N60201.AR.000161
NS MAYPORT
5090.3a

CONTAMINATION ASSESSMENT REPORT FOR BUILDING 191 NS MAYPORT FL

8/1/1994

ENVIRONMENTAL SCIENCE AND ENGINEERING

194

19.03.00.0013

CONTAMINATION ASSESSMENT REPORT
FOR
NAVAL STATION MAYPORT
BUILDING 191
JACKSONVILLE, FLORIDA

Prepared for:

NAVY PUBLIC WORKS CENTER
Jacksonville, Florida

Prepared for:

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.
Gainesville, Florida

ESE Project No. 3945020G

August 1994

This contamination assessment report (CAR) for Naval Station Mayport, Building 191 has been reviewed by Mr. Paul Locascio of Environmental Science & Engineering, Inc. (ESE), Gainesville, Florida, and appears to comply with the current standards and practices in the field of geology in the State of Florida. Our professional services have been performed using the degree of care and skill ordinarily exercised under similar circumstances by other professionals practicing in this field. No other warranty, expressed or implied, is made as to the professional advice in this report.

Paul A. Locascio

Paul A. Locascio, P.G. #1501

8-11-94

Date

TABLE OF CONTENTS

Section		Page
1.0	INTRODUCTION	1-1
1.1	SITE LOCATION	1-1
1.2	SITE HISTORY AND OPERATIONS	1-1
1.3	RESULTS FROM PREVIOUS INVESTIGATIONS	1-4
1.4	OBJECTIVES OF THE CURRENT INVESTIGATION	1-4
2.0	ENVIRONMENTAL SETTING	2-1
2.1	PHYSIOGRAPHY AND TOPOGRAPHY	2-1
2.2	REGIONAL GEOLOGY	2-1
2.3	REGIONAL HYDROGEOLOGY	2-2
2.4	CLIMATE	2-3
3.0	INVESTIGATIVE PROCEDURES	3-1
3.1	RECORDS SEARCH AND WELL INVENTORY	3-1
3.2	SOIL BORINGS AND HEADSPACE ANALYSIS	3-1
3.3	TEMPORARY PIEZOMETER WELL INSTALLATION	3-3
3.4	MONITOR WELL INSTALLATION	3-4
3.5	HYDROGEOLOGICAL CHARACTERIZATION	3-7
3.6	GROUNDWATER QUALITY SAMPLING AND ANALYSIS	3-9
4.0	INVESTIGATIVE RESULTS	4-1
4.1	WELL INVENTORY	4-1
4.2	SITE HYDROGEOLOGY	4-1
4.2.1	WATER LEVEL MEASUREMENTS	4-1
4.2.2	HYDRAULIC GRADIENT	4-9
4.2.3	HYDRAULIC CONDUCTIVITY	4-9
4.2.4	GROUNDWATER FLOW CALCULATION	4-9
4.3	SOIL BORING RESULTS	4-11
4.4	GROUNDWATER ANALYTICAL RESULTS	4-12
5.0	CONCLUSIONS AND RECOMMENDATIONS	5-1
5.1	CONCLUSIONS	5-1
5.2	RECOMMENDATIONS	5-3
	REFERENCES	R-1

LIST OF TABLES

Table		Page
3-1	Monitor Well Construction Details	3-6
3-2	Kerosene Analytical Parameter Group in Accordance with Chapter 17-770.600(8)(b) Florida Administrative Code	3-11
4-1	Inventory of Wells within 0.5 Miles of the Building 191 Site	4-3
4-2	Monitor Well/Piezometer and Groundwater Elevations at the Building 191 Site	4-7
4-3	Aquifer Characteristics	4-10
4-4	Soil Headspace Results	4-13
4-5	Summary of Groundwater Analytical Results	4-17

LIST OF FIGURES

Figure		Page
1-1	Site Location Map	1-2
1-2	Site Map	1-3
3-1	Soil Boring Location Map	3-2
3-2	Monitor Well and Piezometer Location Map	3-5
3-3	Monitor Well Diagram, Unconfined Aquifer	3-8
4-1	Location of Wells within 0.5 miles of the Building 191 Site	4-2
4-2	Generalized Geologic Cross Section	4-4
4-3	Potentiometric Surface - April 15, 1994	4-5
4-4	Potentiometric Surface - May 19, 1994	4-6
4-5	Potentiometric Surface - May 26, 1994	4-8

LIST OF APPENDICES

Appendix	
A	SOIL BORING/HEADSPACE LOGS
B	MONITOR WELL BORING AND CONSTRUCTION LOGS
C	MONITOR WELL DEVELOPMENT RECORDS
D	ELEVATION SURVEY
E	SINGLE-WELL AQUIFER TEST DATA
F	GROUNDWATER SAMPLING LOGS
G	GROUNDWATER ANALYTICAL RESULTS

LIST OF ACRONYMS

BTEX	total benzene, toluene, ethylene, and xylene
CAR	Contamination Assessment Report
°C	degrees Celsius
cm/s	centimeters per second
DI	deionized
EDB	1,2-Dibromoethane
ESE	Environmental Science & Engineering, Inc.
FAC	Florida Administrative Code
FBG	Florida Bureau of Geology
FDEP	Florida Department of Environmental Protection
FID	flame ionization detector
ft	foot/feet
ft-bls	feet-below land surface
ft-msl	feet-mean sea level
ft/ft	feet per foot
ft/min	feet per minute
ft/yr	feet per year
ft^2/day	square feet per day
gal	gallon
IN	inches
µg/L	micrograms per liter
ppb	parts per billion
ppm	parts per million
GC	gas chromatograph
MTBE	Methyl Tert-Butyl Ether
MW	monitor well
PVC	polyvinyl chloride
QA	Quality Assurance
RAP	Remedial Action Plan
SB	soil boring
SCS	U.S. Soil Conservation Service
SJRWMD	St. Johns River Water Management District
SRL	Site Rehabilitation Level
USGS	U.S. Geological Survey
VOA	volatile organic aromatic
VOC	volatile organic compound

1.0 INTRODUCTION

1.1 SITE LOCATION

The Naval Station Mayport, Building 191 site is located approximately 300 feet (ft) south of the Mayport basin at the southeast intersection of Massey Avenue and Bryce Canyon Drive in Jacksonville, Florida within Duval County (Figure 1-1).

1.2 SITE HISTORY AND OPERATIONS

In February 1994, Environmental Science & Engineering, Inc. (ESE) was contracted by the Navy Public Works Center Jacksonville to perform an assessment of a diesel fuel spill at Building 191, located at Naval Station, Mayport, Florida (Figure 1-2). Building 191 consists of a warehouse of approximately 250 by 400 feet which is used for the storage of non-hazardous materials.

Two areas of contamination have been identified at the Building 191 site. The cause of the contamination was from leaking underground fuel lines which serviced a 300-gallon aboveground storage tank. Specifically, the lines were leaking from the vicinity of two underground, in-line splices. The locations of these in-line splices are identified as Contamination Area One and Contamination Area Two (a more detailed diagram of the site is presented in Figure 3-1). The estimated leakage from the two in-line splices was 170 gallons, based on liquid level measurements of the 300 gallon aboveground tank.

Soil remediation in the vicinity of Contamination Area One was completed by Environmental Recovery Incorporated (ERI) on August 13, 1993. One area of suspected contamination within Contamination Area One was not removed because the area was directly under a section of concrete curb and a one foot thick concrete slab which supports the aboveground storage tank.

In Contamination Area Two, ERI found suspected contamination down to the water table, encountered at approximately seven feet below land surface (ft-bls), in the area directly under the respective in-line splice. Based on ERI's investigation, the

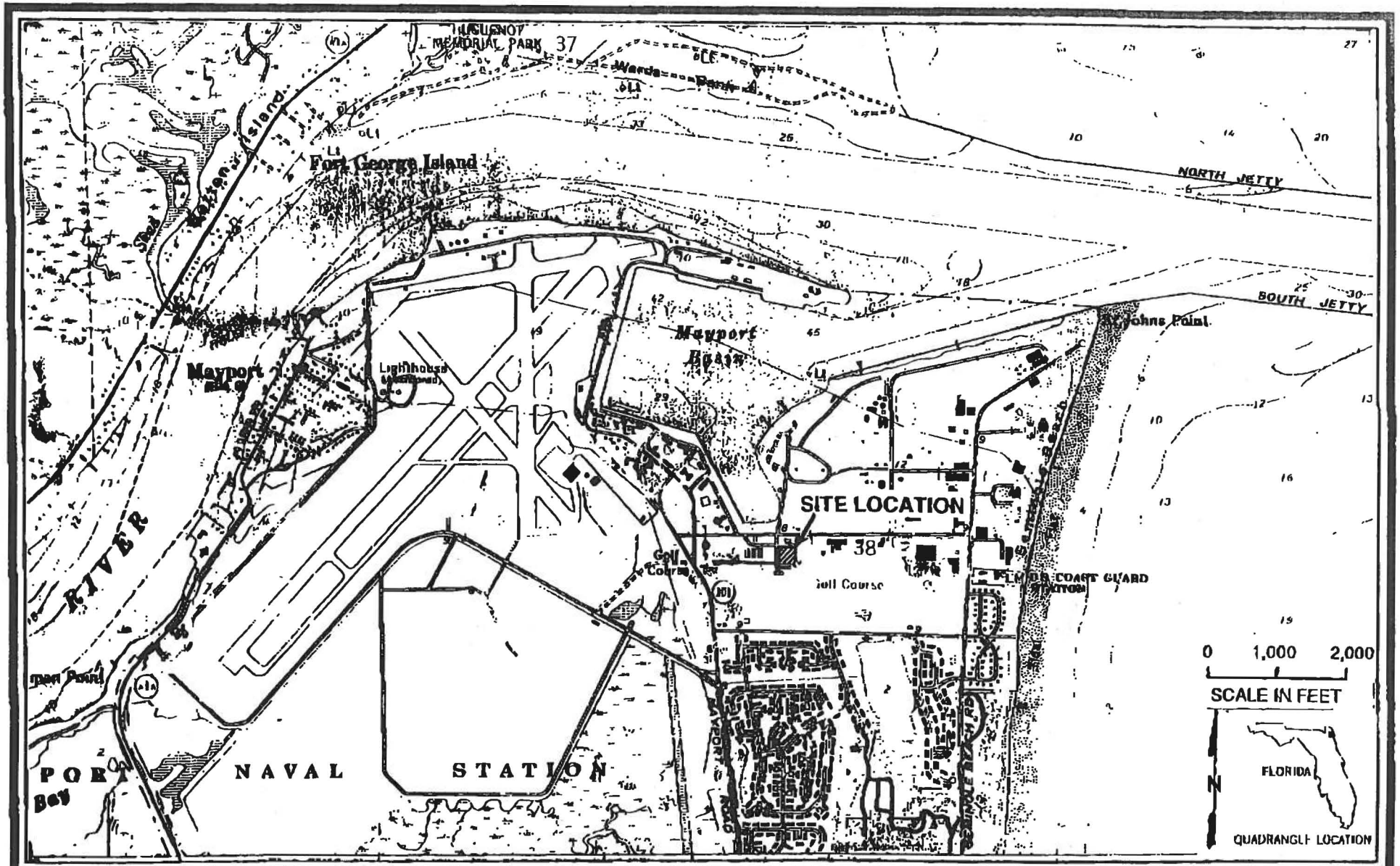

Figure 1-1
SITE LOCATION MAP
NAVAL STATION MAYPORT, BULIDING 191

SOURCES: MAYPORT, FL USGS, 1982; ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

