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INSTALLATION RESTORATION PROGRAM

Final

SITE INVESTIGATION REPORT
VOLUME I

152nd TACTICAL RECONNAISSANCE GROUP
NEVADA AIR NATIONAL GUARD
RENO CANNON INTERNATIONAL AIRPORT
RENO, NEVADA

April 1994

AIR NATIONAL GUARD

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OAK RIDGE NATIONAL LABORATORY
P.O. BOX 2567
GRAND JUNCTION, COLORADO 81502

7. Performing Organization Name(s) and Address(es)

OAK RIDGE NATIONAL LABORATORY
P.O. BOX 2567
GRAND JUNCTION, COLORADO 81502

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Installation Restoration Program

Site Investigation Report

152nd Tactical Reconnaissance Group
Nevada Air National Guard
Reno Cannon International Airport
Reno, Nevada

Submitted by:
Hazardous Waste Remedial Actions Program
Martin Marietta Energy Systems, Inc.
Oak Ridge, Tennessee
for the
U.S. Department of Energy

Submitted to:
Air National Guard Readiness Center
Andrews Air Force Base, Maryland

Prepared by:
Oak Ridge National Laboratory
P.O. Box 2567
Grand Junction, Colorado 81502

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ACRONYMS AND ABBREVIATIONS

AAWC	- Airport Authority of Washoe County
acre-ft/yr	- acre feet per year
AGE	- Aerospace Ground Equipment
amsl	- above mean sea level
ANG	- Air National Guard
ANGRC	- Air National Guard Readiness Center
ARARs	- applicable or relavent and appropriate requirements
ASG	- Automated Sciences Group
bgs	- below ground surface
Bldg.	- building
BNAs	- base neutral acid extractables
CERCLA	- Comprehensive Environmental Response, Compensation, and Liability Act
CRDL	- contract required detection limit
d	- day
1,2-DCA	- 1,2-dichloroethane
1,1-DCE	- 1,1-dichloroethene
1,2-DCE	- 1,2-dichloroethene
DD	- decision document
DOD	- U.S. Department of Defense
DOE	- U.S. Department of Energy
EPA	- U.S. Environmental Protection Agency
eV	- electron volt
FFS	- focussed feasibility study
FFS/RMs	- focussed feasibility study/remedial measures
FS	- feasibility study
ft	- feet

FTA	Fire Training Area
gal	gallons
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
gpm	gallons per minute
GSM	groundwater screening method
h	hours
HARM	Hazard Assessment Rating Methodology
HAZWRAP	Hazardous Waste Remedial Actions Program
IAG	interagency agreement
ICP	inductively coupled plasma
ICS	Interference Check Sample (Report)
ID	inner diameter
IDL	instrument detection limit
in.	inches
IR	immediate response
IRP	Installation Restoration Program
J	Reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.
LCS	Laboratory Control Sample (Report)
MCLs	maximum contaminant levels
m	meters
min	minutes
μL	microliters
mL	milliliters
mm	millimeters
MOU	memorandum of understanding
MS	matrix spike
MS/MSD	matrix spike/matrix spike duplicate

NDEP	- Nevada Division of Environmental Protection
NVANG	- Nevada Air National Guard
OD	- outside diameter
ORNL/ETS	- Oak Ridge National Laboratory/Environmental Technology Section
OWS	- Oil Water Separator
PA	- preliminary assessment
PAHs	- polynuclear aromatic hydrocarbons
PE	- polyethylene
PID	- photoionization detector
PHCs	- petroleum hydrocarbons
POL	- Petroleum, Oil, and Lubricants
ppm	- parts per million
PVC	- polyvinyl chloride
QA/QC	- quality assurance/quality control
RA	- remedial action
RD/RA	- remedial design/remedial action
RI/FS	- remedial investigation/feasibility study
RM	- remedial measure
RRI	- Rapid Response Initiative
RT	- retention time
s	- seconds
SDG	- sample delivery group
SI	- site investigation
SMCLs	- secondary maximum contaminant levels
SPSs	- secondary preferred standards
1,1,1-TCA	- 1,1,1-trichloroethane
TCE	- trichloroethene
TCL	- target compound list
TCLP	- toxicity characterization leaching procedure

