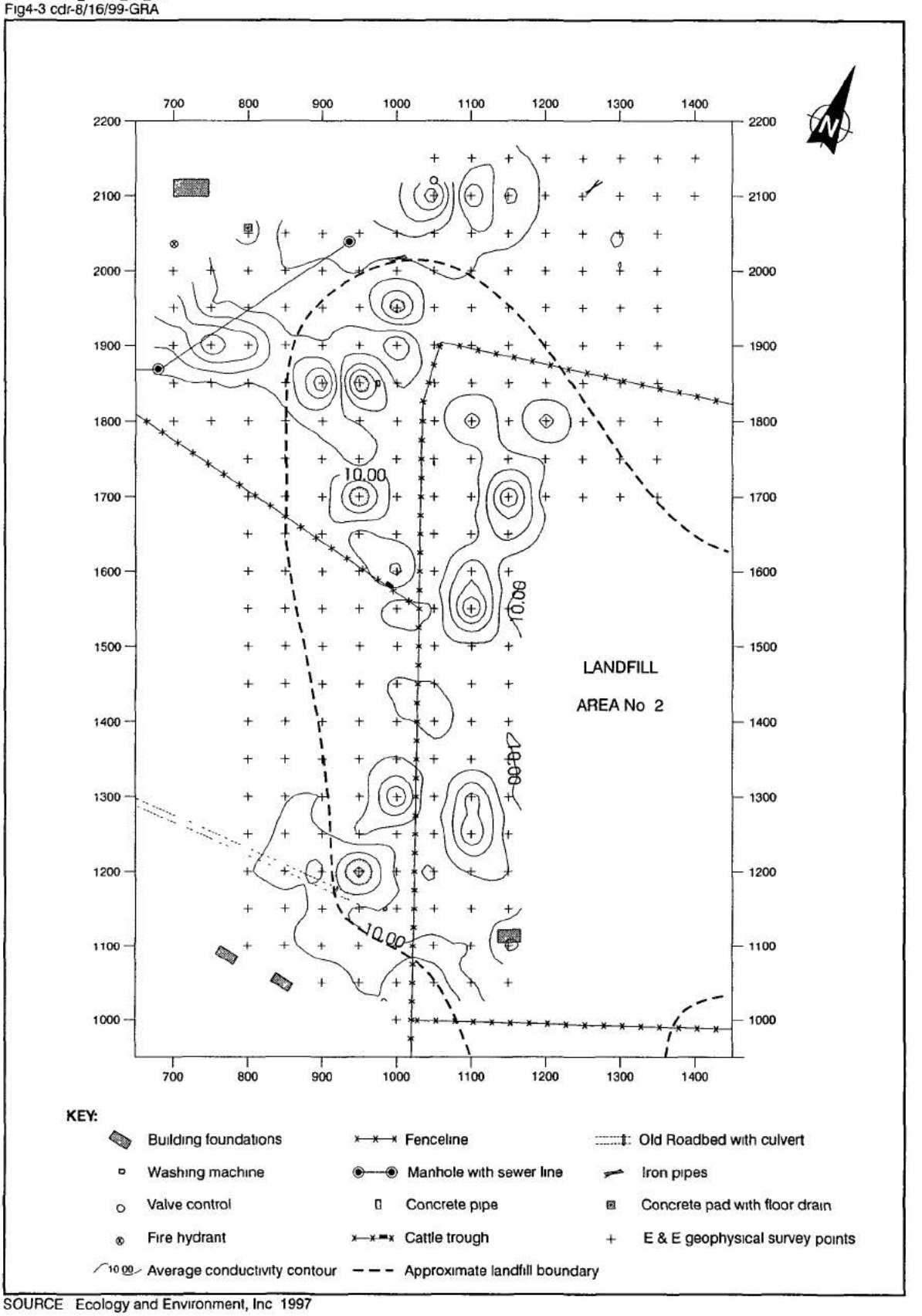
Figure 4-1 GEOPHYSICAL GRID OVERLAY MAP
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO



SOURCE Ecology and Environment, Inc 1997

SCALE
0 200 400 Feet

Figure 4-2 GEOPHYSICAL GRID LOCATION MAP
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO