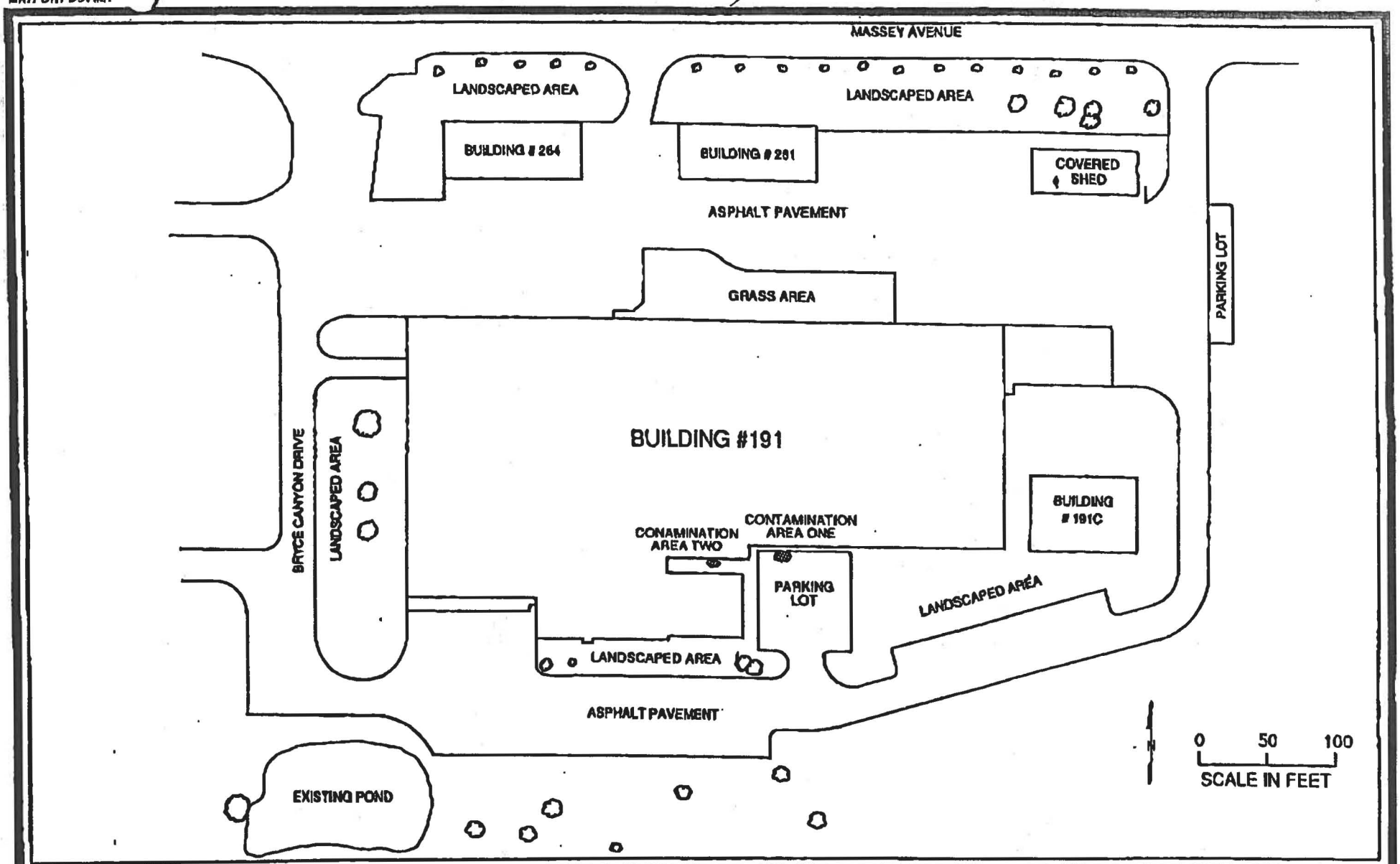

Figure 1-2
SITE MAP
NAVAL STATION MAYPORT, BUILDING 191

SOURCE: ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

horizontal extent of suspected contamination appeared to extend under an adjacent sidewalk to the west of the contaminated area and alongside Building 191, extending approximately 15 feet east of the sidewalk. The area to the south of the in-line splice did not show contamination on the OVA during ERI's investigation. A building footer precluded further soil removal to the groundwater because of possible structural damage which might be caused without proper shoring. A total of ten and one-half, 55-gallon drums of contaminated soil were removed from Contamination Area One and Contamination Area Two by ERI on August 13, 1993.

1.3 OBJECTIVES OF THE CURRENT INVESTIGATION

The objectives of the contamination assessment investigation conducted at the Building 191 site were to meet the criteria of Chapter 17-770.600 FAC. Specifically, the objectives of the investigation included:

1. Establishment of a monitor well network at the site;
2. Evaluation of the site specific hydrogeology;
3. Determination of the lateral and vertical extent of elevated petroleum constituent concentrations, if present, in groundwater and/or soil; and
4. Identification of potential receptors that might be affected by elevated petroleum constituent concentrations in groundwater or soil, if these conditions are present at the site.

2.0 ENVIRONMENTAL SETTING

2.1 PHYSIOGRAPHY AND TOPOGRAPHY

The Building 191 site is located approximately one-half mile inland from the Atlantic Ocean in east central Duval County, Florida, within the Atlantic Coastal Plain Physiographic Province. The topography in Duval County is mostly low, gentle to flat, and composed of a series of ancient marine terraces. The highest altitude is about 190 feet above mean sea level (msl) in the extreme southwest corner of the county, along the eastern slope of a prominent topographic feature known as "Trail Ridge". The terraces play a significant role in determining the configuration of the potentiometric surface of the shallow-aquifer system. The potentiometric surface based on water levels in wells that penetrate the shallow-aquifer system roughly follows the contour of the land surface. As a result, the potentiometric surface is highest where the terraces are highest and lowest where they are lowest. A review of the USGS Mayport Florida 7.5-minute topographic map indicates that the site has an elevation of approximately 10 ft above msl.

2.2 REGIONAL GEOLOGY

The shallow stratigraphy in Duval County consists of undifferentiated sediments of Pleistocene and Holocene age. In the central and eastern portions of the county, Pleistocene and Holocene deposits consist predominantly of unconsolidated sands and green to grey clayey sand. The western edge of the county is underlain by deposits of fine- to medium-grained sand and clayey sand.

Underlying the Pleistocene and Holocene sediments are deposits of interbedded grey-green calcareous silty clay, fine-grained clayey sand, shell, and soft, slightly phosphatic limestone or marl of Upper Miocene and Pliocene age.

The Hawthorn Group of middle Miocene age underlies the Upper Miocene and Pliocene deposits. The Hawthorn Group was deposited in shallow to moderately deep marine waters in a structural basin that received large quantities of clastic sediments.

The sediments of the Hawthorn Group consist of varying amounts of clay, sand, carbonates, and phosphate. The most frequently encountered lithologies in the Hawthorn Group are dolomitic, clayey sands, and clayey, sandy dolomites. Phosphate pebbles occur throughout the Hawthorn Group and serve as the major identification feature of the unit. The Hawthorn Group is present from approximately 70-400 feet below sea level (ft-bsl) in the vicinity of the site (Spechler, R.M., 1994).

The Hawthorn Group overlies the Eocene limestones of the Ocala Group. The limestone units of the Ocala Group in descending sequence include the Crystal River Formation, the Williston Formation, and the Inglis Formation. The Ocala Group consists predominantly of light-colored, massive to granular marine limestones, and grades downward to alternating layers of hard and soft crystalline limestone and dolomitic limestone.

Underlying the Ocala Group are the Avon Park, Lake City, and Oldsmar limestones in descending sequence. The Avon Park Limestone is characterized by alternating beds of crystalline dolomite and granular calcitic limestone. The Lake City Limestone is characterized by massive dolomite and beds of lignite and coquina. The Oldsmar Limestone is characterized by massive granular limestone and fine crystalline dolomite.

2.3 REGIONAL HYDROGEOLOGY

Three distinct water-bearing hydrogeologic divisions can be defined within the geologic units underlying the site: the surficial, the intermediate, and the Floridan aquifers. The surficial aquifer consists of the Holocene and Pleistocene sediments, as well as the more permeable units of the Pliocene and Upper Miocene deposits. This aquifer extends from the water table to a depth between 50 and 150 feet below land surface throughout most of Duval County (Leve, 1966). The basal units of the Pliocene and Upper Miocene deposits function as the upper boundary of the principal aquiclude.

The intermediate aquifer consists of thin discontinuous lenses of sand and shell that occur in the Pliocene and Upper Miocene deposits and the Miocene Hawthorn Formation. The low permeability marls, clays, and dolomitic beds in the Pliocene and Upper Miocene deposits and the Miocene Hawthorn Formation serve as the principal aquiclude beneath the site restricting the vertical movement of water to and from the intermediate aquifer and the Floridan Aquifer.

The artesian Floridan Aquifer consists of the Eocene Age Ocala Group, the Avon Park Limestone, and the Lake City Limestone and permeable beds of the Hawthorn Formation that are in hydrologic contact with the rest of the aquifer. This hydrogeologic unit is the major source of water for irrigation, public supply, and industry in Northeast Florida (Leve, 1966).

2.4 CLIMATE

The climate of the area is classified as humid subtropical. Characteristics of this type of climate include high annual rainfall, moderate annual temperatures with low diurnal and seasonal extremes, and high humidity. According to records of the National Weather Service in Jacksonville, Florida, the mean temperature was 67.9°F during the years 1957 through 1986. The average annual rainfall was about 51.5 inches. Rainfall, however, is unevenly distributed throughout the year (Heath et al., 1981). The driest month is typically November with a mean of 1.5 inches, whereas August, with a mean precipitation of 7.1 inches, is the wettest month.

3.0 INVESTIGATIVE PROCEDURES

3.1 RECORDS SEARCH AND WELL INVENTORY

A records search was conducted to develop a data base of available references in the vicinity of the Building 191 site. Geological and hydrogeological references were obtained from the Naval Station Mayport, United States Geological Survey (USGS), Florida Bureau of Geology (FBG), and St. Johns River Water Management District (SJRWMD) to develop the regional geological setting for the area.

Naval Station Mayport and SJRWMD records were reviewed to compile a well inventory of public and private wells in the vicinity of the site. In accordance with Chapter 17-770 FAC criteria, all permitted private wells within a ¼-mile radius of the site and all public wells within a ½-mile radius of the site were identified. Additionally, well depths, construction details, and well uses were ascertained when available. Well records obtained from Naval Station Mayport and SJRWMD are discussed in Section 4.0.

3.2 SOIL BORINGS AND HEADSPACE ANALYSIS

During the current investigation, 16 soil borings were advanced to the water table at the locations presented in Figure 3-1. In general, the boring locations were placed around the perimeter of the two underground splice areas (Contamination Area One and Contamination Area Two) to define the areal extent of elevated volatile organic compounds (VOC) concentrations in soil, if present, underlying the site.

