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FINAL REMEDIAL INVESTIGATION REPORT REVISION 2 FOR OPERABLE UNIT 2 (OU 2) MCCOY ANNEX LANDFILL VOLUME 1 OF 3 PART A SECTIONS 1.0 THROUGH 4.0 NTC ORLANDO FL

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REMEDIAL INVESTIGATION REPORT

for

OPERABLE UNIT 2
McCOY ANNEX LANDFILL

Naval Training Center
Orlando, Florida

VOLUME I OF III
(TEXT)

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO-0024

MARCH 2001

R4712981

CTO 0024

Tetra Tech NUS, Inc.
Oak Ridge Office

RECORD OF REVIEW

Project No.: 7457 **Date:** 2/19/01

Project Desc.: NTC, Orlando

Project Manager: S. McCoy

Document Title: "Remedial Investigation Report, Operable Unit 2, NTC Orlando" (Final)

Authors: K. Cubbage (ERA), R. Warren (HHRA), A. Jenkins, S. Barton

Date Review to be Completed By: 2/23/01

Reviewers, Document Sections and Scope of Review:

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A:	J. Orient	BE009C465		☒	Exc: 6.0 & 7.0	☒	☐	☒
B:	M. Campbell	"		☐	Revised sections*	☒	☐	☒
C:	S. Smith	"		☒		☐	☐	☒
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S.B. McCoy 3/5/01
Project Manager Signature / Date

Tetra Tech NUS, Inc.
Oak Ridge Office

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(1) Report Title/Product Description: Revisions to OU 2 Ecological Risk Assessment

(2) Copy ____ of ____

(3) Project Name: NTC Orlando OU 2 RI Report

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II. Author/Reviewer Assignment

(7) Prinicpal Author: K. Cabbage Contributing Authors: ____

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	Review Complete (Reviewers Initial/Date)	Results		Comments Reviewed & Resolved (Author Initial/Date)	Resolution Approved (Reviewer Initial/Date)
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S.B. McCoy [signature] 3/5/01
Project Manager Signature and Date

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Technical Manager Signature and Date

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0301-I028

March 7, 2001

Commanding Officer
SOUTHNAVFACENGCOM
ATTN: Ms. Barbara Nwokike, Code 1873
P.O. Box 190010
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North Charleston, SC 29419-9010

Subject: Final Remedial Investigation Report (Rev. 2), Operable Unit 2, McCoy Annex Landfill Naval Training Center, Orlando, Florida
Reference: CLEAN Contract No. N62467-94-D-0888
Contract Task Order No. 0024

Dear Ms. Nwokike:

Enclosed are two copies of the final to Remedial Investigation Report for OU 2. One of the copies has been provided for the Administrative Record. A copy has also been forwarded to Wayne Hansel for the Information Repository at the Orange County Public Library.

This revision contains the following information:

- Changes to Rev. 1 of the Remedial Investigation Report (draft final), issued in March 2000, that resulted from FDEP and USEPA review comments.
- New data from direct push screening activities performed in September 2000 and February 2001.

Please contact me at (865) 220-4730 if you have any questions regarding the report.

Sincerely,

Steven B. McCoy, P.E.
Task Order Manager

SBM:msc

Enclosures (2)

c: Mr. Wayne Hansel, SOUTHNAVFACENGCOM (3)
Mr. David Grabka, FDEP (2)
Ms. Nancy Rodriguez, USEPA Region IV (2)
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Ms. Jacque Van Audenhove, Tetra Tech NUS
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REMEDIAL INVESTIGATION REPORT

for

OPERABLE UNIT 2 McCOY ANNEX LANDFILL

Naval Training Center Orlando, Florida

VOLUME I OF III
(TEXT)

**Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO-0024**

MARCH 2001

REMEDIAL INVESTIGATION REPORT FOR OPERABLE UNIT 2 McCOY ANNEX LANDFILL

NAVAL TRAINING CENTER ORLANDO, FLORIDA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:

Department of the Navy, Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:

Tetra Tech NUS, Inc.
661 Andersen Drive
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Pittsburgh, Pennsylvania 15220

CONTRACT NO. N62467-94-D-0888
CONTRACT TASK ORDER 0024

MARCH 2001

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ACRONYMS AND ABBREVIATIONS

ABB-ES	ABB Environmental Services, Inc.
Air Force	U.S. Air Force
AMSL	above mean sea level
ARAR	applicable or relevant and appropriate requirement
ASTDR	Agency for Toxic Substances and Disease Registry
ASTM	American Society for Testing and Materials
AWQC	ambient water quality criteria
B&R Environmental	Brown & Root Environmental
BAF	bioaccumulation factor
BDL	below detection limit
BERA	baseline ecological risk assessment
bgs	below ground surface
BGSV	background screening value
BOD	biological oxygen demand
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAS	Chemical Abstracts Service
CCME	Canadian Council of Ministers of the Environment
CEC	cation exchange capacity
CERCLA	Comprehensive Environment Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
COD	chemical oxygen demand
COPC	chemical of potential concern
CPT	cone penetrometer testing
CRQL	Contract Required Quantitation Limit
CSF	cancer slope factor
DAevent	dose absorbed per event
DCE	dichloroethene
DEHP	diethylhexylphthalate
DGPS	differential global positioning system
DOD	U.S. Department of Defense
DON	Department of the Navy

ACRONYMS AND ABBREVIATIONS (Continued)

DPT	direct push technology
DQO	Data Quality Objective
DRO	diesel-range organics
EEG	Environmental Enterprise Group
EM	electromagnetic
EPC	exposure point concentration
EPD	effective predictive domain
ER-L	Effects Range-Low
ER-M	Effects Range-Medium
ERA	ecological risk assessment
ERT	Environmental Response Team
FDEP	Florida Department of Environmental Protection
FGFWFC	Florida Game and Fresh Water Fish Commission
FL PRO	Florida petroleum range organics
FNAI	Florida Natural Areas Inventory
FS	feasibility study
FSEV	Florida Sediment Evaluation Value
FSWC	(Florida) Freshwater Surface Water Criteria
GOAA	Greater Orlando Aviation Authority
gpm	gallons per minute
GPR	ground-penetrating radar
GRO	gasoline-range organics
GCTL	groundwater cleanup target level
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IAS	Initial Assessment Study
ICP	inductively coupled plasma
ID	inner diameter
ILCR	incremental lifetime cancer risk
IR	Installation Restoration
IRA	interim remedial action
IRIS	Integrated Risk Information System

ACRONYMS AND ABBREVIATIONS (Continued)

LOAEL	lowest-observed-adverse-effects level
MCL	Maximum Contaminant Level
MHSP&E	Ministry of Housing, Spatial Planning and Environment
MOE	Ministry of the Environment
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable or not available
NACIP	Navy Assessment and Control of Installation Pollutants
Navy	U.S. Navy
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NFESC	Naval Facilities Engineering Service Center
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	no-observed-adverse-effects level
NTC	Naval Training Center
NTU	Nephelometric Turbidity Unit
NWI	National Wetlands Inventory
OC	organic carbon
OPT	Orlando Partnering Team
ORNL	Oak Ridge National Laboratory
ORP	oxidation reduction potential
OU	operable unit
PA	Preliminary Assessment
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PEF	particulate emission factor
PEL	probable effects level
ppt	parts per thousand
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RBC	risk-based concentration
RfC	Reference Concentration

ACRONYMS AND ABBREVIATIONS (Continued)

RfD	Reference Dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	Relative Percent Difference
SACM	Superfund Accelerated Cleanup Model
SCRA	South Carolina Research Authority
SCTL	soil cleanup target level
SDWA	Safe Drinking Water Act
SED	sediment
SEL	severe effects level
SI	Site Inspection
SMDP	Scientific/Management Decision Points
SOUTHDIV	Southern Division, Naval Facilities Engineering Command
SOV	soil organic vapor
SSL	Soil Screening Level
SSV	Sediment Screening Value
SVOC	semivolatile organic compound
SW	surface water
TAL	Target Analyte List
TBC	to be considered
TCE	trichloroethene
TDS	total dissolved solids
TEF	Toxicity Equivalency Factor
TEL	threshold effects level
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
TRV	toxicity reference value
TSS	total suspended solids
UCL	Upper Confidence Limit
UCL-L	Upper Confidence Limit lognormal
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency

ACRONYMS AND ABBREVIATIONS (Continued)

USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound

EXECUTIVE SUMMARY

A Remedial Investigation (RI) was performed at the McCoy Annex Landfill, designated Operable Unit (OU) 2, at the Naval Training Center, Orlando. The investigation was conducted in accordance with the U.S. Environmental Protection Agency's interim guidance, *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills* (USEPA, 1996a). The interim guidance states that containment is an appropriate presumptive remedy if the military landfill contains primarily "municipal-type wastes" (i.e., no high-hazard military specific wastes such as chemical warfare agents or military munitions). The containment presumptive remedy may include the items listed below:

- Landfill cap
- Source area groundwater control to contain plume
- Leachate collection and treatment
- Landfill gas collection and treatment
- Institutional controls to supplement engineering controls

At the McCoy Annex Landfill, because the presumptive remedy was containment, the RI objectives were to (1) define the limits (extent) of the landfill, (2) characterize the existing landfill cover to determine the cover thickness and the nature and extent of contamination, (3) determine the nature and extent of impacted groundwater, (4) characterize the site-specific geology and hydrogeology, (5) determine whether other environmental media (such as sediment or surface water) have been impacted, and (6) determine the human health and ecological risks posed by all impacted media.

Site Background - The Naval Training Center, Orlando, consists of 2,072 acres in Orange County, Florida, and includes four discrete facilities: Main Base, Area C, Herndon Annex, and McCoy Annex. The McCoy Annex, which includes OU 2, encompasses approximately 877 acres and is located approximately 8 miles south of the Main Base, west of Orlando International Airport. The McCoy Annex Landfill (OU 2) is an inactive landfill located in the southern part of McCoy Annex. The landfill occupies approximately 114 acres. A nine-hole golf course now occupies much of the site.

The eastern and western portions of the site were used for landfilling wastes by the U.S. Air Force from about 1960 to 1972, while the eastern portion was used as a landfill by the U.S. Navy from 1972 until about 1978. Landfill operations consisted of excavating ditches (100 to 200 feet long by 20 to 25 feet wide by 10 to 15 feet deep) into which trucks disposed of wastes. Occasional burning of the wastes took place in the ditches. It was estimated that the volume of waste was more than 1,000,000 cubic yards (C.C. Johnson & Associates, 1985).

Previous investigative activities at the Naval Training Center, Orlando included an Initial Assessment Study conducted by C.C. Johnson & Associates (1985) and a Verification Study conducted by Geraghty & Miller (1986). Both of these documents include a chapter on the McCoy Annex Landfill.

Phase I Investigation – The RI of OU 2 was performed in a phased approach. Phase I was begun in May 1997 and was completed in December 1997. The following activities were conducted during the Phase I field investigation:

- Geophysical surveys (electromagnetic terrain conductivity and magnetometer) – to define the limits of the landfill.
- Hand auger borings and ground-penetrating radar – to determine the landfill cover thickness.
- Soil organic vapor survey – to define the limits of the landfill.
- Surface soil sampling – to determine the nature and extent of contamination in the existing landfill cover.
- Surface water and sediment sampling – to determine whether surface waters or sediments had been impacted by landfill contaminants.
- Direct push technology (DPT) groundwater sampling – to determine monitoring well locations for Phase II.
- Cone penetrometer testing – to begin characterization of the site geology and to determine monitoring well locations for Phase II.

The results of Phase I were documented in the *Remedial Investigation Technical Memorandum for Operable Unit 2, McCoy Annex Landfill* (B&R Environmental, 1998a).

Phase II Investigation – The Phase I data were evaluated and used to focus the Phase II investigation. Phase II was begun in March 1998 and was completed in October 1998. The following activities were conducted during the Phase II field investigation:

- Geophysical surveys (electromagnetic terrain conductivity and magnetometer) – to define the western limits of the landfill.

- Hand auger borings and surface soil sampling – to evaluate the thickness and potential contamination of the landfill cover near the western and southern margins of the landfill.

- Surface water and sediment sampling – to evaluate the perimeter areas.

- DPT groundwater sampling – to help further define the locations for the groundwater monitoring wells.

- Piezometer and staff gauge installation – to determine the direction of groundwater flow and the interaction between groundwater and surface water at the site.

- Monitoring well installation and sampling – to investigate groundwater contamination in both the surficial and Hawthorn Group aquifers.

- Aquifer testing – to characterize the site hydrogeology.

Phase III Investigation - The Phase I and Phase II data were evaluated and used to focus the Phase III investigation. The data analysis identified three areas of concern that could impact the interpretation of the thickness of the soil cover over landfilled areas, the nature and extent of contamination, and the baseline risk assessment. The areas of concern were: (1) A shallow water table, thickly vegetated areas, and golf course landscape alterations and irrigation impaired interpretation of the soil cover thickness based on the Phase I and Phase II geophysical survey results. (2) The Phase II groundwater samples collected from monitoring wells tended to contain high levels of turbidity. Sample turbidity could result in false positive detections of chemicals and higher dissolved concentrations of some chemicals in groundwater than exist in non-turbid formation water. (3) Following completion of sediment and surface water sampling performed during Phases I and II, the drainage canals in which the sediment/surface water sample pairs had been collected were dredged, resulting in a potentially significant change in current conditions. In addition, the upstream sediment/surface water samples contained contaminants that did not appear to be related to OU 2 activities. Phase III was begun in February 1999 and was completed in February 2001. The following activities were performed during Phase III to address these data gaps and uncertainties:

- Additional hand auger borings were installed to validate and supplement the geophysical data to aid in the interpretation of the soil cover thickness over landfilled areas.

- Forty-six of the site's 48 monitoring wells were sampled using techniques to reduce well stress and sample turbidity.

- Sediment and surface water samples were collected in the dredged sections of the canals, and several new upstream locations were sampled.

- DPT groundwater samples were collected at 28 locations (2 samples at each location) in the southern portion of the landfill to investigate the extent of contamination in this area.

The combined Phase I, Phase II, and Phase III RI sampling activities consisted of collecting 533 DPT groundwater samples, 129 surface soil samples, groundwater samples from 48 monitoring wells, and surface water and sediment samples from 28 locations. Generally (except for DPT groundwater samples analyzed for volatile organics only), the samples were analyzed for volatile organic compounds, semivolatile organic compounds, inorganic chemicals (metals), total petroleum hydrocarbons, pesticides, herbicides, and radiological parameters. Ten percent of the samples were analyzed for polychlorinated biphenyls, and, if they were present, the samples were analyzed for dioxins.

Investigation Results - The results of the investigation show the following:

- The limits of the landfill unit are consistent with the historical records; all of the landfill areas are located on U.S. Navy property.

- The existing soil cover thickness was found to be typically 1 to 2.5 feet thick over most of the landfill areas. In a few isolated areas of the golf course and in the undeveloped forested area, waste material was visible on the surface; however, hand auger data suggest that this may be trash dumped on the surface after landfill operations were discontinued.

- The Remedial Investigation data show exceedances of the State of Florida Cleanup Target Levels for semivolatile organic compounds, pesticides, total petroleum hydrocarbons, arsenic, barium, magnesium, gross alpha, and gross beta in surface soil; volatile organic compounds and inorganics in groundwater; one semivolatile organic compound, one pesticide, inorganics, and gross alpha in surface water; and one semivolatile organic compound, three pesticides, three inorganics, and gross alpha in sediment.

- Hydrogeologic data and chemical fate and transport evaluation indicate that groundwater in the surficial aquifer flowing beneath the landfill areas transports dissolved contaminants. Flow is predominantly toward the canals that border the entire eastern perimeter of OU 2. However, contaminant retardation due to sorption of chemicals to the aquifer matrix results in a generally low contaminant velocity in groundwater (up to 85 feet/year for some organic chemicals, but 17 feet/year, or less, for all other chemicals including metals). Downward migration of contaminants from the surficial aquifer to the underlying confined aquifer zone in the Hawthorn formation is not indicated by the site data.

In April 1999, an Interim Remedial Action (IRA) was begun at OU 2 with the following objectives:

- Remove polynuclear aromatic hydrocarbon (PAH)-contaminated soil from two "hot spots" located on the McCoy Annex Golf Course.

- Place a 2-foot soil cover over the portion of the landfill indicated in the RI as having insufficient cover over the waste material.

The two PAH hot spots were removed and the excavation sites were filled with clean soil. Approximately 2 feet of soil cover was placed over 28 surface soil locations south of the golf course on a 25-acre portion of the landfill.

From the investigation data, human health and ecological risk assessments were prepared to evaluate the potential impact of the landfill contaminants. The cancer risks calculated in the human health risk assessment are summarized below:

Receptor	Cancer Risk
Maintenance Worker (Current/Future)	1.8E-06
Recreational User (Current/Future)	6.2E-07 to 7.4E-07
Resident (Hypothetical Future)	1.6E-05 to 1.9E-03
Off-site Resident/Visitor/Trespasser (Current/Future)	2.0E-06

The cancer risks to the maintenance worker, the hypothetical future resident, and the visitor/trespasser exceed the maximum risk of 1E-06 set by the Florida Department of Environmental Protection. Despite removal of the two PAH hot spots, risk to the maintenance worker is driven by PAHs in surface soil. In the IRA recently completed, the remaining PAH-contaminated soils as well as several other surface soil sample locations were covered under 2 feet of clean soil. This reduced the risk associated with surface soil at the site. Risk to the visitor/trespasser is driven by bis(2-ethylhexyl)phthalate in surface water. The low concentrations of this contaminant that were detected at OU 2 are often associated with anthropogenic sources (i.e., phthalates are widely used in plastics), but this chemical is also a common laboratory contaminant and these detections may not represent site conditions. In addition, significant uncertainties that may overestimate dermal risk are associated with the model for bis(2-ethylhexyl)phthalate.

The cancer risk to the hypothetical future resident exceeds the allowable risk range of 1E-06 to 1E-04 specified by the U. S. Environmental Protection Agency. The noncarcinogenic risk exceeds a Hazard Index of 1 for the hypothetical future resident only. Deed restrictions are expected to prevent an on-site residential scenario; therefore, results for the hypothetical future resident are presented here for the purposes of completeness.

The ecological risk assessment showed that some potential risks were present from inorganics and organics in surface soils at OU 2. Most of the terrestrial risks are driven by hot spots of contamination, primarily in one or two adjacent samples. However, the IRA activities have reduced or eliminated the ecological risk due to surface soil contamination.

Some food chain risks were present in all sections from inorganics, PAHs, and pesticides. However, most of these risks were driven by localized, elevated concentrations of chemicals. For the most part, the localized, elevated detections of metals in surface soils do not appear to pose potential food chain risks at the population or community level and, most importantly, the IRA activities have reduced or eliminated these potential risks.

The only pervasive ecological risks throughout the operable unit (i.e., regardless of area) appear to be located in the canal along the southeastern side of the operable unit. Concentrations of several inorganics in surface water were elevated throughout the canal's length. Groundwater discharge from the surficial aquifer is likely the source. Nonetheless, the canal is relatively narrow, shallow, and stagnant with generally low water flow. Some aquatic vegetation is present, but the canal serves mainly as a runoff catch system. Also, the canal is dredged periodically, significantly disturbing the available habitat. Transport of OU 2-related inorganics to downgradient Lake Gillooly does not appear to be significant.

Recommendations - Surface soils, groundwater, surface water, and sediment all show exceedances of the State of Florida Cleanup Target Levels. In addition, the risk assessments indicate unacceptable risks for hypothetical future residents exposed to environmental media and sporadic terrestrial and food chain risks for ecological receptors. Therefore, the McCoy Annex Landfill is recommended for evaluation in a feasibility study using the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) presumptive remedy for landfills.

1.0 INTRODUCTION

Tetra Tech NUS, Inc., under contract to the Department of the Navy, Southern Division, Naval Facilities Engineering Command (SOUTHDIV), has prepared this Remedial Investigation (RI) Report for Operable Unit (OU) 2, McCoy Annex Landfill at Naval Training Center (NTC) in Orlando, Florida. The RI and Feasibility Study (RI/FS) are being conducted on behalf of the U.S. Navy (Navy) under Contract No. N62467-94-D-0888.

The technical approach to the RI was developed in conjunction with the Orlando Partnering Team (OPT), which includes representatives from the Florida Department of Environmental Protection (FDEP), the U. S. Environmental Protection Agency (USEPA) Region 4, SOUTHDIV and their contractors, and the Public Works Department at NTC, Orlando.

The RI, which was guided by the RI/FS Work Plan for OU 2 (B&R Environmental, 1997), was conducted in three phases of fieldwork. Phase I was begun in May 1997 and was completed in December 1997, Phase II was begun in March 1998 and was completed in October 1998, and Phase III was begun in February 1999 and was completed in February 2000. This report presents a description of the fieldwork performed, a discussion of the results of the fieldwork, the human health and ecological risk assessments, and the conclusions.

1.1 REGULATORY BACKGROUND

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

The IR program complies with the Base Realignment and Closure Act of 1988 (Public Law 100-526, 102 Statute 2623) and the Defense Base Realignment and Closure Act of 1990 [Public Law 101-510, 104 Statute (1808)], which require that the DOD observe pertinent environmental legal provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Executive

Order 12580 as well as the statutory provisions of the Defense Environmental Restoration Program, the National Environmental Policy Act (NEPA), state statutes and regulations, and any other applicable statutes that protect human health and the environment.

Originally, the Navy's program was called the Navy Assessment and Control of Installation Pollutants (NACIP) program. Early reports reflect the NACIP process and terminology. The Navy eventually adopted the program structure and terminology of the standard IR program.

The IR program is conducted in several stages as follows:

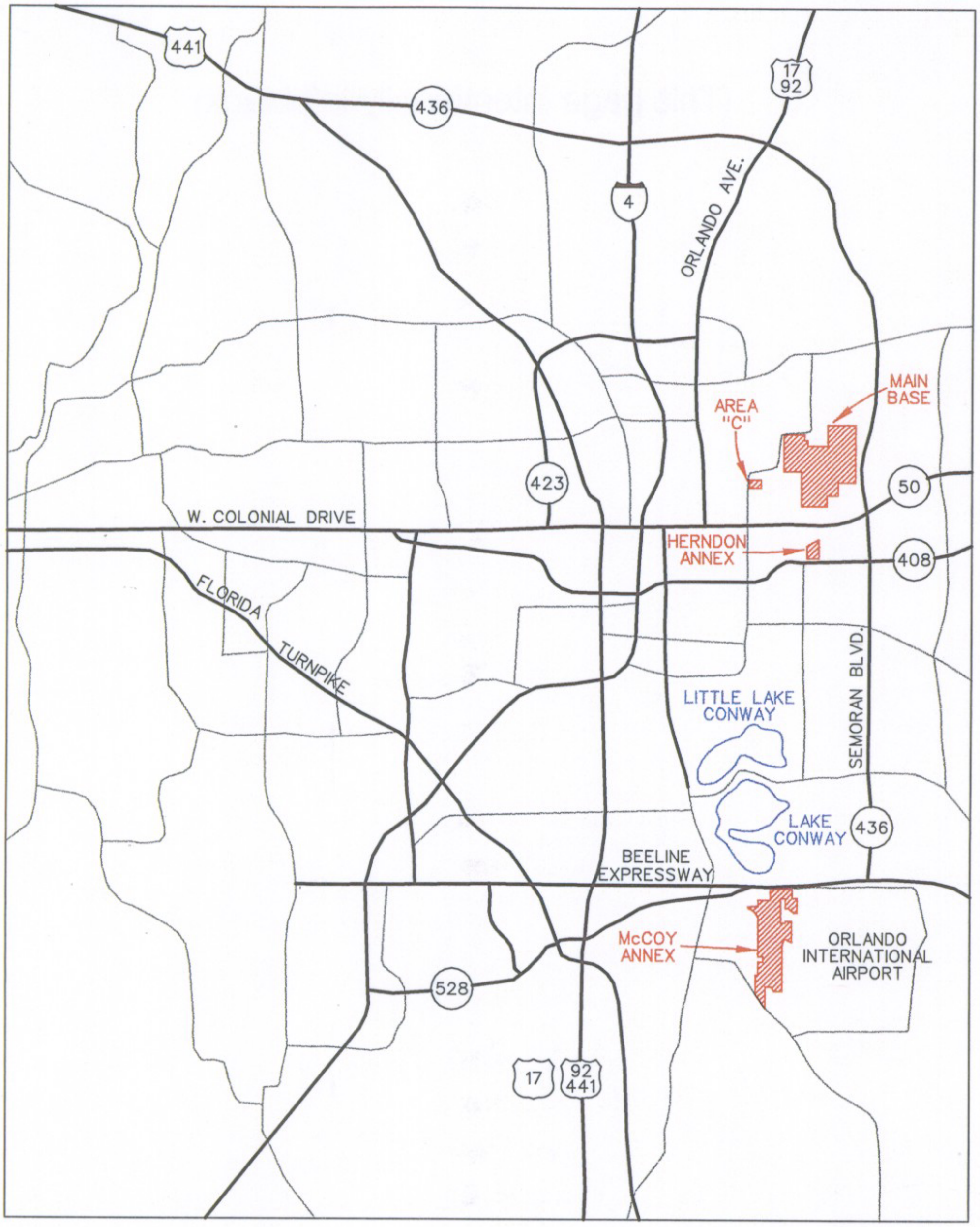
- Preliminary Assessment (PA).
- Site Inspection (SI) [formerly the PA and SI steps were called the Initial Assessment Study (IAS) under the NACIP program].
- RI and FS.
- Proposed Plan and Record of Decision (ROD).
- Remedial Design and Remedial Action.

The goal of the BRAC program is to expedite and improve environmental response actions to facilitate the disposal and reuse of a BRAC installation while protecting human health and the environment.

1.2 FACILITY BACKGROUND

NTC, Orlando consists of 2,072 acres in Orange County, Florida, and includes four discrete facilities: Main Base, Area C, Herndon Annex, and McCoy Annex (Figure 1-2A). Further discussions of Main Base, Area C, and Herndon Annex may be found in the Project Operations Plan [ABB Environmental Services, Inc. (ABB-ES), 1997]. McCoy Annex, which includes OU 2, encompasses approximately 877 acres and is located about 8 miles south of the Main Base, west of Orlando International Airport (Figure 1-2B).

McCoy Annex is flanked to its west by industrially zoned property. The industrial zoning allows heavy industry and aviation-related development although the area is not currently developed. The Beeline Expressway, a major highway running east and west through Orange County, forms the northern boundary of McCoy Annex. The property north of the Beeline Expressway, and within 0.75 mile of McCoy Annex, is used primarily by businesses such as rental agencies, hotels, and restaurants that are directly related to the airport. Adjacent to the southern boundary are undeveloped woodlands.



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4 0 4
SCALE IN MILES

FIGURE 1-2A

FACILITY LOCATIONS
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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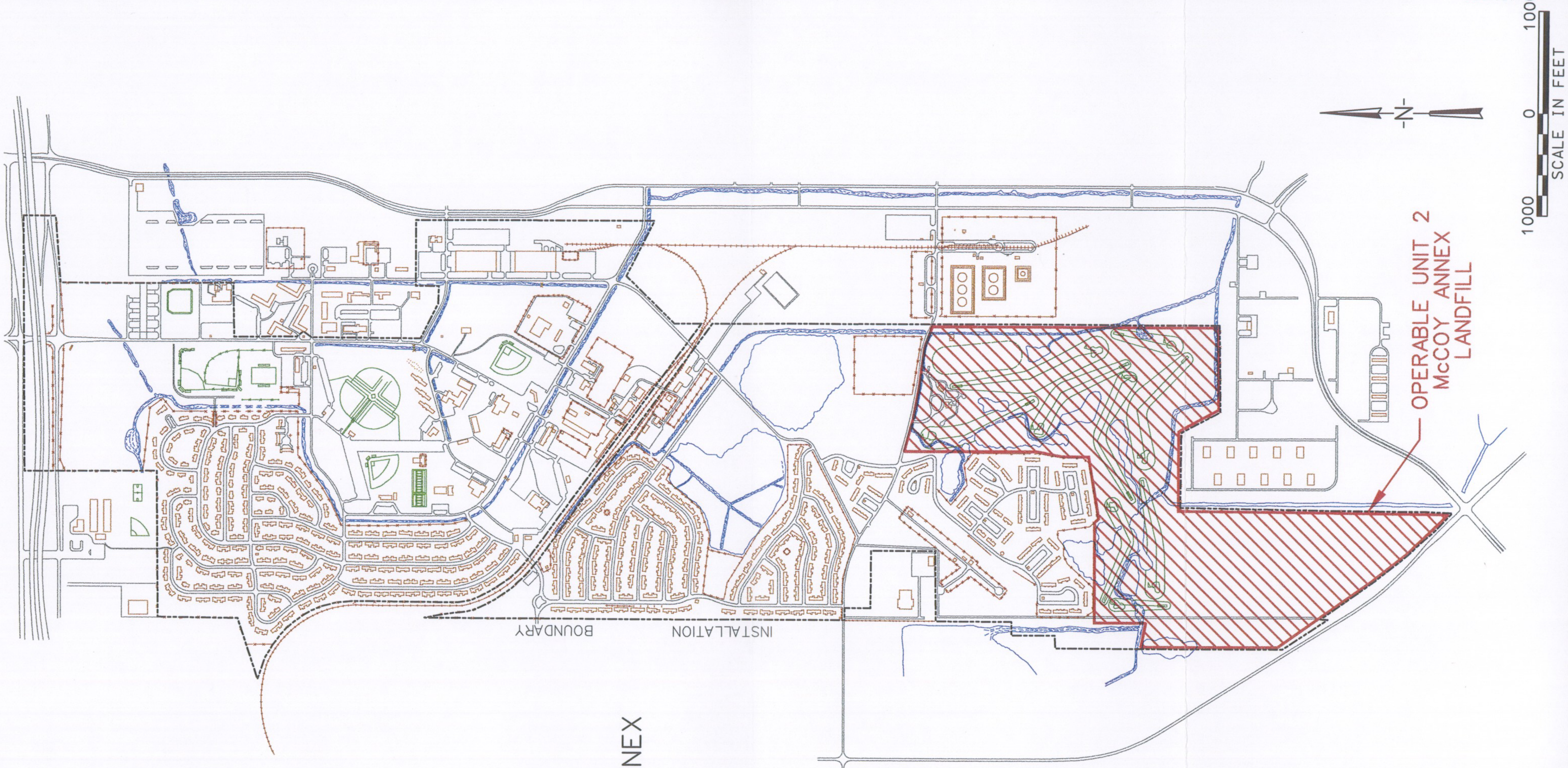

FIGURE 1-2B

SITE LOCATION MAP
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

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The history of McCoy Annex dates to 1941 with the construction of Orlando Municipal Airport No. 2 in Pinecastle, Florida. Before construction of the new airport, the property was undeveloped wetland. In 1942 the city leased the Pinecastle property to the Army Air Corps for construction of Pinecastle Army Air Field. The field was ready for operation in April 1943. At the end of World War II, the base was deactivated and the property returned to the city. The terms of the property transfer included a "reverter for reactivation" clause in case of a national emergency. This clause was exercised in 1952 during the Korean Conflict, and the base was reopened as Pinecastle Air Force Base. The base was renamed McCoy Air Force Base in honor of Colonel Michael N.W. McCoy on May 7, 1958. The U. S. Air Force (Air Force) retained command of the base until its closure in 1973. At that time NTC, Orlando acquired title to part of the property and changed the name to McCoy Annex. McCoy Annex was acquired to serve as a community support annex for NTC, Orlando. The majority of the Air Force base, including runways, aircraft hangars, and maintenance facilities previously used by the Air Force, was not acquired by the Navy. Currently that property is owned and operated by the Orlando International Airport (ABB-ES, 1994).

Previous NACIP investigative activities at the McCoy Annex Landfill included an IAS conducted by C.C. Johnson & Associates (1985) and a Verification Study conducted by Geraghty & Miller (1986).

1.3 SITE BACKGROUND

The McCoy Annex Landfill (OU 2) is an inactive landfill located in the southern part of McCoy Annex, west of Orlando International Airport. The landfill occupies approximately 114 acres, and its relatively flat topography slopes from north to south. A nine-hole golf course now occupies much of the site. The golf course is bounded on the east and south by manmade canals that drain to Lake Gillooly to the south and eventually to Boggy Creek and Boggy Creek Swamp to the southeast. The golf course includes a number of water hazards and has two cypress swamps between fairways.

Reportedly, the western portion of the site was used as a landfill by the Air Force from about 1960 to 1972, while the eastern portion was used as a landfill by the Air Force and the Navy from 1972 until about 1978. Landfill operations consisted of excavating ditches (100 to 200 feet long by 20 to 25 feet wide by 10 to 15 feet deep) into which trucks disposed wastes. Occasional burning of the wastes took place in the ditches. Trenches were filled with waste to within 3 or 4 feet of the ground surface and then backfilled with soil and seeded. The estimated volume of waste is more than 1,000,000 cubic yards (C.C. Johnson & Associates, 1985). Landfill wastes reportedly included the following:

- Paint and paint thinner.
- Asbestos.

- Transformers [possibly with transformer oil containing polychlorinated biphenyls (PCBs)].
- Hospital wastes (including syringes, dressings, blood, and urine samples).
- Low-level radiological waste (from Air Force operations).
- Automobile batteries.
- Steel cable, scrap metal, and sections of pipe.
- Airplane parts.
- Bricks.
- Fire hoses.
- Parachutes.
- Trees, leaves, and scrap wood.
- Paper and plastic.
- Possibly waste oil.

1.4 REMEDIAL INVESTIGATION APPROACH OVERVIEW

The original Superfund remedial program was structured toward long-term remedies that addressed risk as predicted under future-use scenarios. This process led to long study-based investigations to enable detailed alternative selection and evaluation of proposed remedies.

Recognizing that the process was both slow and expensive, USEPA sought to encourage flexibility in the program through the Superfund Accelerated Cleanup Model (SACM) program (USEPA, 1992). SACM encourages early action or development of ways to focus the RI/FS parts of an investigation, especially for certain types of sites with similar characteristics such as landfills. The goal of SACM is to accelerate the entire remedial process.

Based on information collected from similar sites previously investigated, presumptive remedies were developed as a tool for acceleration within SACM that should be applied when appropriate. Presumptive remedies are preferred technologies for common categories of sites, based on historical RI/FS investigations within the Superfund program. Past experience can streamline or focus the site investigation and remedy selection, reducing the cost and time required to clean up the given type of site.

Presumptive Remedy

The USEPA interim guidance, *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills* (1996a), points out that containment is an appropriate presumptive remedy if the military landfill contains primarily "municipal-type wastes" (i.e., no high-hazard military specific wastes such as chemical warfare agents or military munitions). The guidance also points out that "municipal waste" includes a low percentage of industrial solid waste, paints and paint thinner, pesticides, transformer oils, other solvents, etc., in the landfill. The containment presumptive remedy may include the items listed below:

- Landfill cap.
- Source area groundwater control to contain plume.
- Leachate collection and treatment.
- Landfill gas collection and treatment.
- Institutional controls to supplement engineering controls.