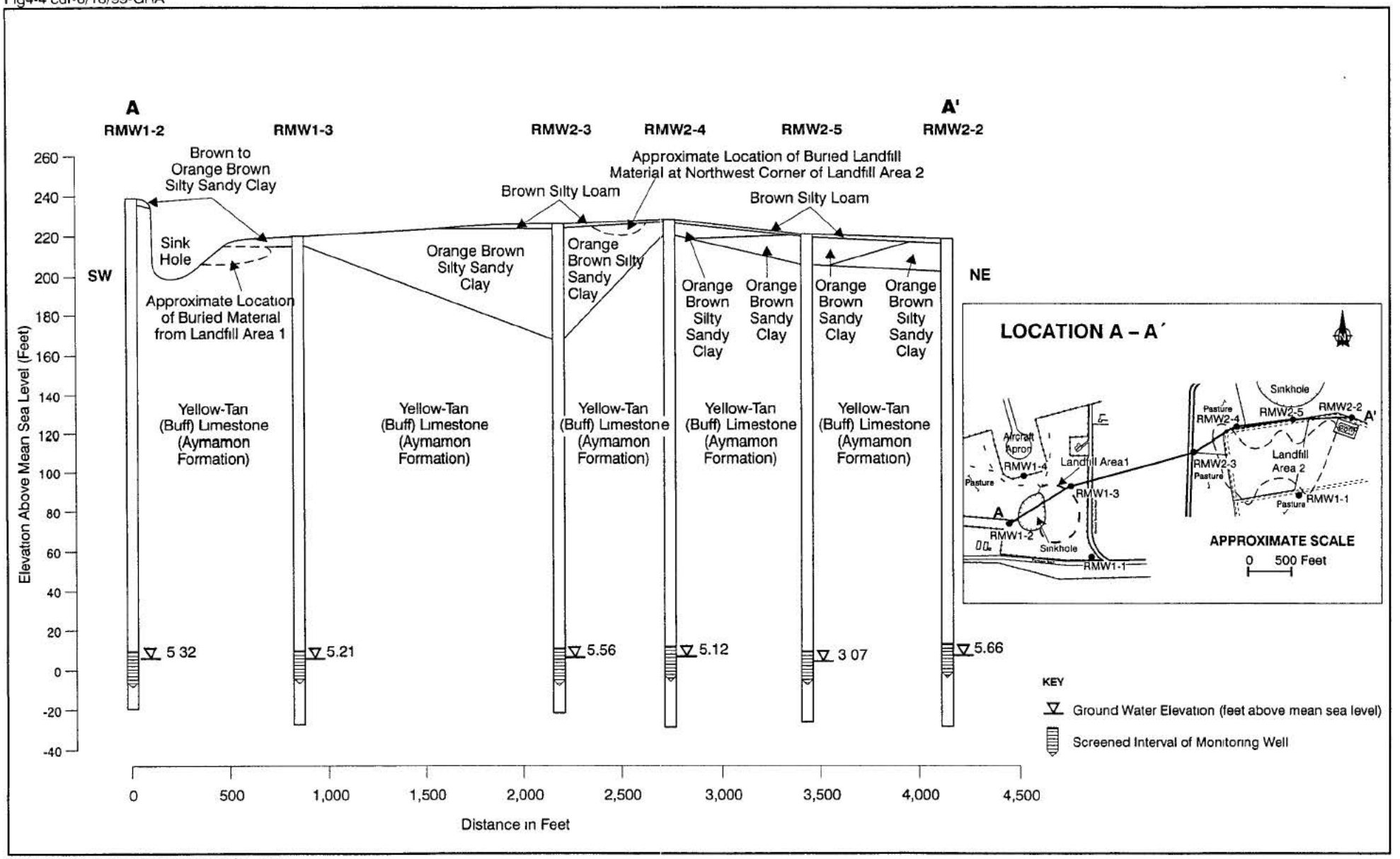


SOURCE Ecology and Environment, Inc 1997

SCALE

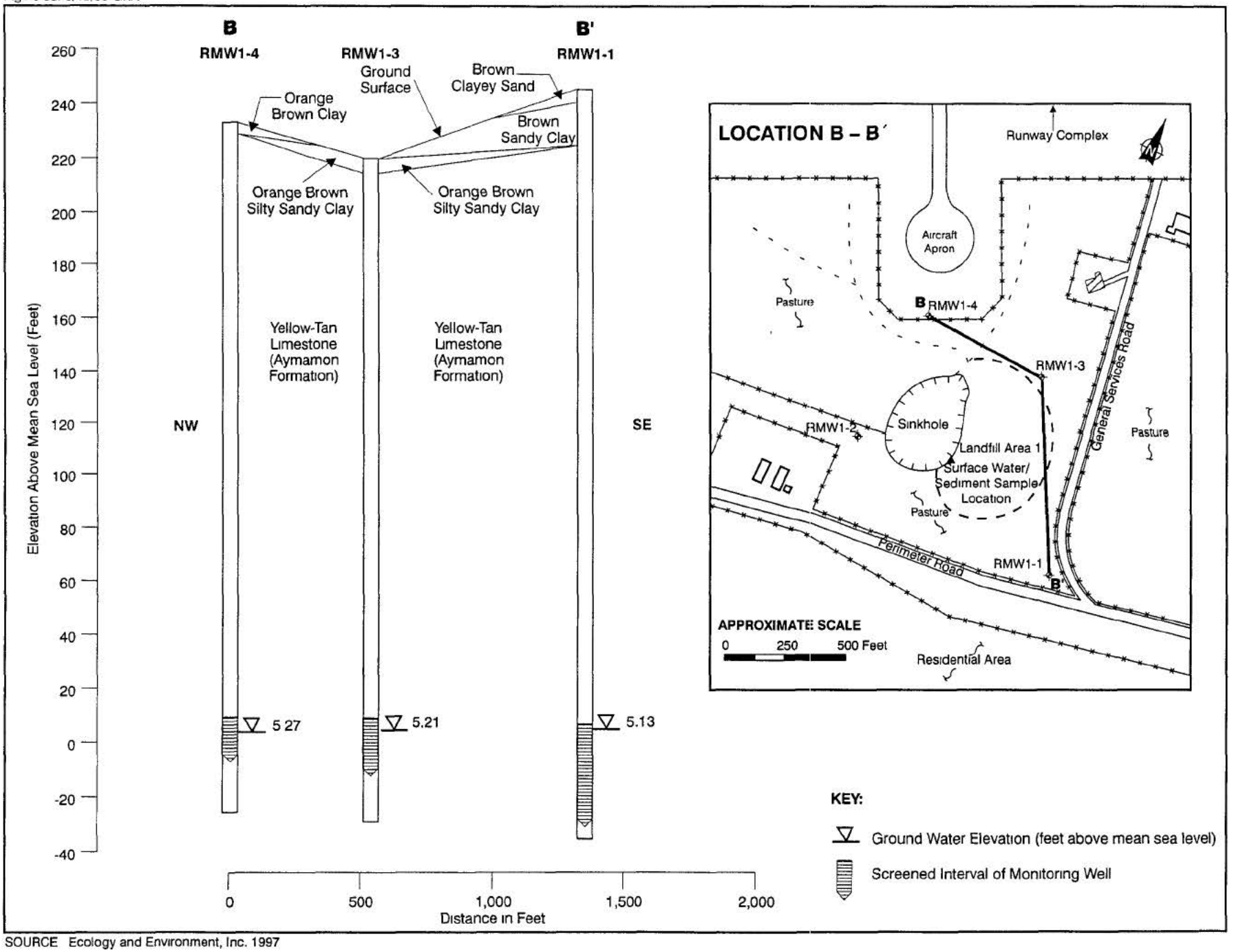
0 200 400 Feet

Figure 4-3 AVERAGE TERRAIN CONDUCTIVITY MAP
LANDFILL AREA 2
FORMER RAMEY AIR FORCE BASE
AGUADILLA, PUERTO RICO



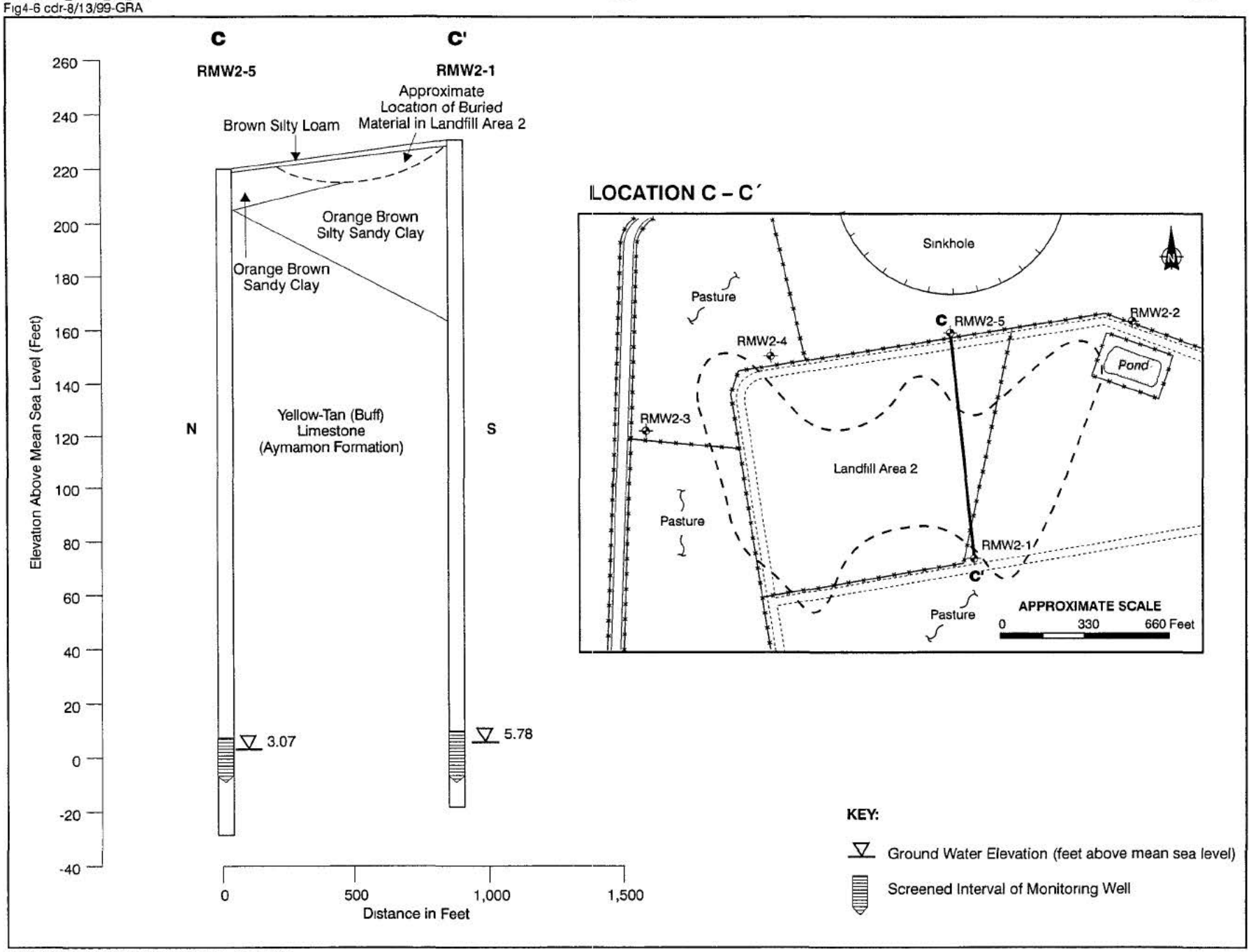
SOURCE Ecology and Environment, Inc 1997