Soil borings were installed using a stainless steel hand auger to define the horizontal and vertical extent of elevated headspace readings in the soils at these locations. The soil borings and the associated headspace readings were performed in accordance with the procedures detailed in FDEP's Guidelines for Assessment and Remediation of Petroleum Contaminated Soils dated May, 1992. Headspace analysis were performed using a Foxboro Model No. 128 OVA equipped with a flame ionization detector (FID) to determine the concentration of VOCs in the soil headspace. Between each sample

MAYPORT 594 MH

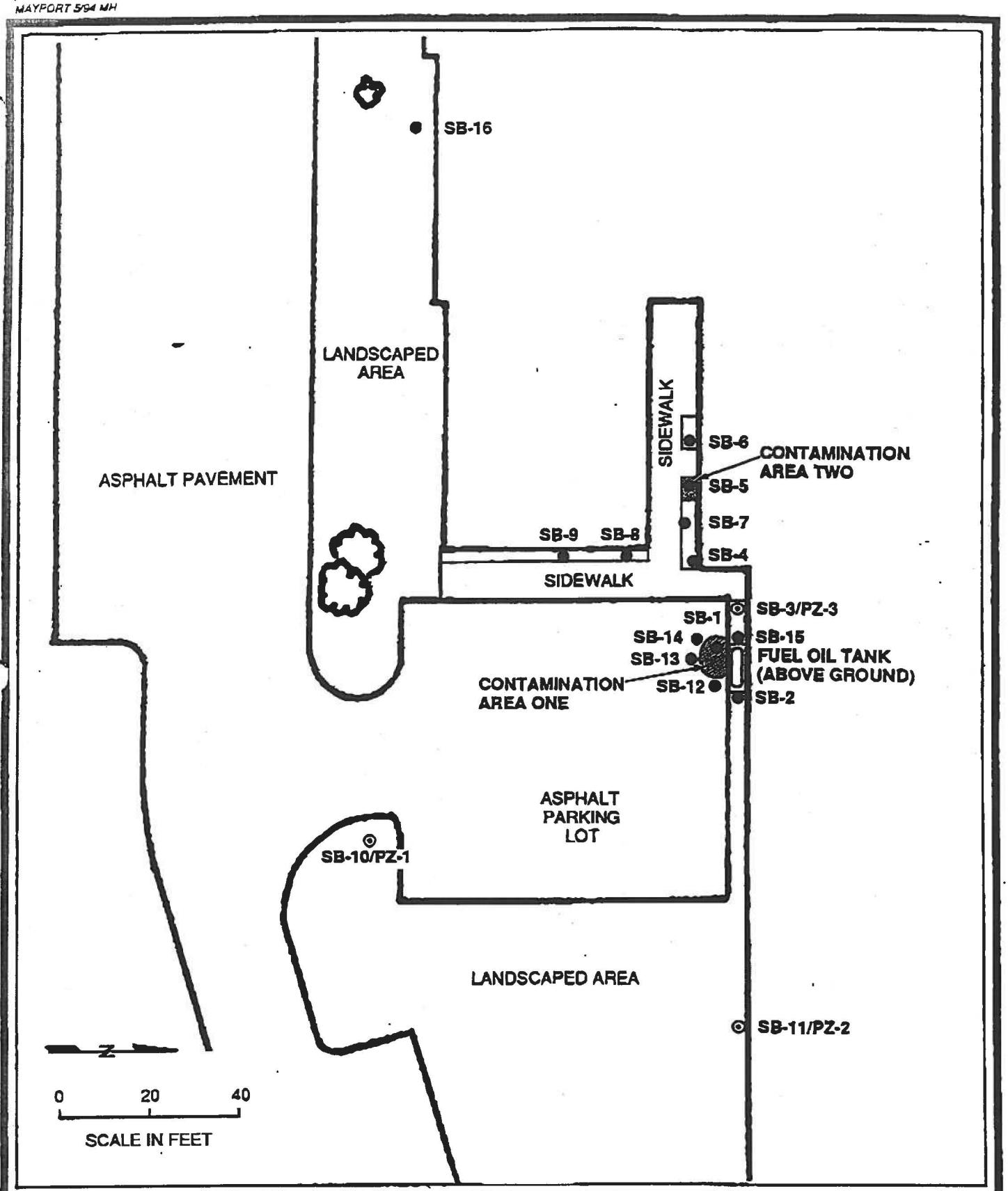

Figure 3-1
SOIL BORING LOCATION MAP
NAVAL STATION MAYPORT, BUILDING 191

SOURCE: ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

collection point, the hand augers were decontaminated as outlined in Section 6.4 of ESE's Comprehensive Quality Assurance (QA) Plan (#860054).

The potential existed for naturally occurring organic compounds to be present in surficial soils underlying the site. Methane, a naturally occurring decay product of native organic debris, could potentially have contributed to the total VOCs measured in soil headspace from each sample. Therefore, each sample interval was analyzed with two types of probes: a nonspecific probe that allows passage of all VOCs, and an activated carbon-filter which allows passage of methane only. The soil samples were analyzed with the nonspecific probe, resealed, then analyzed with the carbon-filter probe. The actual non-methane component of the soil headspace concentration was then calculated by subtracting the methane concentration from the total VOC concentration.

The water table was encountered at a depth of approximately six to seven feet below land surface (ft-bls). Each soil boring was sampled at two foot intervals to the top of the water table for headspace analysis (eg. 0-2, 2-4 ft-bls, etc.). Copies of the original soil boring logs, headspace tables and calibration logs for the headspace analysis are provided in Appendix A. The soil boring results are described in Section 4.0.

3.3 TEMPORARY PIEZOMETER WELL INSTALLATION

Three soil borings were converted to temporary piezometers during the soil boring program completed on April 14, 1994. The piezometers were constructed by placing a 5-ft length of slotted polyvinyl chloride (PVC) piping in the existing boring and backfilling with the formation material. Each new piezometer was surveyed to establish their respective elevations. After allowing the piezometers to reach static liquid levels, the liquid levels were measured with an electric tape (see Table 4-2), and a preliminary potentiometric map of the site was developed.

3.4 MONITOR WELL INSTALLATION

ESE installed four shallow monitor wells (MW-1 through MW-4), and one deep monitor well (MW-1D) during the contamination assessment investigation at the Building 191 site. Monitor well locations are presented in Figure 3-2. Monitor well construction details are presented in Table 3-1. Monitor well boring and construction logs are presented in Appendix B.

The shallow monitor wells, which extend to a depth of approximately 13 ft-bls, were located to delineate the lateral extent of dissolved petroleum constituents in the surficial aquifer underlying the site. The deep monitor well (MW-1D) is located in the central portion of Contamination Area One (adjacent to the aboveground storage tank) and is nested with shallow monitor well MW-1. The deep monitor well, which is screened from 35 to 40 ft-bls, was located to delineate the vertical extent of dissolved petroleum constituents in the surficial aquifer underlying the site.

Prior to initiation of the drilling program, the drill rig, hollow-stem augers, drill rod, wrenches, and other miscellaneous equipment used in the performance of drilling activities were decontaminated by pressure steam cleaning. Additionally, all well casing and screen materials used to construct the monitor wells were decontaminated by steam cleaning immediately prior to installation into the borehole.

The shallow monitor wells were constructed of 4-inch diameter, Schedule 40 polyvinyl chloride (PVC) casing with threaded joints and a 10-ft section of 0.010-inch slot size screen. The top of the screen was set above the water table to intercept phase-separated hydrocarbons on the water table, if present. The annular space surrounding the screen was back-filled with clean, 20/30 silica sand to a depth approximately 1.0 ft above the screened interval. A bentonite clay seal was then placed above the sand pack, and the remaining annular space filled to the surface with a portland cement grout. The deep monitor well (MW-1D) was constructed in the same fashion as the shallow monitor wells, however, a 5-ft section of screen was used.

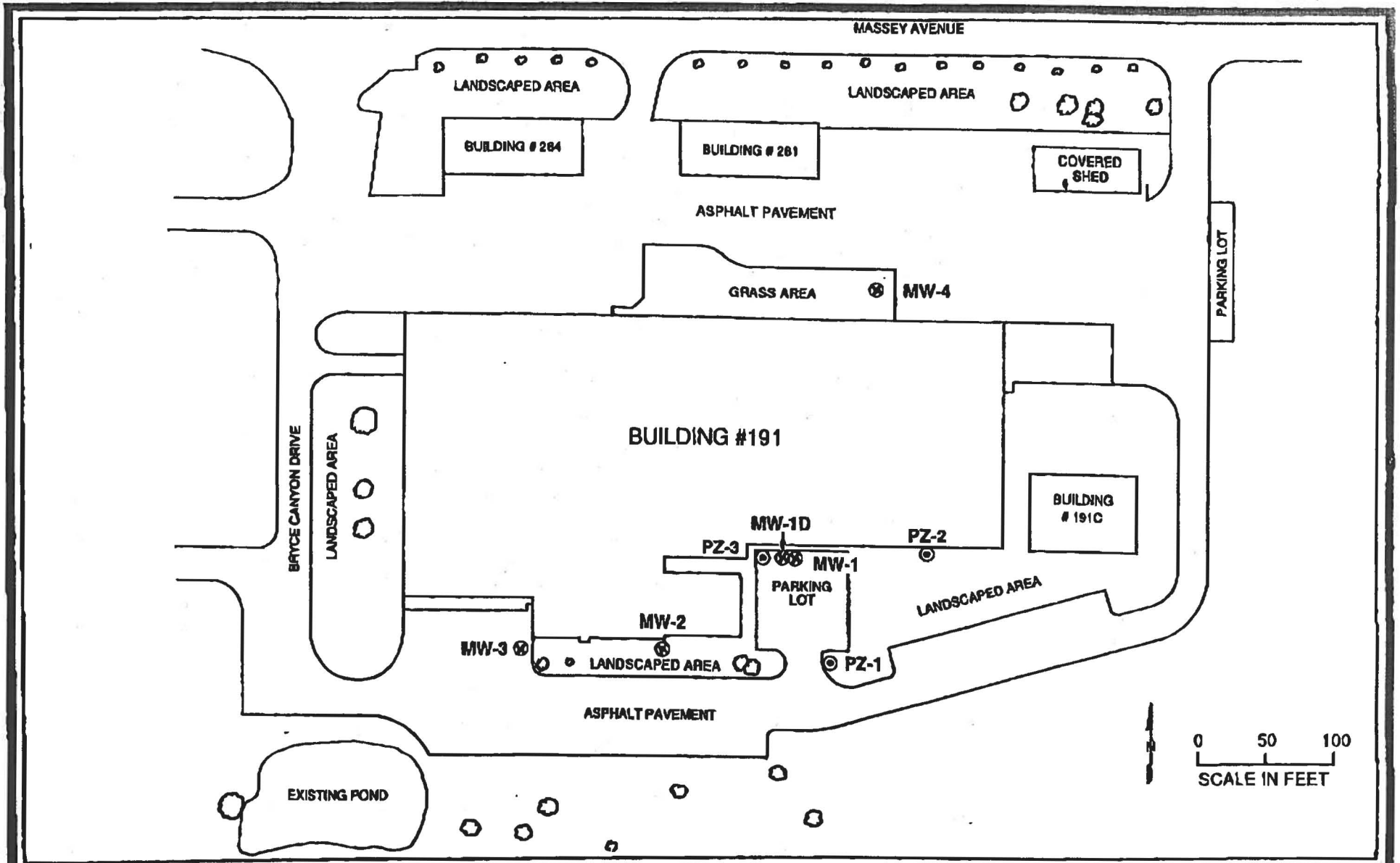

Figure 3-2
MONITOR WELL AND PIEZOMETER LOCATION MAP
NAVAL STATION MAYPORT, BUILDING 191

SOURCE: ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

TABLE 3-1. MONITOR WELL CONSTRUCTION DETAILS

WELL ID	DATE COMPLETED	WELL DEPTH (FT-BLS)	WELL DIA (IN)	CASING MATERIAL	SCREEN LENGTH (FT)	SCREEN SLOT (IN)	ELEV. OF TOC-FEET (RELATIVE TO MSL)
MW-1	05/19/94	13	4	SCH 40 PVC	10	0.010	9.63
MW-1D	05/20/94	40	4	SCH 40 PVC	5	0.010	9.57
MW-2	05/19/94	14	4	SCH 40 PVC	10	0.010	10.91
MW-3	05/19/94	13	4	SCH 40 PVC	10	0.010	8.70
MW-4	05/20/94	13	4	SCH 40 PVC	10	0.010	8.80

Note: ID = Identification
FT = Feet
BLS = Below Land Surface
IN = Inches
PVC = Poly Vinyl Chloride
TOC = Top of Casing

Source: ESE, 1994.