The guidance points out that site-specific conditions may limit the use of the presumptive remedy, for example, high water tables or sensitive environments. The guidance also points out that for 51 military landfills investigated, the RODs specified no action for 10 landfills.

RI Approach

For this investigation of OU 2, the presumptive remedy of containment was used to focus the RI. The necessity of applying additional technologies to the presumptive remedy to meet overall remedial objectives for the site was anticipated.

This approach recognizes that complete site characterization is not possible or necessary and, therefore, the remaining uncertainties must be managed. This approach focuses the collection of data to support decisions. At OU 2, because the presumptive remedy was containment, the RI objectives were to (1) define the limits (extent) of the landfill, (2) characterize the existing landfill to determine the cover thickness and the nature and extent of contamination, (3) determine the nature and extent of impacted groundwater, (4) characterize the site-specific geology and hydrogeology, (5) determine whether other environmental media (such as sediment or surface water) have been impacted, and (6) determine any risks for all impacted media. To make these decisions, data were collected to support a human health risk assessment (HHRA), an ecological risk assessment (ERA), and an FS.

1.5 REPORT ORGANIZATION

The RI Report is organized into nine sections. Section 1.0 presents the regulatory, facility, and site background, and the RI approach. Section 2.0 summarizes the regional and site-specific settings, geology, and hydrogeology. Field investigation activities are discussed in Section 3.0. Section 4.0

presents the site-specific data quality assessment. Section 5.0 presents the results of the field investigation including the extent of the landfill, the landfill soil cover thickness, and the analytical results of environmental sampling. Sections 6.0 and 7.0 provide the human health and ecological risk assessments, respectively. Section 8.0 summarizes contaminant fate and transport. Conclusions and recommendations are presented in Section 9.0. Figures and tables are numbered according to the section numbers in which they appear. Appendix A provides field forms. The analytical data, data plots, the soil organic vapor (SOV) survey, and statistical calculations are presented in Appendix B. Geotechnical data and the cone penetrometer testing (CPT) survey are provided in Appendix C. Aquifer testing data and calculations are provided in Appendix D. Appendix E includes the HHRA calculations and supporting information. Appendix F includes gamma ray logs of the subsurface geology.

2.0 ENVIRONMENTAL SETTING

2.1 REGIONAL SETTING

This section describes the physical setting and geological/hydrogeological characteristics of Orange County, Florida, where OU 2 is located.

2.1.1 Topography, Climate, and Surface Water Hydrology

Orange County is located in the east-central part of the Florida Peninsula and is included in the Atlantic Coastal Plain physiographic province. Three topographic regions are found within the county: a low-lying region in the eastern part of the county where altitudes are generally less than 35 feet, an intermediate region in the middle part of the county with altitudes generally ranging between 35 and 105 feet, and a highlands region in the western part of the county where altitudes are typically above 105 feet. OU 2 is located within the intermediate region (Lichtler, Anderson, and Joyner, 1968).

Orange County has a subtropical climate. The average annual temperature at Orlando is 71.5 °F. The annual rainfall is 51.4 inches and is mostly provided by frequent summer thunderstorms. There are only two pronounced seasons – winter and summer.

Surface streams generally drain the eastern, northern, and southern parts of Orange County. Surface water in the eastern and northern parts of the county generally drains to the St. Johns River and its tributaries. Shingle Creek, Reedy Creek, and Boggy Creek and canals in the upper Kissimmee River basin drain the south-central and southwestern areas. Surface water drains to closed depressions in much of the western and northwestern parts of the county.

2.1.2 Geology

Orange County is underlain by mainly marine limestone, dolomite, shale, sand, and anhydrite to a depth of about 6,500 feet. Granite and other crystalline rocks of the basement complex occur beneath these sediments. The strata in the upper 2,000 feet can be divided into three lithologic units. Surficial deposits consisting of undifferentiated Recent and Pleistocene terrace sediments are generally less than 100 feet thick. The Hawthorn Group occurs beneath the surficial unit and consists of mixed unconsolidated clastics and carbonates of Miocene age. This unit is typically less than 100 feet thick. Beneath the

Hawthorn Group is a sequence of marine carbonates of Eocene age that is usually more than 1,200 feet thick.

The sediments of the uppermost unit consist primarily of quartz sand with varying amounts of silt, clay, and shell fragments (Lichtler, Anderson, and Joyner, 1968). The lithology of this unit is variable both laterally and vertically. Fine sands cemented with iron oxide (locally called "hardpan") are common in the upper part of this unit. The thickness of these sediments ranges from 50 to 100 feet in the region.

The Hawthorn Group generally consists of gray-green calcareous, phosphatic sandy clay and clayey sand with thin discontinuous lenses of phosphatic sand and sandy limestone, limestone, and dolostones. The limestone and dolostone lenses are more common and thicker near the base of the unit. Phosphate is present throughout the Hawthorn Group. The thickness of this group ranges from less than 50 to 150 feet in Orange County (Scott, 1988). The contact between the Hawthorn Group and the overlying surficial sediments is typically gradational in this area. The top of the Hawthorn is usually placed at the first occurrence of phosphate or where a distinct and persistent greenish color appears (Lichtler, Anderson, and Joyner, 1968).

The marine carbonate sediments that lie beneath the Hawthorn Group can be separated into two units of Eocene age: the Ocala Limestone and the Avon Park Formation (Scott, 1992). The Ocala Limestone generally consists of granular to variably muddy (carbonate) granular limestone with some dolomite. The surface and thickness of the Ocala Limestone are highly irregular. The Avon Park Formation is primarily composed of fossiliferous limestone interbedded with vuggy dolostone.

2.1.3 Hydrogeology

Groundwater occurs in three major aquifer systems in this region (Scott, 1992): the surficial aquifer system, the intermediate aquifer system, and the Floridan aquifer system.

The surficial aquifer, which is composed primarily of quartz sand with varying amounts of clay, hardpan, and shell fragments, extends over most of Orange County (Lichtler, Anderson, and Joyner, 1968). The base of this unit is typically found at a depth of approximately 40 feet below ground surface (bgs) in this area. The groundwater occurs under nonartesian conditions in this aquifer. The water table in Orange County ranges from about 0 to 20 feet bgs. Natural recharge is mainly from rainfall. Some recharge also comes from upward leakage from underlying artesian aquifers and seepage from streams where the water level is above the water table. Discharge from this aquifer system in Orange County is by evapotranspiration, seepage into surface water bodies, and downward leakage into the underlying aquifer.

The intermediate aquifer system includes several locally occurring water-yielding zones within the Hawthorn Group. The water-bearing units are typically found at depths ranging from about 60 to more than 150 feet bgs (Lichtler, Anderson, and Joyner, 1968) and are composed of discontinuous shell beds, thin limestone lenses, or permeable sand and gravel zones. Natural recharge to this aquifer system is mainly from downward leakage from the overlying surficial aquifer in most parts of Orange County. In some areas where the potentiometric surface of the Floridan aquifer is above the potentiometric surface of the intermediate aquifer, recharge occurs by upward leakage. Groundwater discharge from this aquifer is by upward or downward leakage. The Hawthorn Group generally acts as a confining unit for the Floridan aquifer and also restricts downward migration of water from the surficial aquifer.

The Floridan aquifer system is the principal aquifer of Orange County. Water occurs in porous limestones, dolostones, or dolomitic limestones. Generally there are two water-producing zones separated by an impermeable zone (Lichtler, Anderson, and Joyner, 1968). The upper zone extends to a depth of 600 feet and the lower zone extends from about 1,100 to 1,500 feet bgs. The potentiometric surface of the Floridan aquifer system slopes to the northeast and east from its highest point in the southwestern part of the county. Most of the natural recharge to the unit in this area is from infiltration of rain through the relatively thin, semipermeable confining beds in the highlands section. Natural discharge is by upward leakage and spring outflow.

2.1.4 Soils

The general soil map published by the U.S. Department of Agriculture, Soil Conservation Service (USDA, 1989) shows that the McCoy Annex lies across an area dominated by the Smyrna-Bassinger-St. Johns and the Urban land-Symrna-Pomello soil mapping units. These soil units are part of a group of units that occur predominantly on the flatwoods, low ridges, and knolls within the county. They are most extensive in the eastern half of Orange County, but are also scattered across the county where topography dictates their occurrence. This group of soils consists of "nearly level to gently sloping, poorly drained, moderately well drained, and very poorly drained soils" (USDA, 1989). All of the soils associated with these groups consist predominantly of fine sand in both the surface and subsurface layers. The soils formed in a sandy, marine sediment.

The general soil map indicates that the former landfill within OU 2 was constructed in an area of the Smyrna-Bassinger-St. John's map unit. These soils are extensive across the Osceola Plain (i.e., the intermediate topographic region of Orange County) and occur in "broad, flatwood areas interspersed with many broad sloughs, depressions, and poorly defined drainageways" (USDA, 1989). Construction of the landfill and other urbanization associated with the golf course, the airport, and the McCoy Annex itself has largely altered the surface and subsurface soil horizons in the study area.

2.2 SITE-SPECIFIC SETTING

2.2.1 Topography and Surface Water Hydrology

The land surface across most of the site is generally flat with a few small isolated depressions. The surface elevation across the site is approximately 90 feet above mean sea level (AMSL). The highest elevations in the county occur to the west and north of the site, and decrease gradually eastward.

Surface water drainage at the McCoy Annex is controlled by a series of drainage canals, ditches, and ponds located in and around the site vicinity. Well-defined drainage canals are located along the eastern and portions of the southern and western boundaries of OU 2. The drainage canal along the southern boundary interconnects with golf course ponds and a canal located along the eastern boundary of the undeveloped wooded area of the site. A poorly defined drainage ditch is also located by the southern boundary of the site along Boggy Creek Road.

Surface runoff from the eastern and southern portions of the golf course flows to the two canals that eventually merge near the southeast corner of the site (Figure 2-2A). Water from the canals eventually flows to a storm water drainage ditch located in the median of Tradeport Drive, flows southward, and eventually drains into Lake Gillooly located east of the intersection of Boggy Creek Road and Tradeport Drive. Surface water runoff from the southern portion of the site flows into the drainage canal along the eastern perimeter and also flows southward into Lake Gillooly.

Surface drainage from the western portion of the site is through a series of ponds and interconnecting bodies of water that flow to the canals described above. Some localized drainage within the golf course is directed to ponds, interconnecting bodies of water, and low-lying marshy areas of the site, where water tends to pond after a rainfall event.

2.2.2 Geology

The local subsurface lithology at OU 2 was determined through evaluation of CPT data and examination of split-spoon samples and auger cuttings brought to the surface during monitoring well and piezometer installation. The investigative activity during the field events was limited to the undifferentiated surficial deposits and the deposits of the Hawthorn Group.

FIGURE 2-2A

SURFACE WATER FLOW
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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2.2.2.1 Cone Penetrometer Investigation

A subsurface cone penetrometer investigation was conducted during Phase I (October to November 1997) at OU 2 following a review of the Phase I direct push technology (DPT) groundwater investigation. Direct push methods were used to conduct a CPT survey and to collect groundwater samples. The cone penetrometer measured several parameters directly, including cone resistance (or end bearing stress), sleeve friction, and pore pressure versus depth. These data were used to interpret subsurface soil and surficial aquifer geotechnical and hydrogeological properties such as stratigraphy and soil classification and to estimate relative soil density and hydraulic conductivity. CPT was performed at 14 locations along the edges of the landfill boundary and on adjacent properties to the east and south.

The CPT was conducted with a 20-ton truck equipped with a hydraulic direct push unit capable of pushing a cone-shaped probe into the subsurface. The probe was attached to hollow, 2-foot-long stainless steel rods that were continuously added as the probe was driven into the ground. The probe was fitted with sensors that recorded data at 1-centimeter-depth intervals as the tip advanced into the subsurface at a constant rate. The probe was stopped at intervals where the data indicated clay. At these locations the pore pressure dissipation rate was measured to estimate hydraulic conductivity of the clay. The subsurface data from the probe were monitored and recorded by a dedicated computer that permitted evaluation of the CPT logs in real time. Table 2-2A contains the horizontal and vertical hydraulic conductivity of the clay intervals derived from the pore pressure dissipation tests.

The complete set of cone penetrometer sounding logs and pore pressure dissipation tests prepared by Williams Earth Sciences, Inc., is presented in Appendix C. Cone resistance, which is a measure of end-bearing stress, sleeve friction, which is a localized index of strength, and pore pressure were measured by sensors on the cone as a function of depth. Measurements were reported in terms of tons per square foot. Soil-bearing stress follows an exponentially increasing curve depending on grain size. Cone end-bearing stress is low in clays and very high in sands. Sleeve friction varies approximately as a linear function of grain size and does not vary as much as cone end-bearing stress measurements in homogenous deposits. The ratio between sleeve friction (fs) and cone resistance (Q) in terms of a percentage (fs/Q x 100) is defined as the friction ratio. The cone penetrometer uses the friction ratio to evaluate soil classification based on the Unified Soil Classification System. The friction ratio is low (0.5 to 2 percent) in sands, intermediate in silts (1 to 4 percent) and high in clays (3 to 8 percent).

Several different soil types were identified in the cone penetrometer logs. Vertical cross sections across the landfill and its vicinity were constructed by connecting cone penetrometer data in one north-south and two east-west planes. Figure 2-2B shows the cross section locations. Figures 2-2C, 2-2D, and 2-2E

TABLE 2-2A
CPT HYDRAULIC CONDUCTIVITY DATA
OPERABLE UNIT 2

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Brown & Root Environmental CPT ID No.	Williams CPT ID No.	Depth (ft)	C_h[a] (ft^2/day)	Soil Type[b]	K_h[c] (ft/day)	K_h[c] (cm/s)	K_v[d] (ft/day)	K_v[d] (cm/s)
CP-1	CPT-R4	42.5	0.43	SC	2.50E-05	8.83E-09	2.08E-05	7.36E-09
		48.5	0.243	C -CS	1.24E-05	4.38E-09	1.03E-05	3.65E-09
		80.5	11.82	SS_d -SS	3.63E-04	1.28E-07	3.03E-04	1.07E-07
CP-2	CPT-R3	45.3	0.061	SS -CS	3.33E-06	1.18E-09	2.78E-06	9.80E-10
		52.5	0.027	CS	1.27E-06	4.49E-10	1.06E-06	3.74E-10
CP-3	CPT-R5	44.5	0.07	C	3.89E-06	1.37E-09	3.24E-06	1.14E-09
		44.9	0.078	C	4.30E-06	1.52E-09	3.58E-06	1.27E-09
		61.5	16.6	SS_d -SS	6.68E-04	2.36E-07	5.57E-04	1.97E-07
CP-4	CPT-R2	36.7	0.251	CS -SC	1.69E-05	5.97E-09	1.41E-05	4.97E-09
		66.6	(e)	SS -CS	(e)	(e)	(e)	(e)
CP-5	CPT-R1	40.7	0.038	C	2.31E-06	8.16E-10	1.93E-06	6.80E-10
CP-6	CPT-Y5	37.6	(e)	S_dS - SC	(e)	(e)	(e)	(e)
		40.5	0.15	CS - C	9.16E-06	3.24E-09	7.63E-06	2.70E-09
		50.5	0.216	CS - SC	1.06E-05	3.74E-09	8.83E-06	3.12E-09
CP-7	CPT-Y1	40.5	0.015	S_dS - SC	9.16E-07	3.24E-10	7.63E-07	2.70E-10
CP-8	CPT-Y6	40.5	0.016	CS -SC	9.78E-07	3.45E-10	8.15E-07	2.88E-10
CP-9 *	CPT-G5	NA	NA	NA	NA	NA	NA	NA
CP-10	CPT-G2	38.5	0.065	SC	4.18E-06	1.48E-09	3.48E-06	1.23E-09
		48.5	0.044	SC - CS	2.24E-06	7.91E-10	1.87E-06	6.59E-10
CP-11	CPT-G3	39.5	0.141	CS -SC	8.83E-06	3.12E-09	7.36E-06	2.60E-09
		49	0.166	CS -SC	8.38E-06	2.96E-09	6.98E-06	2.47E-09
CP-12	CPT-G4	38.5	0.179	SC - C	1.15E-05	4.06E-09	9.58E-06	3.38E-09
		47.6	0.03	CS - C	1.56E-06	5.51E-10	1.30E-06	4.59E-10
CP-13	CPT-G1	53.5	1.18	CS	5.46E-05	1.93E-08	4.55E-05	1.61E-08
		55.4	0.92	SC-SS	4.11E-05	1.45E-08	3.43E-05	1.21E-08
CP-14	CPT-Y2	36.6	0.276	SS_d	1.87E-05	6.60E-09	1.56E-05	5.50E-09
		66.6	4.73	SS_d	1.76E-04	6.22E-08	1.47E-04	5.18E-08

Notes:
(a) Coefficient of Consolidation = C_h (ft^2/day)
(b) Soil Types
C - Clay
CS - Clayey Silt
SC - Silty Clay
SS_d - Silty Sand
S_dS - Sandy Silt
S_d - Sand
(c) Horizontal Hydraulic Conductivity, K_h (ft/day)
(d) Vertical Horizontal Hydraulic Conductivity, K_v (ft/day)
(e) Inconclusive
* Pore pressure dissipation test not performed at CP-9.
NA - Not applicable

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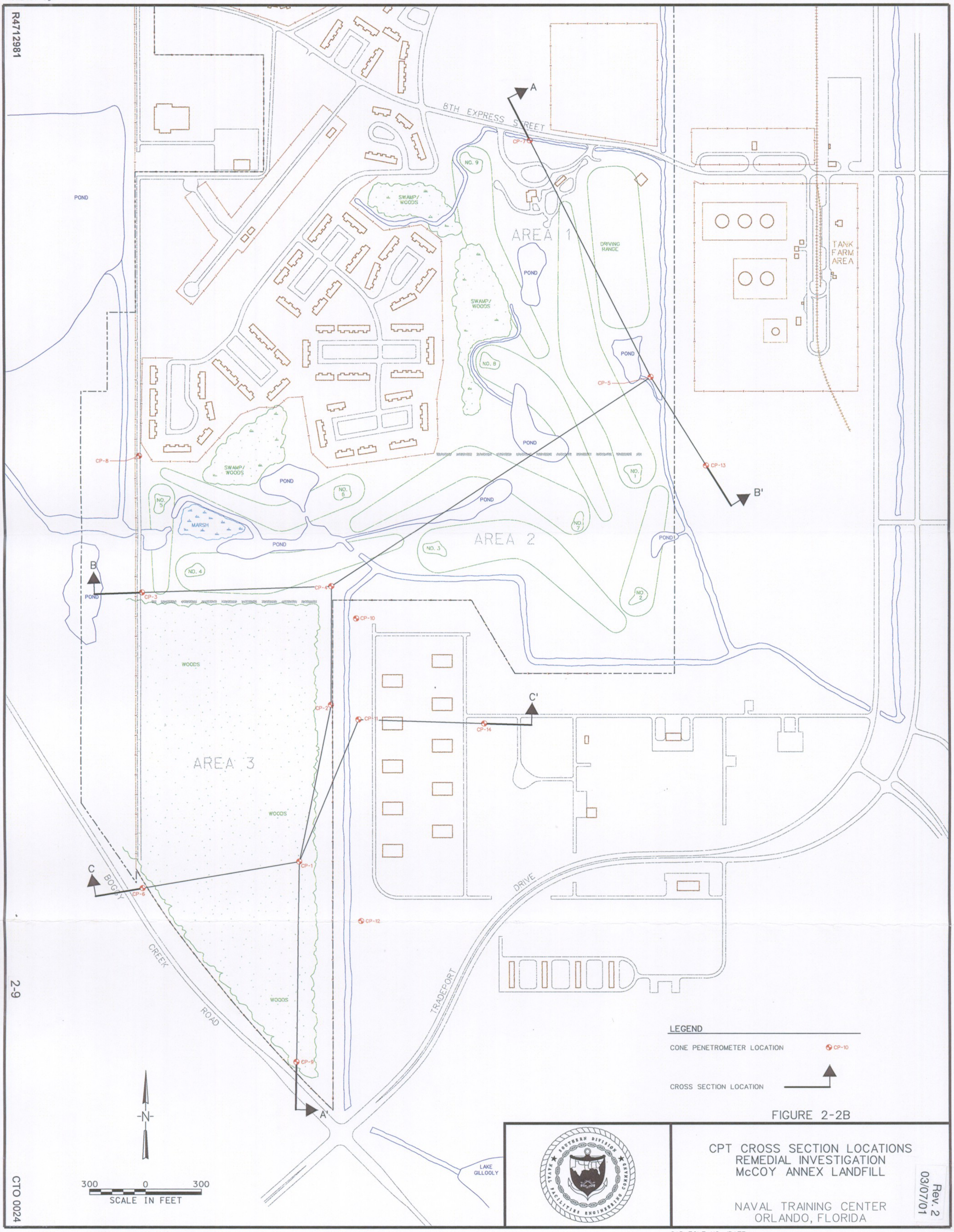

FIGURE 2-2B

CPT CROSS SECTION LOCATIONS
REMEDIAL INVESTIGATION
McCOY ANNEX LANDFILL

NAVAL TRAINING CENTER
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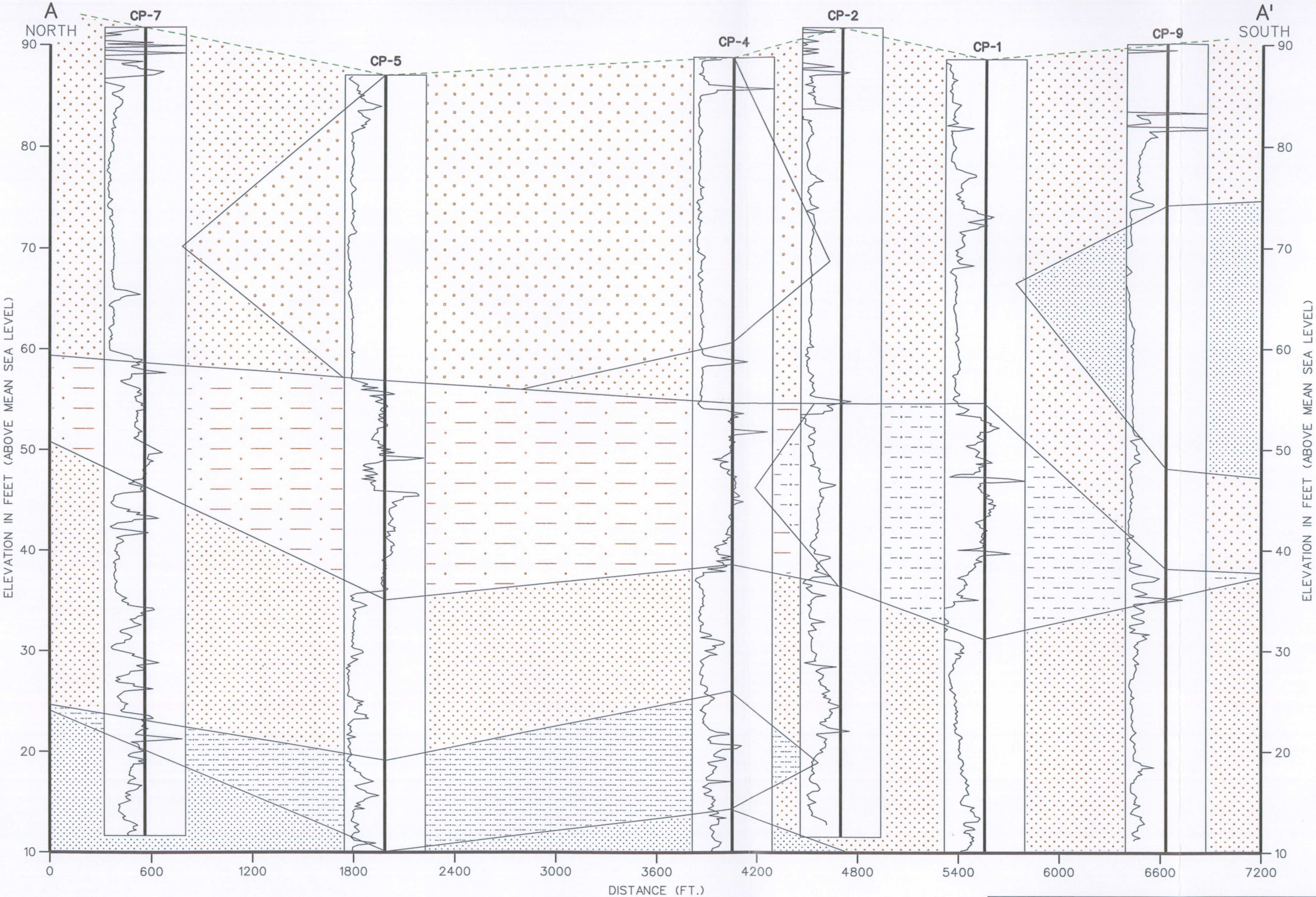

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CROSS SECTION A-A'

VERTICAL EXAGGERATION - 60 X HORIZONTAL

NOTE:
FOR LEGEND, SEE FIGURE 2-2E.

FIGURE 2-2C

CPT CROSS SECTION A-A'
REMEDIAL INVESTIGATION
McCOY ANNEX LANDFILL

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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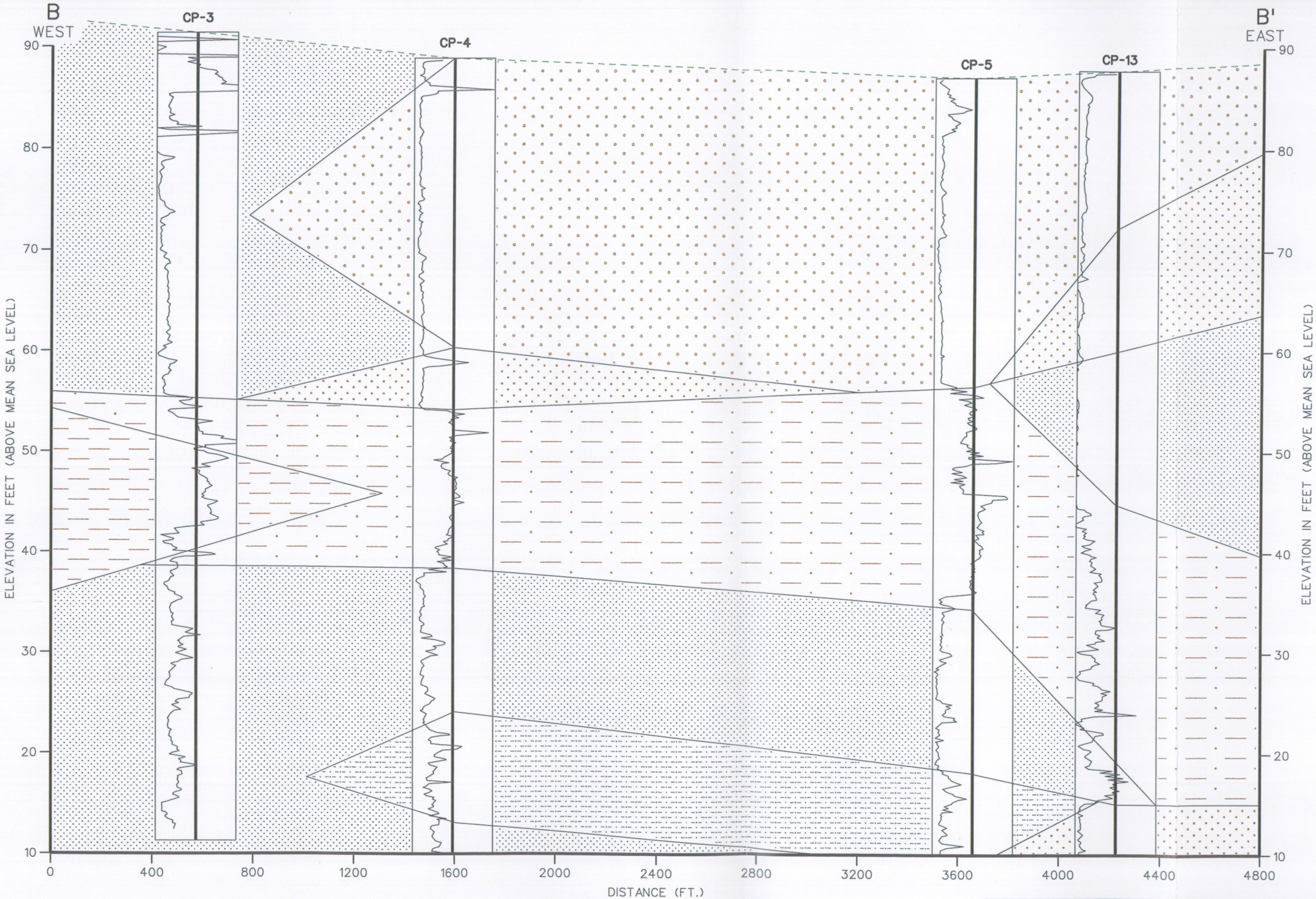

NOTE:
FOR LEGEND, SEE FIGURE 2-2E.

CROSS SECTION B-B'

VERTICAL EXAGGERATION - 40 X HORIZONTAL

FIGURE 2-2D

CPT CROSS SECTION B-B'
REMEDIAL INVESTIGATION
McCOY ANNEX LANDFILL

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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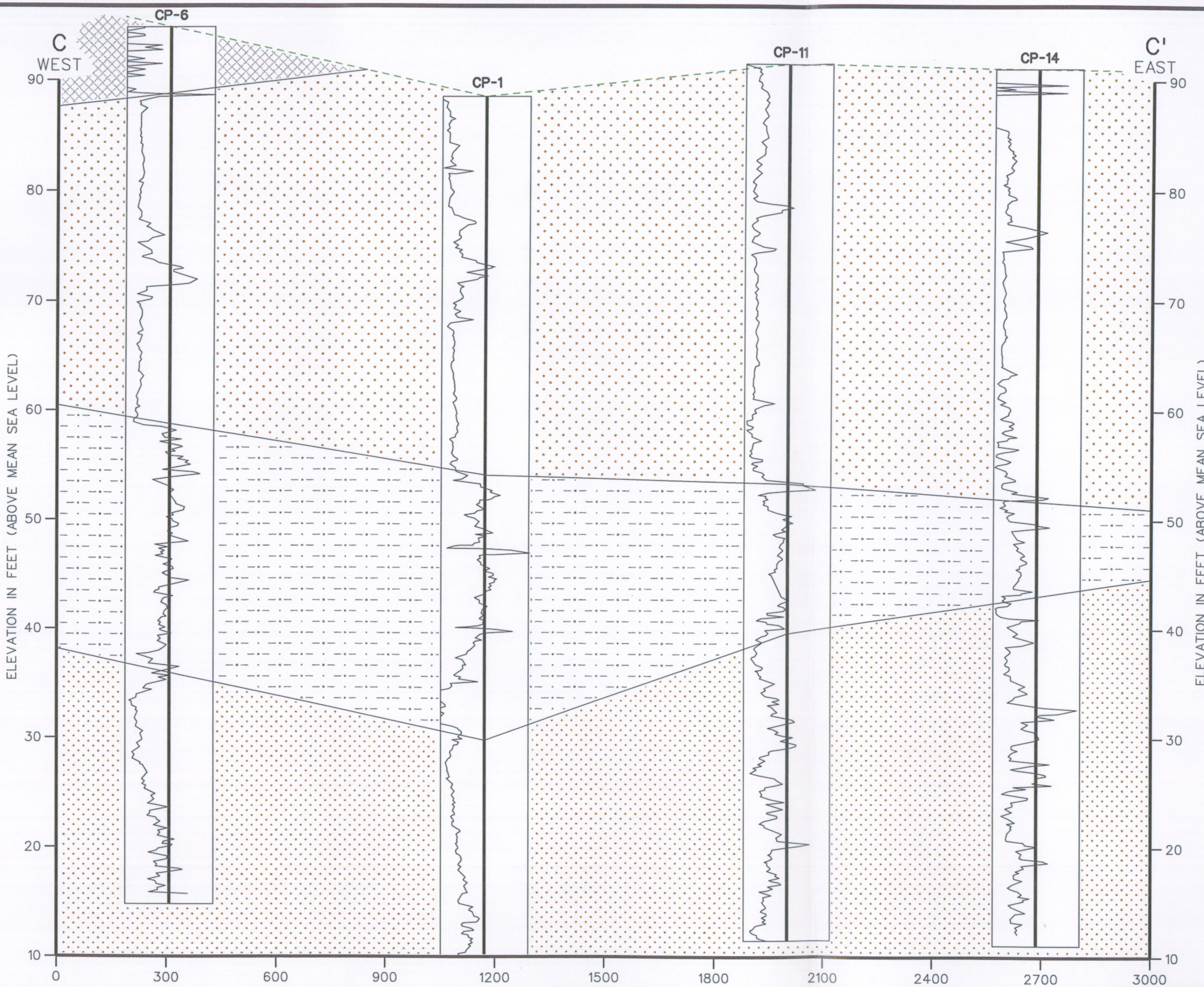

CROSS SECTION C-C'

VERTICAL EXAGGERATION = 30 X HORIZONTAL

LEGEND

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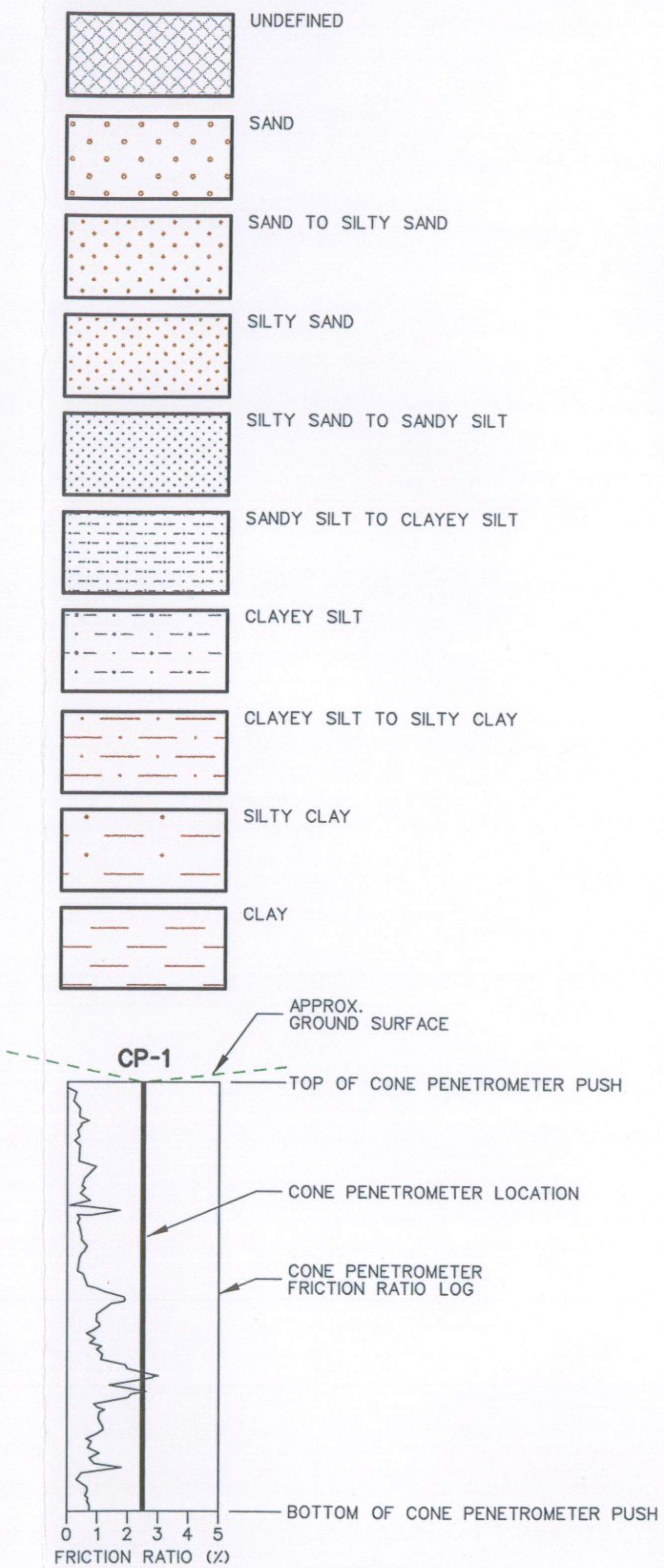

FIGURE 2-2E

CPT CROSS SECTION C-C'
REMEDIAL INVESTIGATION
McCOY ANNEX LANDFILL

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

2-15

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present CPT cross sections A-A', B-B', and C-C', respectively. The layers on the cross sections have been generalized. The CPT data suggest many thin layers, but similar types have been combined to better describe the aquifer.