Figure 4-4 GEOLOGIC CROSS SECTION A-A', (SW TO NE) LANDFILL AREAS 1 AND 2 FORMER RAMEY AIR FORCE BASE, AGUADILLA, PUERTO RICO



SOURCE Ecology and Environment, Inc. 1997

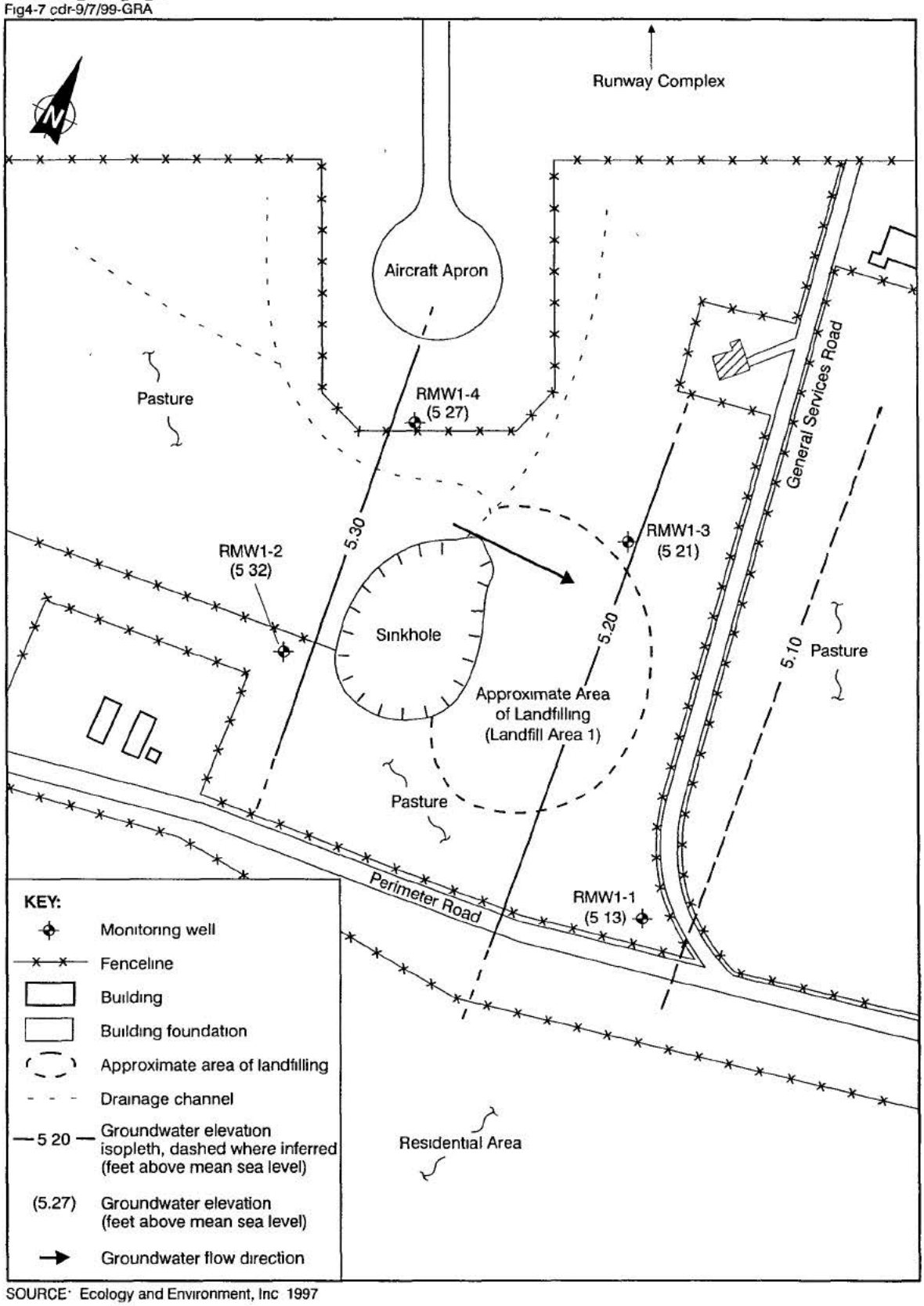
Figure 4-5 GEOLOGIC CROSS SECTION B-B' (NW to SE) LANDFILL AREA 1 FORMER RAMEY AIR FORCE BASE, AGUADILLA, PUERTO RICO