The monitor wells were completed sub-grade with a concrete 2-ft by 2-ft anti-percolation pad, an 8-inch manhole casing and cover, and a locking, water-tight cap. A typical diagram of monitor wells installed during the site investigation is presented in Figure 3-3.

The newly installed monitor wells were developed by purging with a centrifugal pump. Development was discontinued when fine sand and silt were no longer present in the discharge water. Monitor well development records are presented in Appendix C. The elevation of the monitor wells and piezometer at the site were then surveyed by a state certified land surveyor to 0.01-ft accuracy. Additionally, the vertical and horizontal locations of the monitor wells and piezometers were tied into the established Mayport Naval Station base grid system.

3.5 HYDROGEOLOGICAL CHARACTERIZATION

Following groundwater stabilization in the monitor wells, ESE conducted single well aquifer tests (slug tests) on three of the monitor wells to estimate the hydraulic conductivity of the surficial aquifer underlying the site. Slug tests were performed on shallow monitor wells MW-1 and MW-2, and on deep monitor well MW-1D.

Performance of the slug tests required instantaneously changing the water level in the well by introducing (slug-in) and subsequently removing (slug-out) a solid cylinder (the slug) to displace a volume of water. The rate at which the water level in the well recovered to the static level was recorded with the use of a pressure-sensitive transducer and computerized data logger. The data logger was programmed to record the water level at specific time intervals (initially multiple readings per second) during the test.

Following the tests, the data were downloaded from the data logger to a microcomputer for analysis. The raw data were configured into a specific format, then loaded into a computer program which calculates the value of hydraulic conductivity.

MAYPORT 594 MH

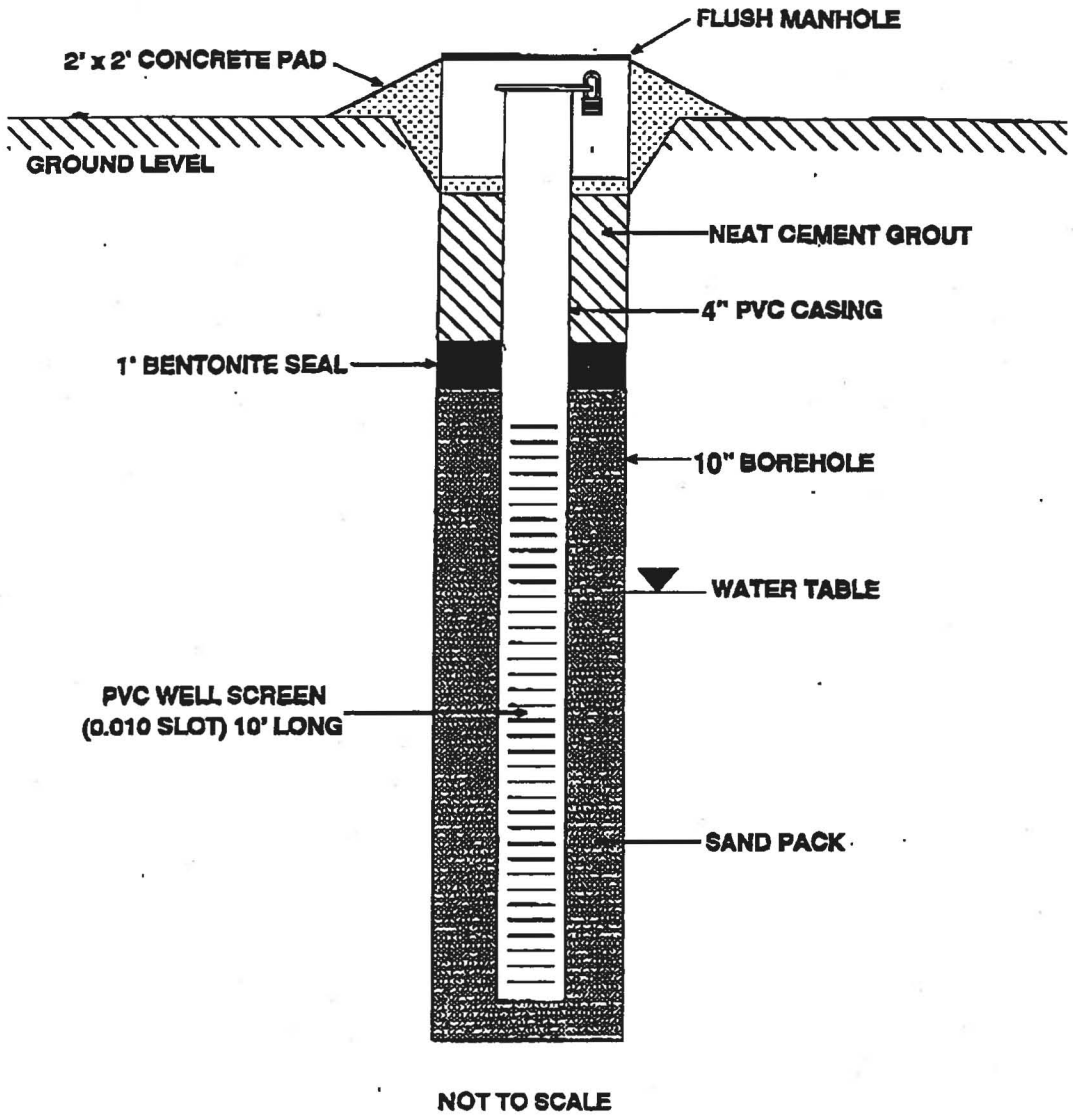

Figure 3-3
MONITOR WELL DIAGRAM, UNCONFINED AQUIFER

SOURCE: ESE

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

Slug test data were analyzed according to the methods developed by Bouwer and Rice (1976). Bouwer has since re-evaluated the slug test analysis (Bouwer, 1989) and determined that the slug-in portion of the test is invalid if the equilibrium water level is within the screened interval. The shallow monitor wells installed at the site were designed so the equilibrium water level would be within the screened interval, therefore, only the slug-out portion of the data was analyzed.

The software program allows the user to select a best fit straight line through the plotted data indicative of an idealized aquifer response using the Theis (1935) equation. From this comparison and a series of calculations, a value for the hydraulic conductivity of the aquifer in the vicinity of the well was determined. Semi-log plots of data and the results of the analysis are provided in Appendix E. Slug test analyses results are described in Section 4.0.

Hydraulic conductivity and hydraulic gradient data were used in conjunction with aquifer lithology characteristics and porosity to estimate groundwater flow velocity in the surficial aquifer underlying the site.

3.6 GROUNDWATER QUALITY SAMPLING AND ANALYSIS

Following sufficient time for the newly installed monitor wells to equilibrate after completion of well development, fluid levels were measured in each of the monitor wells.

All sampling equipment was decontaminated prior to introduction into monitor wells, and sampling procedures were performed in accordance with the FDEP approved ESE Comprehensive QA Plan. During sample collection, duplicate samples, equipment blank samples, and trip blank samples (for VOCs only) were collected and analyzed in accordance with the ESE Comprehensive QA Plan.

Groundwater samples were collected from the monitor wells to define water quality in the vicinity of "Contamination Area One" (adjacent to the aboveground storage tank)

and to define the upgradient and downgradient water quality in the surficial aquifer. Contamination Area Two was not accessible to a drilling rig as it is located within a narrow corridor between two sections of Building 191. A complete set of water level measurements were collected on May 26, 1994, prior to sampling the wells.

Preceding sample collection, 3 to 5 well volumes were purged from the well casing. Prior to introducing any equipment into the wells, all purging and sampling equipment was decontaminated using a Liquinox and tap water wash, followed by a tap water rinse, deionized (DI) water rinse, and a final isopropanol rinse. The sampling equipment was allowed to air dry prior to usage. Laboratory-cleaned and sealed Teflon® bailers were used to sample the monitor wells. Individual Teflon® bailers were dedicated to each well during the sampling effort.

During the purging of each monitor well, in-situ water quality parameters of evacuated groundwater were monitored and recorded on the sample log sheets. Groundwater samples were collected following stabilization of temperature, pH, and conductivity, and after a minimum of three well volumes had been evacuated. Groundwater samples were placed in laboratory-prepared sample containers. The sample containers were labeled for identification, preserved when required, and placed into a cooler and chilled to approximately 4° Celsius (°C). At the completion of groundwater sample collection, the sample coolers were shipped to a FDEP state certified laboratory for analysis. Chain-of-custody documentation accompanied groundwater samples from the point of collection to the analytical laboratory. Groundwater sampling logs are presented in Appendix F.

Groundwater and QA samples collected from the Building 191 site were analyzed for the Kerosene Analytical Group as defined in Chapter 17-770.600(8)(b) FAC (Table 3-2). Detailed analytical data for groundwater analyses are presented in Appendix G. The chemical analysis results for the groundwater and QA samples are described in Section 4.0.

TABLE 3-2 Kerosene Analytical Parameter Group in Accordance with Chapter 17-770.600(8)(b) Florida Administrative Code

1,2-Dichloroethane
Benzene
Toluene
Total Xylenes
Ethylbenzene
1,2-Dibromoethane (EDB)
Methyl Tert-Butyl Ether (MTBE)
Total Volatile Organic Aromatics (VOA)
Volatile Organic Halocarbons
Polynuclear Aromatic Hydrocarbons (PAH)
Total Recoverable Petroleum Hydrocarbons (TRPH)
Lead

4.0 INVESTIGATIVE RESULTS

4.1 WELL INVENTORY

Permitted well records on file with SJRWMD and Naval Station Mayport indicate there are four water supply wells within a one-half mile radius of the Building 191 site. A map showing the well locations is illustrated in Figure 4-1. Table 4-1 presents the details of these wells including owners, usage, map identification as illustrated in Figure 4-1, casing depth, and completion depth.

4.2 SITE HYDROGEOLOGY

Shallow soils underlying the site consist predominantly of fine-grained sand and silty fine-grained sand, extending from the ground surface to a depth of approximately 20 ft-bls. Thin lenses of shell fragments were encountered in MW-1D from approximately 20 ft-bls to 40 ft-bls (the total depth of the soil boring). Groundwater was encountered at approximately 6 ft-bls. Figure 4-2 illustrates the west to east trending geologic conditions underlying the site. The upper confining clay unit of the Hawthorn Formation is reportedly present at a depth of approximately 70 ft-bsl, extending to a depth of approximately 400 ft-bls in the vicinity of the site (Spechler, R.M., 1994).