CPT cross section A-A', drawn in the north-south direction, is shown in Figure 2-2C. Various strata of sand, silty sand, sandy silt, silty clay, clay, and clayey silt were identified. Sand, silty sand, and sandy silt were the major units identified in all CPT locations from the surface to approximately 30 feet bgs (approximately 60 feet AMSL). Underlying the silty sands from north to south was a distinct sandy silt to clayey silt stratum of low permeability. The unit varies in thickness from 12 to 24 feet and appears to taper off at the southern end of the cross section near CP-9. Separated by silty sand, a second low-permeability sandy silt to clayey silt layer was identified in the 60- to 70-foot depth range (approximately 30 to 20 feet AMSL). However, this appears to be a relatively minor stratum, 4 to 11 feet thick, and occurs from the north to the middle portion of the cross section, tapering off after CP-4.

CPT cross section B-B' traverses the middle of the landfill in an east-west direction. The cross section is presented in Figure 2-2D. Strata of sand or silty sand to sandy silt occurred from the ground surface to approximately 30 feet bgs (approximately 60 feet AMSL) in all CPT locations included in the cross section. A clay or silty clay unit underlying the sand unit, approximately 17 to 25 feet thick, was also identified in all the CPT locations. The clay or silty clay layer is also identified by the higher friction ratios that occur in the stratum. A second minor sandy silt to clayey silt layer was located in the 65- to 80-foot (approximately 25 to 10 feet AMSL) substratum. The unit was 9 to 11 feet thick and occurred between CP-4 and CP-5, tapering off before either end of the cross section line.

CPT cross section C-C' traverses the southern section of the wooded area and the adjacent Greater Orlando Aviation Authority (GOAA) property to the east. The cross section is presented in Figure 2-2E. Sand to silty sand and sandy silt to clayey silt were identified in this section of the landfill and the southeastern vicinity. The clayey silt unit transects the silty sand unit throughout the length of the cross section. The unit is approximately 23 feet thick in CP-6 and tapers to the east, occurring in CP-14 at approximately 11 feet of thickness.

Cone penetrometer logs for locations CP-8, CP-10, and CP-12 (not in the planes of the cross sections) were not included in the cross sections. However, the data indicate that conditions at these locations were similar to those encountered in nearby borings.

Hydraulic conductivities of clay-rich strata are estimated from CPT data at various locations and depths (Table 2-2A). The in situ coefficient of consolidation (C_h) is estimated by an interpretative method from pore pressure dissipation measurements (Baligh and Levadoux, 1986). Horizontal (K_h) and vertical hydraulic (K_v) conductivities are calculated assuming an initial vertical effective stress of 154.2 grams per square centimeter per meter of depth (110 pounds per square foot per foot of depth). Horizontal and vertical hydraulic conductivities are empirically related based on the degree of stratigraphic layering. Ranges for K_h and K_v are 3.24E-10 to 2.36E-07 centimeters per second and 2.70E-10 to 1.96E-07 centimeters per second, respectively.

2.2.2.2 Site Stratigraphy

Based on the data collected from the CPT pushes and monitoring wells, the undifferentiated surficial deposits in general consist of three separate units of fine- to medium-grained sands, varying only in color.

The uppermost sand unit consists of a dark gray, fine- to medium-grained sand and varies from 2 to 3 feet thick. The second unit, encountered at 3 feet bgs, is a fine-grained, dark brown sand approximately 4 to 5 feet thick. The third unit consists of a gray to brown, fine-grained sand and occurred to a maximum depth of 44 feet beneath the site.

The Hawthorn Group was encountered beneath the surficial sand deposits at depths ranging from 28 to 44 feet. The unit consists of a moderately dense, gray-green clay layer underlain by a fine-grained, gray-green, phosphatic, calcareous sand that contained shell fragments. The clay layer encountered was generally about 20 feet thick but thinned somewhat (about 10 to 20 feet thick) in the southern part of the site. The phosphatic sands of the Hawthorn Group were encountered to 72.5 feet bgs, the maximum total depth penetrated during the RI.

Geologic cross sections A-A' and B-B' (identified on Figure 2-2F) provided on Figure 2-2G are representative of the local lithology. The north-south cross section A-A' shows a general uniform depth of the Hawthorn Group in that direction. Geologic cross section B-B' is an east-west representation of the site and shows the Hawthorn Group to be dipping gently to the east.

2.2.3 Hydrogeology

The regional geology and hydrogeology described in the literature were reviewed to develop a conceptual model of the hydrogeology at the McCoy Annex. The local hydrogeology was investigated during the RI field investigation using cone penetrometer borings, piezometers, and wells. Water level observations in piezometers, wells, and surface water bodies were also recorded. The RI Phase I investigation of groundwater indicated that impacts to the groundwater from the landfill at OU 2 were restricted primarily to

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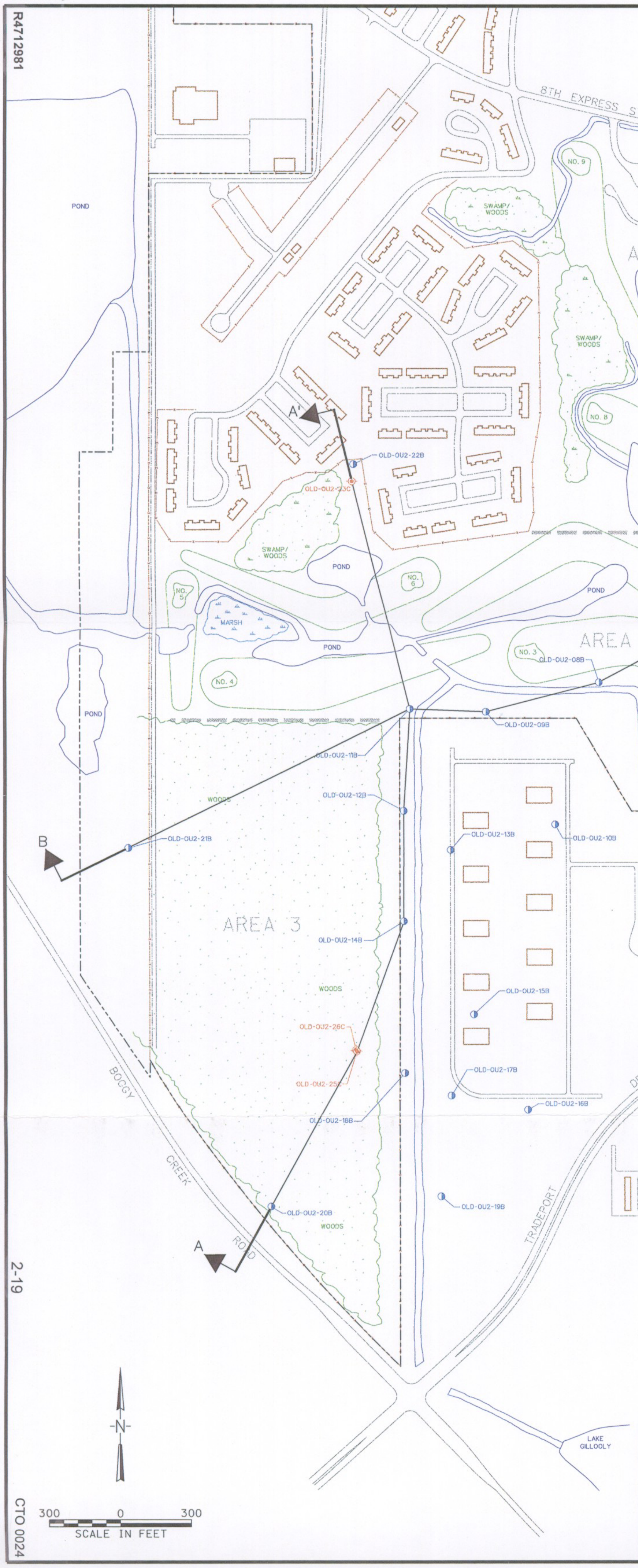

FIGURE 2-2F

GEOLOGIC
CROSS SECTION LOCATION MAP
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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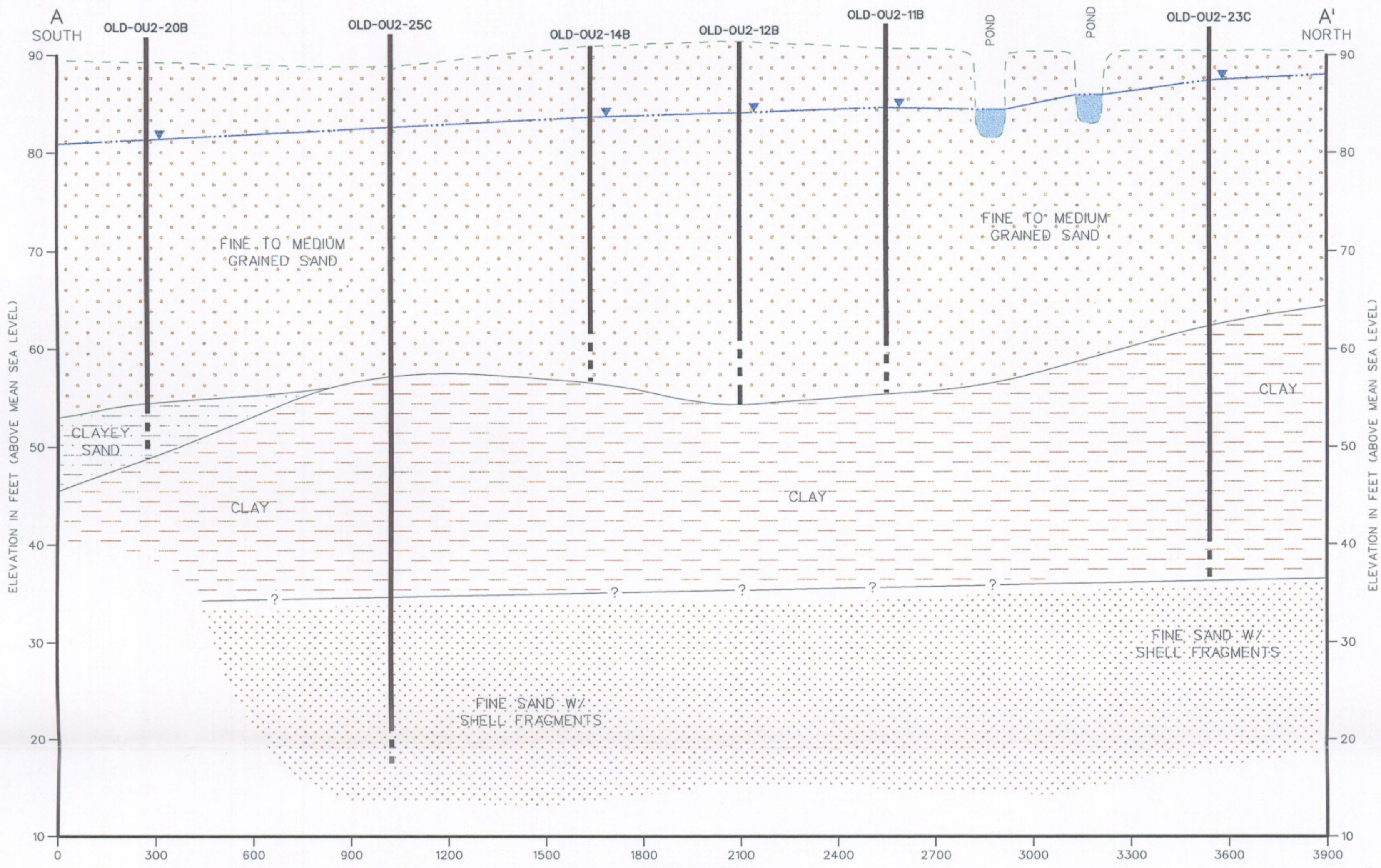
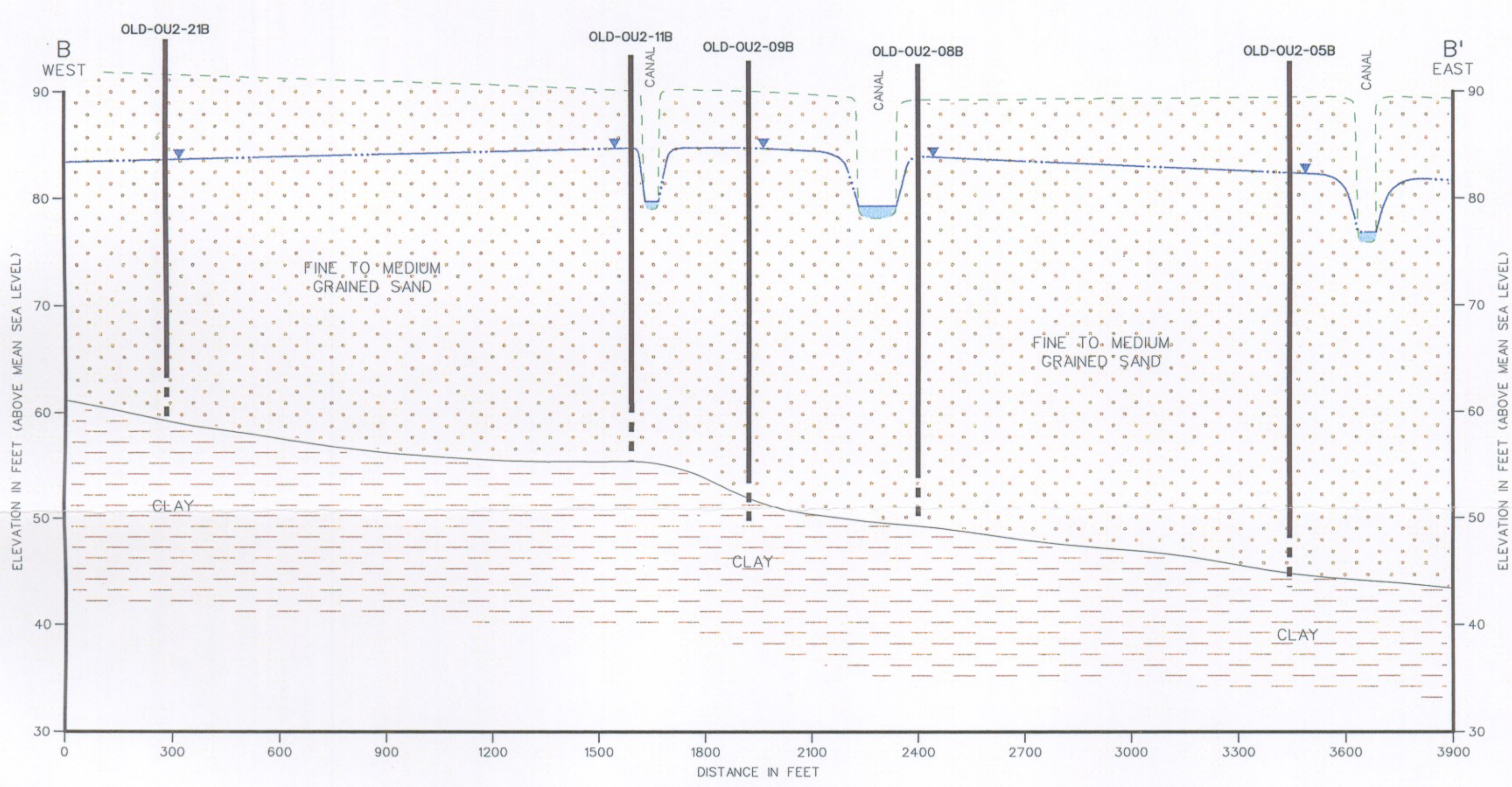


CROSS SECTION A-A'

VERTICAL EXAGGERATION = 30 X HORIZONTAL



CROSS SECTION B-B'

VERTICAL EXAGGERATION = 30 X HORIZONTAL

LEGEND

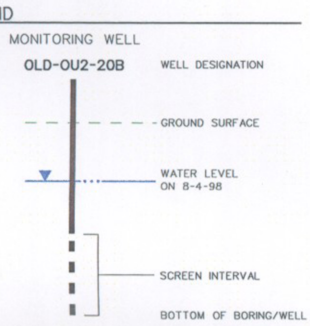


FIGURE 2-2G

GEOLOGIC
CROSS SECTIONS A-A' AND B-B'
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

the surficial aquifer, and possibly to a confined aquifer at a depth between approximately 60 and 73 feet bgs at the McCoy Annex. In addition, the literature suggests that the potentiometric surface of the underlying Floridan aquifer is similar to or slightly higher than the potentiometric surface of the Hawthorn Group aquifer in the vicinity of McCoy Annex. No significant downward gradients are expected. Therefore, hydrogeologic conditions within the deeper hydrostratigraphic units, including the Floridan aquifer, were not investigated.

The cone penetrometer and subsurface boring data, and water level observations (Table 2-2B) showed that the surficial aquifer at the site is unconfined. Its saturated thickness was approximately 25 feet and it consists predominantly of fine- to medium-grained quartz sand. The bottom of the surficial aquifer is delineated by the presence of a laterally extensive, dense, greenish clay at a depth typically 30 feet bgs. The top of the clay appears to dip slightly to the east and to the south of the McCoy Annex where it is encountered at depths of up to approximately 40 feet bgs.

The thickness of the clay unit at the bottom of the surficial aquifer ranges between about 10 to 20 feet. Cone penetrometer data indicate that this layer becomes thinner and contains more sand in the extreme southern portion of the site near Boggy Creek Road (B&R Environmental, 1998a). Geotechnical analyses of samples of the clay and CPT pore pressure dissipation tests suggest that the vertical permeability of this unit is low (e.g., 10^{-6} to 10^{-8} cm/sec range based on grain size analyses). The clay also acts to confine an underlying sand unit. This sand unit was shown to be up to 35 feet thick at several locations where it was penetrated during the RI cone penetrometer investigation (B&R Environmental, 1998a). Based on the physical characteristics and stratigraphic position described in the published literature (Lichtler, 1972), both the clay and the underlying, confined sand unit are considered to represent the top of the Hawthorn Group.

Water level staff gauges were installed during the RI field investigation in several of the ponds and at accessible locations along the drainage canal that bounds the eastern perimeter of the landfill. Water level readings at the staff gauges, which were subsequently converted to surface water elevations, were recorded during the site-wide well measurement surveys conducted in April and August 1998 (Table 2-2B). These data suggest that some of the ponds tend to function as storm water impoundments that slowly release water into the surficial aquifer between storm events; thus, they act as local recharge areas to the unconfined aquifer. The drainage canal data showed that the surficial aquifer was prone to lose water (i.e., discharge) to the canal during baseline conditions. It is suspected that this relationship may reverse itself for short periods of time during and following significant rainfall events; however, these events were not observed during the RI. Previous reports (Geraghty & Miller, 1986) indicate that the southern portion of the drainage canal was constructed post-1986 and did not exist during the time

TABLE 2-2B

WATER LEVEL DATA
OPERABLE UNIT 2

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Well Number	Datum Elevation[a]	Depth to Water on 4/13/98[b]	Water Elevation on 4/13/98[a]	Depth to Water on 4/29/98[b]	Water Elevation on 4/29/98[a]	Depth to Water on 8/4/98[b]	Water Elevation on 8/4/98[a]
SHALLOW PIEZOMETERS							
P1	91.420	3.80	87.62	4.61	86.81	3.81	87.61
P2	90.130	5.23	84.90	5.66	84.47	5.20	84.93
P3 S	92.210	4.66	87.55	5.47	86.74	3.90	88.31
P4	88.380	2.72	85.66	3.65	84.73	3.34	85.04
P5	93.475	6.54	86.94	7.40	86.08	7.75	85.73
P6	94.115	8.40	85.72	9.16	84.96	9.21	84.91
P7	93.685	NM	NM	7.14	86.55	6.43	87.26
P8 N	93.785	6.74	87.05	7.12	86.67	7.09	86.70
P9	90.065	4.90	85.17	5.25	84.82	4.85	85.22
P10	91.635	3.56	88.08	4.35	87.29	5.70	85.94
P11	92.185	5.10	87.09	7.61	84.58	7.75	84.44
P12	90.815	6.26	84.56	7.02	83.80	NM	NM
P13	91.285	6.50	84.79	7.30	83.99	6.87	84.42
P14 E	89.295	2.80	86.50	3.74	85.56	4.46	84.84
P15	90.955	3.71	87.25	4.42	86.54	4.45	86.51
P16	92.120	6.86	85.26	7.43	84.69	7.17	84.95
P17	94.835	6.67	88.17	7.75	87.09	9.95	84.89
P18	96.250	11.40	84.85	12.50	83.75	14.82	81.43
P19	92.800	6.82	85.98	7.62	85.18	8.60	84.20
P20	91.400	5.72	85.68	6.31	85.09	6.70	84.70
P21 N	93.300	11.40	81.90	12.20	81.10	13.45	79.85
P22 S	92.065			5.46	86.61	4.65	87.42
P23	93.475			6.00	87.48	9.02	84.46
SHALLOW MONITORING WELLS							
MW01A	91.040					7.12	83.92
MW02A	92.530					8.90	83.63
MW03A	90.185					6.13	84.06
MW04A	88.860					5.42	83.44
MW05A	92.905					10.19	82.72
MW06A	90.355					6.79	83.57
MW07A	90.695					8.18	82.52
MW08A	92.475					8.70	83.78
MW09A	92.760					7.88	84.88
MW10A	91.060					4.60	86.46
MW11A	93.095					8.75	84.35
MW12A	91.520					7.40	84.12
MW13A	92.090					7.19	84.90
MW14A	91.080					7.38	83.70
MW15A	91.600					6.60	85.00
MW16A	91.420					6.40	85.02
MW17A	91.240					7.05	84.19
MW18A	91.180					8.27	82.91
MW19A	90.520					7.93	82.59
MW20A	91.910					10.65	81.26
MW21A	94.770					11.35	83.42
MW22A	92.405					4.85	87.56
INTERMEDIATE PIEZOMETERS							
P21 S	93.320	11.72	81.60	12.00	81.32	12.75	80.57
INTERMEDIATE MONITORING WELLS							
MW01B	91.030					6.32	84.71
MW02B	92.750					8.33	84.42
MW03B	90.145					5.89	84.26
MW04B	88.880					5.48	83.40
MW05B	93.025					9.70	83.33
MW06B	89.885					7.18	82.71

TABLE 2-2B

WATER LEVEL DATA
OPERABLE UNIT 2

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Well Number	Datum Elevation[a]	Depth to Water on 4/13/98[b]	Water Elevation on 4/13/98[a]	Depth to Water on 4/29/98[b]	Water Elevation on 4/29/98[a]	Depth to Water on 8/4/98[b]	Water Elevation on 8/4/98[a]
INTERMEDIATE MONITORING WELLS (CONTINUED)							
MW07B	90.705					6.70	84.01
MW08B	92.415					8.60	83.82
MW09B	92.810					8.00	84.81
MW10B	91.260					5.85	85.41
MW11B	93.285					8.59	84.70
MW12B	91.380					NM	NM
MW13B	92.060					7.18	84.88
MW14B	90.960					7.24	83.72
MW15B	91.540					5.90	85.64
MW16B	91.370					5.50	85.87
MW17B	91.200					7.02	84.18
MW18B	90.870					7.77	83.10
MW19B	90.250					7.65	82.60
MW20B	91.950					10.85	81.10
MW21B	94.910					11.34	83.57
MW22B	92.415					4.90	87.52
DEEP PIEZOMETERS							
P3 N	92.140	36.51	55.63	36.75	55.39	38.12	54.02
P8 S	93.865	40.18	53.69	40.91	52.96	Destroyed	NM
P14 W	89.635	31.89	57.75	35.56	54.08	39.10	50.54
P22 N	91.755	NI	NM	38.08	53.68	42.80	48.96
DEEP MONITORING WELLS							
MW23C	92.975					44.15	48.83
MW24C	91.950					43.62	48.33
MW25C	92.150					44.25	47.90
MW26C	92.230					44.25	47.98
STAFF GAUGES							
SG1						NM	NM
SG2						5.01	77.99
SG3						NM	NM
SG4						3.26	84.73
SG5						5.02	79.04
SG6						NM	NM
SG7						NM	NM
SG8						10.01	70.99
SG9						NM	NM
SG10						4.00	83.98
SG11							

A blank cell indicates the well or gauge had not yet been installed as of the measurement date.
NI - Not installed
NM - Not measured
[a] Elevation in feet above mean sea level.
[b] Depth in feet below ground surface.

when the landfill was operated. Therefore, it is likely that the water table in the surficial aquifer in the southern portion of the McCoy Annex was typically higher in the past than was observed during the RI.

2.2.3.1 Groundwater Flow Direction

Water levels were recorded in the piezometers and monitoring wells during April and August 1998 (Table 2-2B). Surface water levels recorded at staff gauges installed during the RI are also included on the table. These data sets represent seasonally high and low water conditions, respectively, although the data do not necessarily represent the maximum or minimum annual conditions. All of the data points shown in the table were surveyed to establish a point of measurement elevation with respect to the local geodetic datum (e.g., sea level). The data from the April 1998 measurements were used to construct a potentiometric surface map of the surficial aquifer that was provided in the OU 2 Technical Memorandum (B&R Environmental, 1998a). This map demonstrated that the water table was fairly regular, with a gentle slope (<4 feet/1000 feet) except in close proximity to recharge areas (i.e., ponds) or discharge areas (i.e., the drainage canal) where steeper gradients were observed (4 feet/100 feet). The August 1998 data were likewise used to construct a potentiometric surface (i.e., water table) map of the surficial aquifer that is included as Figure 2-2H.

Because deeper monitoring wells were installed during Phase II of the RI, Table 2-2B includes potentiometric data for the bottom of the surficial aquifer (i.e., intermediate wells) and for the confined aquifer in the upper portion of the underlying Hawthorn Group (i.e., deep wells). These data sets were used to map the potentiometric surface of these hydrostratigraphic intervals, as shown in Figures 2-2I and 2-2J. The maps were constructed by contouring the potentiometric elevations measured in monitoring wells completed at similar depths.

Groundwater flow arrows are drawn on Figures 2-2H through 2-2J to indicate the horizontal component of groundwater flow for each of the potentiometric intervals mapped in the surficial aquifer. Comparisons of the potentiometric surface elevations of the shallow and intermediate well pairs within the surficial aquifer indicate that there is also a vertical component of flow within the aquifer. The data demonstrate that away from the drainage canal there is typically a downward flow component in the surficial aquifer (i.e., well pairs 10A/B, 20A/B, and 22A/B). On the other hand, the well data show that as the aquifer encounters the drainage canal there is an upward flow component (i.e., well pairs 2A/B, 7A/B, 1A/B, and 18A/B). These observations are consistent with the conceptual model of an unconfined aquifer that is drained by a surface stream (Figure 2-2K). A graphic representation of the variation in the potentiometric surfaces of the various aquifer intervals is shown in Figure 2-2L; the traverse shown in the figure follows the trace of geologic cross section B-B' (Figure 2-2G).

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FIGURE 2-2H

SHALLOW GROUNDWATER POTENTIOMETRIC SURFACE ON 8-4-98
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

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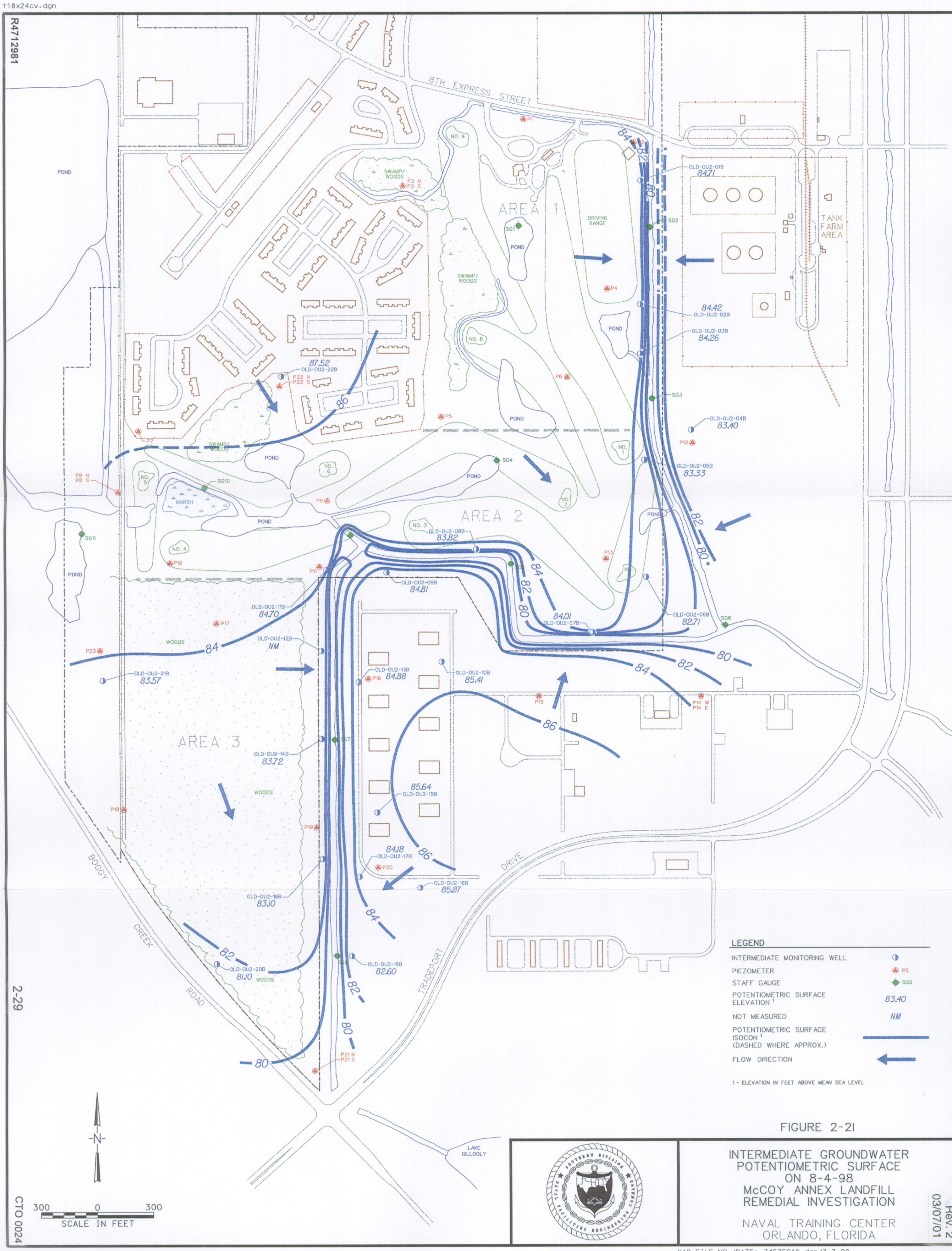

FIGURE 2-21

INTERMEDIATE GROUNDWATER POTENTIOMETRIC SURFACE ON 8-4-98
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

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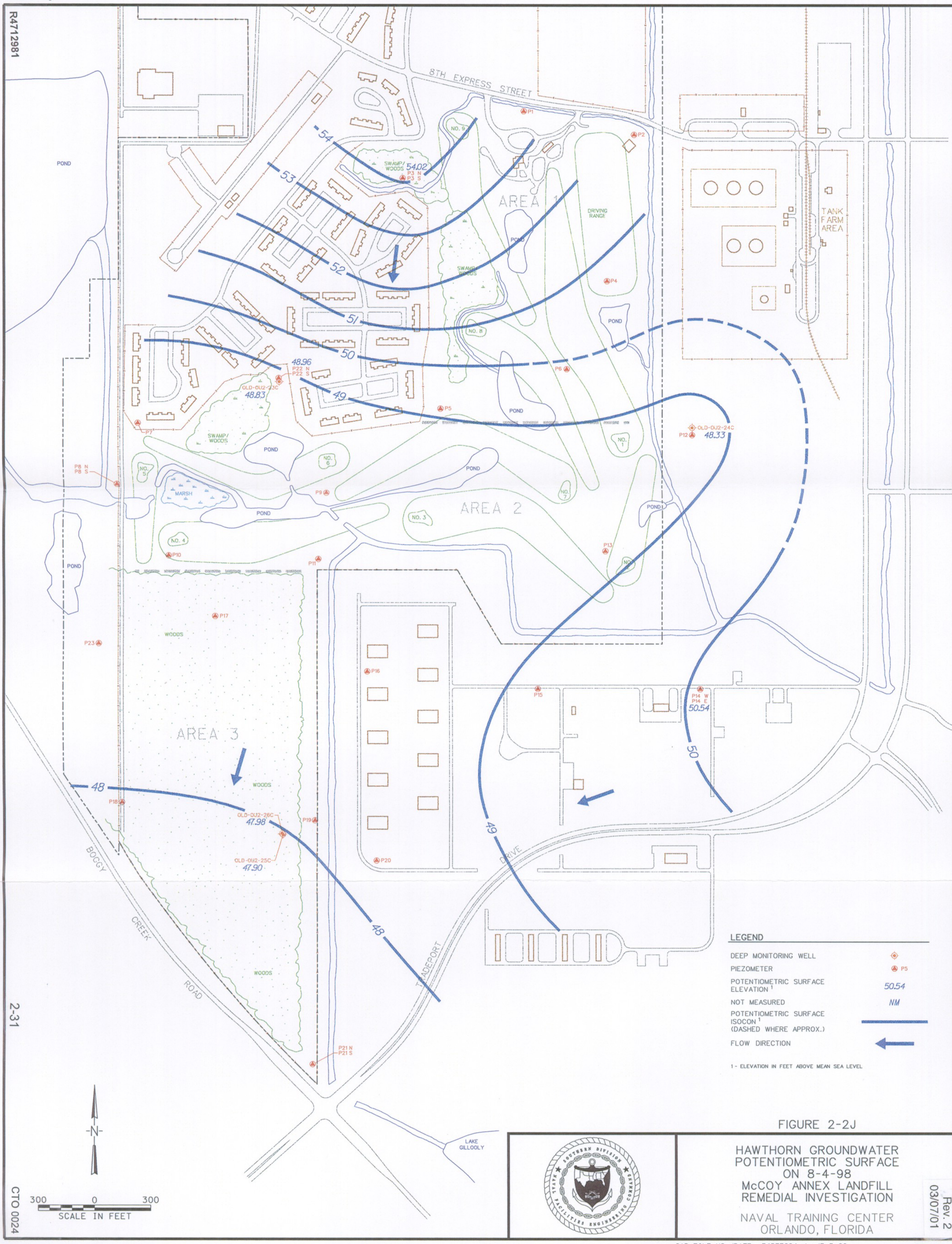