SOURCE Ecology and Environment, Inc. 1997

Figure 4-6 GEOLOGIC CROSS SECTION C-C' (N to S) LANDFILL AREA 2 FORMER RAMEY AIR FORCE BASE, AGUADILLA, PUERTO RICO

02· 000438_VN03_00_05
Fig4-7 cdr-9/7/99-GRA

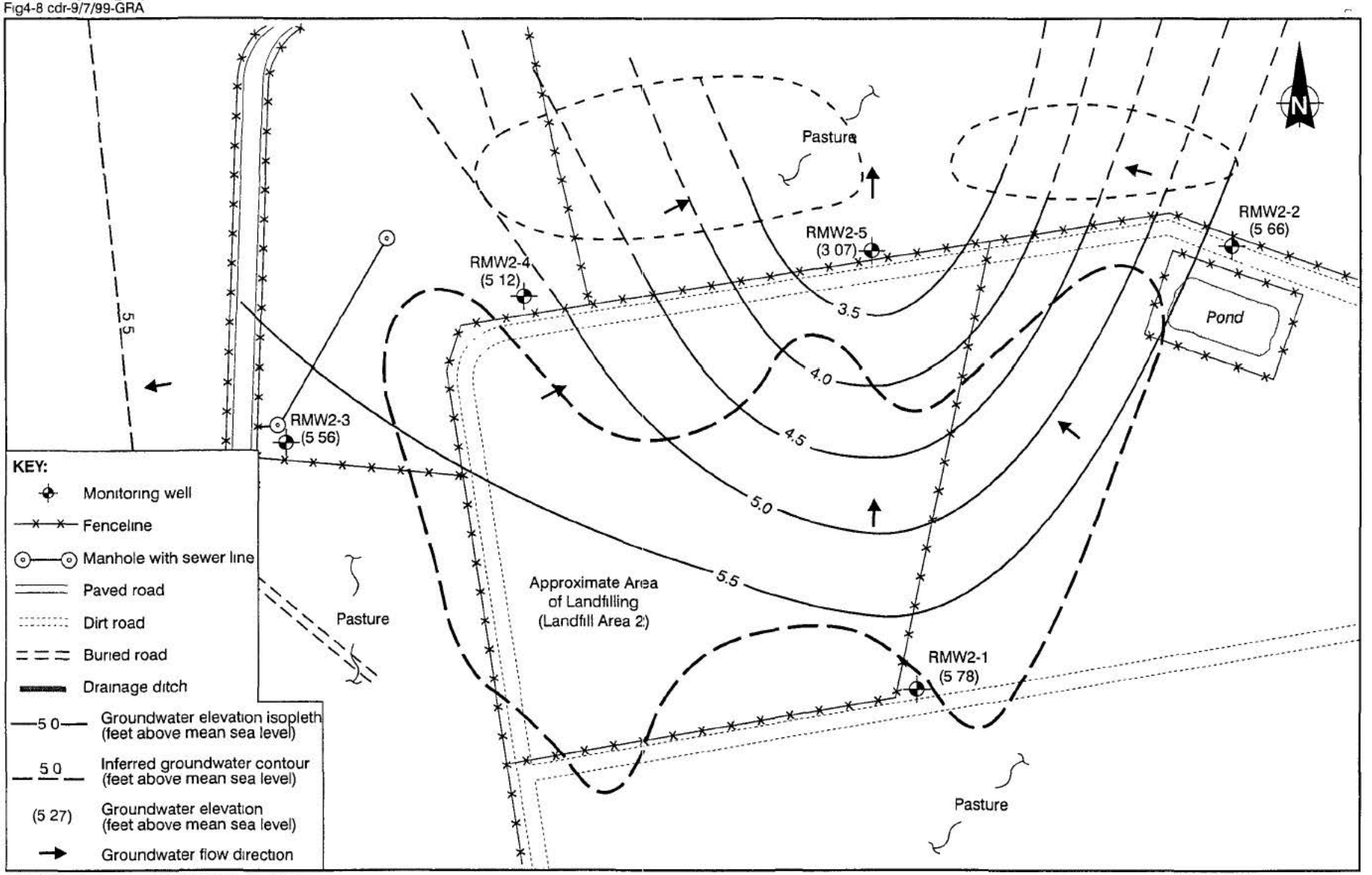


SOURCE· Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 250 500 Feet

Figure 4-7 GROUNDWATER ELEVATION ISOPLETH MAP, LANDFILL AREA 1 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

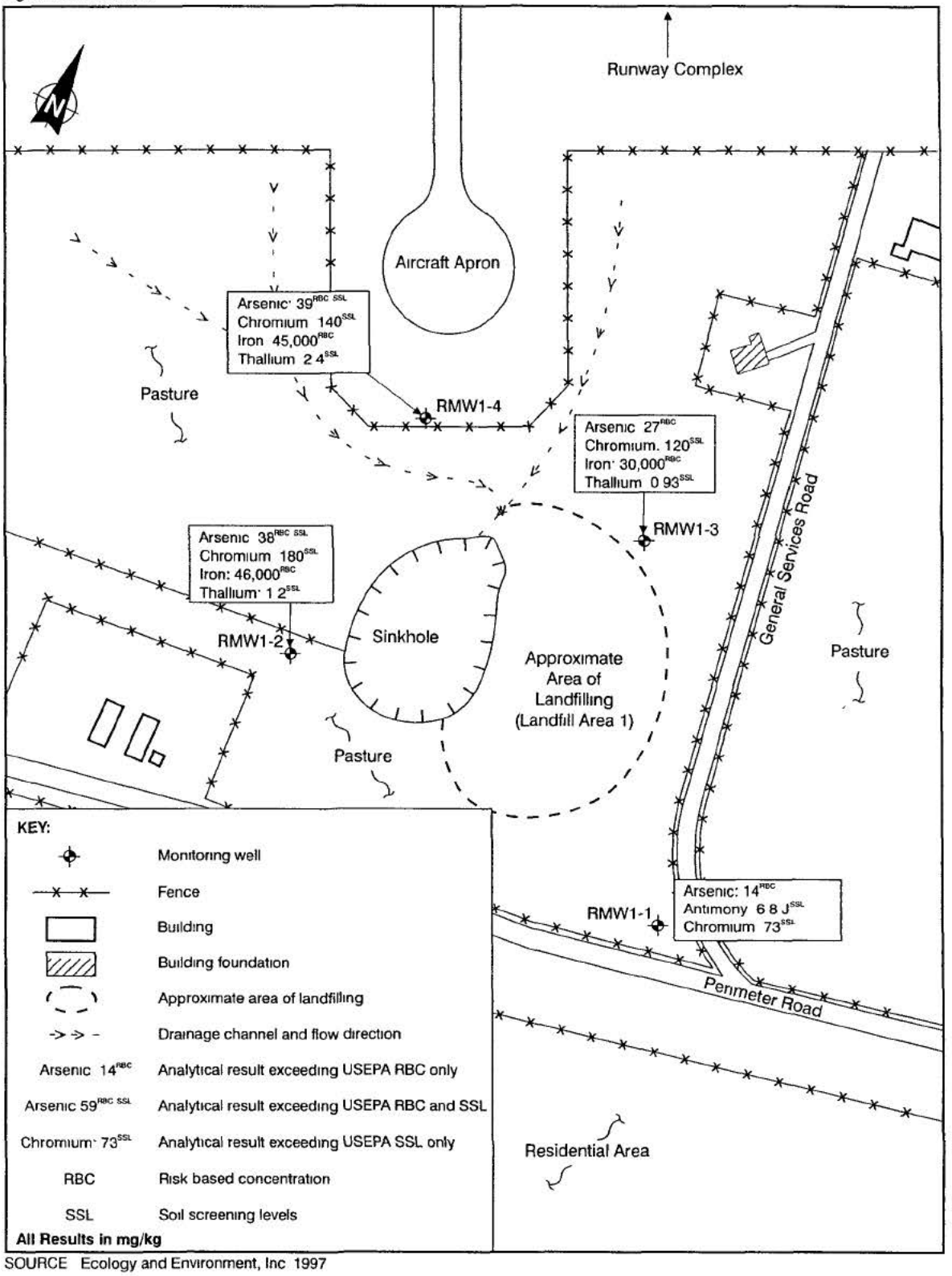
02' 000438_VN03_00_05
Fig4-8 cdr-9/7/99-GRA



SOURCE Ecology and Environment, Inc. 1997

APPROXIMATE SCALE
0 330 660 Feet

Figure 4-8 GROUNDWATER ELEVATION ISOPETH MAP, LANDFILL AREA 2 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