4.2.1 WATER LEVEL MEASUREMENTS

Prior to installation of the monitor wells, water levels in the three piezometers were measured to define the horizontal hydraulic gradient in the surficial aquifer. Potentiometric maps illustrating the water-table configuration on April 15, 1994 and May 19, 1994 are presented in Figure 4-3 and 4-4, respectively. Prior to sampling the monitor wells, ESE collected a full round of water level measurements in the piezometers and monitor wells to further define the horizontal hydraulic gradient in the surficial aquifer. Water level measurements and groundwater elevations are provided in Table 4-2. A potentiometric map illustrating the water-table configuration on May 26, 1994 (following installation of the monitor wells) is presented in Figure 4-5.

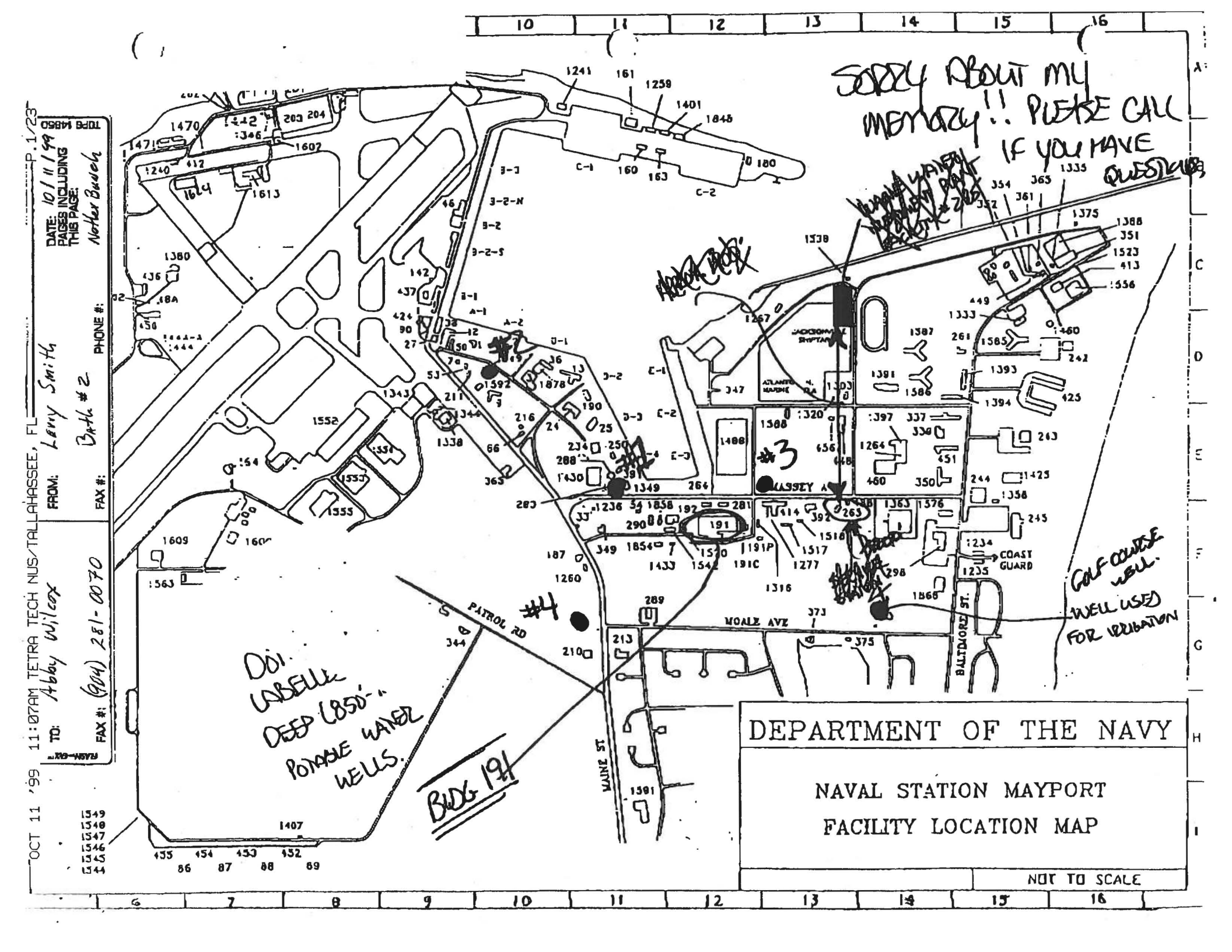
SORRY ABOUT MY MEMORY!! PLEASE CALL IF YOU HAVE QUESTIONS
DEPARTMENT OF THE NAVY
NAVAL STATION MAYPORT
FACILITY LOCATION MAP
NOT TO SCALE
DOI LABELLE DEED 1850's POTABLE WATER WELLS.
BLDG 191
#3
#4
MOALE AVE
PATROL RD
MAINE ST
BALTIMORE ST.
COAST GUARD
GOLF COURSE WELL - WELL USED FOR IRRIGATION
TO: Abby Wilcox
FAX #: (904) 281-0070
FROM: Larry Smith
Bath #2
DATE: 10/11/99
PAGES INCLUDING THIS PAGE:
Mother Board
OCT 11 '99 11:07AM TETRA TECH NUS/TALLAHASSEE, FL P.1/23

TABLE 7

POTABLE WATER WELL SURVEY

BUILDING 1601 - CLASSIFIED INCINERATOR
MAYPORT NAVAL STATION
MAYPORT, FLORIDA

Well No.	Usage	Total Depth (feet)	Casing Depth (feet)	Notes
1	Potable	1001	435	Completed 10/06/61
2	Potable	1000	435	Completed 04/03/58
3	Potable	1000	433	Completed 07/20/79
4	Potable	500	419	Completed 05/29/79

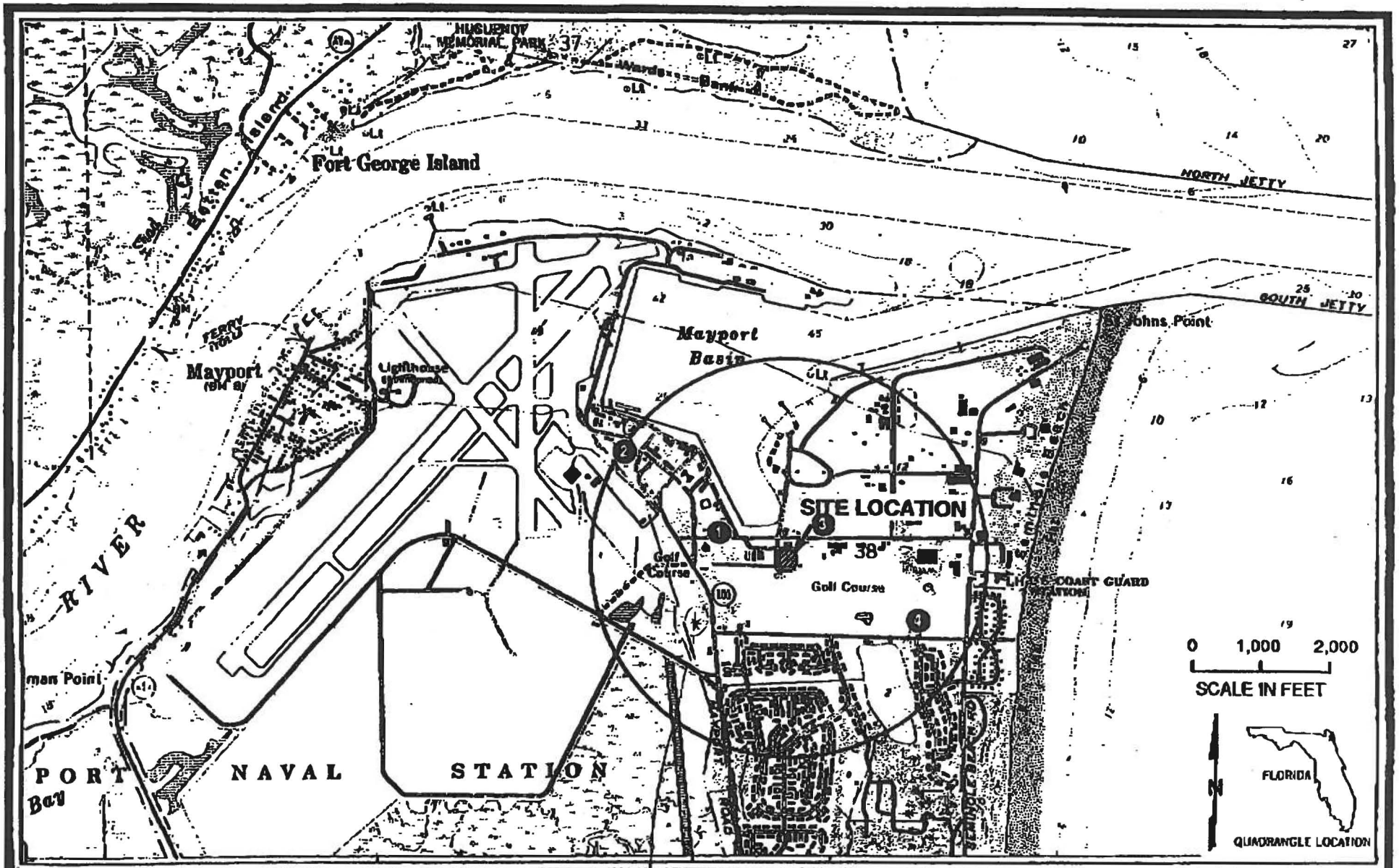

Figure 4-1
LOCATION OF WELLS WITHIN 0.5 MILE RADIUS OF NAVAL STATION MAYPORT, BUILDING 191

SOURCES: MAYPORT, FL USGS, 1982; ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

TABLE 4-1. INVENTORY OF WATER SUPPLY WELLS WITHIN 0.5 MILES OF THE BUILDING 191 SITE

OWNER	USAGE	MAP NUMBER (FIGURE 4-1)	CASING DEPTH (FT)	TOTAL DEPTH (FT)
NAVAL STATION MAYPORT	POTABLE	1	435	1001
NAVAL STATION MAYPORT	POTABLE	2	435	1000
NAVAL STATION MAYPORT	POTABLE	3	433	1000
NAVAL STATION MAYPORT	IRRIGATION	4	419	500

Source: Naval Station Mayport, 1994: personal communication with Cheryl Mitchel.