LEGEND

DEEP MONITORING WELL	
PIEZOMETER	P5
POTENTIOMETRIC SURFACE ELEVATION [1]	50.54
NOT MEASURED	NM
POTENTIOMETRIC SURFACE ISOCON [1] (DASHED WHERE APPROX.)	
FLOW DIRECTION	

1 - ELEVATION IN FEET ABOVE MEAN SEA LEVEL

FIGURE 2-2J

HAWTHORN GROUNDWATER POTENTIOMETRIC SURFACE ON 8-4-98
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

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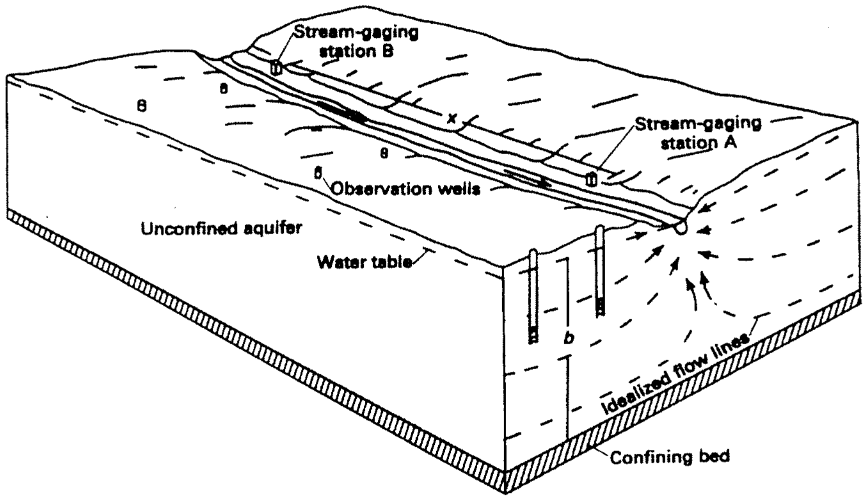
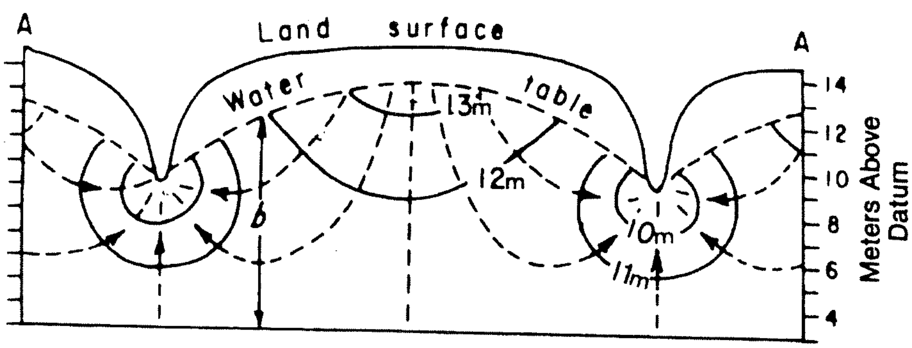


A. Conceptual model of unconfined aquifer discharging to stream



B. Cross section through conceptual aquifer flow net

FIGURE 2-2K

CONCEPTUAL MODEL OF SURFICIAL AQUIFER
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Source: EPA/625/4-85/016

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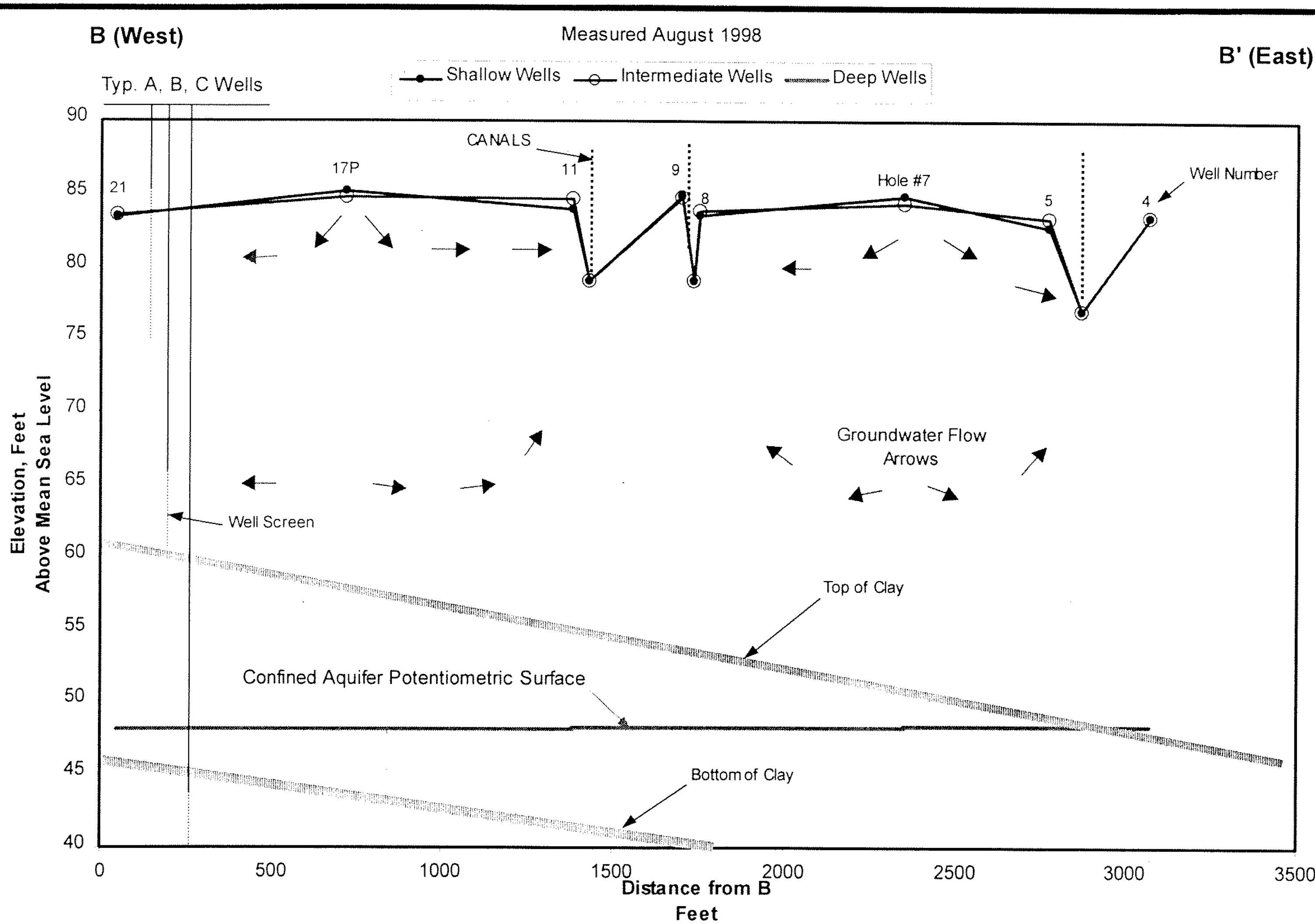

FIGURE 2-2L

POTENTIOMETRIC SURFACES
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

The potentiometric data from the confined aquifer that lies below the surficial aquifer show that there is a downward gradient across the clay interval (compare wells 4A/24C and 22A/23C in Table 2-2B). The flow direction mapped for the confined sand in Figure 2-2J is generally toward the south and southwest. This direction is consistent with discharge of this aquifer into surface water bodies, streams, and rivers that are part of the Kissimmee River Basin that lies to the south of the site. Surface water flow in this basin is to the south. The relative absence of chemicals (except methane) in the confined aquifer suggests that there is little downward movement of groundwater (see Section 5.3). The large difference in potentiometric levels in these two units supports this conclusion. The interconnection between the aquifer layers could be facilitated by breaks (e.g., faults) or by stratigraphic discontinuities in the clay layer, although none were identified during the field investigation.

2.2.3.2 Aquifer Properties

The occurrence and movement of groundwater beneath the McCoy Annex are dependent upon the physical properties of the sediments that compose the aquifer and confining layers. The RI identified three hydrogeologic layers that were the focus of the groundwater investigation: surficial, fine to medium sand from the surface to a depth of about 30 feet bgs; moderately dense, stiff clay at depths of about 30 feet to 50 feet bgs; and fine sand with shell fragments below 50 feet bgs. These materials were investigated by directly observing core samples and drill/hand auger cuttings, conducting geotechnical analyses on select samples, measuring water levels in wells and streams, conducting slug tests in a number of wells spaced across the site, and conducting a 72-hour, constant-rate aquifer pumping test in the surficial aquifer. A summary of the physical property information obtained from these various data collection activities is provided in the following sections.

Aquifer Composition and Texture

Direct observation of soil samples shows that the surficial aquifer consists of a fairly consistent fine- to medium-grained quartz sand with a low percentage of dark minerals and fines. Sorting was difficult to determine with the unaided eye, but grain-size analysis (Appendix C, pp. C-206 through C-248) confirms the fine-grained nature of the material and shows that it is well to moderately well sorted with generally a small percentage of silt (<10 percent) and an even smaller clay content (<3 percent). The predominant unified soil classification for the aquifer would be SP or SW. Observations of black to dark brown coloration in the upper few feet of material suggest the presence of organics and/or of oxidation products that are documented in the published soil survey information. Standard Penetration Test blow counts indicate a loose density for the sand. The cone penetrometer sleeve resistance ratios suggest that there may be a zone of more dense sand or of higher clay content sediment near the middle of the surficial aquifer layer (about 15 feet bgs) that was not directly observed in the soil samples. The development of additional representative aquifer parameters to support fate and transport of contaminants in groundwater is addressed in Section 8.3.

Gamma ray logs were run in all of the intermediate and deep monitoring wells (Appendix F). These data indicate that the percentage of clay minerals generally increases with depth in the surficial aquifer. The gamma ray logs also show that there is commonly a relatively clean sand at the base of the surficial aquifer. In addition, the data show that there are some discontinuous clayey stringers at various depths within the surficial aquifer. There is a semicontinuous layer at about 20 feet bgs that has a higher gamma ray response. This generally indicates more clay content; however, no clay increases were identified in the boring logs (Appendix A) in these zones. A possible explanation is an increase in the phosphate content in this layer. Gamma ray logs run in the Hawthorn Group wells show that this unit is quite variable.

The clay at a depth of about 30 feet bgs was observed in split spoon samples collected in the monitoring well borings and was also penetrated by the cone penetrometer. The boring logs describe the clay as stiff to very stiff, and the blow counts show a significant increase compared to the overlying and underlying sand lithologies. The cone penetrometer sleeve resistance ratios show a consistent pattern for the clay interval across the site, with the exception of the southern terminus of the landfill near wells MW20A and MW20B where sandy or silty clay is indicated.

Geotechnical analyses were performed on Shelby tube samples collected in the clay at deep monitoring well locations MW23C through MW26C (see Appendix C, pp. C-209 through C-221, samples NTC-0129, -0140, -0235, -0333, -0348, and -0433). The analyses show that the clay layer typically contains greater than 70 percent by weight material that passes the No. 200 sieve (i.e., 0.075 mm diameter). Based on the liquid and plastic limits and grain size data, the material lying at depths between 29 and 40 feet bgs (i.e., upper portion of the clay layer) is classified as a CL to CH soil using the Unified Soil Classification System. One sample at a depth of 48 feet bgs is classified as ML. The specific gravity of the solids within the clay samples varied from about 2.5 to 2.8, which is within the range for quartz, glauconite, calcite, muscovite, kaolinite, and chlorite (typical for marine depositional environments). Using the average specific gravity of 2.69 for the CL/CH samples and a water content of 0.32 (based on sample NTC-0232 that contained a high silt/clay content), and assuming saturated conditions, a porosity of 0.46 was calculated for the clay layer (see Calculation D-1 in Appendix D).

The sand below the clay (i.e., top of Hawthorn Group) was sampled at a much lower frequency because only four borings were drilled for deep monitoring wells. The boring logs describe brownish, fine sand with numerous shell fragments. The total thickness of this sand was not penetrated during the investigation. The literature (Lichtler, 1972) states that the Hawthorn Group sediments include lenses of highly permeable shell deposits along with sand, clay, phosphorite, limestone, and sandstone, and that the thickness of the Hawthorn Group is quite variable across Orange County.

Aquifer Pump Test

An aquifier pump test was conducted in the surficial aquifer to obtain information about the transmissivity and storativity of the aquifer, about the ability of pumping to develop a cone of depression, and to observe variability within the area of influence that occurred in response to aquifer pumping. In addition, because the groundwater sampling data showed that chemicals released from the landfill occur in close proximity to the drainage canals, the pump test location was selected so that potential interaction with the drainage canals that circumvent most of the eastern perimeter of the landfill at OU 2 could be evaluated.

A 72-hour pump test of the surficial aquifer was performed October 6 - 9, 1998. The test was conducted in the unconfined aquifer that is underlain by a low permeability clay layer at a depth of approximately 34 feet bgs at the test location. The observation and pumping wells for the test were installed as fully penetrating. The test was performed on the adjacent GOAA property at a location east of the southern section of the landfill.

Eight observation wells (OW01-OW08), one pumping well (PW-1), and two monitoring wells (MW17A and MW17B) were included in the pump test array (Figure 2-2M). The well array consisted of four observation wells at 25-, 50-, 100- and 200-foot intervals south of the pumping well, three observation wells at 25-, 50- and 100-foot intervals east of the pumping well, and one observation well 100 feet west of the pumping well adjacent to the canal. A shallow/intermediate monitoring well pair (MW17A and MW17B) was located 25 feet north of the pumping well and was also monitored during the pump test. In addition, five distant monitoring wells (i.e., background wells) were monitored at a lower frequency during the pumping phase of the test.

Groundwater samples from monitoring wells 17A and 17B and a pre-test sample from pumping well P-1 showed that the groundwater within the test area had not been impacted by chemicals released from the landfill. The extracted groundwater, therefore, was discharged to the ground surface a sufficient distance away from, and across the drainage canal from, the pumping well so that it would not interfere with the

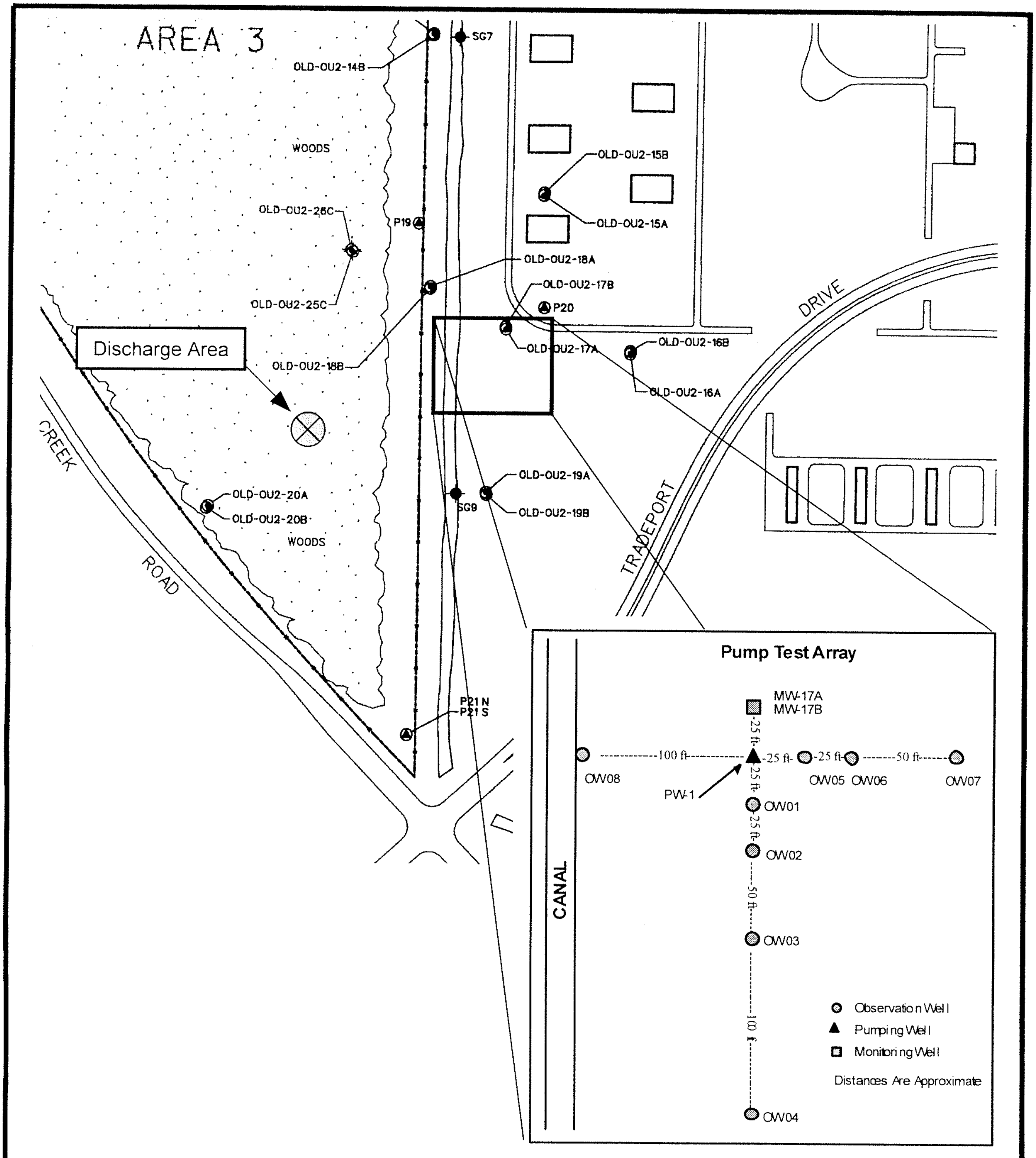

FIGURE 2-2M

N

SCALE: 1" = 340 ft

PUMP TEST WELL ARRAY
McCOY ANNEX LANDFILL
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test (Figure 2-2M). A sample collected near the end of the test that was analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), inorganics, pesticides, herbicides, PCBs, and total petroleum hydrocarbons (TPH) confirmed that chemicals of concern were not present in the extracted groundwater.

The aquifer stress was created by a submersible pump in the 4-inch-diameter pumping well. The pump was suspended in the well with the bottom of the pump approximately 3.5 feet above the bottom of the well. A portable, diesel fuel-driven generator was used to provide the power for the pump. The pump was connected to a discharge system that consisted of a 1.5-inch inner diameter (ID) flexible hose from the pump outlet to a gate valve, an inline flow meter, a sampling port, and a 1.5-inch ID, Schedule 40 polyvinyl chloride (PVC) discharge pipe.

The gate valve was used to regulate the flow of water from the pump, while the flow meter allowed direct measurements of the volume of water discharged and calculation of the flow rate. The inline sampling port in the discharge pipe allowed for collection of a water sample. The PVC discharge pipe transported the pumped water to the discharge area approximately 700 feet southwest of the pumping well. The discharge area was in the southern section of the wooded area of OU 2, on the opposite side of the canal from the pump test location. This area was located approximately 100 feet south of the landfill boundary identified at OU 2 and approximately 300 feet west of the canal. The canal provided a hydraulic barrier and prevented the discharged water from impacting the pump test well array.

The data collection system consisted of an eight-channel data logger and eight pressure transducers. The transducers were installed approximately 10 feet below static water level in six of the observation wells and in monitoring well MW17A. The transducer in the pumping well was set approximately 2 feet above the top of the pump to avoid electrical interference from the pump motor. All transducers were connected to the data logger. The water levels in three observation wells (OW04, OW07, and OW08) and background data from five more distant monitoring wells in the vicinity (MW-13, MW-15, MW-16, MW-18, and MW-19) were manually gauged with a precision of 0.01 foot.

Prior to starting the pump test, the equipment was tested for proper operation. The pre-test check included a short period of pumping to check for proper water flow, leaks in the discharge piping, and operation of the gate valve and sampling port. The pre-test pumping also allowed the gate valve to be set to achieve the desired flow rate of about 10 gallons per minute (gpm). The transducers were then installed in each well and a static reading was taken using the data logger. These results were compared to manual measurements to ensure proper operation of the equipment. Transducer parameters (type, linearity, scale, offset, and top of casing) were initialized into the data logger. Static water levels were recorded manually, and the reference level for each transducer was set to the static depth to water below top of casing. Static water levels in the more distant wells without transducers and the surface water level in the adjacent canal were also recorded immediately prior to the test.

The test was initiated by starting the pump and data logger at the same time. The flow rate was monitored to ensure that approximately 10 gpm was achieved and confirmed by measuring the time required to fill a 55-gallon drum at the point of discharge. The calculated and measured flow rates were periodically recorded throughout the test. After the required pumping rate was achieved, water level readings being recorded by the data logger were manually viewed to ensure proper operation of the equipment. Throughout the test, various measurements and calculations were recorded, including water levels in the observation wells at specified intervals, volume of water pumped, calculated flow rate, measured flow rate, and water levels in background monitoring wells. In addition, elevation of the surface water in the nearby canal and weather conditions were also recorded. Field analysis of the drawdown data in the pumping well was performed every 3 hours to determine if the adjacent canal was impacting the test data or that steady state drawdown had been achieved. Drawdown in the surficial aquifer at the end of the pumping is shown in Figure 2-2N.

Upon completion of the pumping phase of the test, data collection from the recovery phase of the test was initiated immediately by "stepping" the test on the data logger and simultaneously turning off the pump. The recovery phase was completed when the water level in the pumping well had recovered to approximately its pre-test static position. After the test was completed, all transducers were removed, the discharge system was dismantled, observation and pumping wells were abandoned, and the area was restored to its original condition.

The pump test data were evaluated using the Cooper and Jacob (1946) modification of the Theis (1935) nonequilibrium well equation. Although the aquifer is unconfined, actual drawdown during the test was only about 10 percent of the saturated thickness, and all of the remaining theoretical assumptions of the Theis model were reasonably satisfied. This method allows for a simplified graphic analysis using a semi-log plot of the distance vs. the drawdown observed in multiple observation wells.

The analysis was performed independently for both the eastern and southern sets of observation wells (see Figures 2-2O and 2-2P). The results of the analyses provide an average estimate of transmissivity of about 602 $feet^2$/day (4,500 gallons/day/feet) and an average estimate of storativity of 0.04 for the surficial aquifer. Based on a saturated thickness of 24 feet during the test, the estimate for the hydraulic conductivity is 25 feet/day, or 0.009 cm/sec.

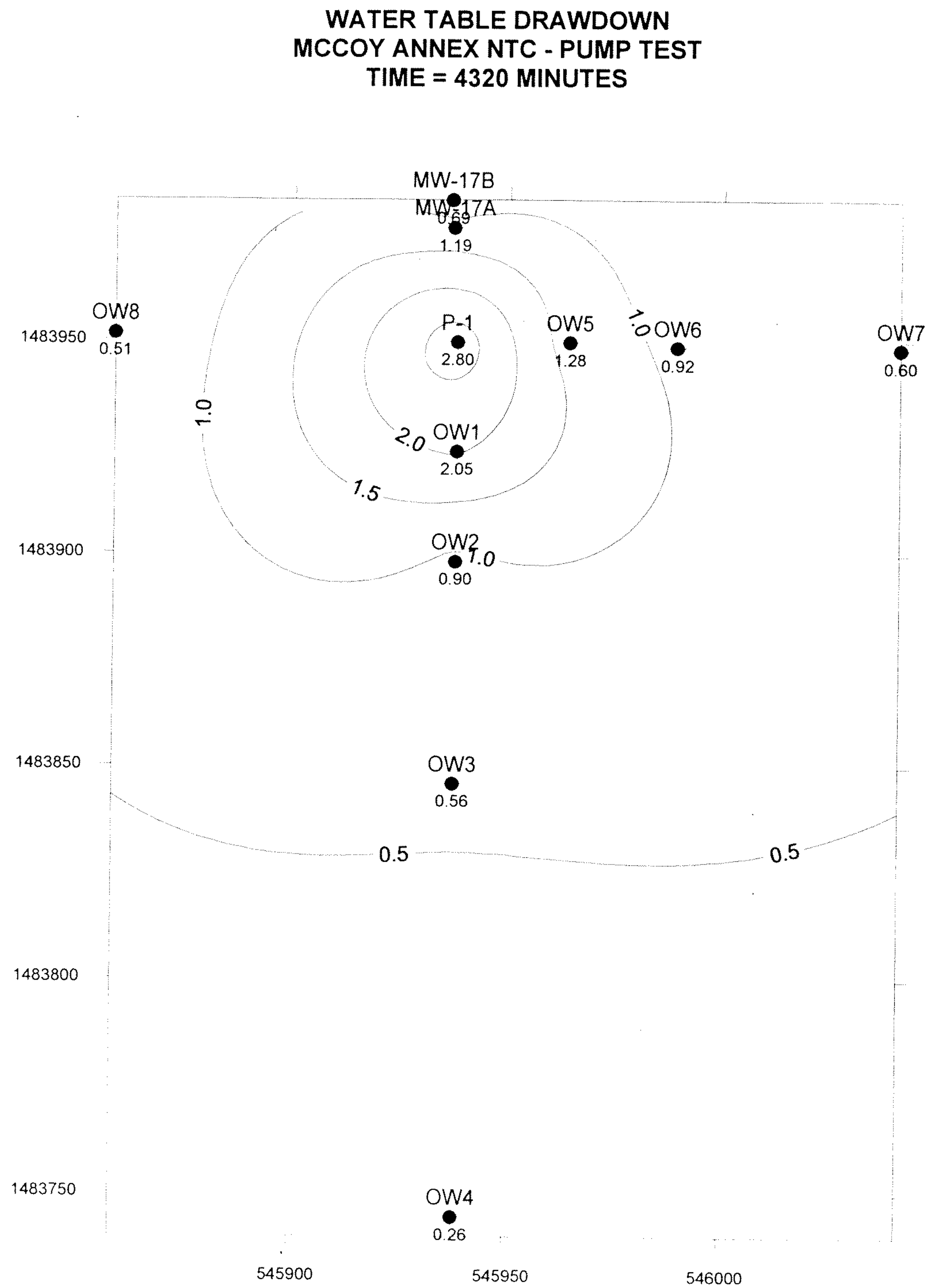

FIGURE 2-2N

DRAWDOWN AT END OF PUMP TEST
McCOY ANNEX LANDFILL
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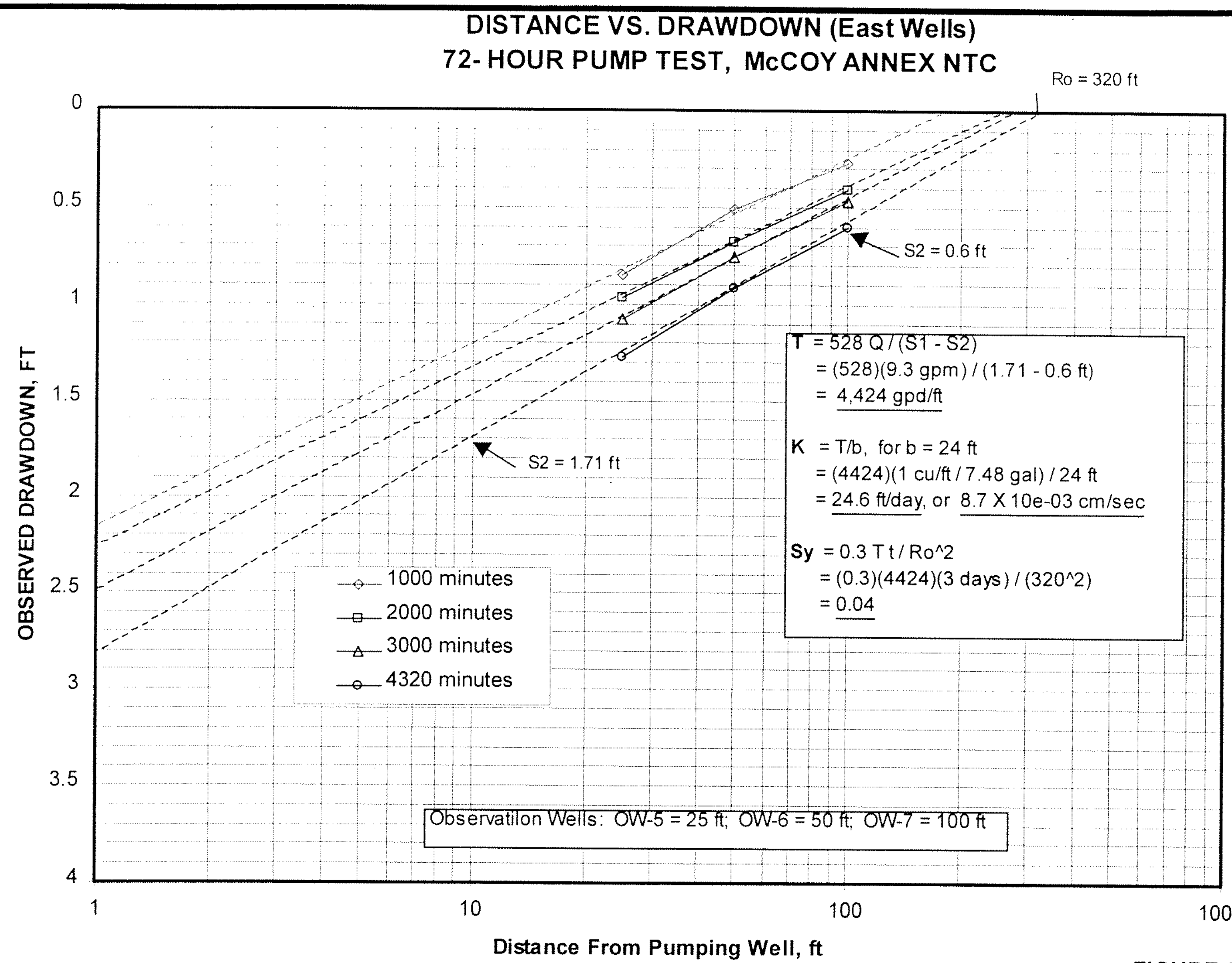

FIGURE 2-20

AQUIFER DATA ANALYSIS - EAST WELLS
McCOY ANNEX LANDFILL
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DISTANCE VS. DRAWDOWN (South Wells)
72- HOUR PUMP TEST, McCOY ANNEX NTC

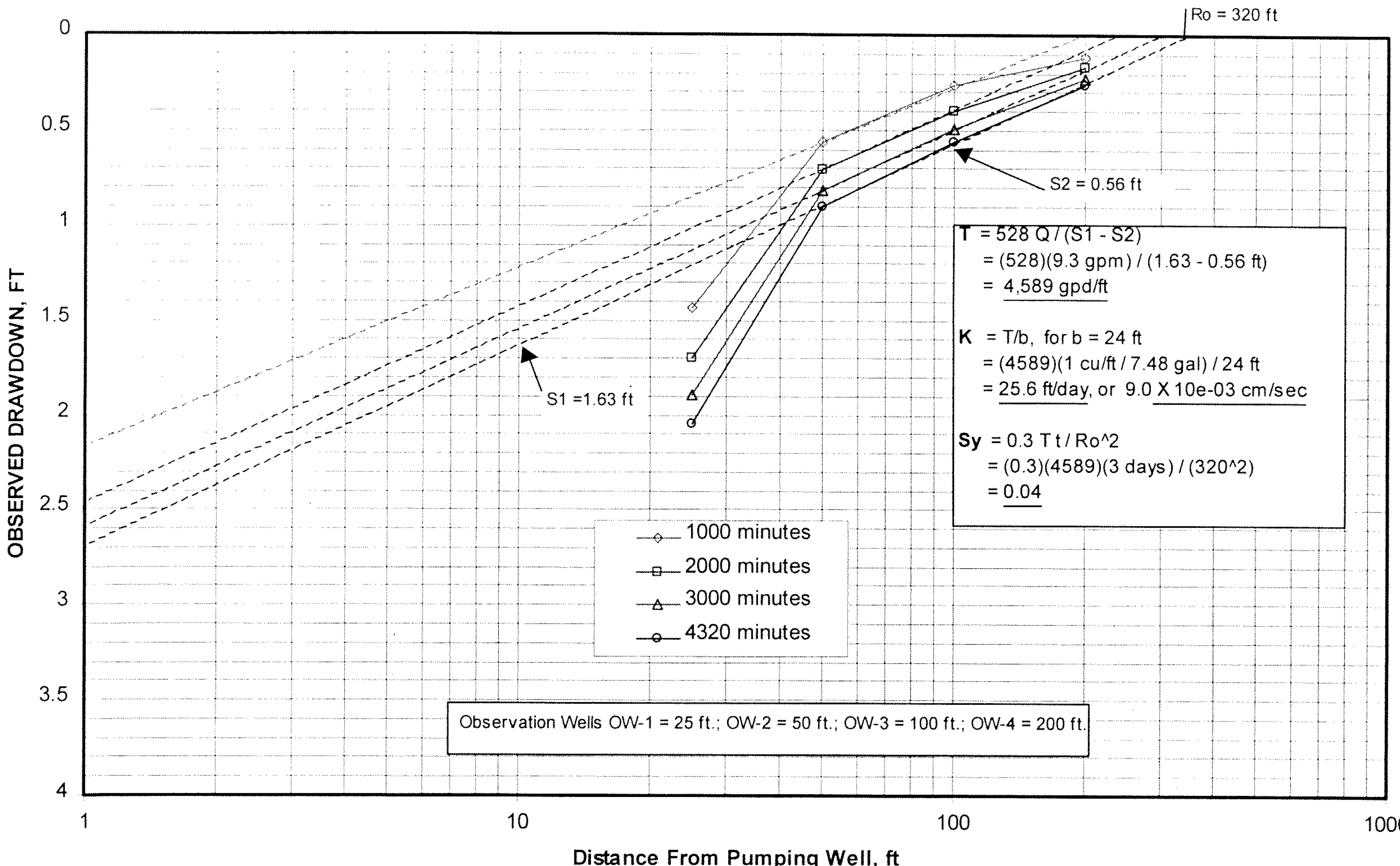

FIGURE 2-2P

AQUIFER DATA ANALYSIS - SOUTH WELLS
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

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ORLANDO, FLORIDA

Additional presentation of the pump test data, plots of the water table surface and cone of depression, time vs. drawdown plots, and interpretation of the pump test results are provided in Appendix D.