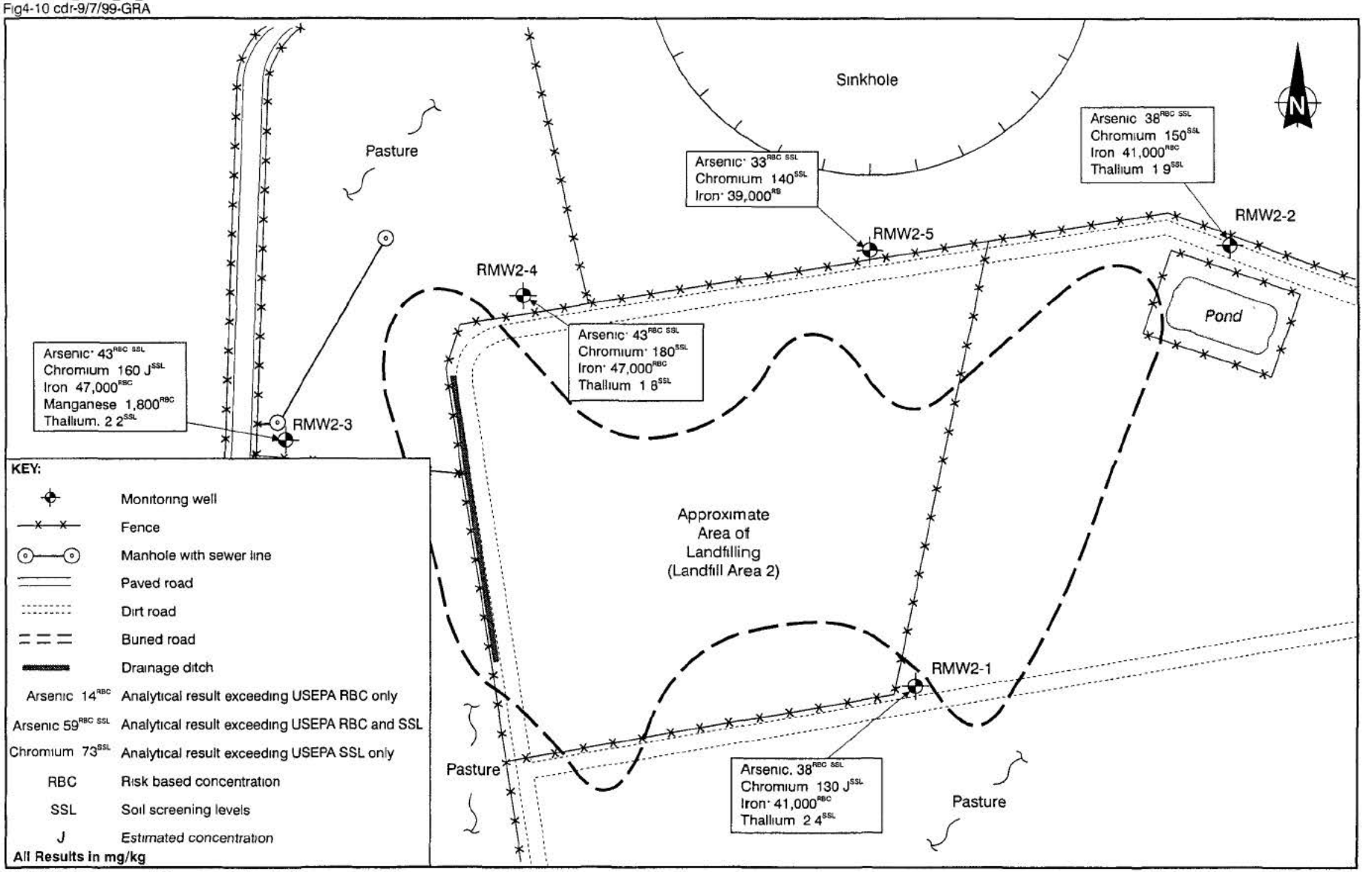


SOURCE Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 250 500 Feet

Figure 4-9 SURFACE SOIL SAMPLE LOCATIONS EXCEEDING RESIDENTIAL RBCs AND/OR SSLs LANDFILL AREA 1 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

02 000438_VN03_00_05
Fig4-10 cdr-9/7/99-GRA

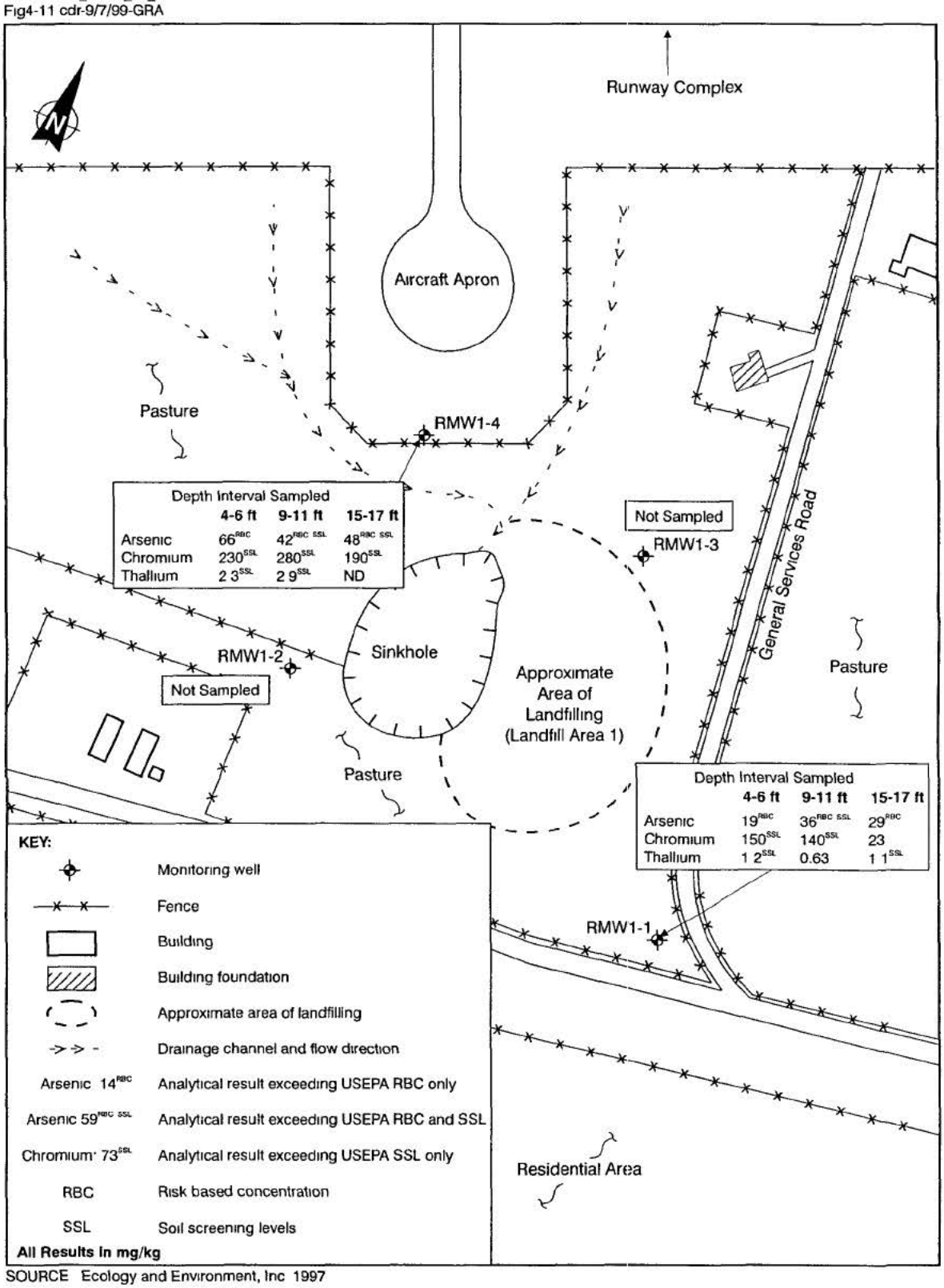


SOURCE Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 330 660 Feet

Figure 4-10 SURFACE SOIL SAMPLE LOCATIONS EXCEEDING RESIDENTIAL RBCs AND/OR SSLs LANDFILL AREA 2 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