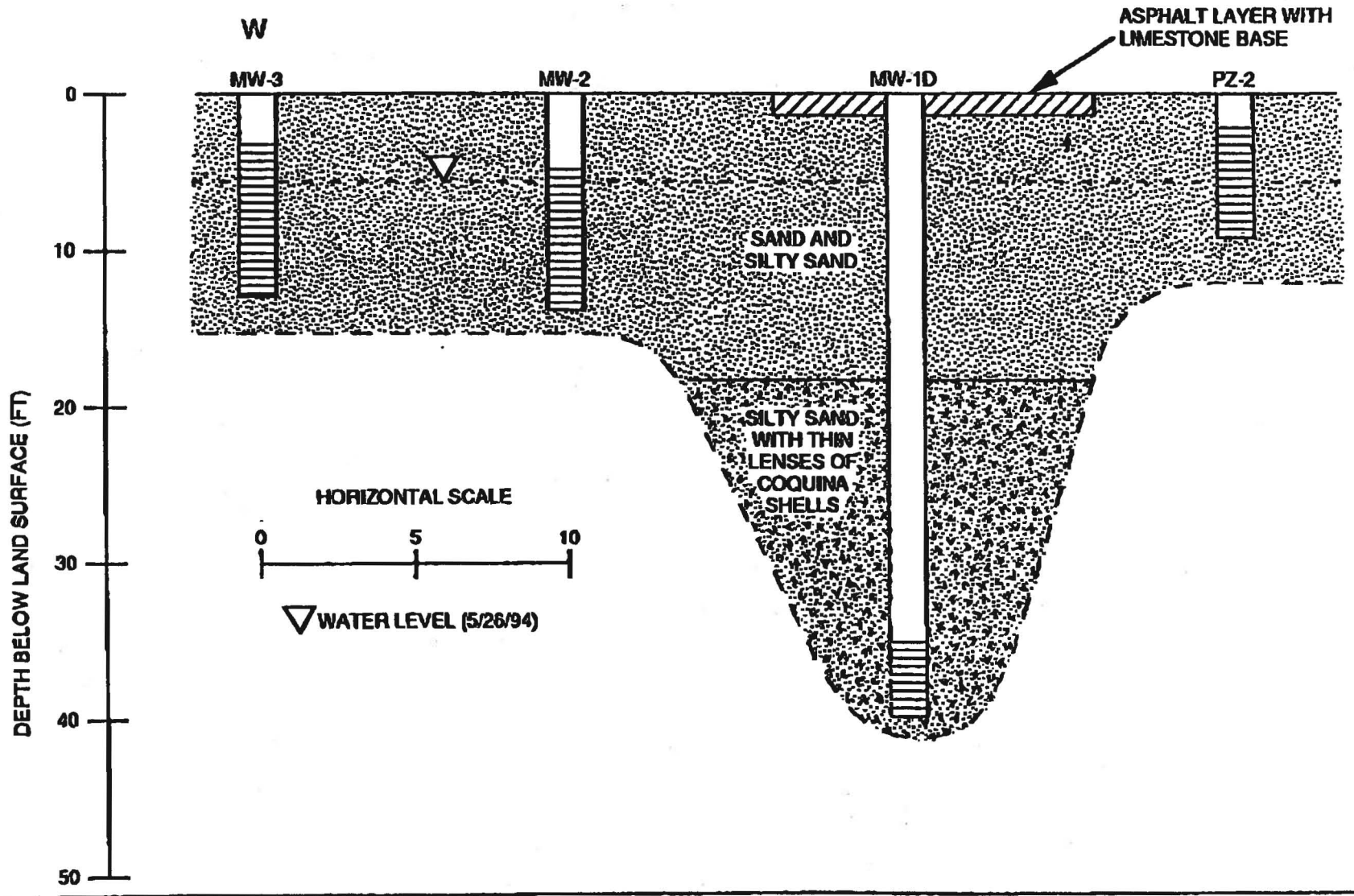

Figure 4-2
GENERALIZED GEOLOGIC CROSS SECTION
NAVAL STATION MAYPORT, BUILDING 191

SOURCE: ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

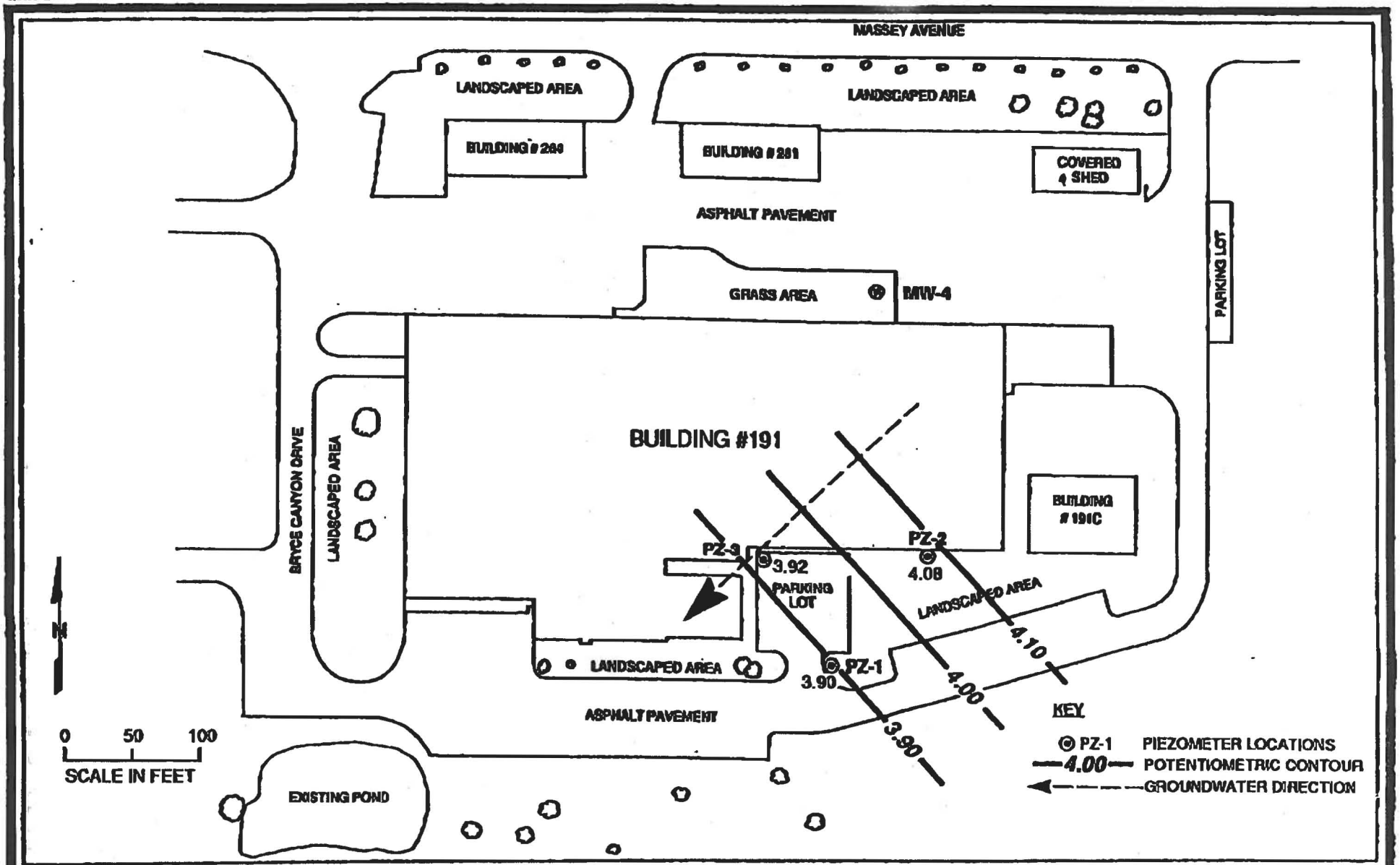

Figure 4-3
POTENTIOMETRIC SURFACE – APRIL 15, 1994
NAVAL STATION MAYPORT, BUILDING 191

SOURCE: ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

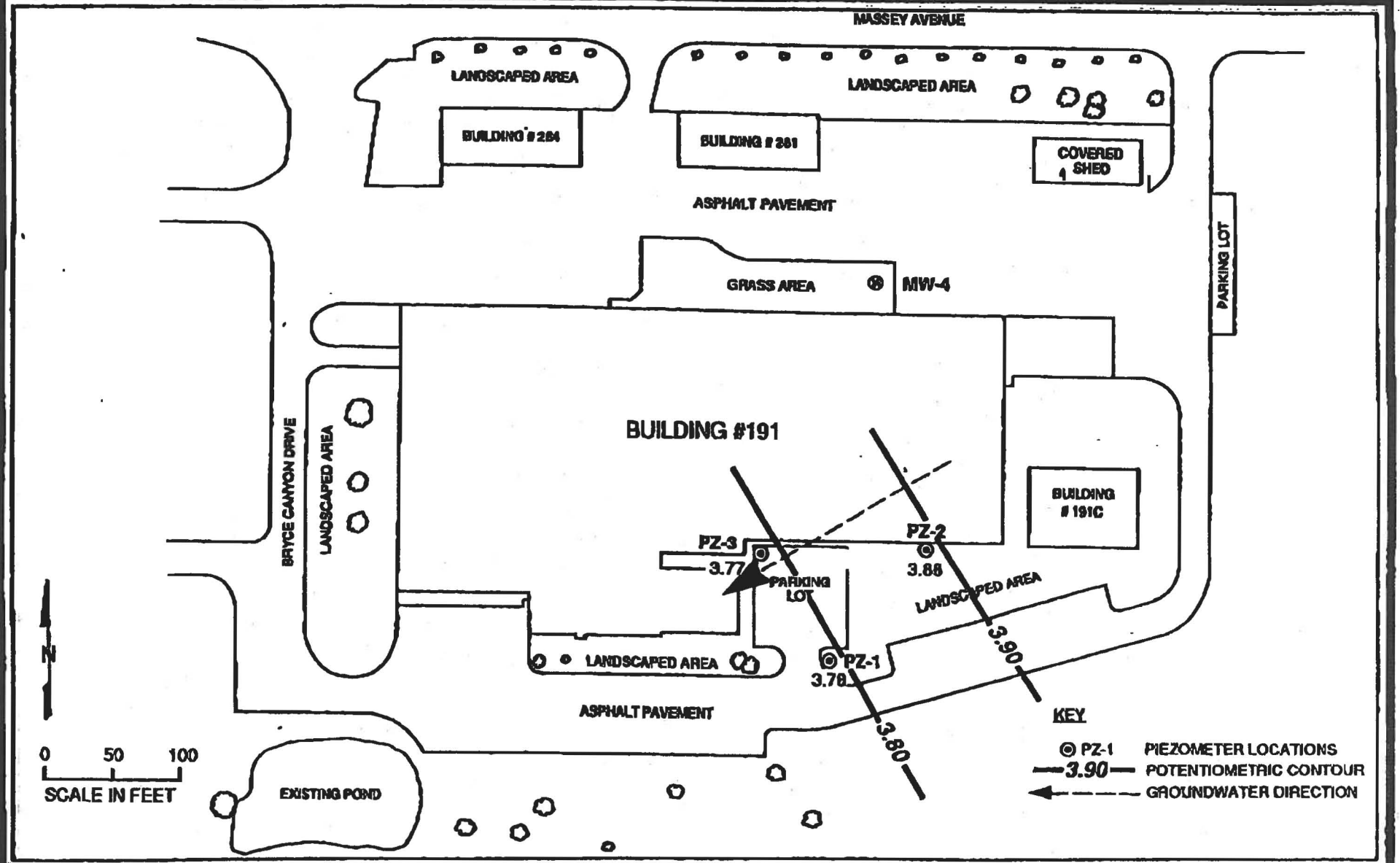

Figure 4-4
POTENTIOMETRIC SURFACE – MAY 19, 1994
NAVAL STATION MAYPORT, BUILDING 191

SOURCE: ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

TABLE 4-2. MONITOR WELL/PIEZOMETER AND GROUNDWATER ELEVATIONS AT THE BUILDING 191 SITE

MONITOR WELL/ PIEZOMETER NUMBER	TOP OF CASING ELEVATION (ft)	APRIL 15, 1994		MAY 19, 1994		MAY 26, 1994	
		Depth to Groundwater (ft)	Groundwater Elevation (ft)	Depth to Groundwater (ft)	Groundwater Elevation (ft)	Depth to Groundwater (ft)	Groundwater Elevation (ft)
PZ-1	11.52	7.62	3.90	7.74	3.78	7.78	3.74
PZ-2	11.77	7.69	4.08	7.89	3.88	7.96	3.81
PZ-3	13.11	9.19	3.92	9.34	3.77	9.38	3.73
MW-1	9.63	NI	NI	NI	NI	5.84	3.79
MW-2	10.91	NI	NI	NI	NI	7.25	3.66
MW-3	8.70	NI	NI	NI	NI	5.12	3.58
MW-4	8.80	NI	NI	NI	NI	4.84	3.96
MW-ID	9.57	NI	NI	NI	NI	5.92	3.65

Note: All elevation data reported in feet relative to Mayport Naval Station Bench Mark.
Piezometer elevations include stick-up height.