TICs - tentatively identified compounds
TPH - total petroleum hydrocarbons
TRG - Tactical Reconnaissance Group
VOCs - volatile organic compounds
USEPA - United States Environmental Protection Agency
USTs - underground storage tanks
VOLs - analysis for volatile organic compounds
WCDHD - Washoe County District Health Department

EXECUTIVE SUMMARY

As part of the National Guard Bureau's Installation Restoration Program, a site investigation (SI) was conducted at the 152nd Tactical Reconnaissance Group of the Nevada Air National Guard, located at the Reno Cannon International Airport, Reno, Nev. The objectives of the SI were to confirm the presence or absence of contaminants and to evaluate the potential for contaminant migration.

Seven sites were investigated, five former Fire Training Areas (FTAs) and two other sites. Recommendations for disposition of each site are based on remediation standards set forth in the Nevada Division of Environmental Protection's *Contaminated Soil and Ground Water Remediation Policy*. The sites and recommendations are:

Site 2, FTA No. 2: no soil or groundwater contamination above standards was found. Prepare a no-further-action decision document for soils. Install an additional monitoring well downgradient of the site to confirm the origin of observed downgradient contamination and to support a no-further-action decision document for groundwater.

Site 3, FTA No. 3: no soil or groundwater contamination above standards was found. Prepare a no-further-action decision document.

Site 4, FTA No. 4: soil contamination was found. A Remedial Investigation/Feasibility Study (RI/FS) is recommended for this site.

Site 5, FTA No. 5: soil contamination was found. An RI/FS is recommended for this site.

Site 7, Petroleum, Oil, and Lubricants Storage Facility: soil contamination was found. An RI/FS is recommended for this site.

Site 13, Storm Drains at the Aerospace Ground Equipment Storage Yard: no soil or groundwater contamination above standards was found. Prepare a no-further-action decision document.

Site 14, Oil Water Separator at Building 82: soil contamination was found. An RI/FS is recommended for this site.

1. INTRODUCTION

1.1 Purpose of Report

The Department of Defense (DOD) has initiated the Installation Restoration Program (IRP) for evaluating suspected problems associated with past waste disposal and spill sites at DOD facilities. As part of this program, the Air National Guard Readiness Center (ANGRC), through Air Force Engineering and Services Center, has entered into an interagency agreement (IAG No. 1489-1489-A1) with the Department of Energy (DOE) under which DOE will provide technical assistance for the implementation of the ANGRC IRP and related activities. Martin Marietta Energy Systems, Inc. (Energy Systems) has been assigned responsibility for managing this effort under the IAG.

This document is the site investigation report (SI) for the 152nd Tactical Reconnaissance Group (TRG), Nevada Air National Guard (NVANG), Reno, Nevada (hereinafter referred to as the Base). The report has been prepared by the Oak Ridge National Laboratory Environmental Technology Section (ORNL/ETS) under agreement with the Hazardous Waste Remedial Actions Program (HAZWRAP) operated by Energy Systems, Inc. in Oak Ridge, Tenn. This report presents the activities and the data gathered during the site investigation.

A preliminary assessment (PA) was completed by Automated Sciences Group, Inc. (ASG 1989). The PA identified seven potentially contaminated sites that were rated using the Hazard Assessment Rating Methodology (HARM). These rated sites required further investigation under the IRP. No additional sites were identified in the PA.

Seven additional sites were identified by Base personnel in May 1991 that had not been rated using HARM. Two of these seven additional sites were reinvestigated under the IRP. The remaining five sites were investigated under the Rapid Response Initiative (RRI) and were not addressed by the SI. The RRI is a program developed by the Air National Guard (ANG) to conduct site assessments, evaluate potential corrective actions, and design selected remedies at leaking underground storage tanks (USTs) and spill sites at ANG facilities. Additionally, investigations at two of seven sites addressed by the PA

(Sites 1 and 6) were performed by the Airport Authority of Washoe County (AAWC) under a memorandum of understanding (MOU) with the ANG.