02 000438_VN03_00_05
Fig4-11 cdr-9/7/99-GRA

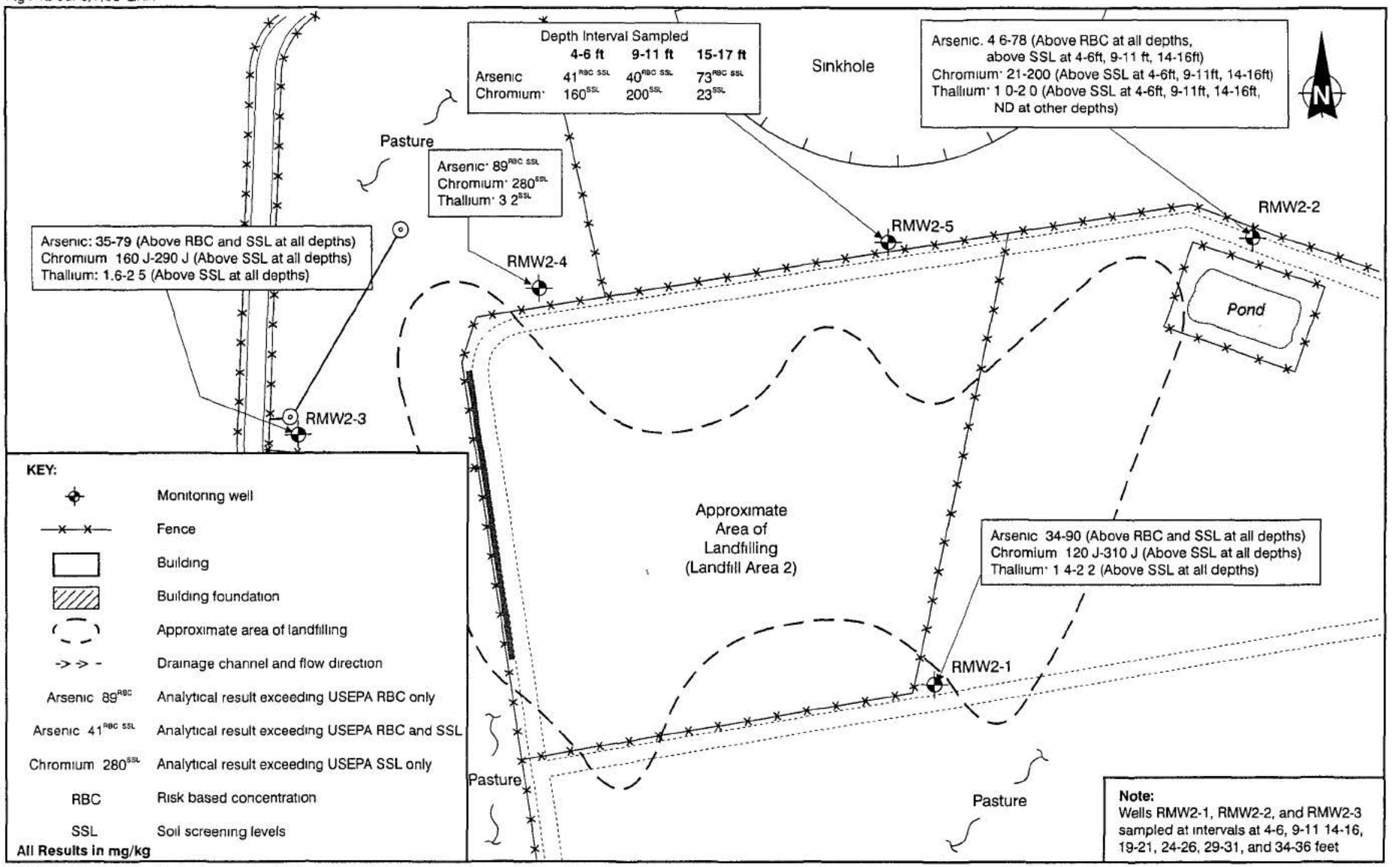


SOURCE Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 250 500 Feet

Figure 4-11 SUBSURFACE SOIL SAMPLE LOCATIONS EXCEEDING INDUSTRIAL RBCs AND/OR SSLs LANDFILL AREA 1 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