NI = Well was not yet installed on the date the water level measurements were taken.
ft = feet

Source: ESE, 1994.

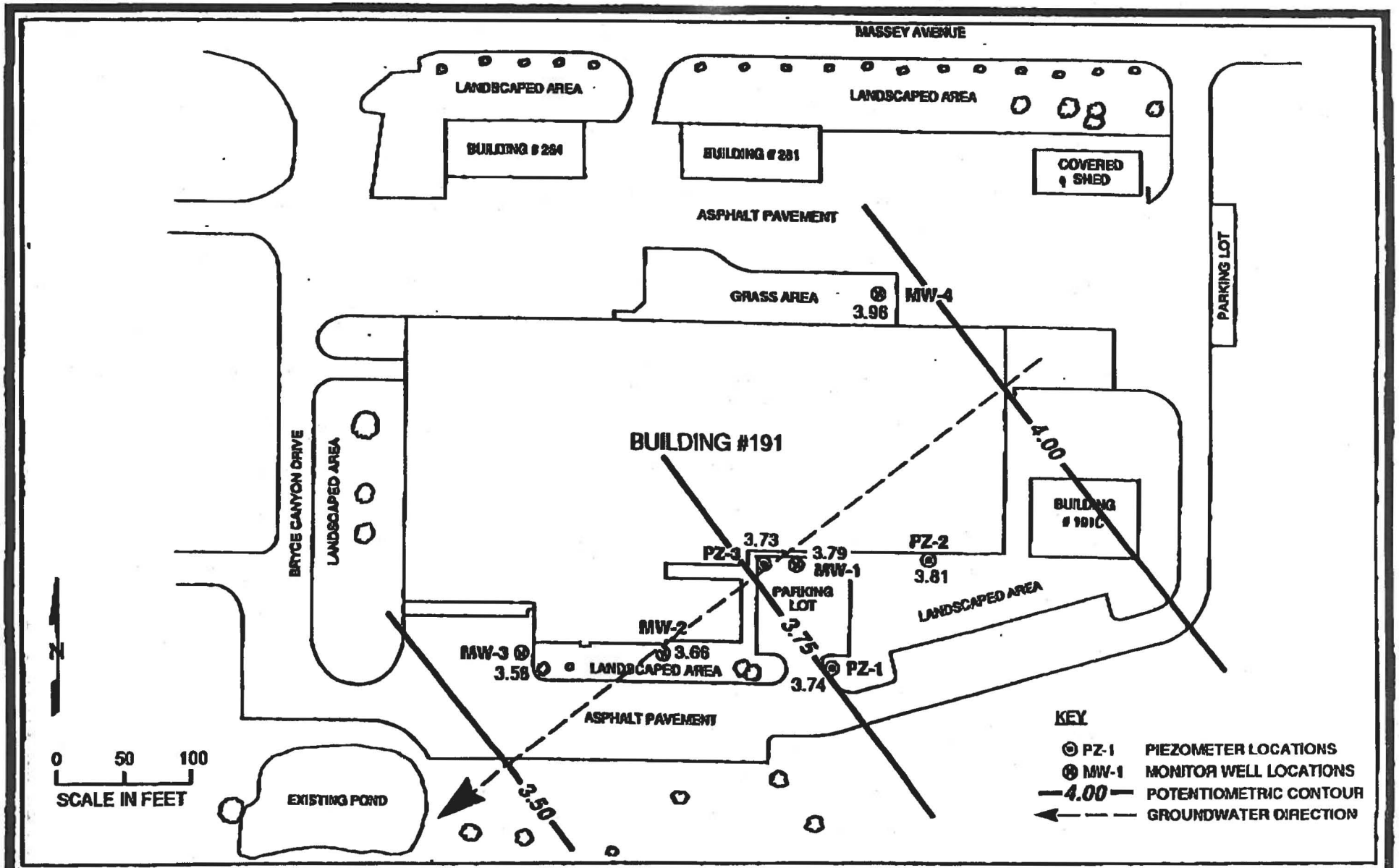

Figure 4-5
POTENTIOMETRIC SURFACE – MAY 26, 1994
NAVAL STATION MAYPORT, BUILDING 191

SOURCE: ESE.

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.

The hydrogeologic conditions exhibited in the upper surficial aquifer were similar during the three water level survey events, with groundwater flow toward the southwest (toward an existing pond).

4.2.2 HYDRAULIC GRADIENT

The hydraulic gradient for the site was derived from water level measurements collected during the May 26, 1994 survey event. The average hydraulic gradient during May 1994 was approximately 1.1×10^{-3} feet per foot (ft/ft). The direction of groundwater flow in the site vicinity is southwest.

4.2.3 HYDRAULIC CONDUCTIVITY

Single well aquifer tests (slug tests) were conducted on two shallow surficial monitor wells (MW-1 and MW-2) and the one deep surficial monitor well (MW-1D) at the Building 191 site. Hydraulic conductivity values were calculated for the slug-out portion of the tests on each well using the methods described by Bouwer and Rice (1976), as previously described in Section 3.2. These values are shown in Table 4-3 and were used to obtain an average hydraulic conductivity value of 6.10×10^{-3} feet per minute (ft/min) for the shallow surficial aquifer. The deep surficial hydraulic conductivity value, as estimated from MW-1D, was 1.28×10^{-3} ft/min. A value of 70 ft for the aquifer thickness was used to obtain an aquifer transmissivity value of 614 square feet per day (ft^2/day) for the shallow surficial aquifer and 129 ft^2/day for the deep surficial aquifer.

4.2.4 GROUNDWATER FLOW CALCULATION

The average linear flow velocity of shallow groundwater underlying the site was calculated using the average hydraulic gradient of 1.1×10^{-3} ft/ft and the average hydraulic conductivity value of 6.10×10^{-3} ft/min. An estimated porosity of 30 percent was assumed for the water-table aquifer underlying the site, based on the

TABLE 4-3. AQUIFER CHARACTERISTICS

WELL NUMBER	HYDRAULIC CONDUCTIVITY (ft/min)	TRANSMISSIVITY* (ft^2/day)
MW-1D	1.28×10^{-3}	129
MW-1	8.34×10^{-3}	840
MW-2	3.85×10^{-3}	388
Average (MW-1 and MW-2)	6.10×10^{-3}	614

* Assumes an aquifer thickness of 70 ft.

Source: ESE, 1994.

presence of silt in the predominantly sand aquifer. The horizontal groundwater flow velocity was calculated using the following formula:

$$v = K \times I/n$$

where: v = horizontal groundwater flow velocity,
K = horizontal hydraulic conductivity,
I = hydraulic gradient, and
n = estimated porosity.

Using the site average hydraulic conductivity, hydraulic gradient value, and an assumed effective porosity of 30 percent, the horizontal groundwater flow velocity of the upper water-table aquifer was calculated to be an average of 2.2×10^{-5} ft/min or 12 feet per year (ft/yr) across the site.

4.3 SOIL BORING RESULTS

Soil samples collected during the soil boring program were screened for total volatile organics with an FID. The samples were initially screened using the FID without a filter and the value recorded. An activated carbon filter was then attached to the FID and a second reading was obtained. The activated carbon removes methane from the soil headspace, eliminating false hits.

Headspace analysis of soil collected during the soil boring program indicated excessive soil contamination in only one boring, SB-5, located within Contamination Area Two (see Figure 3-1). When the suspected contaminant is from the Kerosene Group, excess soil contamination is defined as those soils yielding a value of over 50 parts per million (ppm) on an OVA when using an FID in accordance with the method prescribed in Chapter 17-770, FAC. The 2-4 ft interval and the 4-6 ft intervals in SB-5 had slightly elevated FID headspace values of 14 and 8 ppm, respectively. The 6-8 ft interval had an elevated FID value of 92 ppm. The water table was encountered at

approximately 7 ft-bls in SB-5. Results of the headspace analysis of soil collected during the site investigation are presented in Table 4-4.

In using the hand auger during the soil boring phase of the investigation, a depth of greater than 3 ft-bls was not obtainable in soil boring SB-1, located in the central portion of Contamination Area One, due to an obstruction (ie. buried asphalt or concrete). After several attempts to advance the hand auger below 3 ft, the boring was terminated. During the monitor well installation program, MW-1 was constructed in the vicinity of SB-1, allowing for the collection of headspace samples to the water table (approximately 6 ft-bls). Data for soil sample headspace analysis collected from SB-1 had FID readings of 34 ppm in the 0-2 ft interval and 24 ppm in the 2-4 ft interval. However, the 4-6 ft interval of MW-1 was only 18 ppm, all of which were below the 50 ppm FID value which defines excess soil contamination. An attempt was made to advance SB-14, located approximately 5 ft southwest of SB-1, to the water table. However, as in SB-1, an obstruction was again encountered at approximately 3.5 ft-bls, and after several attempts, the boring was terminated.

Soil boring SB-8, located approximately 30 ft southwest of Contamination Area One, exhibited a slightly elevated FID reading of 28 ppm in the 4-6 ft interval and 22 ppm in the 6-8 ft interval. Soil boring SB-13, located approximately 5 ft southeast of SB-1, had a slightly elevated FID reading of 20 ppm in the 4-6 ft interval of the boring. Based on the soil boring program, ESE feels the extent of "excessive soil contamination" at the Building 191 site has been defined.

4.4 GROUNDWATER ANALYTICAL RESULTS

The water quality data for the Building 191 site are presented in Table 4-5. The FDEP target level criteria for site remediation under Chapter 17-770 F.A.C are included in the table for comparison. Complete analytical results are provided in Appendix G.