Slug Tests

Slug tests were conducted in selected monitoring wells across the site to estimate the hydraulic conductivity of the surficial aquifer and the upper sands of the Hawthorn Group. This testing was performed to obtain a broader picture of the horizontal and vertical variability within the aquifer layers across the site beyond the area of influence of the pumping test. Testing was conducted in six shallow wells, six intermediate wells, and two deep wells. The tests were conducted by instantaneously changing the water levels in the wells by inserting or withdrawing a solid slug and by recording the water level response using an electronic pressure transducer and data logger. The test results were analyzed using the Bower and Rice (1976) methodology for fully or partially penetrating wells in unconfined or confined aquifers. The data were electronically manipulated and the estimates of hydraulic conductivity were obtained using the AQTESOLV® software program.

Copies of the test data, the data tables and analyses, and the computer analysis outputs are provided in Appendix D. The data are summarized for each aquifer interval in Table 2-2C. The data from wells MW1A, MW1B, and MW10A contained spurious water level responses (see plots in Appendix D) and were not included in the average values shown in Table 2-2C, although interpretation of the data resulted in estimates that are consistent with the hydraulic conductivity ranges shown.

The results show that the hydraulic conductivity estimates for the surficial aquifer are somewhat variable, ranging between 4 and 24.7 feet per day. But, the results for all wells lie within one order of magnitude and are within the same order of magnitude as the aquifer pumping test result (i.e., 25 feet/day) conducted in the surficial aquifer. The data suggest that the lower portion of the surficial aquifer is slightly more conductive than the upper portion (average of 12.6 vs. 8.2 feet/day). The data also indicate the underlying confined aquifer is significantly less conductive than the surficial aquifer (i.e., 0.8 vs. 8.2 to 12.6 feet/day).

2.2.4 Soils

The detailed soil map published by the U.S. Department of Agriculture, Soil Conservation Service (USDA, 1989) shows that the former landfill area and golf course at the McCoy Annex lie across an area dominated by the Smyrna fine sand soil mapping unit with smaller areas occupied by the Ona-Urban land complex and the Bassinger fine sand, depressional units. The USDA mapping also shows an area of "Pits" located across the southern, wooded portion of the study area. The relationship of the landfill area to the detailed soil map is shown in Figure 2-2Q.

TABLE 2-2C

**SLUG TEST DATA SUMMARY
OPERABLE UNIT 2**

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Well Number	Screen Interval During Test	Slug Type	Hydraulic Conductivity (cm/s)	(ft/day)
SHALLOW WELLS				
MW-01A[a]	water table	solid slug out	0.0014	4.0
MW-06A	submerged	solid slug out	0.0032	9.1
MW-10A[a]	water table	solid slug in	0.0020	5.7
MW-19A[a]	water table	solid slug out	0.0042	11.9
MW-21A	water table	solid slug out	0.0019	5.4
MW-22A	submerged	solid slug out	0.0026	7.4
		Average	0.0030	8.4
INTERMEDIATE WELLS				
MW-01B[a]	submerged	solid slug out	0.0015	4.3
MW-06B	submerged	solid slug out	0.0029	8.2
MW-10B	submerged	solid slug out	0.0056	15.9
MW-19B	submerged	solid slug out	0.0087	24.7
MW-21B	submerged	solid slug out	0.0031	8.8
MW-22B	submerged	solid slug out	0.0036	10.2
		Average	0.0048	13.6
DEEP WELLS				
MW-23C	confined	solid slug out	0.0006	1.7
MW-26C	confined	solid slug out	0.0001	0.3
		Average	0.0004	1.0

[a] Data not included in average values.

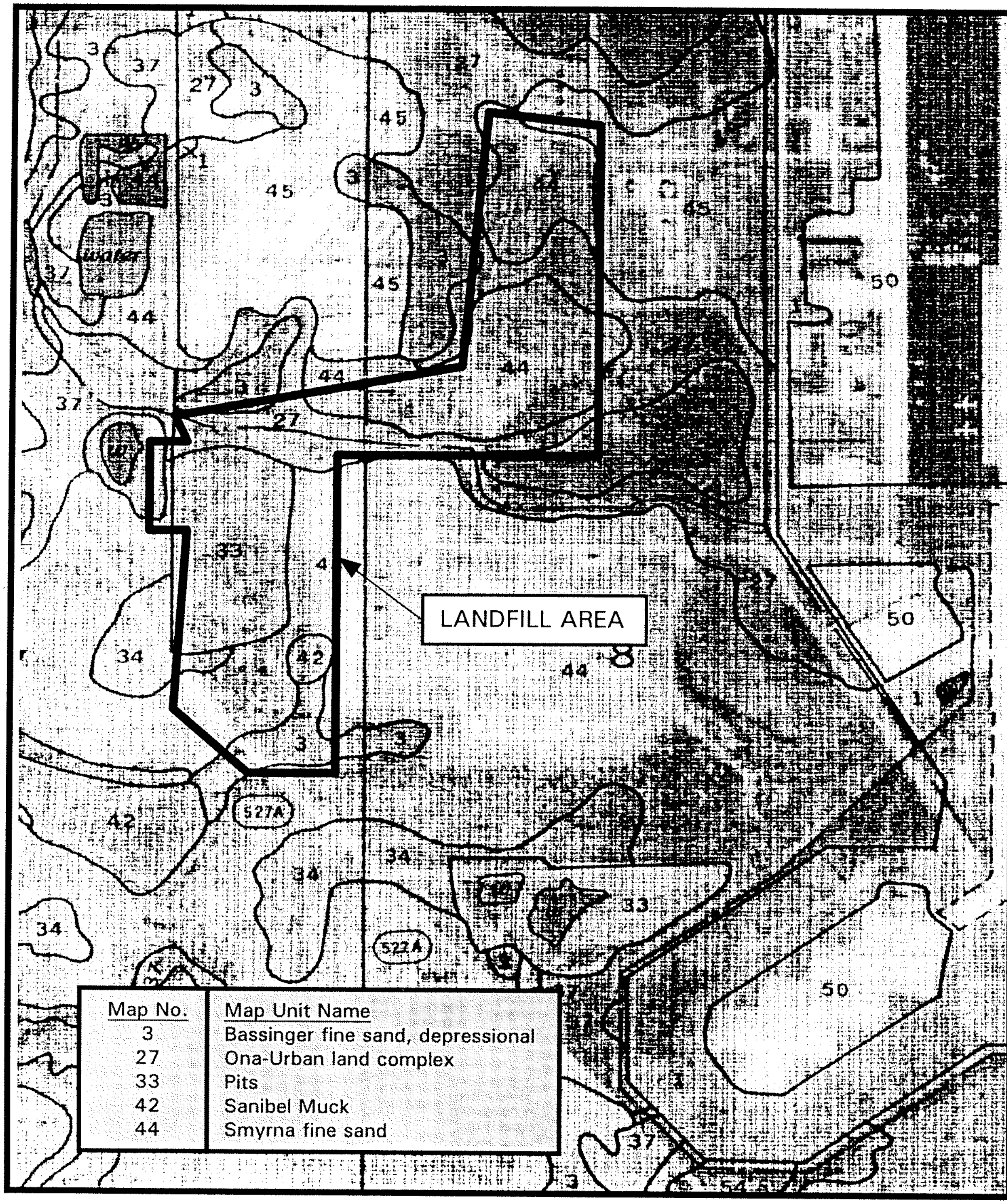

FIGURE 2-2Q

N

Scale: 1" = approximately 900 ft

Source: Soil Survey of Orange County, Florida (USDA, 1989)

SOILS MAP
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

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ORLANDO, FLORIDA

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The Smyrna and Ona-Urban land complex map units are both poorly drained soils that formed in sandy marine sediment. The A horizon for both units typically is a black, fine sand that is 3 to 4 inches thick. The subsurface layer and subsoil layers of the Smyrna soil alternate between gray, dark brown, light gray, and pale brown in color; the Ona soils alternate between dark reddish-brown, gray, and light gray in color. Both soils remain a fine sand throughout their depth and greater than 80 percent by weight passes a No. 40 soil sieve (i.e., 0.017-inch diameter). Both soils support a seasonal high water table within about 10 inches of the surface for 1 or 2 months of the year in undrained areas. The permeability of the surface and subsurface layers is rapid and is moderate to moderately rapid in the subsoil of both soils. The Urban land part of this complex is covered by buildings, paving, or other essentially impervious surfaces, and some areas have been altered by grading and shaping. The natural fertility of the Smyrna soils is low, and the Ona soils are not generally used for cultivated crops. Both soils have severe limitations for sanitary facilities, excavations, buildings, and recreational uses.

The soil mapping performed by the USDA suggests that the landfill was active (i.e., Pits mapping unit) only in the southern portion of the study area defined by the geophysical surveys (see Section 3.2). The mapping, however, predates much of the later development of the site that included landfilling in the northern part of the study area, construction of the drainage canal along the eastern perimeter of the southern portion of the study area, and construction of the golf course. These activities have altered the surface and subsurface horizons of the mapped soil units shown in Figure 2-2Q. Site-specific surface soil sampling was conducted during the field investigation of the study area and is discussed in Section 5.2. The evaluation of surface soil samples included laboratory analyses of chemical, radiological, and geotechnical properties.

3.0 FIELD INVESTIGATIONS

This section outlines the objectives of the RI and describes the fieldwork performed. The results of the fieldwork and laboratory analyses are presented in Section 5.0. Section 3.0 also provides a summary of the interim remedial actions (IRAs) performed at OU 2.

The field investigation was conducted to meet the requirements of the CERCLA presumptive remedy for landfills (see Section 1.4). This approach recognizes that complete site characterization is not possible or necessary and, therefore, the remaining uncertainties must be managed. At OU 2, because the presumptive remedy was containment, the field investigation objectives were to (1) define the limits (extent) of the landfill unit, (2) characterize the existing landfill to determine the cover thickness and the nature and extent of contamination, (3) determine the nature and extent of impacted groundwater, (4) characterize the site-specific geology and hydrogeology, and (5) determine whether other environmental media (such as sediment or surface water) have been impacted.

The field investigation, which was guided by the Work Plan for OU 2 (B&R Environmental, 1997), was conducted in three phases of fieldwork. The main purpose for Phase I was to address field investigation Objectives 1, 2, 4, and 5 and to collect data to determine the placement of groundwater wells for Objective 3. The main purpose for Phase II was to follow up on any objectives not completed during Phase I and to install and sample the groundwater monitoring wells to meet Objective 3. The main purpose for Phase III was to collect additional soil cover thickness data, groundwater quality data, and sediment and surface water quality data to address data gaps and uncertainties identified during the evaluation and analysis of the Phase I and Phase II data. Phase I was begun in May 1997 and was completed in December 1997, and Phase II was begun in March 1998 and was completed in October 1998. Phase III was conducted between February 1999 and February 2000. The following activities were conducted during the Phase I field investigation:

- Geophysical surveys [electromagnetic (EM) terrain conductivity and magnetometer] – to address Objective 1.
- Hand auger borings and ground-penetrating radar (GPR) – to address Objective 2.
- SOV survey – to address Objective 1.
- Surface soil sampling – to address Objective 2.
- Surface water and sediment sampling – to address Objective 5.
- Direct push groundwater sampling – to determine monitoring well locations for Phase II.
- CPT – to address Objective 4 and to determine monitoring well locations for Phase II.

Based on the results of Phase I, follow-up activities were required to address an area to the west of the golf course, the wooded area to the south of the landfill, and an off-site area. In addition, the results from the direct push groundwater sampling and the CPT program were used to identify locations for the groundwater monitoring wells. The following activities were conducted during the Phase II field investigation:

- Geophysical surveys – for the area to the west of the golf course.
- Hand auger borings and surface soil sampling – for the area to the west of the golf course, and the wooded area to the south.
- Surface water and sediment sampling – for sampling of the perimeter areas.
- Direct push groundwater sampling – to help further define the locations for the groundwater monitoring wells.
- Piezometer and monitoring well installation and monitoring well sampling – to address Objective 3.
- Aquifer testing – to address Objective 4.

The data collected during Phases I and II were evaluated and interpreted to prepare the draft RI Report that was issued in January 1999 (Tetra Tech NUS, 1999). Concurrently, several data gaps and uncertainties were identified that were deemed to have a potential impact on the data representativeness and on the RI conclusions regarding the nature and extent of contamination and the risks associated with environmental media. To remedy the data gaps and uncertainties, an additional round of field investigation sampling and analyses was performed. The Phase III investigation rationale and work scope are summarized below:

- Interpretation of the Phase II geophysical data used to investigate the thickness of the existing soil cover over former landfill areas was complicated by the shallow depth of the water table, by soil filling and earthwork activities associated with construction of the golf course, and by thick surface vegetation in the southern portion of the site that limited access of the geophysical surveys. Additional hand auguring was therefore performed to validate the geophysical interpretations and to supplement the soil cover thickness data over the landfilled areas.

- Nearly all monitoring well samples analyzed during Phase II contained concentrations of one or more inorganic chemicals and/or gross alpha/beta that exceeded the screening criteria. Many of these wells were located on off-site property that is hydraulically protected from potential contaminant releases to groundwater at OU 2. Many of the groundwater samples contained turbidity levels that may have affected the analytical results. The remedy was to resample all wells using techniques to reduce well stress (i.e., drawdown) during purging and sampling and lower turbidity. The samples were analyzed using the same laboratory methods and protocols described in the work plan.

- Following the Phase I and Phase II collection of surface water and sediment samples along the canal that borders the eastern perimeter of the Navy property, the canal was dredged. This action removed sediments that were sampled during the RI field investigation. The dredging also had the potential to expose sediments that are not represented by the previous sampling. Consequently, surface water quality may be changed. The remedy consisted of re-sampling all surface water and sediment locations in the canals adjoining the eastern boundaries of OU 2.

- Upstream surface water and sediment samples collected during Phases I and II contained exceedances of the screening criteria that appeared to be the result of contaminant sources/releases not associated with past or present activities on Navy property. Six new upstream surface water and sediment collection locations were identified and sampled to investigate potential off-site impacts to surface water and sediment quality.

Details regarding the scope, methods, and procedures used to conduct the Phase III investigation are described in the following sections.

3.1 RADIATION SURVEYS

Prior to the initiation of all Phase I intrusive activities, a general radiation survey was conducted using a Ludlum Model 19 micro-R meter. This instrument contains an internal sodium iodide detector and the unit of measure is the micro-R per hour. The instrument was precalibrated at the factory before shipment. A certification of calibration was provided by the manufacturer stating its accuracy to be within 10 percent.

At the site the instrument's battery was checked on startup and every 2 hours thereafter. An instrument reading was then taken at a designated background location and established as the baseline ambient reading. This procedure was followed daily before the start of any field activity. The instrument type, the serial number, a description of the data collection location, and the time of data collection were also recorded on a daily basis.

The survey was performed in the vicinity of each surface soil location and at each hand auger location in the wooded areas and those associated with the GPR traverses. Instrument readings were also recorded during the DPT and CPT sampling surveys. During all intrusive activities the instrument was run continuously in close proximity to the boring rods during drilling and upon their removal from the subsurface. No readings exceeded the background values during the intrusive fieldwork at the site.

3.2 ELECTROMAGNETIC TERRAIN CONDUCTIVITY AND MAGNETOMETER SURVEYS

High-resolution EM terrain conductivity and magnetometer surveys were performed on May 12 - June 17, 1997 (Phase I), and February 16 - 26, 1998 (Phase II), to determine the lateral extent of the landfill boundaries (RI Objective 1, see Section 1.4). Figure 3-2 shows the areas included in these surveys. EM and magnetometer equipment is used extensively for mapping buried anthropogenic features for environmental and archaeological investigations. Both the EM terrain conductivity meter and the magnetometer were connected to a differential global positioning system (DGPS) to provide accurate station location data. The use of a DGPS minimized disruption to the golf course operations because a conventional staked reference grid was not required for accurate geophysical station location. The accuracy of the DGPS used for this investigation in the open areas of the site was typically ±0.7 feet (20 centimeters) when using a single-frequency, 12-channel DGPS. The accuracies of the DGPSs in the forested areas of the site were approximately ±3 feet using a dual-frequency, 12-channel DGPS and ±50 feet using the single-frequency DGPS. The dual-frequency DGPS was used for most of the data collection in the forested areas, while the single-frequency DGPS was used for data collection in the open areas of the site.

The information known about the past landfilling operations at this site indicated that these geophysical techniques would provide excellent results in delineating the historic landfill boundaries based on suspected contrasts between the natural or clean fill soils of the site and the suspected waste materials.

3.2.1 High-Resolution Electromagnetic Terrain Conductivity Survey

Natural soils and clean fill at the site were sandy in texture. Sandy soils typically are electrically resistive. Landfill waste is typically very electrically conductive due to the presence of elevated moisture content, elevated levels of electrolytes in pore fluids, and metallic debris. The electrical contrast between the resistive natural and clean sandy fill materials and the conductive landfill waste was expected to be substantial at this site. For this reason a high-resolution EM terrain conductivity survey using a Geonics EM31 was recommended and performed at this site.

The EM31 is a frequency domain EM device that utilizes the principle of EM induction to measure the apparent conductivity and magnetic susceptibility of materials and their pore fluids. The instrument is

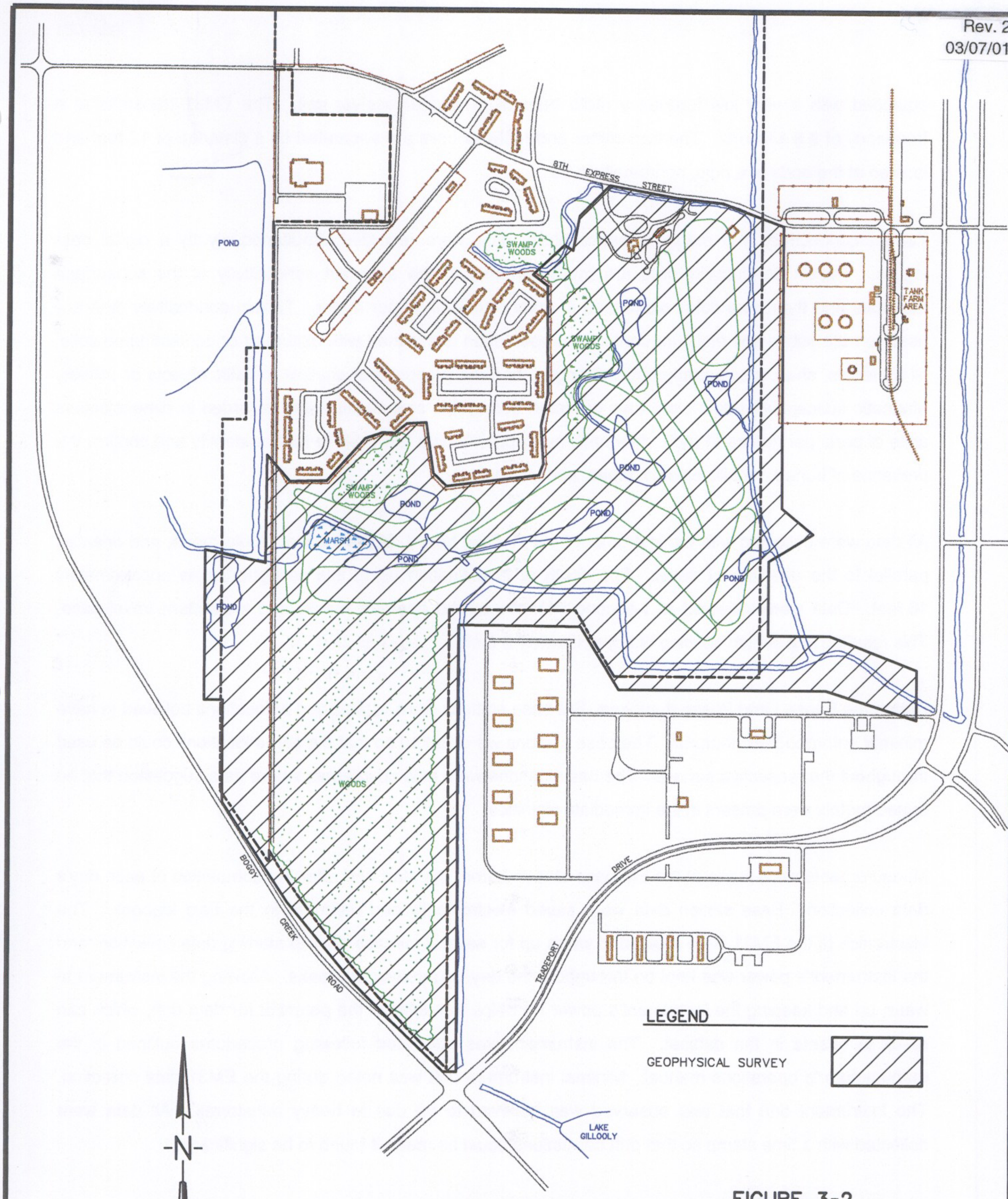

FIGURE 3-2

GEOPHYSICAL SURVEYS
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

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equipped with a very low frequency radio transmitter and a receiver coil. The EM31 transmits at a frequency of 9.8 kilohertz. The transmitter and receiver coils are separated by a distance of 12 feet and located at the ends of a rigid, nonmetallic pole.

Terrain conductivity and magnetic susceptibility data were recorded simultaneously by a digital data logger. Terrain conductivity data are measurements of the apparent conductivity of the subsurface materials and their pore fluids expressed in units of millimhos per meter. Terrain conductivity data are used to map subtle soil moisture content changes often associated with disturbed or contaminated soils, fill materials, shallow soil stratigraphic changes, and the presence of shallow metallic objects or utilities. Magnetic susceptibility data were also collected during this investigation and recorded in dimensionless units of parts per thousand (ppt). Magnetic susceptibility data are used to further identify and confirm the presence of buried metallic objects, pipes, and utilities.

All data were collected with the instrument held at waist height, in the vertical dipole mode, and oriented parallel to the direction of travel. The depth of investigation using this configuration is approximately 16 feet. Data were collected at 1-second intervals as the operator maintained a constant travel pace. This resulted in a station spacing of approximately 3 feet.

During the Phase I and Phase II surveys, EM base stations were established at locations believed to have minimal anthropogenic features. The base stations were staked so that the same locations could be used throughout the respective surveys. The base stations were located in areas where data suggested that no buried metals were present in the immediate vicinities.

Measurements were made at the EM base station before the start and after the completion of each day's data collection. Base station data were saved electronically and recorded in the field logbook. The electronics of the EM31 were allowed to warm up for several minutes prior to starting data collection, and the instrument's power was kept on throughout the day, regardless of breaks. Allowing the instrument to warm up and keeping the instrument's power on helps to minimize the potential for data drift, which can result in offsets in the dataset. The instrument was calibrated following procedures outlined in the manufacturer's operations manual. Minimal instrument drift was noted during the EM31 data collection. The instrument drift that was observed was believed to be due to heavy rainstorms. All data were collected with a time stamp so that drift corrections could be made if found to be significant.

A digital data logger was used to collect the spatial and temporal data at each site. Surface features observed during data collection were recorded in the data logger as text and later used to assist in data interpretation. All data were downloaded to a portable laptop computer at the completion of each day's data collection.

3.2.2 High-Resolution Magnetometer and Gradiometer Survey

The landfilled waste was expected to contain metallic objects and debris. For this reason a magnetometer and vertical gradiometer survey was performed at this site to assist in determining the lateral limits of landfilling. A magnetometer was used because the magnetic contrast between the waste and the clean fill of the site was thought to be significant.

A magnetometer was used to measure the total field and the vertical gradient. Total field data are used to map the presence of large features such as clusters of metallic objects. The vertical gradient was also measured at each data point. Vertical gradient data are often of higher resolution than total field data, so smaller individual metallic objects can be delineated.

A high-resolution Geometrics G-858 cesium vapor magnetometer and gradiometer was used at this site to map the presence of buried metallic debris and objects associated with the historic landfill operation. The G-858 was equipped with two magnetic field sensors located on the end of an aluminum pole that positioned the sensors approximately 6 feet ahead of the operator. The first magnetic field sensor was referred to as Sensor 1. All total field magnetic data were collected with the Sensor 1 located 1 foot off the ground and vertically oriented. Total field data are susceptible to diurnal drift and are recorded in units of nanoTeslas.

A second magnetic field sensor (Sensor 2), attached 2.6 feet above the first sensor, was also vertically oriented. The total field magnetic data obtained from Sensor 2 were subtracted from the total field magnetic data obtained from Sensor 1, and the difference was divided by the separation distance (2.6 feet). The results represent measurements of the vertical magnetic gradient in units of nanoTeslas per meter.

Vertical gradient data can be either positive or negative. Positive vertical gradient data represent buried features that have a constructive remanent magnetization signal in the ambient field, while negative values represent buried features that have a destructive signal in the ambient field. Areas representative of background conditions have vertical gradients of approximately 0 nanoTeslas per meter. Vertical gradient data are not susceptible to diurnal drift.

3.2.2.1 Magnetic Survey Diurnal Corrections

Severe magnetic storms due to solar activity can render magnetometer data useless for environmental surveys. Forecasting and identifying a magnetic storm are critical when collecting magnetic data. Magnetic storms can result in rapid and significant localized changes in the earth's magnetic field that can equal or exceed several hundred nanoTeslas. The Space Environmental Agency, which provides magnetic forecast data for military and civilian purposes that indicate the presence of or project the potential for magnetic storms, was contacted each day prior to the initiation of the magnetic surveys.

Active sunspots were forecast during the May 15, 1997, data collection that resulted in magnetic drifts of 50 nanoTeslas with occasional spikes of 1,000 nanoTeslas or more. A major magnetic storm was forecast for the evening of June 8, 1997, through June 9, 1997. Magnetic data were not collected on June 9, 1997, due to this magnetic storm. Data for the May 15, 1997, survey, however, were corrected and utilized. All other days when magnetic data were collected were forecast to be quiet to unsettled solar conditions, which resulted in a drift of 0 to 20 nanoTeslas.

Diurnal drift data were monitored and recorded in the field using a Geometrics 856AX proton precession base station magnetometer. For the Phase I and Phase II surveys, the base station was set up in areas thought to be free of buried metallic objects or other anthropogenic features that might cause signal interference. The proton precession magnetometer device was designated the base station magnetometer and programmed to record a measurement every 30 seconds during the field investigations. The use of a proton precession magnetometer was acceptable because the background dynamic range at the base station location was expected to be small.

The daily initial and final readings of the base station magnetometer were recorded in the field logbook to identify any potential problems with unexpected solar storms or instrument failure. Base station data were downloaded daily to a laptop computer using the manufacturer's software, Magloc. The total field magnetic data were corrected for diurnal drift utilizing the manufacturer's software, Magmap96. This software automatically corrected the cesium vapor magnetometer's total field magnetic data based on the trends of the proton precession base station data.

3.3 GROUND-PENETRATING RADAR SURVEY AND HAND AUGER BORINGS

The thickness and continuity of the landfill cover (RI Objective 2, see Section 1.4) were investigated with GPR (Phase I) and hand auger borings (Phases I, II, and III) (Figure 3-3A). Approximately 6 miles of

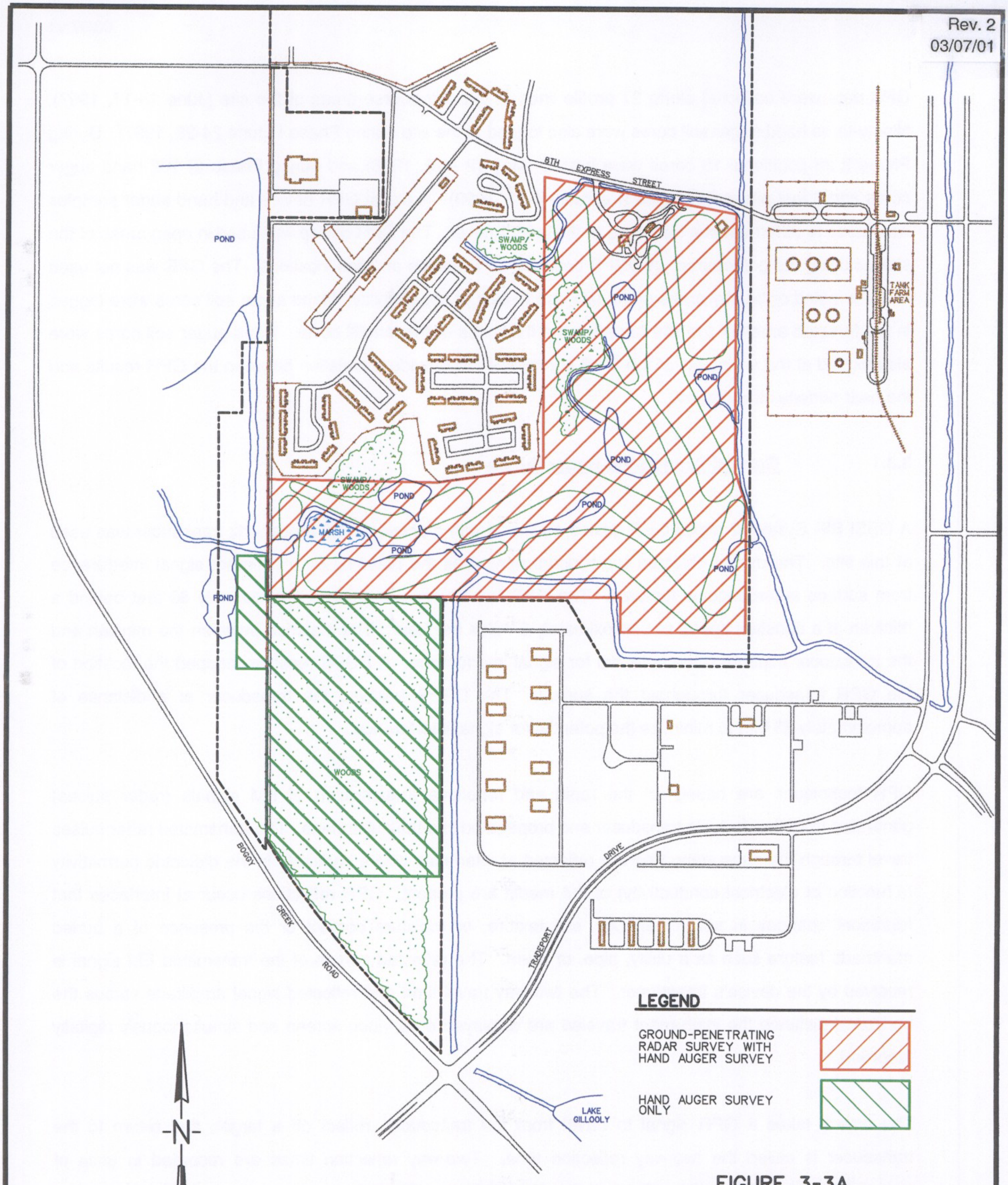

FIGURE 3-3A

800 0 800

SCALE IN FEET

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GROUND-PENETRATING RADAR AND HAND AUGER SURVEYS McCOY ANNEX LANDFILL REMEDIAL INVESTIGATION

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GPR data were collected along 27 profile lines at the golf course areas of the site (June 15-17, 1997). Ninety-three hand auger soil cores were also logged at the site during Phase I (June 24-28, 1997). During Phase II an additional 13 cores were logged (May 12 - 15, 1998) and during Phase III 102 hand auger cores and 6 test pits were logged (February 4-11, 1999). A digital GPR device and hand auger samples were used to determine the thickness of the landfill cover. The GPR device was used in open areas of the site including the golf course. A DGPS provided GPR station and line locations. The GPR was not used in the forested or brushy areas of the site due to lack of accessibility. Hand auger soil cores were logged in the forested areas of the site to define the thickness of the landfill cover. Hand auger soil cores were also logged at the endpoints of the GPR survey lines to provide correlation between the GPR results and the near-surface stratigraphy.

3.3.1 Ground-Penetrating Radar Survey

A GSSI SIR System-2 digital GPR device equipped with a shielded 300 megahertz transducer was used at this site. The use of shielded transducers minimizes the potential for instrument signal interference from surface anthropogenic features. The GPR transducer was towed approximately 80 feet behind a minivan at a constant speed of approximately 6 miles per hour. The distance between the minivan and the transducer minimized the potential for signal interference. A DGPS receiver mapped the location of the GPR transducer throughout the survey. The DGPS followed the transducer at a distance of approximately 33 feet to minimize the potential for signal interference.

GPR techniques are based on the rapid and repetitive transmission of EM signals (radar pulses) generated from the device's transducer and propagated into the subsurface. The transmitted radar pulses travel through the subsurface and are reflected at interfaces where contrasts in the dielectric permittivity (a function of electrical conductivity) of the media are present. GPR reflections occur at interfaces that represent changes in soil mineralogy, soil texture, or moisture content or the presence of a buried manmade feature such as a utility, pipe, or drum. The reflected portion of the transmitted EM signal is received by the device's transducer. The two-way travel time and reflected signal amplitude versus the horizontal distance the instrument traveled are displayed on a video screen and simultaneously digitally recorded.

The time it takes a GPR signal to travel from the transducer, reflect off a target, and return to the transducer is called the two-way reflection time. Two-way reflection times are recorded in units of nanoseconds and vary depending on the electrical properties of the subsurface materials. As the subsurface material's permittivity increases, the two-way travel time increases and the velocity of the GPR signal decreases. Areas of clayey soils, shales, or saline groundwater have high permittivities, relatively long two-way reflection times, and low velocities. GPR signals in these materials also attenuate rapidly, resulting in depths of investigation that may be limited to less than 3 feet. Conversely, dry sandy soils have low permittivities that result in relatively short two-way reflection times and high GPR signal velocities. The depth of investigation, therefore, is often much greater in dry sandy soils than in clayey soils. The depth of investigation for this survey was approximately 10 feet bgs.

The instrument was calibrated following procedures outlined in the operations manual. Depth-of-investigation measurements were made across areas that contained metallic drainage pipes of known depth. The results were also calibrated to hand auger results that were located at the beginning and end of each GPR profile line. Two-way reflection travel times were converted into units of depth where signal propagation velocities were known or could be estimated. Signal propagation velocities can be estimated by collecting data over targets of known depths, performing a common midpoint sounding, or estimating soil permittivities based upon known or published values.