02 00438_VN03_00_05
Fig4-12 cdr-9/7/99-GRA

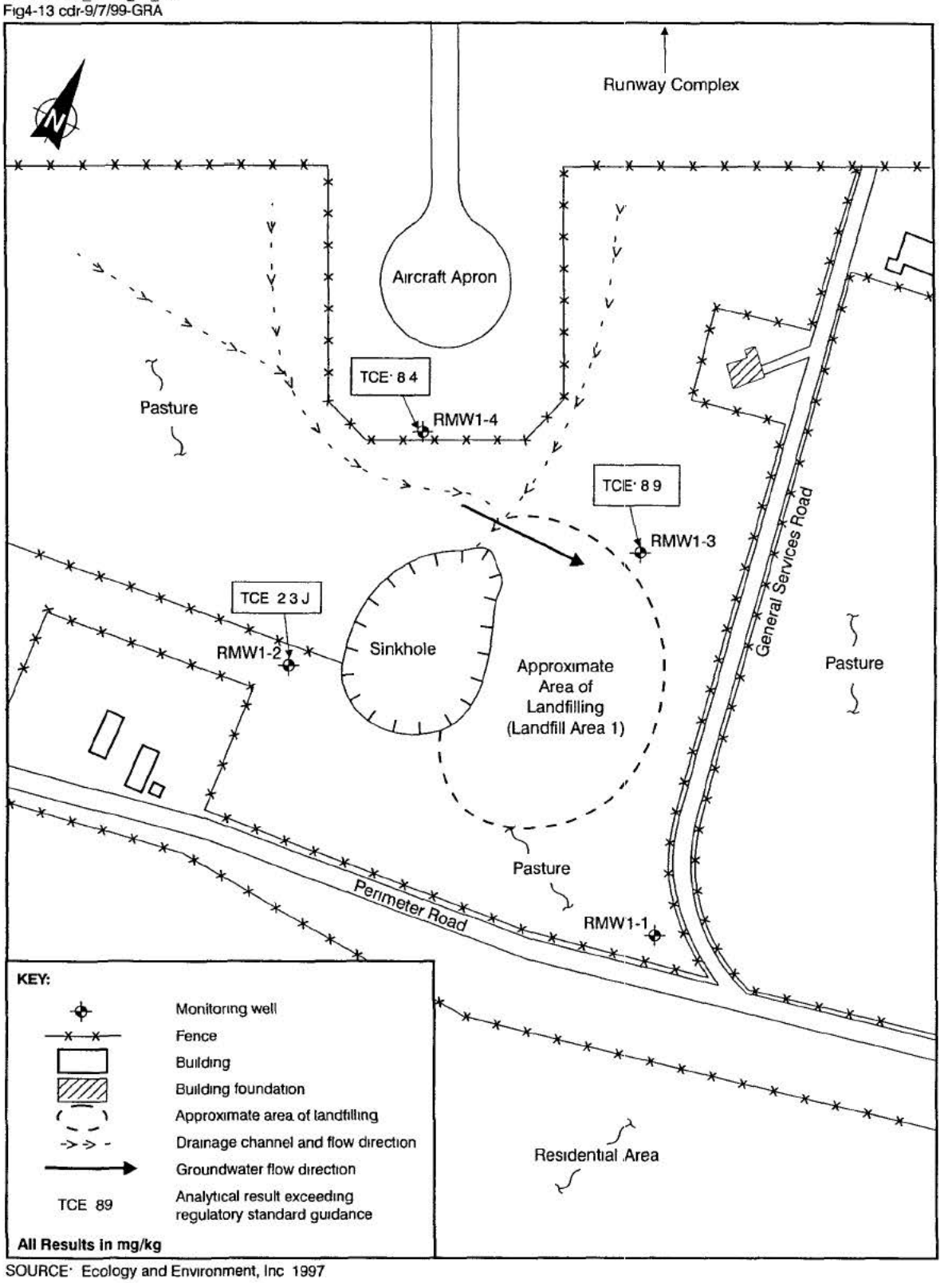


SOURCE Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 330 660 Feet

Figure 4-12 SUBSURFACE SOIL SAMPLE LOCATIONS EXCEEDING INDUSTRIAL RBCs AND/OR SSLs LANDFILL AREA 2 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

02· 000438_VN03_00_05
Fig4-13 cdr-9/7/99-GRA

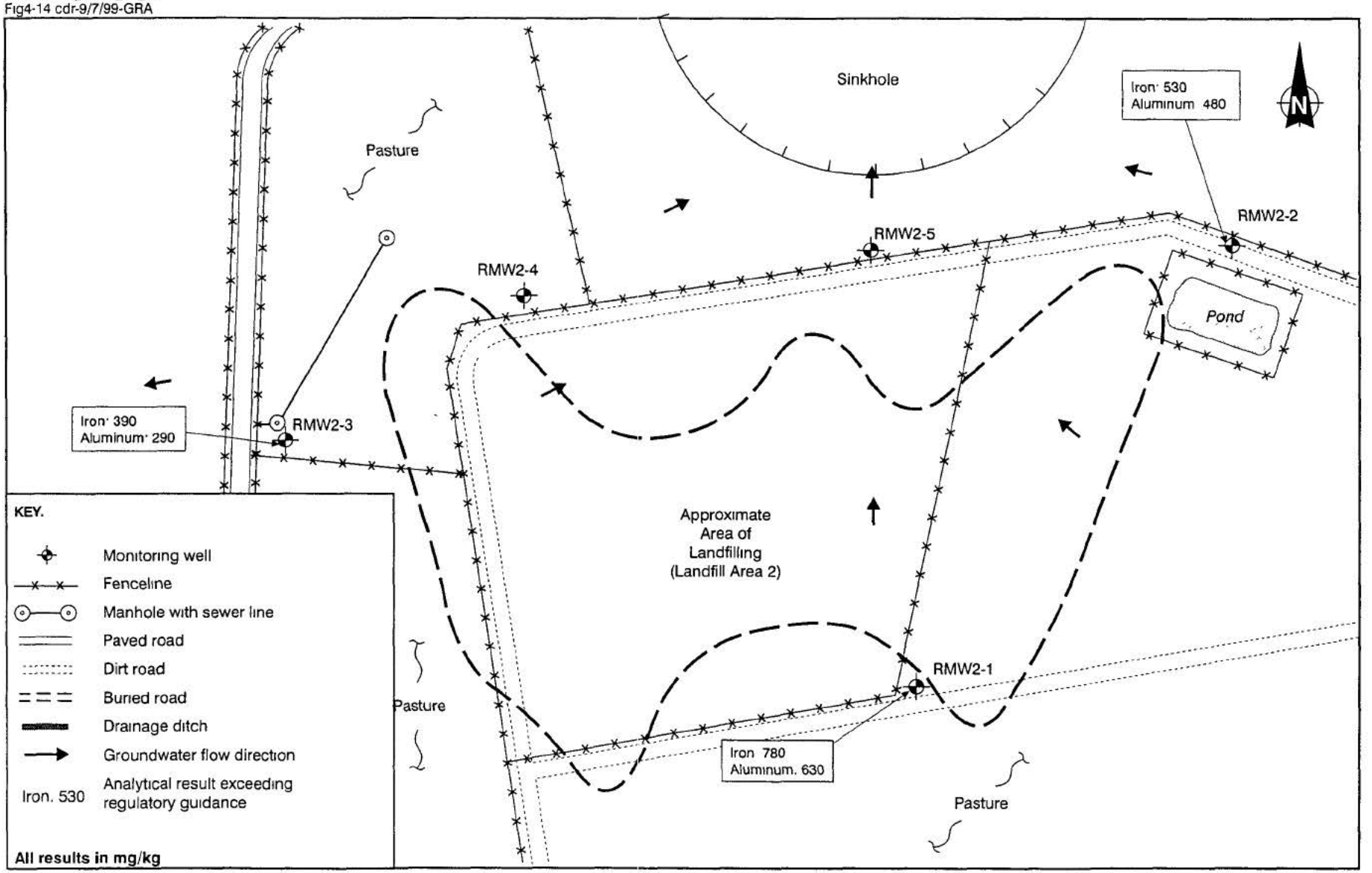


SOURCE· Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 250 500 Feet

Figure 4-13 EXCEEDANCES OF REGULATORY STANDARDS/GUIDANCES 1998 GROUNDWATER SAMPLE RESULTS LANDFILL AREA 1 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

02 000438_VN03_00_05
Fig4-14 cdr-9/7/99-GRA



SOURCE Ecology and Environment, Inc 1997

APPROXIMATE SCALE
0 330 660 Feet

Figure 4-14 EXCEEDANCES OF REGULATORY STANDARDS/GUIDANCE - 1998 GROUNDWATER SAMPLE RESULTS LANDFILL AREA 2 FORMER RAMEY AIR FORCE BASE AGUADILLA, PUERTO RICO

5 Conclusions and Recommendations

Several inorganic constituents were consistently found above RBCs or SSLs in surface and subsurface soil samples at both landfill areas. The RBCs and SSLs are not intended as cleanup goals, but rather as conservative, initial screening levels. The RBCs were developed by EPA using generic, conservative default assumptions and are based on human health risks via an ingestion pathway. The SSLs were also developed by EPA and are based on the leaching and migration of contaminants in the soil to the groundwater.