The overall scope of the SI was to perform a site-wide characterization, taking into account five sites identified in the PA and the two additional sites identified by Base personnel. The objectives of the SI were to identify, verify, and, if necessary, delineate the extent of contamination at past hazardous-waste-disposal and spill areas. The first phase of the IRP performed at the Base was the PA (ASG 1989), which recommended that further IRP investigation be implemented at the seven sites identified in that document. Although not part of the PA, two sites identified by Base personnel were also included for further IRP investigation. The second phase consisted of the SI, which identified the following decision points:

1. develop a plan and implement an immediate response (IR),
2. take no further action and prepare a decision document (DD),
3. initiate a focused feasibility study/remedial measures (FFS/RMs), or
4. proceed with a remedial investigation/feasibility study (RI/FS).

1.2 Report Organization

A complete description of each of the seven sites identified in the PA and the two sites identified by Base personnel is presented. Each site was investigated to determine the nature of potential contamination in the soil and groundwater and to determine if the contaminant levels are harmful to human health and the environment. As part of the SI, data were collected on the site geology and hydrology that were used to determine exposure pathways.

Following the main body of the report are a series of appendices:

- Appendix A: Technical Memoranda on Field Activities
- Appendix B: Monitoring Well/Piezometer/Borehole Records and Casing/Ground Elevation Data
- Appendix C: Hydraulic Testing Data
- Appendix D: Significant Analytical Data
- Appendix E: Quality Control Summary
- Appendix F: Data Validation Report

1.3 Installation Restoration Program Approach

The IRP is an environmental program developed by the DOD. The objectives of the IRP are to:

- identify former waste, spill, storage, and disposal sites;
- evaluate the extent and nature of contamination if present; and
- initiate appropriate remedial action.

Figure 1.1 presents the IRP decision flow chart, which illustrates the components of the IRP and the various decision points that exist. The sections below describe the major components of the IRP.

1.3.1 Site Investigation

The primary objective of the SI is to confirm the existence or absence of suspected contamination at the sites and to determine the public health and environmental