3.3.2 Hand Auger Borings

A hand auger boring program was conducted during each of the three phases of field investigation. Tabulated field data for all phases of the investigation are provided in Appendix A. These shallow borings were used to investigate the physical properties of shallow soils and to determine their thickness over landfilled areas. Forty borings were advanced in the wooded areas, while 53 were advanced at the ends of the GPR transverses during Phase I (June 28 – July 1, 1997). Thirteen borings were advanced in the wooded areas at the southern and western boundaries during Phase II (May 12-13, 1998). Forty-nine hand auger borings were advanced in the wooded area south of the hole no. 4 fairway and 53 were advanced within the golf course during Phase III of the field investigation (February 4-11, 1999). Samples were collected using a standard 2-inch-diameter, stainless steel bucket hand auger equipped with a cross handle to rotate the tool, and quick-connect extension rods. During Phases I and II the auger was advanced to refusal, to the water table, or to a depth of 6 feet bgs, whichever was encountered first, at each location. During Phase III, the borings were terminated at 4 feet bgs. The breathing zone was monitored for organic vapors and radiation during all boring activities.

The Phase I and Phase II borings were augered at selected surface soil sample locations within the landfill boundaries based on the magnetic and EM data (see Section 3.4.3). Phase III locations, shown on Figure 3-3B, were chosen to provide greater coverage in the wooded areas and to provide confirmation of geophysical data in selected areas of the golf course. A description of the soil from each 6-inch auger bucket was entered in the logbook, as was a description of any manmade material and the associated depth where the material was encountered.

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FIGURE 3-3B

HAND AUGER LOCATIONS
PHASE III
REMEDIAL INVESTIGATION
McCOY ANNEX LANDFILL

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During Phase III, six test pits (two in the wooded area and four within the golf course) were also dug using hand tools. The pits, about 2 feet square, were dug at selected locations where manmade material was encountered in the upper 2 feet of a boring, but not below. This was done in order to determine whether the material was spurious or part of the landfill. Observations concerning soil type and manmade material were logged.

After all the information for each boring was entered into the field logbook, the soil was returned to the borehole or pit and the ground surface was restored as closely as possible to its original state. The hand auger tools were decontaminated in accordance with the Project Operations Plan (ABB-ES, 1997). During Phases I and II, the augers were decontaminated prior to use at each location, but during Phase III the hand augers were decontaminated prior to the first use and after the last use each day. Rigorous decontamination was performed during Phases I and II because soil samples were also collected for chemical analysis.

3.4 SURFACE WATER, SEDIMENT, AND SURFACE SOIL INVESTIGATION

Surface water, sediment, and surface soil are media that could be impacted by the landfill. Contaminated storm water runoff or groundwater could flow across the site and into nearby drainage ditches or ponds, causing these media to become contaminated. The surface soil investigation was conducted to determine the impact to this medium (RI Objective 2, see Section 1.4). Collectively, these investigations were conducted to determine the nature and extent of contamination and to meet RI Objective 5 (see Section 1.4).

3.4.1 Surface Water Sampling

Phases I and II

Surface water samples were collected from ten locations (SW001 through SW010) during Phase I of the field investigations (Figure 3-4A). Samples were collected on July 1, 2, and 18, 1997. Location SW010 was re-sampled on September 24, 1997 (Figure 3-4A). Nine of the locations, including drainage ditches, golf course ponds, and interconnecting bodies of water were within the boundaries of the landfill. One sample was collected from a drainage ditch downstream of the landfill on the adjacent property to the southeast owned by the GOAA. These samples were collected to determine if these water bodies had been impacted by surface runoff or groundwater in contact with the landfill material. All appropriate quality control (QC) samples were also collected. These QC samples included field duplicates (1 per 10

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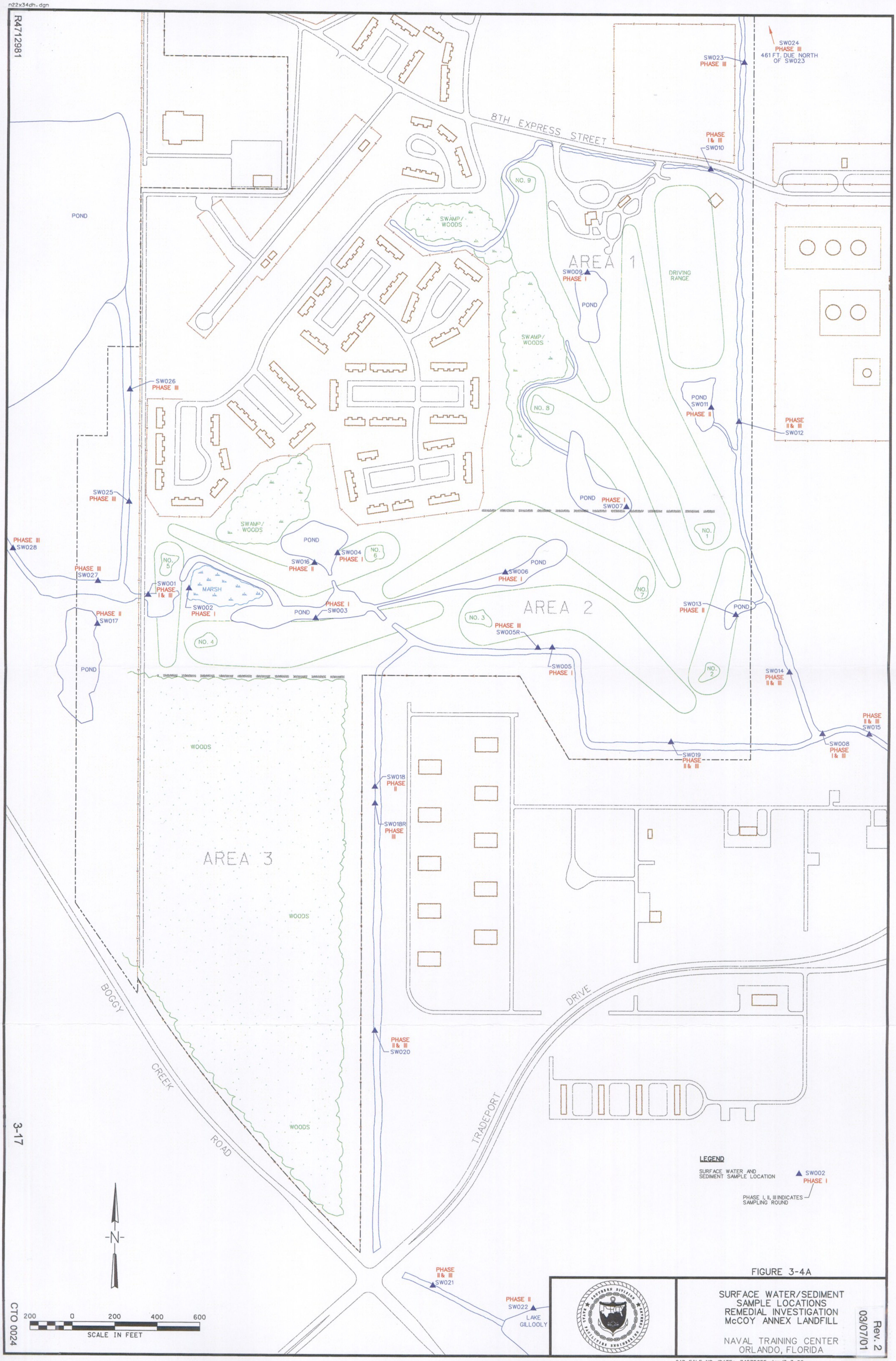

FIGURE 3-4A

SURFACE WATER/SEDIMENT SAMPLE LOCATIONS
REMEDIAL INVESTIGATION
McCOY ANNEX LANDFILL

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environmental samples), trip blanks (one per day of VOC sampling), and matrix spike/matrix spike duplicates (MS/MSDs, 1 per 20 environmental samples).

An additional 12 surface water samples (SW011 through SW022) were collected during the Phase II field investigation on August 25 - 27, 1998. The locations of these samples are shown in Figure 3-4A. Five of the samples were collected from drainage canals along the boundaries of the landfill and the adjacent GOAA property. Three samples were from golf course ponds, and one sample was from the pond along the western boundary of the site. In addition, three samples were collected downstream of the landfill: one southeast of the site, one in the drainage canal at the intersection of Boggy Creek Road and Tradeport Drive, and one from Lake Gillooly, located southwest of the site (Figure 3-4A). All appropriate QC samples were also collected. These QC samples included field duplicates (1 per 10 environmental samples), trip blanks (one per day of VOC sampling), and MS/MSDs (1 per 20 environmental samples). Rinsate and field blanks were not required because no sampling equipment was used.

The water samples were collected by immersing the sample container below the surface of the water, where possible, and holding it at a 45-degree angle until the entire container was filled. The clean container provided by the laboratory was first rinsed with the water to be sampled before the sample was collected.

Surface water samples were analyzed for VOCs, SVOCs, inorganics, TPH, total dissolved solids (TDS), total suspended solids (TSS), hardness, alkalinity, pesticides/herbicides, gross alpha, and gross beta. A gamma scan was performed on the Phase II samples. A sample for PCB and possible dioxin analyses was also collected for every tenth sample (from locations SW006, SW019, and SW021). As specified in the Work Plan (B&R Environmental, 1997) dioxin analysis was not performed because PCBs were not detected in any samples. At each location a sample was also collected for possible specific radionuclide analyses.

Phase III

Seventeen surface water samples, along with two field duplicates, were collected between August 10 and September 21, 1999, as part of Phase III of the field investigations. Eleven of the Phase I and Phase II sample stations were re-sampled during Phase III at or near the same location to obtain a representative sample of conditions after canal dredging occurred in the fall of 1998. Six of the samples were collected at new off-site locations, upstream of the landfill, to determine the potential contributions of off-site sources to the distribution of contaminants in on-site surface water bodies. Surface water flow is shown in Figure 2-2A. Two of the upstream locations (SW023 and SW024) are in the canal that forms the eastern boundary of the golf course, north of 8th Express Street and the Driving Range. Two upstream locations (SW025 and SW026) are in the drainage canal on the western boundary of OU 2 near the Army Reserve Center. Two other upstream locations (SW027 and SW028) are in the drainage canal that flows onto the site from the west and eventually forms the water hazard on hole No. 5. Figure 3-4A shows the location of the sample stations and indicates the phase of the investigation in which it was sampled.

The Phase III samples were collected in the same manner as the Phase I and Phase II samples, and in accordance with the work plan (B&R Environmental, 1997). The sample container was immersed below the surface of the water, depth permitting, and was held at a 45-degree angle until the entire container was filled. These surface water samples were collected at arm's length from the edge of the canal. Two duplicates (SW010 and SW020), one MS/MSD (SW026), and two trip blanks were also collected for QC to satisfy the requirements as specified in the work plan.

Upstream surface water samples (SW023 – SW028) were analyzed for VOCs, SVOCs including polynuclear aromatic hydrocarbons (PAHs), pesticides, herbicides, TPH, Target Analyte List (TAL) metals, mercury under ultra-clean conditions, gross alpha, gross beta, TDS/TSS, hardness, and alkalinity using methods specified in the work plan. PCBs were analyzed at only two upstream locations, SW026 and SW023. Downstream samples collected in the dredged canals within the boundary of OU 2 were analyzed for SVOCs including PAHs, TAL metals, gross alpha, and gross beta.

3.4.2 Sediment Sampling

Phases I and II

Sediment samples were collected concurrently with and in the same locations as the surface water samples (Figure 3-4A) using a scoop sampler to collect the sediment at the bottom of the water body. Sediment samples were analyzed for VOCs, SVOCs, inorganics, TPH, total organic carbon (TOC), cation exchange capacity (CEC), pesticides, herbicides, gross alpha, and gross beta. A gamma scan was performed on the Phase II samples. A sample for PCB and possible dioxin analyses was also collected for every tenth sample (from locations SD006, SD017, and SD019). As specified in the Work Plan (B&R Environmental, 1997) dioxin analysis was not performed because PCBs were not detected in any samples. At each location a sample was also collected for possible specific radionuclide analyses. All appropriate QC samples were also collected. These QC samples included field duplicates (1 per 10 environmental samples), trip blanks (one per day of VOC sampling), and MS/MSDs (1 per 20 environmental samples). Rinsate and field blanks were not required because disposable sampling equipment was used.

Phase III

Sediment samples were collected during Phase III concurrent with the surface water samples (Figure 3-4A) and at the same location using a garden trowel or scoop. The grab samples were collected from the edge of the water by reaching into the canal.

Upstream sediment samples (SD023 – SD028) were analyzed for VOCs, SVOCs, pesticides, herbicides, TPH, TAL metals, gross alpha, and gross beta. Downstream samples in dredged canals within the boundary of OU 2 were analyzed for pesticides, TAL metals, gross alpha, and gross beta. Two duplicates (SD010 and SD020), one MS/MSD (SD026), and two trip blanks were collected for QC at the rate specified in the work plan.

3.4.3 Surface Soil Sampling

During Phase I of the field investigations, 127 surface soil samples (including duplicates) were collected (June 28-July 1, 1997) from within the landfill boundaries and analyzed for chemical and radiological parameters (Figure 3-4B). At 30 of these locations, samples were also collected for geotechnical analyses. Geotechnical samples were collected to determine the engineering properties of the soil cover. During Phase II, 13 additional surface soil samples were collected adjacent to the western and southern boundaries of the landfill (May 12 - 13, 1998) for chemical and radiological analyses. Additional samples were required in the western area because the results of the Phase II geophysical program indicated that the landfill extended into this area. The samples in the southern area were collected because subsurface obstructions were encountered during the Phase II DPT program and reevaluation of the geophysical data indicated possible landfill material. Also during Phase II, 10 samples and a field duplicate were collected to evaluate the levels of pesticides and herbicides in areas of the golf course that do not overlie landfill material (i.e., background samples). Samples were also analyzed for VOCs to confirm that the locations had not been impacted by landfill material.

The samples for chemical and radiological analyses were collected from each acre within the landfill boundaries from the 0- to 1-foot interval. The samples for VOC analysis were collected at the center point of each 1-acre block. The samples for the other analyses were collected as composites from five portions. One portion of the sample was collected from the center point of each acre, and four other equal portions were collected approximately 74 feet to the northeast, southeast, northwest, and southwest. The

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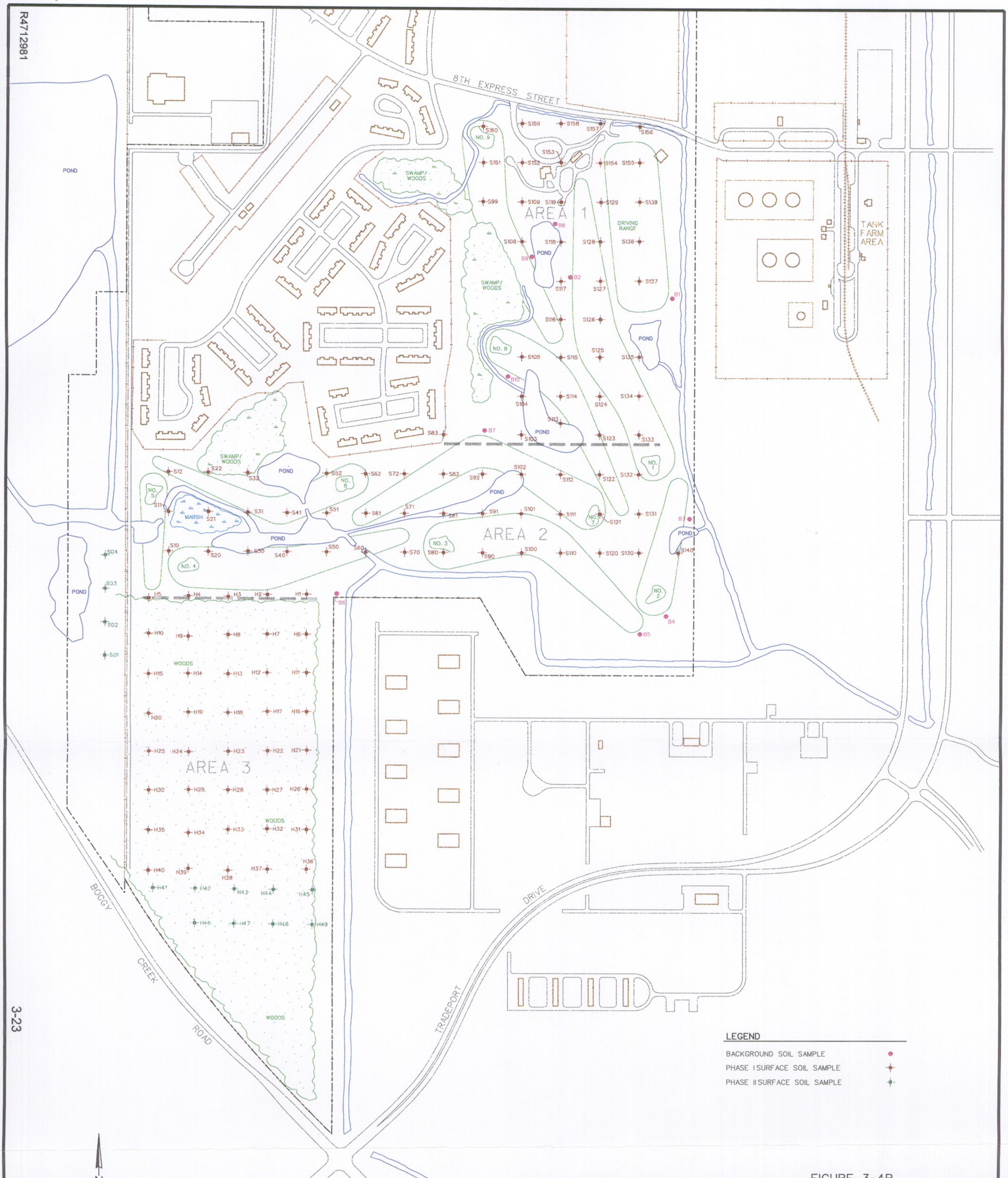

FIGURE 3-4B

SURFACE SOIL SAMPLE LOCATIONS
McCOY ANNEX LANDFILL
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locations were cleared of debris and sampled. The sample material was placed in a stainless steel bowl and thoroughly mixed with a stainless steel trowel to obtain a composite of five subsamples within the acre. The composite sample was then placed in containers precleaned by the laboratory and preserved on ice for shipment to the laboratory. All sampling equipment was properly decontaminated prior to each sampling event and between sampling locations.

The surface soil samples were analyzed for VOCs, SVOCs, inorganics, pesticides/herbicides, TPH, gross alpha, and gross beta. A gamma scan was performed on the Phase II samples. A sample for PCB and possible dioxin analyses was also collected for every tenth sample. Dioxin analysis was performed on one sample and its duplicate because PCBs were detected in the sample. At approximately 25 percent of the locations, samples were also collected for TOC and CEC analysis. At each location a sample was also collected for possible specific radionuclide analysis. The samples collected to evaluate pesticide/herbicide "background" levels were analyzed for pesticides, herbicides, and VOCs. All appropriate QC samples were also collected. These QC samples included field duplicates (1 per 10 environmental samples), rinsate blanks (1 per 10 environmental samples), trip blanks (one per day of VOC sampling), one field blank from each water source used for decontamination (potable and deionized water), and MS/MSDs (1 per 20 environmental samples).

One soil sample was collected for geotechnical analyses from every 4 acres within the landfill during Phase I. At each sampling location, soil was collected in one 16-ounce jar, two Shelby tubes, and a 6-inch by 12-inch concrete cylinder mold. Samples for the 16-ounce container were collected by removing the topsoil or debris from the ground surface and placing the underlying soil in the container for analyses of grain size, Atterberg limits, and moisture content.

The Shelby tube liners were 2-inch ID by 6-inch long. The liners were placed in a metal shoe head attached to a slide hammer core sampler. Prior to sampling, about 6 inches of soil or sod were removed from the surface. The core sampler was advanced into the ground to the middle of the shoe head using the slide hammer assembly at the top. The sample was then retrieved by gently pushing the slide hammer back and forth, thereby breaking the adhesion between soil particles and releasing the core sampler. The sampler was then held horizontally and the Shelby tube liner was removed from the shoe. Plastic caps were placed at both ends of the tube and secured with duct tape. The sample was used to determine the undisturbed vertical permeability, moisture content, in-place density, and soil classification.

At each geotechnical sampling location, one 6-inch by 12-inch concrete cylinder mold was filled with soil using a trowel. This sample was used to conduct a Standard Proctor Test to determine the degree of compactibility of the existing soil cover.

3.5 SOIL ORGANIC VAPOR SURVEY

An SOV survey was performed during Phase I (July 2-17, 1997) within the suspected landfill boundaries (Figure 3-5) to identify specific areas in OU 2 where groundwater and soil are contaminated with VOCs and SVOCs and to evaluate the presence of methane. The purpose of the SOV survey was to support the determination of the limits of the landfill unit (RI Objective 1) and to indicate if the landfill unit is producing gases. For the VOC and SVOC survey, the Gore-Sorber system, in which an absorbent sensing element is placed in a polytetrafluoroethylene membrane tube, was used for the survey. The membrane tube is impermeable to water, but transparent to VOC and SVOC vapors, which migrate through the membrane to be absorbed by the sensing element. A total of 182 Gore-Sorber Modules was installed approximately 2 feet deep using a slide hammer and insertion rod at the surface soil sampling locations (see Figure 3-4B) and around the OU 2 perimeter. The slide hammer and insertion rod were decontaminated prior to each insertion.

After an exposure period of approximately 2 weeks, the modules were retrieved and shipped in coolers to the W.L. Gore & Associates laboratory for analysis by a modified USEPA Method 8240B/8270B. The analytical results reported the masses of compounds in micrograms desorbed from the screening modules.

A methane gas survey was conducted in association with the SOV module installation at each surface soil sampling location and at selected direct push locations along the northern, southern, eastern, and western boundaries of the landfill. The survey was performed with a Neotronics Digiflame 2000 vapor analyzer. The instrument is a self-calibrating vapor detector that responds to the presence of methane gas in the ambient air. Results are reported in percentages of a given aliquot of air sampled.

The Digiflame 2000 is a self-contained battery-powered unit with an intake sampling hose attachment. On startup the instrument conducts a self-diagnostic test and performs a calibration. After 30 seconds the instrument is ready to record methane vapor values. Prior to the insertion of the SOV module into the borehole, the sampling hose was inserted a few inches down the opening. The hose was held in place for approximately 20 seconds, and the methane value from the instrument was recorded. This procedure was performed at each sampling location prior to insertion of the SOV module.

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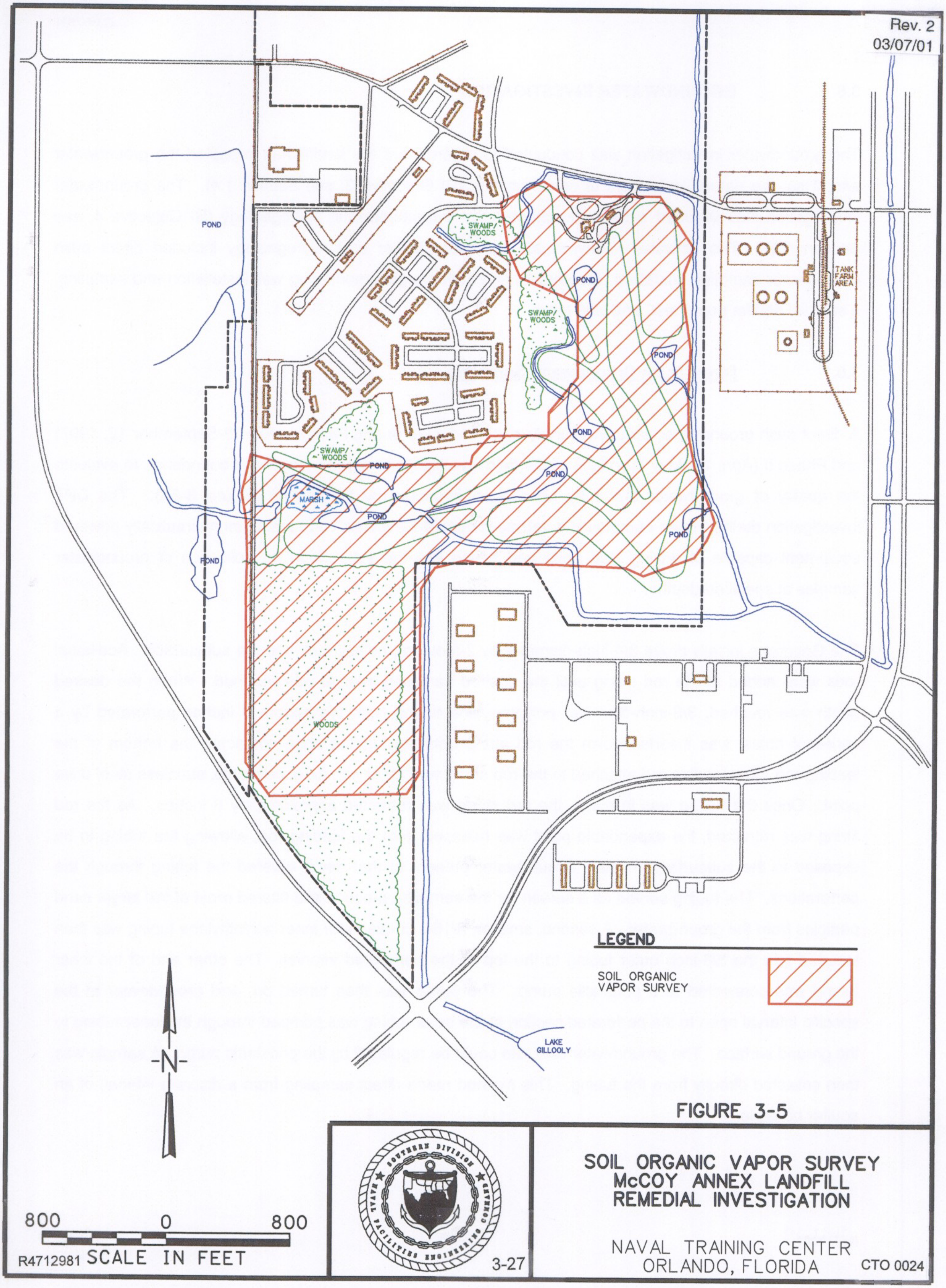

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FIGURE 3-5

SOIL ORGANIC VAPOR SURVEY
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3.6 GROUNDWATER INVESTIGATION

The groundwater investigation was conducted to determine if the landfill has impacted the groundwater and, if so, the nature and extent of contamination (RI Objective 3, see Section 1.4). The groundwater investigation also included activities to characterize the site-specific hydrogeology (RI Objective 4, see Section 1.4). The activities to investigate the groundwater and hydrogeology included direct push groundwater sampling, installing piezometers and staff gauges, monitoring well installation and sampling, a surficial aquifer pump test, and slug tests.

3.6.1 Direct Push Groundwater Sampling

A direct push groundwater sampling survey was conducted during Phase I (July 23-September 12, 1997) and Phase II (April 14- May 10, 1998) of the field investigations around the landfill boundaries to evaluate the quality of groundwater that may have been impacted by the landfill (Figure 3-6A). The DPT investigation during Phase I employed a vehicle-mounted Geoprobe® unit that uses hydraulically powered equipment capable of driving steel rods and tubing into the subsurface for collection of groundwater samples at specified depths.

The Geoprobe initially drove 3/4-inch-diameter by 2-foot-long hollow rods into the subsurface. Additional rods were added to the rod string until the desired sampling interval was reached. When the desired depth was reached, 3/8-inch-diameter polypropylene tubing, with the bottom 6 inches perforated by a series of holes, was inserted down the rod string until the leading edge contacted the bottom of the leading rod. The leading rod attached to the rod string was fitted with an expendable, stainless steel drive point. Once the tubing was in place, the rod string was retracted approximately 8 inches. As the rod string was retracted, the expendable point was released from the leading rod, allowing the tubing to be exposed to the subsurface media. Groundwater present at that depth entered the tubing through the perforations. The tubing served as a screen for the sampling process and filtered most of the larger sand particles from the groundwater. A second, smaller, 3/16-inch-diameter inner polyethylene tubing was then inserted into the 3/8-inch outer tubing to the top of the perforated interval. The other end of the inner tubing was connected to a peristaltic pump. The pump was then turned on, and groundwater at the specific interval open to the perforated section of the outer tubing was pumped through the inner tubing to the ground surface. The groundwater flow rate could be regulated by the peristaltic pump. A sample was then collected directly from the tubing. This method made direct sampling from a discrete interval of an aquifer possible.

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LEGEND

DPT (DIRECT PUSH TECHNOLOGY) LOCATION ● G09

NOTE:

1) PHASE I DPT LOCATIONS ARE G01 THROUGH G174.
2) PHASE II DPT LOCATIONS ARE G198 THROUGH G279.

FIGURE 3-6A

DIRECT PUSH
GROUNDWATER SAMPLING LOCATIONS
McCOY ANNEX LANDFILL
REMEDIAL INVESTIGATION

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After collecting the sample, the rod string was removed from the ground and decontaminated in accordance with the Project Operations Plan (ABB-ES, 1997), Section 4.4.4.2 (Cleaning Procedures for Downhole Equipment), prior to being moved to the next location. The inner and outer polypropylene tubing was disposed of, and new tubing was used for the next location. This procedure reduced the risk of cross contamination from one location to the next. The boring made by the rods was pumped full of grout as the rods were withdrawn. The grout sealed the hole and prevented the introduction of contaminants into the deeper intervals of the aquifer.

During Phase II, a Strataprobe® unit was used to collect groundwater samples. The Strataprobe performed the same functions as the Geoprobe® but was larger and had a more efficient hydraulic unit. The Strataprobe initially drove 1-inch-diameter by 2-foot-long hollow rods into the subsurface. The leading rod was fitted with a retractable sleeve and a 1-foot slotted screen. Once the desired depth had been reached, the sleeve was retracted, exposing the slotted screen to the aquifer and allowing water to enter the hollow rod string. After the water in the rod string reached equilibrium, polyethylene tubing was inserted into the rods to the top of the water. The other end of the tubing was connected to a peristaltic pump to collect the sample. A sample collection procedure similar to Phase I was used. After collecting the sample, the rod string was removed from the ground and decontaminated in accordance with the Project Operations Plan (ABB-ES, 1997), Section 4.4.4.2 (Cleaning Procedures for Downhole Equipment), prior to being moved to the next location. The boring was filled with grout as rods were withdrawn.

At each Phase I location two separate borings were installed along the boundary of the landfill to sample the groundwater at shallow (generally 9 feet bgs) and intermediate (approximately 30 feet bgs) zones of the surficial aquifer. During Phase I, 347 samples were collected. During Phase II, 140 samples were collected. The Phase II samples were collected at specific depths based on the results of the Phase I program.

The samples were collected in 40-milliliter, Teflon-sealed glass vials. During Phase I, the samples were analyzed on-site by a mobile laboratory using USEPA Method 8021 or 8260 for trace-level detection on selected VOCs. Duplicates were collected from 10 percent of the samples and submitted to an approved fixed-base laboratory to verify the results obtained during Phase I by the mobile laboratory in the field. During Phase II the samples were analyzed by a fixed-base laboratory using USEPA Method 8260B.

3.6.2 Cone Penetrometer Groundwater Sampling

A CPT investigation, using direct push methods, was conducted during Phase I (October 22—November 12, 1997) following a review of existing groundwater data from the Phase I DPT groundwater investigation (see also Section 2.2.2). Groundwater samples were collected for analysis at selected CPT locations and at specific depths based on the results of the Phase I DPT investigation.

The CPT program was conducted with a 20-ton truck equipped with a hydraulic direct push unit capable of pushing a cone-shaped probe into the subsurface. The probe was attached to hollow, 2-foot-long stainless steel rods that were continuously added as the probe was driven into the ground. The rods, samplers, and probes were retracted and decontaminated after each use in accordance with the Project Operations Plan (ABB-ES, 1997), Section 4.4.4.2 (Cleaning Procedures for Downhole Equipment), prior to being moved to the next location. Upon completion of the data collection or groundwater sampling at each location, the holes were abandoned by using a tremie pipe to fill the open interval of the hole with grout from the bottom to approximately the ground surface. The grout was a mixture of 5 percent bentonite and 95 percent Portland cement. The grout was allowed to set up for a minimum of 24 hours, after which it was checked for settlement and the hole was refilled, if necessary. The holes were then completed to grade with the appropriate native material.

Fourteen CPT locations (Figure 3-6B) were installed at designated locations along the western, southern, eastern, and northern boundaries of the landfill and on the adjacent properties to the east and south of the landfill. At selected locations, after the data from the CPT push were analyzed, the rig was repositioned approximately 1 foot from the point of CPT entry and groundwater sampling was conducted. The CPT probe was fitted with a sampler tip that allowed the collection of groundwater from discrete intervals in the subsurface. The sampler probe was driven into the subsurface by the direct push rig until the desired depth had been reached. Once at the desired depth, the outer sleeve of the sampler was retracted, permitting entry of groundwater into the sampler. The groundwater sample was collected in a glass vial that was lowered through the rods into the sampler. During the first part of the CPT program, the collected samples were analyzed at a field laboratory using USEPA Method 8010-8020 for trace-level detection of selected VOCs. Duplicates were collected from 10 percent of the samples and submitted to an approved fixed-base laboratory to verify the results obtained by the field laboratory. A table for cross referencing CPT locations with groundwater sample numbers is also presented in Appendix C.

During the CPT investigation the field laboratory contractor was unable to complete the program; therefore, a fixed-base laboratory was used for the remaining portion of the CPT program. The samples were analyzed using USEPA Method 8260.