TABLE 4-4. SOIL HEADSPACE RESULTS

BORING NUMBER	SAMPLE INTERVAL (FT)	PID VALUE (PPM)		NON-METHANE COMPONENT (PPM)
		unfiltered	filtered	
SB-1	0.5-2	34	0	34
SB-1	2-3	24	0	24
SB-2	0-2	0	0	0
SB-2	2-4	0	0	0
SB-2	4-6	4	0	4
SB-3	0-2	0	0	0
SB-3	2-4	0	0	0
SB-3	4-6	0	0	0
SB-3	6-8	22	0	22
SB-4	0-2	0	0	0
SB-4	2-4	0	0	0
SB-4	4-6	0	0	0
SB-5	0-2	0	0	0
SB-5	2-4	14	0	14
SB-5	4-6	8	0	8
SB-5	6-8	92	0	92
SB-6	0-2	0	0	0
SB-6	2-4	0	0	0

TABLE 4-4. SOIL HEADSPACE RESULTS (page 2 of 4)

BORING NUMBER	SAMPLE INTERVAL (FT)	FID VALUE (PPM)		NON-METHANE COMPONENT (PPM)
		unfiltered	filtered	
SB-6	4-6	0	0	0
SB-6	6-8	0	0	0
SB-7	0-2	0	0	0
SB-7	2-4	0	0	0
SB-7	4-6	0	0	0
SB-7	6-8	0	0	0
SB-8	0-2	0	0	0
SB-8	2-4	0	0	0
SB-8	4-6	28	0	28
SB-8	6-8	22	0	22
SB-9	0-2	0	0	0
SB-9	2-4	0	0	0
SB-9	4-6	0	0	0
SB-9	6-8	0	0	0
SB-10	0-2	0	0	0
SB-10	2-4	0	0	0
SB-10	4-6	160	160	0
SB-10	6-8	480	480	0

TABLE 4-4. SOIL HEADSPACE RESULTS (page 3 of 4)

BORING NUMBER	SAMPLE INTERVAL (FT)	FID VALUE (PPM)		NON-METHANE COMPONENT (PPM)
		unfiltered	filtered	
SB-11	0-2	0	0	0
SB-11	2-4	0	0	0
SB-11	4-6	0	0	0
SB-11	6-8	0	0	0
SB-12	0-2	0	0	0
SB-12	2-4	0	0	0
SB-12	4-6	0	0	0
SB-12	6-8	0	0	0
SB-13	0-2	0	0	0
SB-13	2-4	0	0	0
SB-13	4-6	22	2	20
SB-13	6-8	26	0	26
SB-14	0-2	0	0	0
SB-14	2-3.5	0	0	0
SB-15	0-2	0	0	0
SB-15	2-4	0	0	0
SB-15	4-6	0	0	0
SB-15	6-8	0	0	0

TABLE 4-4. SOIL HEADSPACE RESULTS (page 4 of 4)

BORING NUMBER	SAMPLE INTERVAL (FT)	FID VALUE (PPM)		NON-METHANE COMPONENT (PPM)
		unfiltered	filtered	
SB-16	0-2	0	0	0
SB-16	2-4	0	0	0
SB-16	4-6	0	0	0
SB-16	6-8	0	0	0
MW-1	0-2	26	0	26
MW-1	2-4	28	0	28
MW-1	4-6	18	0	18

Note: FID = Flame Ionization Detector
PPM = Parts Per Million

Source: ESE, 1994.

TABLE 4-5. SUMMARY OF GROUNDWATER ANALYTICAL RESULTS

ANALYTE	GUIDANCE CONCENTRATIONS	MW-1	MW-2	MW-3	MW-4	MW-1D
Benzene	1 ug/L •	<1	<1	<1	<1	<1
1,2-Dibromoethane (EDB)	0.02 ug/L •	<0.02	<0.02	<0.02	<0.02	<0.02
Total Volatile Organic Aromatics (BTEX)	50 ug/L •	1	<6	<6	<6	<6
PAHs (excluding Naphthalenes)	10 ug/L •	<10	<10	<10	<10	<10
Total Naphthalenes	100 ug/L •	<10	<10	<10	<10	<10
Lead	15 ug/L •	<5	<5	<5	<5	<5
Methyl Tert-Butyl Ether (MTBE)	50 ug/L •	<2	<2	<2	<2	<2
Total Recoverable Petroleum Hydrocarbons	5 mg/L •	<1	<1	<1	<1	<1
Tetrachloroethene	3 ••	<1	<1	<1	22	<1
Trichloroethene TCE	3 ••	<1	<1	<1	5	<1
Total Xylenes (Primary Drinking Water Standard)	10,000 ug/L ••	1	<1	<1	<1	<1
Total Trihalomethanes †	100 ••	<1	4	2	<1	12

• FDEP 17-770 FAC Target Cleanup Level

•• Florida Groundwater Guidance Concentrations (current as of June 1994).

† Total Trihalomethanes (Bromoform, Dibromochloromethane, Chloroform and Bromodichloromethane). No Florida Groundwater Guidance Concentration available.

NA = Not Available

None of the FDEP target levels for the Kerosene Analytical Group were exceeded at the Building 191 site. Xylene, detected in MW-1 at a concentration of 1.0 ug/L, was the only analyte detected of those listed for the FDEP target levels (hence, a total volatile organic aromatics value of 1.0 ug/L). The Florida Groundwater Guidance Concentration (Primary Drinking Water Standard) for total xylenes is 10,000 ug/L.

Tetrachloroethene, which has a Florida Groundwater Guidance Concentration (Primary Drinking Water Standard) of 3 ug/L, was detected at a concentration of 22 ug/L in MW-4 (background well). The remaining wells were below the detection limit (BDL) for tetrachloroethene. Trichloroethene, with a Florida Groundwater Guidance Concentration (Primary Drinking Water Standard) of 3 ug/L, was detected at a concentration of 5 ug/L in the background well, MW-4.

Total trihalomethanes were detected in MW-2, MW-3, and MW-1D at concentrations of 4 ug/L, 2 ug/L, and 12 ug/L, respectively. FDEP 17-770 FAC target cleanup levels and/or Florida Groundwater Guidance Concentrations are not available for total trihalomethanes. However, the Federal Groundwater Guidance Concentrations (Primary Drinking Water Standard) for total trihalomethanes is 100 ug/L. The total trihalomethane concentrations detected in MW-2, MW-3 and MW-1D are well below the Federal Guidance Concentrations.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Shallow soils underlying the site consist predominantly of fine-grained sand and silty fine-grained sand, extending from the ground surface to a depth of approximately 20 ft-bls. Thin lenses of shell fragments were encountered in MW-1D from approximately 20 ft-bls to 40 ft-bls (the total depth of the soil boring). Groundwater was encountered at approximately 6 ft-bls. The upper confining clay unit of the Hawthorn Formation is reportedly present at a depth of approximately 70 ft-bsl, extending to a depth of approximately 400 ft-bls in the vicinity of the site (Spechler, R.M., 1994).

Permitted well records supplied by Naval Station Mayport indicate there are three potable wells and one irrigation well within a one-half mile radius of the Building 191 site, all of which are located within the boundaries of the Naval Station. The potable wells are all cased into the underlying Hawthorn confining unit at depths ranging from 433 ft-bls to 435 ft-bls. The completion depths of these wells are approximately 1,000 ft-bls. The irrigation well, which supplies irrigation water for the base's golf course, is cased to 419 ft-bls with a completion depth of 500 ft-bls.

The hydraulic gradient at the Building 191 site was calculated to be 1.1×10^{-3} ft/ft during May 1994. The direction of groundwater flow has consistently been to the southwest, toward a pond located approximately 300 ft downgradient of source areas. The average hydraulic conductivity value for the upper surficial aquifer was estimated to be approximately 6.10×10^{-3} ft/min. The average hydraulic conductivity value for the lower surficial aquifer (35-to-40 ft-bls) was estimated to be approximately 1.28×10^{-3} ft/min.

The average linear flow velocity of the shallow groundwater underlying the site was calculated to be approximately 12 feet per year (ft/yr).

Based on headspace analysis of soil samples collected during the soil boring program, SB-5 (central portion of Contamination Area Two) was the only boring with a soil headspace concentration which exceeded FDEP criteria to be classified as contaminated or excessively contaminated soil (greater than 50 ppm on an FID). Soil remediation in the vicinities of Contamination Area One and Contamination Area Two was completed by ERI on August 13, 1993 during which time ten and one-half 55-gallon drums of contaminated soil were removed. A building footer precluded further soil removal to the groundwater in the vicinity of Contamination Area Two because of possible structural damage which might be caused.

The groundwater analytical data for the Building 191 site indicates that there is no groundwater contamination exceeding Groundwater Guidance Concentrations associated with Contamination Area One and Contamination Area Two. Xylene, detected in MW-1 at a concentration of 1.0 ug/L, was the only analyte detected of those listed in the FDEP target levels, resulting in a total volatile organic aromatics value of 1.0 ug/L. The Florida Groundwater Guidance Concentration (Primary Drinking Water Standard) for total xylenes is 10,000 ug/L.

Tetrachloroethene, which has a Florida Groundwater Guidance Concentration (Primary Drinking Water Standard) of 3 ug/L, was detected at a concentration of 22 ug/L in MW-4 (background well). The remaining wells were below the detection limit (BDL) for tetrachloroethene. Trichloroethene, which has a Florida Groundwater Guidance Concentration (Primary Drinking Water Standard) of 3 ug/L, was detected at a concentration of 5 ug/L in MW-4.

Total trihalomethanes (bromoform, dibromochloromethane, chloroform, and bromodichloromethane) were detected in MW-2, MW-3, and MW-1D at concentrations of 4 ug/L, 2 ug/L, and 12 ug/L, respectively. The Florida Groundwater Guidance Concentration (Primary Drinking Water Standard) for total trihalomethanes is 100 ug/L. The total trihalomethane concentrations detected in MW-2, MW-3 and MW-1D are well below the Florida Groundwater Guidance Concentration.

5.2 RECOMMENDATIONS

Based on soil and groundwater quality data obtained during the site investigation, the Building 191 site qualifies for "No Further Action" as outlined in Chapter 17-770 FAC. This conclusion is based on the following results:

- a Quality Assurance Project Plan has been approved pursuant to Rule 17-770.400 FAC;
- free-product is not present at the site;
- the petroleum contamination site is located in an area of G-II groundwater, the total volatile organic aromatics concentration in the groundwater is less than 50 ug/L, and potable wells are located within one-quarter mile radius of the site;
- With the exception of one soil boring (SB-5) located within Contamination Area Two, the soil boring program conducted during the site investigation determined that soil headspace VOC concentrations at the site are below the Chapter 17-770 FAC criteria. Soil remediation in the vicinity of Contamination Area Two was conducted on August 13, 1993. However, a building footer precluded soil removal to the groundwater, encountered at approximately 7 ft-bls. Based on the FID headspace value determined for the 6-to-8 ft interval of SB-5 (92 ppm), and because no groundwater contamination was detected in monitor wells MW-2 and MW-3, ESE does not feel that further soil remediation is warranted.
- None of the FDEP target levels for the Kerosene Analytical Group as identified in Chapter 17-770.730(5)(a)(2) were exceeded; and
- The vertical extent of dissolved hydrocarbon constituents has been determined to be below the detection limit.

REFERENCES

Bouwer, H. 1989. The Bouwer and Rice Slug Test--An Update. Journal of Groundwater, Volume 27, Number 3. National Water Well Association. Dublin, Ohio.

Bouwer, H., and Rice, R.C. 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells. Water Resources Research. 12(3):423-428.

Heath, R.C., and Conover, C.S. 1981. Hydrologic Almanac of Florida. U.S. Geological Survey. Open-File Report No. 81-1107. Tallahassee, Florida.

Leve, G.W. 1966. Groundwater in Duval and Nassau Counties, Florida. U.S. Geological Survey Report of Investigation. No. 43. Tallahassee, Florida.

Naval Station Mayport. 1994. Personal communication with Cheryl Mitchel.

Spechler, R.M. 1994. Saltwater Intrusion and Quality of Water in the Floridan Aquifer System, Northeastern Florida. U.S. Geological Survey. Water Resources Investigations Report 92-4174.