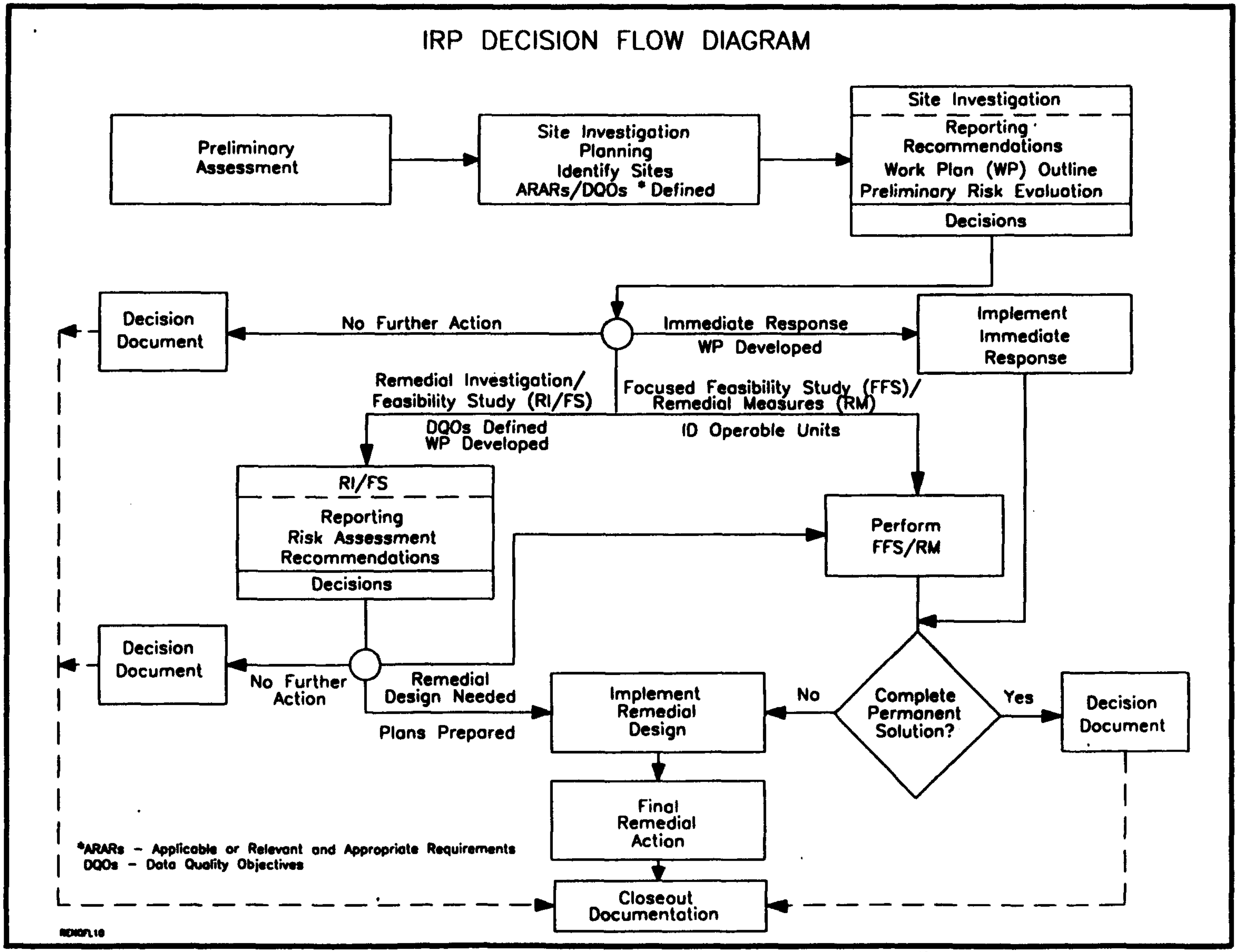

Fig. 1.1. Installation Restoration Program decision flow diagram.

ramifications. Activities include: 1) evaluation of existing reports and data; 2) preparation and implementation of a work plan; 3) collection and verification of geologic, hydrologic, and analytical data; and 4) preparation of an SI report. Also, included are screening, confirmation, and optional activities. Screening activities are conducted to gather preliminary data on each site. Data obtained from the following activities are considered screening data: piezometer installation, stream staff-gauge installation, screened-auger groundwater sample analysis in the field, and soil-sample-headspace analysis in the field. Field screening activities confirm the presence or absence of contamination, identify contaminants of concern, target future confirmation sampling efforts by providing an areal location of contamination, and provide the basic hydrologic data required for further study.

Confirmation activities include specific-media sampling and laboratory analysis to confirm or deny the presence of contamination. Methods used during confirmation activities include surface and subsurface soil sampling and analyses from soil borings, surface-water and sediment sampling and analysis, and monitoring well installation and groundwater sampling. The purpose of confirmation activities is to provide defensible data from which site-specific decisions regarding remediation actions can be made.

The optional activities can be used if additional data are needed to reach a decision point for a site. For example, if additional data are needed to define the extent of soil contamination at a site to meet the needs of an FFS, a Remedial Investigation/Feasibility Study (RI/FS) will be initiated.

1.3.2 Focused Feasibility Study and Remedial Measures

An FFS is a feasibility study of one or more operable units. An operable unit may be a particular medium, such as soil or groundwater, or may be one source, such as a waste lagoon or spill area. The purpose of the FFS is to develop a range of measures that may be employed to remediate contamination at the operable unit. These measures, termed remedial alternatives, are evaluated on technical, cost, and environmental considerations.

The FFS is used to select the most appropriate remedial alternative for an operable unit, to prepare cost estimates, and to initiate the remedial design.

RMs may be taken to alleviate immediate threats to human health or the environment. An RM may be implemented for an operable unit; for example, a waste pile may be covered or fenced in to prevent human contact with hazardous substances. FFSs and RMs may be initiated at any point in the IRP process if the need becomes obvious. FFSs for several operable units may be combined to produce an FS for the entire Base.