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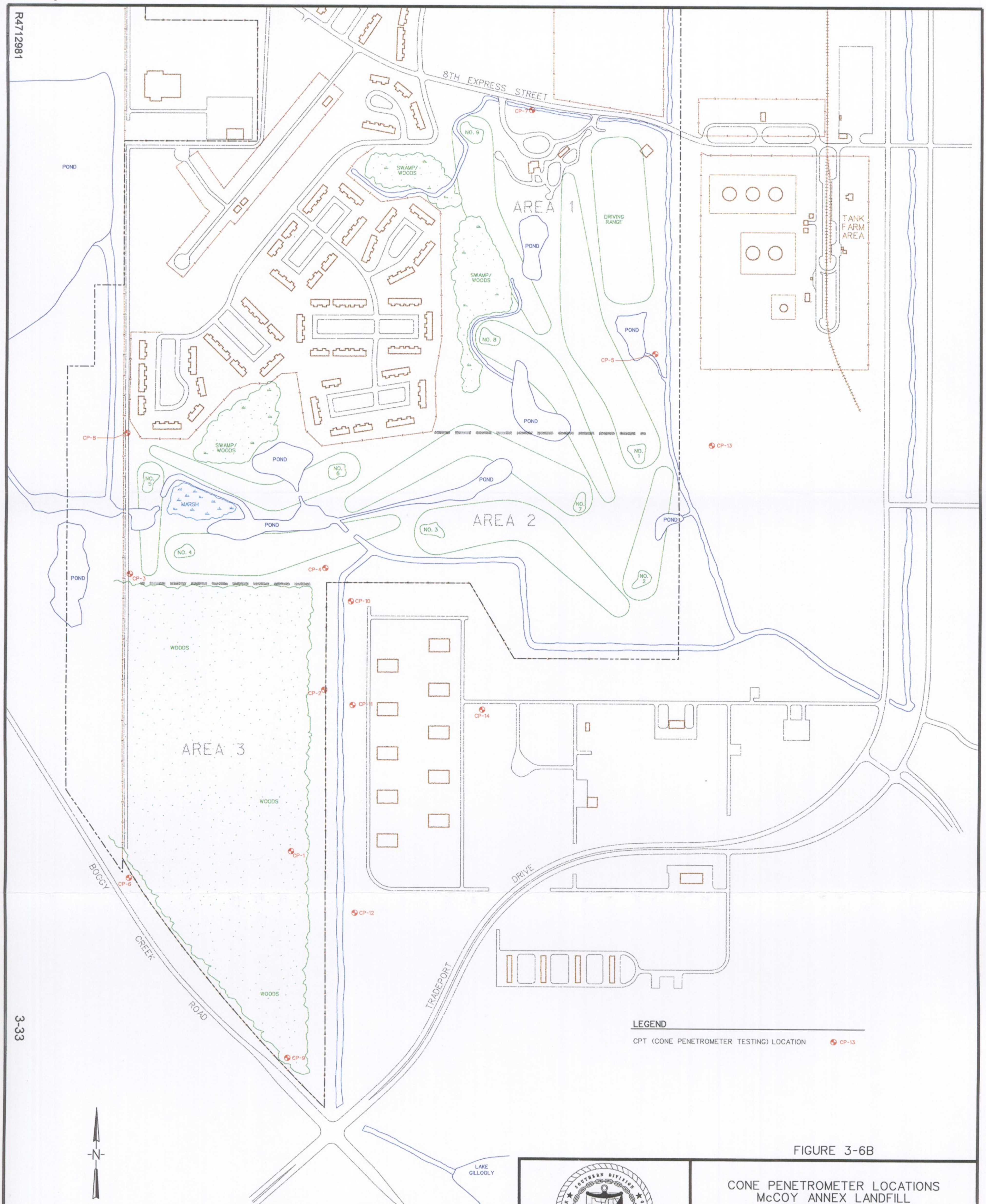

FIGURE 3-6B

CONE PENETROMETER LOCATIONS
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3.6.3 Piezometer and Staff Gauge Installation

A total of 25 piezometers and 11 staff gauges were installed during Phase II of the field investigation at OU 2 (Figure 3-6C). The piezometers were installed to determine the direction of groundwater flow across the site in the surficial aquifer and in the upper sand aquifer of the Hawthorn Group. The staff gauges were installed to determine the elevation of surface water in, and adjacent to, OU 2 to evaluate the interaction of groundwater and surface water at the site.

Eleven piezometers were installed using DPT; the remaining 13 were installed using the hollow stem auger method. At four locations, piezometer pairs were installed to determine the potentiometric relationship between the surficial aquifer and the confined, sand aquifer in the upper section of the Hawthorn Group.

The piezometers installed using DPT were constructed of 0.75-inch ID Schedule 40 PVC and 0.010-inch slot screen. The piezometers were installed to a total depth of 15 feet bgs, with 10 feet of screen and 5 feet of riser for at-grade construction. Piezometers installed above grade had an additional 3 feet of riser above land surface. Protective steel casing with a 4-inch ID and a locking cap was installed around the piezometers constructed above grade. A 20/30 grade sand pack was used to fill the annulus to 2 feet above the top of the screen. Approximately 0.5 foot of bentonite pellets were used as a seal above the sand pack. The remainder of the annulus was grouted to the surface. One piezometer was installed to a total depth of approximately 50 feet, using 5 feet of screen and 45 feet of riser. The construction details were similar to the shallow piezometers.

The remaining 13 piezometers were installed using hollow stem auger drilling techniques. Eleven of these piezometers were installed in the surficial aquifer to a total depth of approximately 15 feet. Three of these piezometers were installed in the Hawthorn Group to a total depth of approximately 50 feet. These piezometers were installed as pairs with each located adjacent to a surficial aquifer piezometer.

The piezometers installed using the drilling rig were constructed of flush-threaded, Schedule 40, 2-inch ID PVC pipe and flush-threaded well screens factory slotted to 0.010-inch size. Upon completion of each boring, the piezometers were installed through the augers to the appropriate depth. The annulus around the piezometer was filled through the augers with a clean 20/30 silica sand pack to approximately 3 feet above the screen. A seal consisting of a 1-foot-thick layer of 30/65 fine silica sand and a 2-foot-thick layer of bentonite pellets was installed above the sand pack. The remainder of the annulus was filled with grout to the surface using a tremie pipe. The piezometers were completed either at or above surface grade.

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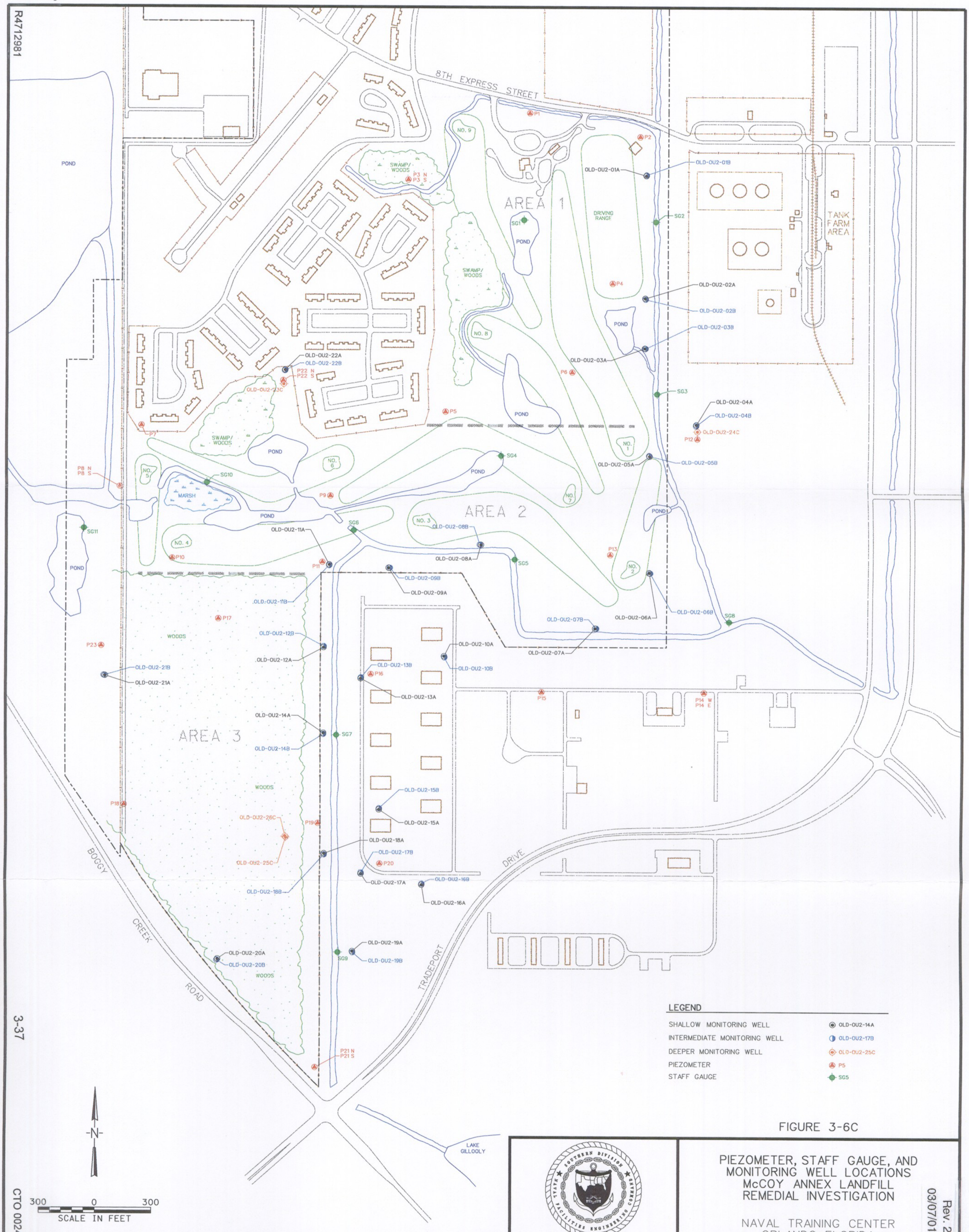

FIGURE 3-6C

PIEZOMETER, STAFF GAUGE, AND MONITORING WELL LOCATIONS
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Piezometers completed at grade were finished with a 2-foot by 2-foot by 6-inch thick concrete pad constructed around a flush-mount, 8-inch-round security vault with a sealing gasket. Piezometers completed above grade were finished with the same type of pad and a 4-inch protective steel casing equipped with a locking cap, and a locking "J-plug type" cap was placed on top of each piezometer. Keyed-alike locks were installed on all piezometers.

Following completion, measuring point elevation marks were established on each piezometer and the location and elevation of each were surveyed by a licensed contractor to a common datum with a precision of ±0.01 foot.

Eleven staff gauges were installed in the surface water bodies in and around OU 2 to measure surface water elevations and to investigate their relationship to groundwater elevations. Three gauges were installed in ponds located on the golf course: one was located in the pond on the western boundary of the site, five were located in drainage canals on the boundaries of the site, and two were located in drainage canals on the golf course.

The gauges consisted of hollow Schedule 40 PVC pipe that was manually driven approximately 2 feet directly into the respective water body bed. A graduated measuring rod was attached to the PVC pipe, and the locations and elevations were surveyed to a common datum with a precision of ±0.01 foot. Water levels were read directly off the graduated rod and surface water elevations were calculated.

3.6.4 Monitoring and Pump Test Well Installation

Results of the DPT investigation were used to locate a series of monitoring wells during Phase II. A pump test well array was also installed during the investigation. A total of twenty-two 2-inch ID monitoring well pairs in the surficial aquifer, four 2-inch ID wells in the underlying Hawthorn Group sands, one 4-inch ID pumping well in the surficial aquifer, and eight 2-inch ID observation wells in the surficial aquifer were installed during Phase II (Figure 3-6C). Boring logs and well completion diagrams are provided in Appendix A. The monitoring well pairs and the deeper Hawthorn Group wells were used to further investigate the extent of potential groundwater contamination in the subsurface at OU 2. One pumping well and eight observation wells were installed to investigate the aquifer characteristics at the site.

During the installation of the monitoring well pairs, split spoon samples were collected and logged continuously from two intermediate-depth (i.e., surface to the bottom of the surficial aquifer) wells. At eight other locations, split spoon samples were collected at 5-foot intervals. At all other intermediate well locations, continuous split spoon samples were logged from 25 feet bgs to the total depth of the well.

Samples were also collected for grain size analysis from nine wells at varying depths. Hydrometer analysis was conducted on ten of the grain-size samples collected.

The 22 monitoring well pairs, the one pumping well, and eight observation wells were installed using the hollow stem auger drilling method. The four Hawthorn Group wells were installed using mud rotary drilling techniques. The monitoring wells were constructed of flush-threaded, Schedule 40, 2-inch ID PVC riser pipe and flush-threaded, factory-slotted well screen with a threaded end cap. The well pairs consisted of a shallow well with a 10-foot screen intersecting the water table and an intermediate depth well with a 5-foot screen at the base of the surficial aquifer. The wells were installed through the augers upon completion of each well boring. A clean silica sand pack was installed through the augers as they were removed from the boring. Clean 20/30 silica sand was used and extended from 0.5 foot below the well screen to 2 feet above the top of the well screen. The wells were then gently surged with a surge block for approximately 10 minutes to ensure no bridging of the sand pack occurred during emplacement. The top of the sand pack was sounded to verify the depth after surging. Additional sand was placed if the level of the sand pack had subsided. Following this procedure a 2-foot-thick fine sand seal of clean 30/65 silica sand was placed above the sand filter pack. The filter pack and fine sand seal were allowed to settle for a minimum of 24 hours following which a 2-foot-thick bentonite pellet seal was placed above the fine sand seal and allowed to hydrate. The remaining annulus above the bentonite seal was backfilled to the surface, using a tremie pipe, with a 10:1 cement/bentonite grout mix.

The wells were either completed at or above surface grade. A 2-foot by 2-foot by 6-inch thick concrete pad was constructed around the wells completed at grade. The well covers consisted of 8-inch-round bolt down security vaults with sealing gaskets to reduce the amount of water infiltration. A 3-foot by 3-foot by 6-inch thick concrete pad was constructed around each monitoring well completed above grade. A protective 4-inch-diameter steel casing equipped with a locking cap was installed around the well and was grouted approximately 3 feet into the ground in the center of the concrete pad.

Following installation, all monitoring wells were developed using a centrifugal pump. Well development forms are provided in Appendix A. During development, pH, conductivity, turbidity, dissolved oxygen, and temperature were measured at regular intervals. Development was considered complete when at least four of the parameters were within 10 percent of the previous reading.

The pumping and observation wells were constructed of PVC material similar to the monitoring wells. The pumping well had a 4-inch ID, with a total depth of approximately 34 feet and a 20-foot screen of 0.020-inch slot size. The observations wells were 2-inch diameter with total depths of 20 feet and 10-foot screens of 0.020-inch slot size. The annulus for each of the wells was completed with sand to the surface, and the wells were abandoned after the pump test was completed.

Four wells were installed in the uppermost sands of the Hawthorn Group immediately underlying the clay aquitard found at the top of this unit. The wells were of double-cased construction and were installed using mud-rotary drilling techniques. A 6-inch outer casing was first set approximately 3 feet into the clay aquitard to prevent cross connection with shallower aquifers. The outer casing was allowed to set in place for a minimum of 24 hours before the well was drilled out through the outer casing to the desired depth. Well construction materials and specifications were similar to those of the shallow monitoring wells. Five-foot well screens were used and placed such that the top of the screen was set approximately 2 feet below the bottom of the clay aquitard at the top of the Hawthorn Group. At one location (well 25C), the well was installed with a 5-foot screen set at approximately 67.5 feet to 72.5 feet bgs, or about 15 feet below the bottom of the clay.

During installation of all four Hawthorn Group wells, split spoon samples were collected continuously from 25 feet bgs to approximately 5 feet into the clay aquitard to determine the depth to set the 6-inch outer casing. In addition, split spoon samples were collected continuously from the bottom of the outer casing to the total depth of the well.

Six Shelby tube samples were collected from the Hawthorn Group wells at approximately the top and bottom of the clay aquitard. The samples were analyzed for specific gravity, Atterburg limits, and grain size with hydrometer analysis.

3.6.5 Monitoring Well Sampling

Phase II

The 22 surficial aquifer well pairs and four Hawthorn wells were sampled between July 15 and August 6, 1998, during Phase II of the field investigations. Monitoring well sampling forms are provided in Appendix A. The wells were sampled following the guidance document *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells* (USEPA, 1996b). The procedures used were also consistent with the low-flow groundwater sampling methodology prescribed by the *Project Operations Plan for Site Investigations and Remedial Investigations* (ABB-ES, 1997). Stainless steel bladder pumps, as recommended, were used to sample the wells. The four wells completed in the Hawthorn Group were purged and sampled using bailers due to the slow recharge of this aquifer unit.

In preparation for sampling, water levels were recorded and the wells checked for floating free product prior to installing the pump in the wells. The pump was lowered slowly into the well and positioned such that the intake coincided with the midpoint of the saturated screen length. This procedure ensured that the pump intake was at least 2 feet above the bottom of the well to minimize disturbance of particulates that may have been present in the bottom of the well. Following installation, a minimum time period of one hour was allowed to elapse prior to starting the pump. After the waiting period, the pump was turned on at the lowest setting and the speed slowly increased until discharge occurred. The water level was checked next, and the pumping speed adjusted to achieve a stable drawdown (maximum 0.5 foot) and discharge rate. Six field parameters (temperature, specific conductance, pH, oxidation reduction potential, dissolved oxygen, and turbidity) were monitored and recorded at periodic intervals using a flow-through cell. Purging was considered complete when all field parameters had stabilized. For the Hawthorn wells, purging was considered complete when the wells were bailed dry and allowed to recover three times.

After purging was complete, the flow-through cell was disconnected and samples were collected directly from the pump discharge tubing. Samples from Hawthorn wells were collected by carefully pouring the groundwater from the bailer into the sample jars. Samples were collected for analyses for the following parameters: VOCs, SVOCs, inorganics, pesticides, herbicides, heterotrophic microbial plate count, anions (Cl, SO_4, NO_3, NO_2, and PO_4), Florida petroleum range organics (FL PRO), TDS, TSS, chemical oxygen demand (COD), TOC, pH, hardness, biological oxygen demand (BOD), oxidation reduction potential (ORP/Eh), dissolved methane, alkalinity, gross alpha, gross beta, and gamma scan. A sample for PCB and possible dioxin analyses was also collected for every tenth sample. As specified in the Work Plan (B&R Environmental, 1997), dioxin analysis was not performed because PCBs were not detected in any samples. Additional parameters were measured using Hach® field kits. Samples were collected directly from the discharge tubing or the bailers and the tests were performed immediately in the field. Tests were run for dissolved oxygen, dissolved carbon dioxide, ferrous iron, and hydrogen sulfide.

The VOC samples were collected first into pre-preserved sample containers. Other sample containers were filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. A filtered sample for metals analysis was collected in addition to an unfiltered sample if the turbidity value was greater than 10 Nephelometric Turbidity Units (NTUs). A 0.45-micron disposable in-line filter was used to collect the sample. All samples were immediately placed on ice and packed for transport to the laboratory.

All appropriate QC samples were also collected during the sampling event. These QC samples included field duplicates (1 per 10 environmental samples), rinsate blanks (1 per 10 environmental samples), trip blanks (one per day of VOC sampling), one field blank from each water source used for decontamination (potable and deionized water), and MS/MSDs (1 per 20 environmental samples).

After collection of the samples, the pump and associated tubing were decontaminated using potable water, Alconox, deionized water, and isopropanol. The outside of the pump was first decontaminated prior to pumping approximately 5 gallons of potable water and Alconox through the pump and discharge tubing, followed by approximately 5 gallons of deionized water. The pump was then air dried and wrapped in aluminum foil to prevent contamination during storage before sampling the next well.

Phase III

The second round of monitoring well sampling, Phase III, was conducted between late June and early August 1999. The goal of the sampling was to reduce sample turbidity and to eliminate potential analytical bias resulting from entrained solids in the preserved groundwater samples. Due to an analysis omission, well MW14A was sampled and analyzed again in February 2000. All wells previously sampled during the Phase II event were sampled again, with the exception of wells MW5A and MW12A. These two wells were not sampled because they did not contain any chemical concentrations above the screening criteria during the 1998 sample event (see Section 5.3.1). All other wells contained at least one chemical at a concentration above the RI screening criteria.

The wells were purged and sampled in accordance with the RI Work Plan as described above for Phase II. However, additional measures were used to reduce the drawdown and to reduce the sample turbidity. All wells in which the static water level was within approximately 20 feet of the ground surface were purged and sampled using a peristaltic pump and dedicated tubing. A small diameter, variable speed submersible pump was used only at wells MW23C, MW24C, MW25C, and MW25C where the depth to water exceeded 20 feet bgs. Using either pump, the goal was to limit drawdown to no more than 0.3 foot below static level and purge at rates not to exceed 100 mL/min (i.e., microflow purging) to obtain sample turbidity less than 10 NTUs.

The groundwater samples collected during Phase III were submitted to a fixed-base laboratory and were analyzed using the same methodologies described above for Phase II, with the exceptions of pesticides, herbicides, PCBs, and dioxins that were not detected in groundwater during Phase II. Additionally, not all wells were analyzed for all analytical fractions. The Phase III sampling program is summarized in Table 3-6 that provides the analytical rationale. In general, wells were only analyzed for organic

TABLE 3-6

GROUNDWATER PHASE III - SAMPLE PROGRAM RATIONALE
OPERABLE UNIT 2

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WELLS	SAMPLE RATIONALE	ANALYTICAL PROGRAM
3A, 3B, 11B, 12B, 15B, 18B, 20A, 21B, and 26C	Sample all wells with exceedance of screening criteria for VOCs or SVOCs; provide additional data for trend analysis.	VOCs for all wells; SVOCs for wells 15B and 21B only.
All wells on GOAA property: 4A, 4B, 10A, 10B, 13A, 13B, 15A, 15B, 16A, 16B, 17A, 17B, 19A, 19B, and 24C Wells on Navy property but across the canal from the landfill area: 9A and 9B	Collect samples with low turbidity. Evaluate local background concentration for metals and gross alpha/gross beta using data from off-site wells.	Metals, gross alpha, gross beta
Wells on Navy property: 1A, 1B, 2A, 2B, 3A, 3B, 5B, 6A, 6B, 7A, 7B, 8A, 8B, 11A, 11B, 12B, 14A, 14B, 18A, 18B, 20A, 20B, 21A, 21B, 22A, 22B, 23C, 25C, and 26C	Collect samples with low turbidity from all wells with non-organic concentrations above screening criteria and/or background values.	Metals, gross alpha, gross beta (on a well-by-well basis; only analyze for fractions exceeded during Phase II)

parameters (i.e., VOCs and SVOCs) if the RI screening criteria were exceeded during the Phase II analysis. All wells were analyzed for inorganics and gross alpha/beta because of the frequent and widespread exceedances of these fractions during the Phase II analysis. There were no detections of pesticides, herbicides, or PCBs (and consequently no dioxin analyses) during the Phase II analysis.

During the Phase III sampling it was discovered that microflow purging could not lower turbidity below the field meter's upper limit (1100 NTUs) in 5 of the 48 wells and turbidity was greater than 50 NTUs in one other well. Three of these six wells had Phase II turbidity readings greater than 1100 NTUs, two had readings between 850 and 980, and one had a prior reading of 294. The first attempt to reduce turbidity consisted of additional well development; this approach was not successful for these wells. The second attempt to reduce turbidity in these wells consisted of installing a microwell that was placed inside the existing 2-inch-diameter PVC wells. The existing wells were constructed with 0.010-inch slots and a 20/30 sand filter pack. Further evaluation of the aquifer grain size data and observation of the turbid samples indicated that the turbidity was due, in part, to very fine sand and some silt/clay-sized sediment that the wells produced when pumped. Based on this analysis the microwells were constructed with a 30/65 sand-size filter pack sandwiched between two 5-foot-long sections of 0.006-inch slotted PVC well screen. The 30/65 filter sand selected had a uniformity coefficient of 2.2 and an effective grain size (i.e., 10 percent finer) of 0.18 millimeters. The wells were constructed using factory-made custom materials. The inside and outside diameters of the composite microwell were 0.5 and 1.25 nominal inches, respectively. The pre-packed microwell was lowered into the existing 2-inch well and the riser pipe was positioned using PVC centralizers. Well purging and sampling were conducted using a peristaltic pump with dedicated, down-hole tubing placed inside the 0.5-inch nominal diameter riser pipe attached to the microwell. The effectiveness of the microwells for reducing turbidity is discussed in Section 5.3.2.2.

3.6.6 Additional Direct Push Groundwater Sampling

To more accurately define the distribution of VOC contamination identified by Phase I, Phase II, and Phase III groundwater investigations, additional DPT groundwater sampling was conducted. Located in the interior of Area 3 (south of the golf course), the additional sample points were positioned using a Trimble Pro XRS GPS system (Figure 3-6D). The sample points were arranged in five lines, lines 2 and 4 being oriented north to south, and lines 1, 3, and 5 oriented east to west. The additional DPT groundwater sampling involved two field events. The first was conducted on July 24-29, 2000, the second on September 18-23, 2000.

A Strataprobe® unit was used to collect groundwater samples during the first event. The samples were collected in the same manner as described for Phase II, with the exception of using a 4-foot-long lead

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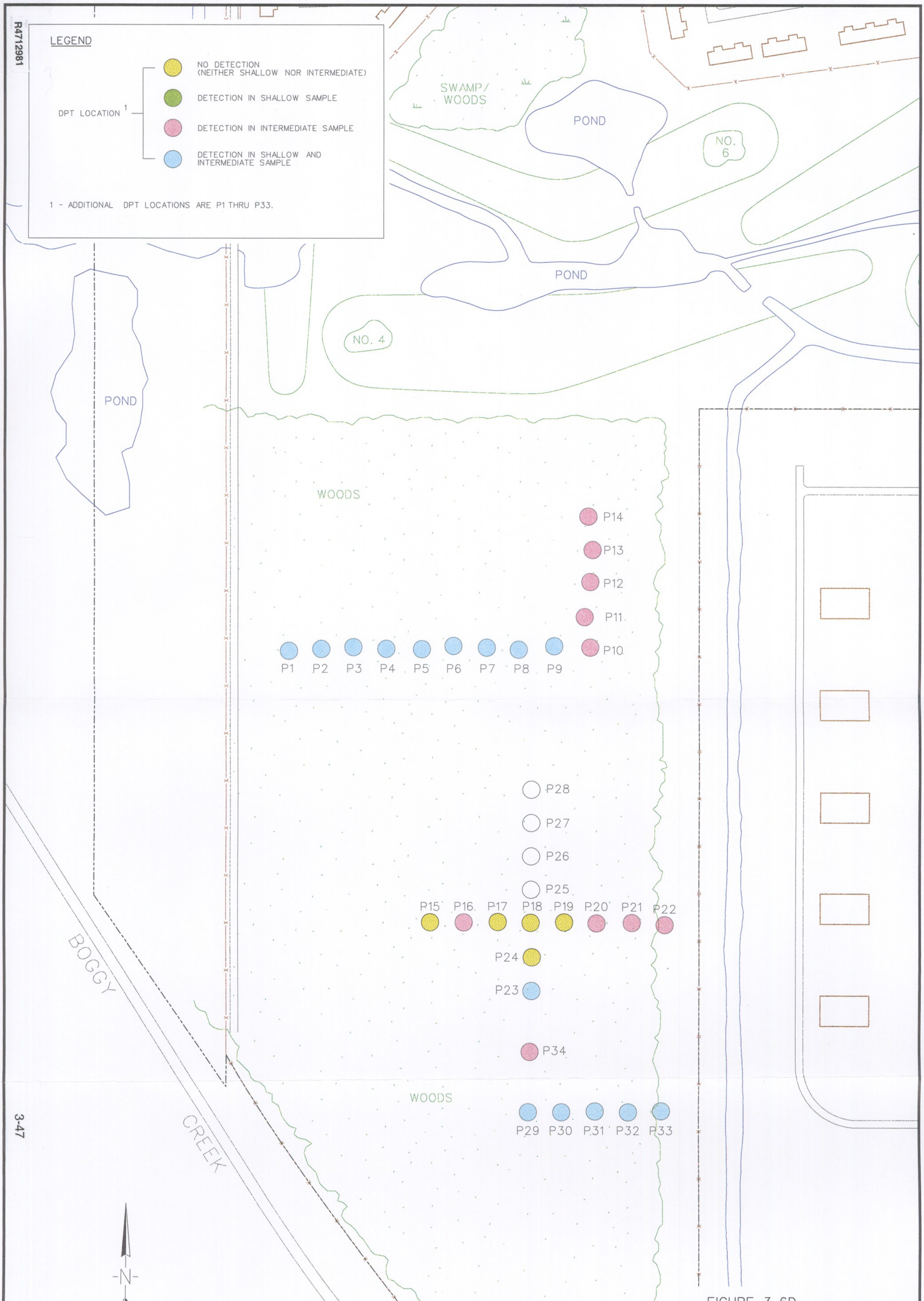

FIGURE 3-6D

ADDITIONAL DIRECT-PUSH GROUNDWATER SAMPLING LOCATIONS
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rod/screen and 4-foot-long drive rods. Sample analysis was performed by a mobile laboratory and field chemist. A problem with the field laboratory resulted in inaccurate analytical results, thereby making a second event necessary. Confirmation samples collected during the first event were shipped to a fixed-base laboratory for analysis.

A Strataprobe® unit was used for the second event also. The Strataprobe drove 1-inch-diameter by 4-foot-long hollow rods into the subsurface. The lead rod was fitted with an expendable stainless steel drive point, a retractable sleeve, and a 4-foot stainless steel slotted screen. Once the desired depth was reached, the rod string was retracted approximately 4 feet, which released the expendable point and exposed the screen to the aquifer, thereby allowing groundwater to enter the hollow rod string. After the water in the rod string reached equilibrium, polyethelene tubing was inserted into the rods to the top of the water, or, in the case of deeper samples, to the top of the screen. The tubing was connected to a peristaltic pump to collect the sample. A sample collection procedure similar to Phase I was used. Approximately one gallon of water was purged from the rods prior to sample collection in order to lessen the turbidity of the sample. After the sample was collected, the rod string was removed from the ground and decontaminated in accordance with the Project Operations Plan as described for Phase I and Phase II, prior to use at another depth or location. Using a weighted tag line to ensure effectiveness, each boring was sealed with bentonite immediately after the rods were withdrawn.

Two separate borings, one shallow (14 to 16 feet bgs) and one intermediate (28 to 30 feet bgs), were advanced at each additional DPT sampling location during both events. During the first event 68 samples were collected and 67 were collected during the second event. The samples were collected in 40-millimeter, Teflon-sealed glass vials. For both events the samples were analyzed on-site by a mobile laboratory using USEPA Method 8260 for trace-level detection of selected VOCs. Duplicates were collected from 10 percent of the samples and submitted to an approved fixed-base laboratory (using USEPA Method 8260B) to verify the results obtained from the mobile laboratory in the field. For further confirmation, samples were collected from monitoring well 18B and the mobile laboratory results compared with Phase II and Phase III results.

3.7 INTERIM REMEDIAL ACTIONS

Two IRAs were conducted at OU 2. One of these actions was a contaminated surface soil removal, and the other involved placement of additional soil cover in the southern portion of the OU.

3.7.1 Contaminated Surface Soil Removal

The objective of the first action was to remove surface soil contaminated with PAHs at surface soil sample locations S91, north of the fairway for hole No. 3, and S103, north of the fairway for hole No. 7 (see Figure 3-4B). The area excavated at each location was a square approximately 157 feet on a side, centered on the sample location (Figure 3-7A). The size of the excavation was limited wherever a pond was encountered. One foot of soil was excavated and removed at each location for a total of 2,000 cubic yards (Bechtel, 2000). The soil was then used as soil cover over sample locations G28 and G29 on the landfill (Figure 3-7A). The material excavated from sample location areas S91 and S103 was spread to a maximum 1-foot-thick layer and subsequently covered with 1 foot of "clean" borrow material. Clean borrow material was procured to complete the 2-foot soil cover over the landfill extending beneath the fairway for hole No. 4. A total of 13,212 cubic yards of soil was purchased from Material Placement Corporation for use as soil cover on the landfill and backfill at sample location areas S91 and S103 (Bechtel, 2000). The excavation was then backfilled with 2 feet of certified clean fill from a borrow source. The backfill material was placed in lifts and compacted. The cover was then graded to provide a smooth uniform surface that promotes gravity drainage and seeded.

3.7.2 Placement of Additional Soil Cover

A second action was conducted at OU 2 to provide additional soil cover for an approximately 25-acre portion of the area south of the golf course (Figure 3-7A). The site was cleared prior to spreading the new soil cover. Twenty-eight surface soil locations were covered with 2 feet of additional soil. The cover was composed of an initial 6 inches of soil from the Main Base golf course that contained levels of arsenic below the industrial standard (EEG, 2000). The initial cover was followed by 18 inches of soil from a clean borrow source. After all the soil was spread the site was graded to allow for proper drainage and minimize ponding. Seed, fertilizer, and mulch were then applied for final site restoration. Figure 3-7B is an aerial view (looking toward the south) of the southern portion of OU 2 after completion of the IRA.

During this IRA, a gopher tortoise burrow was found at the site. This animal is a protected species in Florida. A relocation permit was obtained from the Florida Game and Freshwater Fish Commission and the tortoise was relocated to the Reedy Creek Mitigation Bank in Polk County (EEG, 2000).

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FIGURE 3-7A

IRA SOIL COVER EXTENT
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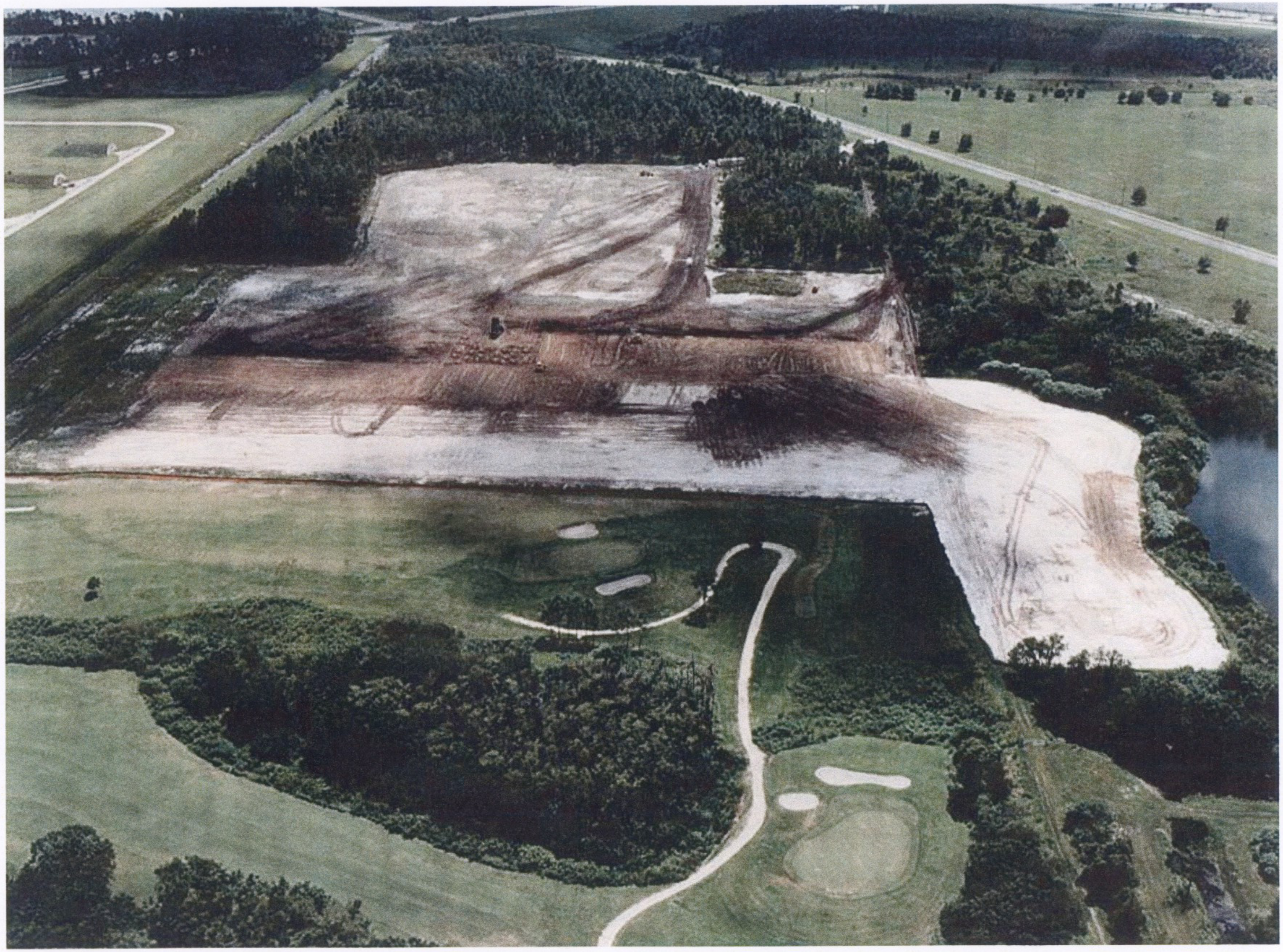

Figure 3-7B. The Southern Portion of OU 2 after the IRA.