Arsenic and iron levels exceeded the residential RBC in most of the surface soil samples, and arsenic exceeded the industrial RBC in all the subsurface samples. Arsenic, chromium and thallium were commonly present above SSLs in both surface and subsurface soil samples. The generally uniform distribution of the constituents that exceeded RBCs and SSLs suggest that there are (or have been) non-landfill sources present or that the concentrations observed are consistent with background levels. E & E recommends that background surface and subsurface soil samples be collected for TAL metals and compared to site data. If background levels are consistent with site concentrations, no further action for soil is needed. If background levels are consistently lower for those constituents that exceeded the RBCs, a risk assessment may be warranted. No further evaluation of the constituents which exceed the SSLs is warranted since none of the analytes were present in the groundwater at levels of concern. If leaching of contaminants from soil to groundwater was occurring, it would be evident in the groundwater by now, given the age of the landfill.

A few groundwater sample analytical results exceeded the PRWQS or EPA MCLs for drinking water and/or EPA RBCs for tapwater. Each of these regulatory standards or guidance concentrations has been based on human consumption of groundwater. At Landfill Area 1, TCE was detected in all four wells. Concentrations in all wells were low; however, guidance levels in three of the wells were exceeded. The maximum TCE concentration was 8.9 μg/L ,which was detected in RMW1-3. A risk evaluation should be conducted to determine if the low levels of TCE pose a risk to human health.

At Landfill Area 2, TCE was detected in four of the five wells, but at levels below guidance concentrations. The only constituents to exceed regulatory levels at Landfill Area 2 were iron and aluminum. They exceeded secondary drinking water standards which are based on aesthetics and not human health risks. It is possible that these metals are the result of turbidity in the sample and not actual groundwater contamination. E & E recommends collecting and analyzing samples for filtered (dissolved) metals at Landfill Area 2 (RMW2-1, RMW2-2, and RMW2-3) to help determine if iron and aluminum are the result of turbidity. The well at the U.S. Customs office should be sampled and analyzed for VOCs and TAL metals.

A few sediment sample analytical results from Landfill Area 1 exceeded EPA Residential RBCs for iron and a few BNs. Puerto Rico has not established standards for sediment. As discussed, the sinkhole where the sample was collected receives stormwater runoff from the entire southern portion of the municipal airport runway complex and industrial park. The constituents detected may be unrelated to DOD landfilling activities. E & E recommends the collection of additional sediment samples along the course of the drainage channels to determine if the landfill is the source of these constituents. Samples should be analyzed for BNs, pesticides/PCBs, and metals.

Exposed landfill material, particularly medical wastes at Landfill Area 1, presents a physical hazard to the tenant farmers, livestock, recreational site users, and site trespassers. It is unclear if the medical wastes at Landfill Area 1 were deposited as a result of DOD activity. Landfill material is actively being eroded from both landfills. E & E recommends the landfills be stabilized (at a minimum) and engineered erosional controls be established to prevent the further exposure of landfill material.

6 References

Agency for Toxic Substance and Disease Registry (ATSDR), 1995, Toxicological Profile for Polycyclic Aromatic Hydrocarbons, Prepared by Research Triangle Institute for U.S. Department of Health and Human Services, Public Health Service, ATSDR.

_____, 1993, Toxicological Profile for Arsenic, Update, Prepared by Life Systems, Inc., for U.S. Department of Health and Human Services, Public Health Service, ATSDR.

Commonwealth of Puerto Rico, Environmental Quality Board, September 27, 1990, Puerto Rico Water Quality Standards Regulation, As Amended.

CRC Press, Inc., 1982, CRC Handbook of Chemistry and Physics, 63rd Edition, Boca Raton, Florida.

Ecology and Environment, Inc., 1997a, Work Plan for the Site Investigation at Landfill Areas 1 and 2, Former Ramey Air Force Base, Aguadilla, Puerto Rico.

_____, 1997b, Chemical Data Acquisition Plan for the Site Investigation at Landfill Areas 1 and 2 at the Former Ramey Air Force Base, Aguadilla, Puerto Rico.

_____, 1997c, Data Management Plan for the Site Investigation at Landfill Areas 1 and 2 at the Former Ramey Air Force Base, Aguadilla, Puerto Rico.

_____, 1997d, Geologic Data Acquisition Plan for the Site Investigation at Landfill Areas 1 and 2 at the Former Ramey Air Force Base, Aguadilla, Puerto Rico.

_____, 1997e, Project Management Plan for the Site Investigation at Landfill Areas 1 and 2 at the Former Ramey Air Force Base, Aguadilla, Puerto Rico.

_____, 1997f, Project Field Logbook, Landfill Areas 1 and 2 at the Former Ramey Air Force Base, Aguadilla, Puerto Rico.

Puerto Rico Aqueduct and Sewer Authority (PRASA), 1983, Water Supply Systems Maps for Aguadilla, Puerto Rico.

Ramos, Jose, 1996, Personal communication between Perry Kelso and Jose Ramos.

Richards, Ronald T., 1997, U.S. Geological Survey, Caribbean District, Telephone Conversation with John Williams.

Sittig, Marshall, 1985, Handbook of Toxic and Hazardous Chemicals and Carcinogens, Second Edition, Park Ridge, New Jersey.

U.S. Army Corps of Engineers, Savannah District, March 1996a, Scope of Work for the Site Investigation of Landfill Areas 1 and 2 at the Former Ramey Air Force Base, Aguadilla, Puerto Rico.

_____, 25 March 1996b, Geophysical Survey Memorandum.

_____, 30 June 1995, Requirements for the Preparation of Sampling and Analysis Plans, EM 200-1-3.

_____, 15 April 1992, Sight Survey Summary Sheet for DERP-FUDS, Site No. IOZPR087900, Rafael Hernandez Airport (Former Ramey AFB).

U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, 1992, Toxicological Profile for Beryllium, TP-92/04, Washington, D.C.

United States Environmental Protection Agency, 1999, Region 3, Table of Risk-Based Concentrations, April 12, 1999.

_____, 1997a, Memorandum from Roy L. Smith (Toxicologist) to RBC table mailing list, Re: Updated risk-based concentration table, March 17, 1997.

_____, 1997b, Region 3 Updated Risk-Based Concentration Table.

_____, 1996a, Office of Water, Drinking Water Regulations and Health Advisories, October 1996.

_____, 1996b, Office of Solid Waste and Emergency Response, Soil Screening Guidance: Technical Background Document, May 1996.

_____, 1995a, Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletin No. 1, Data Collection and Evaluation, November, 1995.

_____, 1995b, Drinking Water Regulations and Health Advisories, Office of Water, May, 1995.

_____, 1991a, Engineering Compliance Branch Standard Operating Procedures and Quality Assurance Manual.

_____, 1991b, Compendium of ERT Surface Water and Sediment Sampling Procedures, Interim Final, OSWER Directive 9360.4-03, Washington, D.C.

_____, 1987, A Compendium of Superfund Field Operation Methods, EPA/540, Office of Emergency and Remedial Response, Washington, D.C.

_____, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD), OSWER-9950.1, Washington, D.C.

7 Puerto Rico Professional Engineer Certification

I hereby sign the Site Investigation Report for Landfill Areas 1 and 2 at the former Ramey Air Force Base in Aguadilla, Puerto Rico, in accordance with the laws and regulations of the Commonwealth of Puerto Rico.

Name: Jim Bolleter, P.E.

License No.: 17648

Jim Bolleter, P.E.

3-15-01

Date

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