4.0 DATA QUALITY

Various QC measures were implemented during the 1997, 1998, and 1999 (Phases I, II, and III) field sampling and laboratory analyses. These measures were conducted to ensure that the resultant data were suitable for their intended uses (e.g., nature and extent determination, risk assessment, etc.). A brief summary of the measures is provided in the following sections.

4.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) for all field and laboratory analyses, which include requirements for precision, accuracy, and completeness, are summarized in this section.

4.1.1 Precision

Precision characterizes the amount of variability and bias inherent in a data set. This parameter also describes the reproducibility of measurements of the same parameters for samples under similar conditions. Precision is expressed as a Relative Percent Difference (RPD), which is defined as the relation of the range relative to the mean RPDs, which are typically expressed as percentages, are used to evaluate both field and laboratory duplicate precision, and are calculated as follows:

$$RPD = \frac{V_1 - V_2}{(V_1 + V_2)/2} \times 100\%$$

where

RPD = relative percent difference

V_1, V_2 = two results obtained by analyzing duplicate samples.

The precision objectives for Contract Laboratory Program (CLP) parameters are specified in the associated analytical protocols. For non-CLP data, the precision objectives of ±50 percent for solid matrices and ±30 percent for aqueous matrices were employed for this project.

Field duplicates monitor the consistency with which environmental samples were obtained and analyzed. Laboratory duplicates measure the reproducibility of laboratory-generated results. RPDs were calculated for each set of field and laboratory duplicates generated for the investigation. Failures in meeting the precision objectives resulted in the qualification (as per data validation protocols) of the associated analytical data. The qualification of the 1997, 1998, and 1999 analytical data, as well as the implication of the data qualifications, are discussed in Section 4.3.

4.1.2 Accuracy

The degree of accuracy of a measurement, which is expressed as a percent recovery, is based on a comparison of the measured value with an accepted reference or true value. Accuracy measurements are determined by the analysis of "spiked" samples (i.e., blank, surrogate, or matrix spikes). These analyses measure the accuracy of the laboratory operations as affected by the sample matrix. Percent recovery is calculated using the following equation:

$$\%R = \frac{S_s - S_0}{S} \times 100\%$$

where

$\%R$ = percent recovery

S_s = result of spiked sample

S_o = result of non-spiked sample

S = concentration of spiked amount.

In general, the accuracy objective for the 1997, 1998, and 1999 analytical data is defined as 75 to 125 percent (percent recovery). Failures in meeting the accuracy objectives resulted in the qualification (as per data validation protocols) of the associated analytical data. A discussion of the qualification of the 1997, 1998, and 1999 analytical data and the implication of the data qualifications is provided in Section 4.3.

4.1.3 Completeness

Completeness is a measure of the amount of valid data obtained from the field and laboratory analyses in relation to the total amount of data collected. Completeness is typically expressed as a percentage and is determined using the following equation:

$$\%C = \frac{V}{T} \times 100\%$$

where

$\%C$ = percent completeness

V = number of results determined to be valid

T = total number of results.

Under ideal conditions, the completeness objective would be 100 percent. However, samples can be rendered unusable during shipping or preparation (e.g., bottles broken or extracts accidentally destroyed) or analysis (e.g., loss of instrument sensitivity, strong matrix effects). The calculated percent completeness for all chemical analytical data collected during the 1997, 1998, and 1999 sampling events is 98.6 percent (i.e., 670 chemical analytical results out of a total of 46,565 data points were qualified as unusable), indicating that the data completeness objective for the project was achieved.

Table 4-1 contains a list of those sample results that were determined to be invalid and unusable via data validation. Section 4.3 contains a summary of the data validation results and describes, in general, the rationale behind the rejection of these analytical results.

4.2 FIELD QUALITY CONTROL SAMPLES

The following field QC samples were collected for the 1997, 1998, and 1999 sampling efforts and analyzed in accordance with DQO requirements, as specified in the RI/FS Work Plan (B&R Environmental, 1997):

- Field duplicates were obtained at a frequency of 1 per every 10 samples (10 percent per matrix). Field duplicates for soil samples are two separate samples collected from the same source. Aqueous sample duplicates are collected simultaneously. Duplicates assess the overall precision of the sampling and analysis program.

- Trip blanks of analyte-free water were generated by the laboratory, taken to the sampling site, and returned to the laboratory with the environmental samples to be analyzed for VOCs. Analytical results for trip blanks are used to determine the level of contamination associated with the transportation of environmental samples. One trip blank was collected per each cooler containing samples for VOC analysis and was analyzed for VOCs.

- Rinsate blanks were obtained by pouring analyte-free water over sample collection equipment (e.g., bailers, etc.) after decontamination to assess the effectiveness of field decontamination procedures. Samples were obtained at a frequency of 1 per 10 environmental samples per medium per analysis.

- Field blanks consisted of source water samples used in steam cleaning and/or decontamination and are used to determine the level of contamination associated with the source water. Field blanks were obtained at a frequency of one per event per decontamination water source.

TABLE 4-1

REJECTED RESULTS
OPERABLE UNIT 2

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

SAMPLE	MATRIX	PARAMETER	SAMPLING ROUND
NTCFB17197	GW	Dalapon, MCPA, MCPP, 2-Butanone, Acetone	Phase I
NTCFB27197	GW	Dalapon, MCPA, MCPP	Phase I
NTCRB47197	GW	Dalapon, MCPA, MCPP	Phase I
OU2RB00300	GW	Aluminum, Antimony, 2-Butanone, Acetone	Phase II
OU2RB00400	GW	Aluminum, Antimony, 2-Butanone, Acetone	Phase II
OU2RB00500	GW	Aluminum, Antimony, 2-Butanone, Acetone	Phase II
OU2FB00100	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2FB00200	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW01A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW01B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW02A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW02A00-D	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW02B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW03A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW03B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW04A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW04A00-D	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW04B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW06A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW06B00	GW	Antimony, 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2-Chlorophenol, 2-Methylphenol, 2-Nitrophenol, 3- & 4-Methylphenol, 4,6-Dinitro-2-methylphenol, 4-Chloro-3-methylphenol, 4-Nitrophenol, Phenol, 2-Butanone, Acetone, TPH	Phase II
OU2MW07A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW07B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW08A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW08B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW09A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW09B00-D	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW10A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW10B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW11A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW11A00-D	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW11B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW12A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW12B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW13A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW13B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW14A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW14B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW15A00	GW	Antimony, Acetone	Phase II
OU2MW15B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW16A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW16B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW17A00	GW	Antimony, 2-Butanone, Acetone, Methane	Phase II
OU2MW17B00	GW	Antimony, 2-Butanone, Acetone, Methane	Phase II

TABLE 4-1

**REJECTED RESULTS
OPERABLE UNIT 2**

**NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

SAMPLE	MATRIX	PARAMETER	SAMPLING ROUND
OU2MW18A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW18B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW19A00	GW	Antimony, Methane	Phase II
OU2MW19B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW20A00	GW	Antimony, Acetone	Phase II
OU2MW20B00	GW	Antimony, Acetone	Phase II
OU2MW21A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW21B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW22A00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW22B00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW23C00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW24C00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW25C00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW26C00	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2RB00100	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2RB00200	GW	Antimony, 2-Butanone, Acetone	Phase II
OU2MW01A00-F	GW	Antimony	Phase II
OU2MW01B00-F	GW	Antimony	Phase II
OU2MW02A00-F	GW	Antimony	Phase II
OU2MW02A00-F-D	GW	Antimony	Phase II
OU2MW02B00-F	GW	Antimony	Phase II
OU2MW03A00-F	GW	Antimony	Phase II
OU2MW06A00-F	GW	Antimony	Phase II
OU2MW06B00-F	GW	Antimony	Phase II
OU2MW10A00-F	GW	Antimony	Phase II
OU2MW10B00-F	GW	Antimony	Phase II
OU2MW11A00-F	GW	Antimony	Phase II
OU2MW11A00-F-D	GW	Antimony	Phase II
OU2MW11B00-F	GW	Antimony	Phase II
OU2MW13A00-F	GW	Antimony	Phase II
OU2MW13B00-F	GW	Antimony	Phase II
OU2MW14B00-F	GW	Antimony	Phase II
OU2MW15A00-F	GW	Antimony	Phase II
OU2MW15B00-F	GW	Antimony	Phase II
OU2MW16A00-F	GW	Antimony	Phase II
OU2MW16B00-F	GW	Antimony	Phase II
OU2MW17A00-F	GW	Antimony	Phase II
OU2MW17B00-F	GW	Antimony	Phase II
OU2MW18A00-F	GW	Antimony	Phase II
OU2MW18B00-F	GW	Antimony	Phase II
OU2MW19A00-F	GW	Antimony	Phase II
OU2MW20A00-F	GW	Antimony	Phase II
OU2MW20B00-F	GW	Antimony	Phase II
OU2MW21A00-F	GW	Antimony	Phase II
OU2MW21B00-F	GW	Antimony	Phase II
OU2MW23C00-F	GW	Antimony	Phase II
OU2MW25C00-F	GW	Antimony	Phase II

TABLE 4-1

**REJECTED RESULTS
OPERABLE UNIT 2**

**NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

SAMPLE	MATRIX	PARAMETER	SAMPLING ROUND
OU2MW26C00-F	GW	Antimony	Phase II
OU2MW04A00-F	GW	Sodium	Phase II
OU2MW04A00-F-D	GW	Sodium	Phase II
OU2MW07B00-F	GW	Sodium	Phase II
NTCRB162997	GW	Cyanide	Phase I
NTCRB262997	GW	Cyanide, Acetone	Phase I
NTCTB117197	GW	2-Butanone, Acetone	Phase I
NTCTB127197	GW	2-Butanone, Acetone	Phase I
NTCTB147194	GW	2-Butanone, Acetone	Phase I
NTCTB157197	GW	2-Butanone, Acetone	Phase I
OU2TB00200	GW	2-Butanone, Acetone	Phase II
OU2TB00300	GW	2-Butanone, Acetone	Phase II
OU2TB00400	GW	2-Butanone, Acetone	Phase II
OU2TB00500	GW	2-Butanone, Acetone	Phase II
OU2TB00600	GW	2-Butanone, Acetone	Phase II
OU2TB00700	GW	2-Butanone, Acetone	Phase II
OU2TB00800	GW	2-Butanone, Acetone	Phase II
OU2TB00900	GW	2-Butanone, Acetone	Phase II
OU2TB01000	GW	2-Butanone, Acetone	Phase II
OU2TB01100	GW	2-Butanone, Acetone	Phase II
OU2TB01200	GW	2-Butanone, Acetone	Phase II
OU2TB01300	GW	2-Butanone, Acetone	Phase II
OU2TB01400	GW	2-Butanone, Acetone	Phase II
OU2TB01500	GW	2-Butanone, Acetone	Phase II
OU2TB01600	GW	2-Butanone, Acetone	Phase II
OU2TB01700	GW	2-Butanone, Acetone	Phase II
OU2TB01800	GW	2-Butanone, Acetone	Phase II
OU2TB01900	GW	2-Butanone, Acetone	Phase II
NTCSW00600-D	GW	2-Butanone	Phase I
NTCSW00700	GW	Acetone	Phase I
NTCSW00900	GW	Acetone	Phase I
NTCSW01000	GW	Acetone	Phase I
NTCTB00500	GW	Acetone	Phase I
NTCTB00600	GW	Acetone	Phase I
NTCTB00700	GW	Acetone	Phase I
NTCTB1600	GW	Acetone	Phase I
NTCSS10300	SO	Dalapon, MCPA, MCPP	Phase I
NTCSS10400	SO	Dalapon, MCPA, MCPP	Phase I
NTCSS10500	SO	Dalapon, MCPA, MCPP	Phase I
NTCSS10800	SO	Dalapon, MCPA, MCPP, 2-Butanone, Acetone	Phase I
NTCSS10900	SO	Dalapon, MCPA, MCPP, 2-Butanone, Acetone	Phase I
NTCSS11300	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS11400	SO	Dalapon, MCPA, MCPP	Phase I
NTCSS11500	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS11600	SO	Dalapon, MCPA, MCPP	Phase I
NTCSS11700	SO	Dalapon, MCPA, MCPP	Phase I

TABLE 4-1

**REJECTED RESULTS
OPERABLE UNIT 2**

**NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

SAMPLE	MATRIX	PARAMETER	SAMPLING ROUND
NTCSS11800	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS11900	SO	Dalapon, MCPA, MCPP	Phase I
NTCSS12300	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS12400	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS12400-D	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS12500	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS12600	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS12700	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS12800	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS12900	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS13300	SO	Dalapon, MCPA, MCPP, Acetone, Benzene	Phase I
NTCSS15100	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS15100-D	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS15200	SO	Dalapon, MCPA, MCPP, 2-Butanone, Acetone	Phase I
NTCSS15300	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS15400	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS15700	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS15800	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS15900	SO	Dalapon, MCPA, MCPP, 2-Butanone, Acetone	Phase I
NTCSS16000	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSSS8300	SO	Dalapon, MCPA, MCPP	Phase I
NTCSSS9900	SO	Dalapon, MCPA, MCPP, Acetone	Phase I
NTCSS10000	SO	Cyanide	Phase I
NTCSS10100	SO	Cyanide	Phase I
NTCSS11000	SO	Cyanide	Phase I
NTCSS11100	SO	Cyanide	Phase I
NTCSS12000	SO	Cyanide	Phase I
NTCSS12100	SO	Cyanide	Phase I
NTCSS13000	SO	Cyanide	Phase I
NTCSS13100	SO	Cyanide, Acetone	Phase I
NTCSS14000	SO	Cyanide, Acetone	Phase I
NTCSSH0100	SO	Cyanide, Acetone	Phase I
NTCSSH0200	SO	Cyanide, Acetone	Phase I
NTCSSH0300	SO	Cyanide, Acetone	Phase I
NTCSSH0600	SO	Cyanide, Acetone	Phase I
NTCSSH0700	SO	Cyanide, Acetone	Phase I
NTCSSH0800	SO	Cyanide, Acetone	Phase I
NTCSSH1100	SO	Cyanide	Phase I
NTCSSH1200	SO	Cyanide, Acetone	Phase I
NTCSSH1300	SO	Cyanide, Acetone	Phase I
NTCSSH1400	SO	Cyanide, Acetone	Phase I
NTCSSH1500	SO	Cyanide, Acetone	Phase I
NTCSSH1500-D	SO	Cyanide, Acetone	Phase I
NTCSSH1600	SO	Cyanide, Acetone	Phase I
NTCSSH1700	SO	Cyanide, Acetone	Phase I
NTCSSH1800	SO	Cyanide, Acetone	Phase I

TABLE 4-1

**REJECTED RESULTS
OPERABLE UNIT 2**

**NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

SAMPLE	MATRIX	PARAMETER	SAMPLING ROUND
NTCSSH1900	SO	Cyanide, Acetone	Phase I
NTCSSH2000	SO	Cyanide, Acetone	Phase I
NTCSSH2100	SO	Cyanide	Phase I
NTCSSH2200	SO	Cyanide	Phase I
NTCSSH2300	SO	Cyanide	Phase I
NTCSSH2400	SO	Cyanide	Phase I
NTCSSH2500	SO	Cyanide	Phase I
NTCSSH2500-D	SO	Cyanide, Acetone	Phase I
NTCSSH2600	SO	Cyanide	Phase I
NTCSSH2700	SO	Cyanide	Phase I
NTCSSH2800	SO	Cyanide	Phase I
NTCSSH2900	SO	Cyanide	Phase I
NTCSSH3000	SO	Cyanide	Phase I
NTCSSH3100	SO	Cyanide	Phase I
NTCSSH3200	SO	Cyanide	Phase I
NTCSSH3300	SO	Cyanide	Phase I
NTCSSH3400	SO	Cyanide	Phase I
NTCSSH3500	SO	Cyanide	Phase I
NTCSSH3500-D	SO	Cyanide	Phase I
NTCSSH3600	SO	Cyanide	Phase I
NTCSSH3700	SO	Cyanide	Phase I
NTCSSH3800	SO	Cyanide	Phase I
NTCSSH3900	SO	Cyanide	Phase I
NTCSSH4000	SO	Cyanide	Phase I
NTCSSS1000	SO	Cyanide	Phase I
NTCSSS1000-D	SO	Cyanide	Phase I
NTCSSS1100	SO	Cyanide, Acetone	Phase I
NTCSSS2000	SO	Cyanide	Phase I
NTCSSS2100	SO	Cyanide, Acetone	Phase I
NTCSSS3000	SO	Cyanide	Phase I
NTCSSS3100	SO	Cyanide, Acetone	Phase I
NTCSSS4000	SO	Cyanide	Phase I
NTCSSS4100	SO	Cyanide, Acetone	Phase I
NTCSSS5000	SO	Cyanide	Phase I
NTCSSS5100	SO	Cyanide, Acetone	Phase I
NTCSSS6000	SO	Cyanide	Phase I
NTCSSS6100	SO	Cyanide, Acetone	Phase I
NTCSSS7000	SO	Cyanide	Phase I
NTCSSS7100	SO	Cyanide, Acetone	Phase I
NTCSSS8000	SO	Cyanide, Acetone	Phase I
NTCSSS8000-D	SO	Cyanide, Acetone	Phase I
NTCSSS8100	SO	Cyanide, Acetone	Phase I
NTCSSS9000	SO	Cyanide, Acetone	Phase I
NTCSSS9100	SO	Cyanide	Phase I
NTCSSS9100-D	SO	Cyanide	Phase I

TABLE 4-1

**REJECTED RESULTS
OPERABLE UNIT 2**

**NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

SAMPLE	MATRIX	PARAMETER	SAMPLING ROUND
NTCSD00100	SO	2-Butanone, Acetone	Phase I
NTCSD00200	SO	2-Butanone, Acetone	Phase I
NTCSD00300	SO	2-Butanone, Acetone	Phase I
NTCSD00400	SO	2-Butanone, Acetone	Phase I
NTCSD00500	SO	2-Butanone, Acetone	Phase I
NTCSD00600	SO	2-Butanone, Acetone	Phase I
NTCSD00600-D	SO	2-Butanone, Acetone	Phase I
NTCSD00700	SO	2-Butanone, Acetone	Phase I
NTCSD00900	SO	2-Butanone, Acetone	Phase I
NTCSD01000	SO	2-Butanone, Acetone	Phase I
NTCSS10000	SO	2-Butanone, Acetone	Phase I
NTCSS13500	SO	2-Butanone	Phase I
NTCSS13700	SO	2-Butanone	Phase I
NTCSS13700-D	SO	2-Butanone	Phase I
NTCSS13800	SO	2-Butanone	Phase I
NTCSS13900	SO	2-Butanone	Phase I
NTCSSH0400	SO	2-Butanone	Phase I
NTCSSH0500	SO	2-Butanone	Phase I
NTCSSH0500-D	SO	2-Butanone	Phase I
NTCSSH0900	SO	2-Butanone	Phase I
NTCSSH1000	SO	2-Butanone	Phase I
NTCSSS1200	SO	2-Butanone	Phase I
NTCSSS2200	SO	2-Butanone	Phase I
NTCSS10100	SO	Acetone	Phase I
NTCSS10200	SO	Acetone	Phase I
NTCSS10200-D	SO	Acetone	Phase I
NTCSS11000	SO	Acetone	Phase I
NTCSS11100	SO	Acetone	Phase I
NTCSS11200	SO	Acetone	Phase I
NTCSS12100	SO	Acetone	Phase I
NTCSS13200	SO	Acetone	Phase I
NTCSS13400	SO	Acetone	Phase I
NTCSS13500	SO	Acetone	Phase I
NTCSS13700	SO	Acetone	Phase I
NTCSS13700-D	SO	Acetone	Phase I
NTCSS13800	SO	Acetone	Phase I
NTCSS13900	SO	Acetone	Phase I
NTCSS14000	SO	Acetone	Phase I
NTCSS15500	SO	Acetone	Phase I
NTCSS15600	SO	Acetone	Phase I
NTCSSH0500	SO	Acetone	Phase I
NTCSSH0500-D	SO	Acetone	Phase I
NTCSSH1000	SO	Acetone	Phase I
NTCSSH1100	SO	Acetone	Phase I
NTCSSS1200	SO	Acetone	Phase I
NTCSSS2200	SO	Acetone	Phase I

TABLE 4-1

REJECTED RESULTS
OPERABLE UNIT 2

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

SAMPLE	MATRIX	PARAMETER	SAMPLING ROUND
NTCSSS9200	SO	Acetone	Phase I
NTCSSS8200	SO	Acetone	Phase I
NTCSD01003	SD	alpha-Chlordane	Phase III
NTCSD01203	SD	Heptachlor	Phase III
NTCSD02403	SD	4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Aldrin, alpha-BHC, alpha-Chlordane, beta-BHC, delta-BHC, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, gamma-BHC (Lindane), gamma-Chlordane, Heptachlor, Heptachlor epoxide, Methoxychlor	Phase III
NTCSD02603	SD	MCPP, delta-BHC, Endosulfan sulfate, gamma-BHC (Lindane)	Phase III
NTCSD02703		4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Aldrin, alpha-BHC, alpha-Chlordane, beta-BHC, delta-BHC, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, gamma-BHC (Lindane), gamma-Chlordane, Heptachlor, Heptachlor epoxide, Methoxychlor, Toxaphene	Phase III
NTCSW00103	SW	hexachlorocyclopentadiene	Phase III
NTCSW00503	SW	hexachlorocyclopentadiene	Phase III
NTCSW00803	SW	4-chloroaniline	Phase III
NTCSW01003	SW	4-chloroaniline	Phase III
NTCSW01203	SW	hexachlorocyclopentadiene	Phase III
NTCSW01403	SW	hexachlorocyclopentadiene	Phase III
NTCSW01503	SW	4-chloroaniline	Phase III
NTCSW01803	SW	4-chloroaniline	Phase III
NTCSW01903	SW	hexachlorocyclopentadiene	Phase III
NTCSW02003	SW	4-chloroaniline	Phase III
NTCSW02003-D	SW	4-chloroaniline	Phase III
NTCSW02103	SW	4-chloroaniline	Phase III
NTCSW02303	SW	Thallium, hexachlorocyclopentadiene, Toxaphene	Phase III
NTCSW02303-D	SW	Thallium, hexachlorocyclopentadiene	Phase III
NTCSW02403	SW	Thallium, hexachlorocyclopentadiene	Phase III
NTCSW02503	SW	Thallium, hexachlorocyclopentadiene	Phase III
NTCSW02603	SW	Hexachlorocyclopentadiene, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, Heptachlor epoxide, Methoxychlor	Phase III
NTCSW02703	SW	Thallium, hexachlorocyclopentadiene	Phase III
NTCSW02803	SW	Thallium, hexachlorocyclopentadiene	Phase III
OU2MW11B02	MW	2-butanone, acetone	Phase III
OU2MW15B02	MW	hexachlorocyclopentadiene	Phase III
OU2MW18B02	MW	1,1-dichloroethene, 2-butanone, acetone	Phase III
OU2MW20A02	MW	2-butanone, acetone	Phase III
OU2MW21B02	MW	hexachlorocyclopentadiene	Phase III
OU2MW26C02	MW	2-butanone, acetone	Phase III

SW – Surface water
MW – Monitoring well
SD - Sediment

4.3 DATA VALIDATION

All samples collected as part of the 1997, 1998, and 1999 field efforts and sent to the laboratory for chemical analyses were subjected to data validation. Data validation is an objective systematic process in which analytical data are reviewed to ascertain the validity of the reported results and to identify for the data user the possible limitation of these results. This section summarizes the various aspects of the data validation process.

4.3.1 General Data Validation Procedures

Validation of data generated for samples collected during the 1997, 1998, and 1999 field efforts was completed in accordance with the procedures as outlined in Navy guidance (*Navy Installation Restoration Laboratory Quality Assurance Guide*, NFESC, 1996). Data validation was performed for all samples analyzed via the USEPA's CLP methods, as well as for some samples analyzed via SW-846 methods which are similar to the CLP methods (e.g., the 8000 series methods). Data were validated in accordance with the USEPA's CLP National Functional Guidelines for Organic and Inorganic Data Review (USEPA 1994 a,b), as amended for use in USEPA Region 4.

At a minimum, the validation process included consideration of the following: data completeness, holding time compliance, mass calibrations, field QC and laboratory-generated blanks, internal standards, surrogate spikes, blank spikes, MSs, field duplicate precision, chemical interferences, quantitation, detection limits, and system performance.

Evaluation of laboratory and field QC blank analyses aided in the elimination of false positive results that were identified as laboratory artifacts. The overall determination of data utility or reliability was based upon laboratory compliance with specified methods and adherence to QC requirements. Noncompliances observed during the validation process typically resulted in the qualification of the associated analytical data. The qualifiers alert the data user to imprecise or estimated results and, in the worst case, unreliable and unusable data.

The net results of the validation process were summarized in sample delivery group-specific technical reports consisting of a memorandum, a section of qualified analytical results, and a supporting documentation section which provided the rationale for changes and/or qualification of the data. These memoranda provide a detailed explanation of the results of the data validation review. All data validation documentation is currently retained on file by Tetra Tech NUS, in the Pittsburgh, Pennsylvania, office.

4.3.2 Data Validation Qualifiers

As mentioned previously, the qualification of analytical data during the validation process (i.e., application of U, J, UJ, UR, and R qualifiers) was conducted as required by the USEPA Functional Guidelines. The attachment of the data qualifiers to analytical results signifies the occurrence of QC noncompliances that were noted during the course of data validation. The various data qualifiers are defined as follows:

- **U** - Indicates that the chemical was not detected at the numerical detection limit (sample-specific quantitation limit) noted. Nondetected results from the laboratory are reported in this manner. This qualifier is added to a positive result (reported by the laboratory) if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.

- **J** - Indicates that the chemical was detected. However, the associated numerical result is not a precise representation of the amount that is actually present in the sample. The laboratory reported concentration is considered to be an estimate of the true concentration.

- **UJ** - Indicates that the chemical was not detected. However, the detection limit (sample-specific quantitation limit) is considered to be estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.

- **UR** - Indicates that the chemical may or may not be present. The nondetected analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies (i.e., holding times missed by a factor of two times the specified time limit, severe calibration noncompliances, or extremely low QC recoveries).

- **R** - Indicates that the chemical may or may not be present. The positive analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies.

The preceding data qualifiers may be categorized as indicative of major or minor problems. Major problems are defined as issues that result in the rejection of data, qualified with UR and R data validation qualifiers. These data are considered invalid and are not used for risk assessment and decision-making purposes. Minor problems are defined as issues resulting in the estimation of data, qualified with U, J, and UJ data validation qualifiers. Estimated analytical results are considered to be suitable for risk assessment and decision-making purposes.

4.3.3 Summary of Data Validation Results

A brief summary of the data validation results for the 1997, 1998, and 1999 sampling efforts is provided in the remainder of this section.

4.3.3.1 Organic Analyses Phases I and II

No laboratory blank contamination was noted for organic analyses. One sample, OU2MW24C00, was qualified due to field blank contamination by bis(2-ethylhexyl)phthalate. Detection limits for bis(2-ethylhexyl)phthalate in the affected environmental sample were elevated during the data validation process because the positive result for this chemical is considered to be attributable to blank contamination.

In general, analytical results for organic compounds were qualified as estimated, J or UJ, for observed noncompliances with calibration, holding times, surrogate spike analysis, and internal standards. Positive results reported at concentrations less than the Contract Required Quantitation Limit (CRQL) were also qualified as estimated because of potential uncertainty near the CRQL.

Because of missed holding times, organic results for methane in the following environmental samples were rejected, UR:

- OU2MW17A00
- OU2MW17B00
- OU2MW19A00

Holding time exceedances were considered to be a gross noncompliance for these samples.

Surrogate recovery noncompliances (i.e., recovery <10 percent) resulted in the rejection of the following results in sample OU2MW06B00:

- TPH, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2-chlorophenol, 2-methylphenol, 2-nitrophenol, 3- & 4-methylphenol, 4,6-dinitro-2-methylphenol, 4-chloro-3-methylphenol, 4-nitrophenol, phenol.

Severe calibration noncompliances (i.e., relative response factors < 0.050 and/or grossly noncompliant continuing calibration verifications) were noted for 2-butanone and acetone in both the groundwater and soil samples. Refer to Table 4-1 for a listing of the affected samples. Benzene in sample NTCSS13300 was also rejected due to calibration noncompliances. These gross noncompliances resulted in the rejection, UR, of the associated data (nondetected results) in the affected samples.

MS/MSD noncompliances (i.e., recovery <10 percent) resulted in the rejection, UR, of Dalapon, MCPA, and MCPP in both the groundwater and soil samples. Refer to Table 4-1 for a listing of the affected samples. These gross noncompliances resulted in the rejection of the associated nondetected results in the affected samples.

No qualifiers were assigned due to laboratory blank contamination, laboratory control sample noncompliance, or field duplicate imprecision.

4.3.3.2 Organic Analyses Phase III

Methylene chloride and 1,2-dichloroethane were noted as laboratory blank contaminants for organic analyses. Methylene chloride, 1,2-dichlorobenzene, and chlorobenzene were noted as field blank contaminants during organic analyses. Detection limits for these compounds in the affected environmental samples were elevated during the data validation process because the positive results for these chemicals are considered to be attributable to blank contamination.

In general, analytical results for organic compounds were qualified as estimated, J or UJ, for observed noncompliances with calibration, surrogate spike analysis, MS/MSDs, blank spikes, and field duplicate precision. Positive results reported at concentrations less than the CRQL were also qualified as estimated because of potential uncertainty near the CRQL.

Surrogate recovery noncompliances (i.e., recovery <10 percent) resulted in the rejection of the pesticide fraction in samples NTCSD02403 and NTCSD02703. Results for all pesticides were rejected, UR, in both samples.

Calibration noncompliances (i.e., relative response factors < 0.05) resulted in the rejection, UR, of 2-butanone and acetone in the following samples: OU2MW11B02, OU2MW18B02, OU2MW20A02, and OU2MW26C02.

Blank spike noncompliances (i.e., recovery <10 percent) resulted in the rejection, UR, of hexachlorocyclopentadiene and 4-chloroaniline in sediment samples. Refer to Table 4-1 for a listing of the affected samples. These gross noncompliances resulted in the rejection of the associated nondetected results in the affected samples.

MS/MSD noncompliances (i.e., recovery <10 percent) resulted in the rejection, UR, of 4-chloroaniline, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, Heptachlor epoxide, and Methoxychlor in both the groundwater and sediment samples. Refer to Table 4-1 for a listing of the affected samples. These gross noncompliances resulted in the rejection of the associated nondetected results in the affected samples.

The percent difference between analytical columns exceeded 100 percent for Toxaphene, alpha-Chlordane, Heptachlor, and MCPP in both sediment and groundwater samples. Refer to Table 4-1 for a listing of the affected samples. These gross noncompliances resulted in the rejection of the associated positive results in the affected samples.

No qualifiers were assigned due to holding time noncompliances or internal standard recoveries.

4.3.3.3 Inorganic Analyses Phases I and II

Several inorganic chemicals were detected as contaminants in the laboratory blanks at varying concentrations. The most common laboratory contaminant was beryllium. Aluminum, barium, iron, beryllium, calcium, and zinc were detected as contaminants in the field blanks at varying concentrations. The most common field blank contaminant was barium. The detection limits of those results that were found to be attributable to blank contamination were raised during the validation process.

Inorganic sample results were typically qualified as estimated based on problems noted with MSs, laboratory control samples, laboratory duplicate precision, field duplicate precision, chemical interferences [inductively coupled plasma (ICP) only], and serial dilution analyses (ICP only).

Severe MS noncompliance (i.e., recovery <30 percent) resulted in the rejection of the following data:

- OU2RB00300 – aluminum
- OU2RB00400 – aluminum
- OU2RB00500 – aluminum
- OU2MW04A00-F – sodium
- OU2MW04A00-F-D – sodium
- OU2FB07B00-F – sodium

Severe MS noncompliance was also noted for antimony in both groundwater and soil samples. Refer to Table 4-1 for a complete listing of the affected samples.

Note that no qualifiers were assigned on the basis of holding time.

4.3.3.4 Inorganic Analyses Phase III

Several inorganic chemicals were detected as contaminants in the laboratory blanks at varying concentrations. The most common laboratory contaminant was zinc. Aluminum, chromium, manganese, and nickel were detected as contaminants in the field blanks at varying concentrations. The most common field blank contaminant was chromium. The detection limits of those results that were found to be attributable to blank contamination were raised during the validation process.

Inorganic sample results were typically qualified as estimated based on problems noted with calibration, MSs, laboratory control samples, field duplicate precision, chemical interferences (ICP only), serial dilution analyses (ICP only), and post digestion spikes.

Severe blank spike noncompliance (i.e., recovery <30 percent) resulted in the rejection, UR, of nondetected results for thallium. Refer to Table 4-1 for a listing of the affected samples. These gross noncompliances resulted in the rejection of the associated nondetected results in the affected samples.

4.3.3.5 Miscellaneous Analyses Phases I and II

Field blank contamination was noted for the following analytes:

- Chloride
- Nitrate as nitrogen
- Nitrate/nitrite as nitrogen
- Sulfate

Affected results were qualified as nondetected at the reported concentration.

Miscellaneous sample results were typically qualified as estimated, J and UJ, based on problems noted with laboratory control samples and holding time.

Because of missed holding times, some cyanide results were rejected, UR, for both groundwater and soil samples. Refer to Table 4-1 for a complete listing of the affected samples. Holding time exceedances were considered to be gross noncompliance.

4.3.3.6 Miscellaneous Analyses Phase III

Nondetected results for TDS and TSS were qualified as estimated, UJ, due to holding time exceedance in sample OU2MW13A02. Positive results for gross beta were qualified as estimated, J, due to calibration noncompliances in several groundwater samples. No other qualifiers were assigned to the miscellaneous data.