1.3.3 Remedial Investigation/Feasibility Study

If the data from the SI indicate an additional need for further study, an RI/FS work plan is prepared to: 1) support additional data-gathering requirements, 2) describe the scope and activities for the baseline risk assessment, and 3) outline the scope and level of the RI report. The RI/FS work plan uses the SI report, the health and safety plan, and the quality assurance project plan to support development and implementation of RI efforts. It incorporates applicable requirements of the U.S. Environmental Protection Agency's (EPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (U.S.EPA 1988a). FS activities are described in the work plan. However, the decision to proceed with the site-specific FS is made during the RI.

The objectives of the RI field program are to: 1) acquire the data necessary to define the spatial distribution and magnitude of environmental contamination identified during the SI; and 2) develop a refined assessment of risks to health, welfare, and the environment associated with the identified contamination. To accomplish these objectives, the RI effort increases the environmental data base established during the SI to define the size and extent of the contamination sources, focusing on areas downgradient of confirmed contamination. If necessary, the RI effort provides characterization of the hydrogeology and potential contamination of any deeper aquifers at the Base and provides an investigation of the nature of groundwater movement within and between shallow and deeper aquifers. Lastly, the RI effort also provides a quantitative risk evaluation.

Upon completion of RI data analysis, an RI report is prepared and submitted to the regulators. The RI report includes a summary and interpretation of data gathered during the RI and a risk evaluation. For each site, one of the following three recommendations is made and supported: 1) take no further action (DD required), 2) initiate preparation of engineering plans and specifications for removal of contamination (IR), or 3) conduct an FS.

The FS incorporates applicable technology review, development of preliminary response objectives, and review of applicable or relevant and appropriate requirements (ARARs), all of which are coordinated with risk assessment and RI report development. These activities support appropriate remedial design, FS, or no further action/monitoring recommendations. FS activity begins during the RI.

1.3.4 Remedial Design/Remedial Action

Remedial design/remedial action (RD/RA) follows the selection of a remedial alternative. The RD, developed on the basis of the FS, is a detailed design of the selected RA and includes all specifications and design drawings. The RD is used to implement the RA.

The RA is the implementation of the remedial alternative selected. This action may include several technologies and may affect one or several media and source areas.

1.3.5 Regulatory Involvement

Throughout all segments of the IRP, the ANGRC attempts to work closely with the EPA and the state regulatory agencies. The IRP encourages the early and continuous participation of federal and state regulatory agencies during meetings and review of work plans and reports. Installations considered for the IRP are prioritized under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) with respect to health risks, hazard levels, and Defense Environmental Restoration Account funding availability.

1.4 Preliminary Remedial Objectives

Preliminary remedial objectives for the Base are evaluated prior to undertaking a FFS/RM. Remedial objectives are warranted if the preliminary qualitative risk evaluation (or subsequent quantitative risk assessment, if conducted) concluded that significant risks to human health and/or the environment are present via one or more pathways. Remedial objectives include source control measures and migration control measures.

2. FACILITY BACKGROUND

2.1 Facility History

Reno Cannon International Airport complex is located approximately 5 miles southeast of downtown Reno, Nev. (Fig. 2.1). The Base presently occupies approximately 60 acres of land in the southern portion of the northwest quadrant of the airport complex and employs 1136 military personnel of which 287 are full-time employees (ASG 1989).

In April 1948, the Base was established as the 192nd Fighter Squadron. This designation was changed to the 192nd Fighter Bomber Squadron in April 1951. The unit was redesignated as the 192nd Fighter Interceptor Squadron in June 1955 and retained this designation until April 1958 when the unit was renamed the 152nd Fighter Group. In February 1961, the 152nd Fighter Group acquired its present designation, the 152nd Tactical Reconnaissance Group (ASG 1989).

Initially, the Base was equipped with P-51 aircraft and was located at the Stead Army Air Base, Reno, Nev. In 1953, the Base leased 29 acres of land at Hubbard Field (Reno Cannon International Airport) from the city of Reno, Nev. Base operations were moved from Stead to their present location in 1954. F-86A aircraft were assigned to the 192nd from 1956 until 1961, when the group converted to the RB-57 aircraft. In 1965, the Base converted from RB-57 to RF-101 aircraft, which were flown until 1975 when the Base converted to the RF-4Cs presently being operated at the Base (ASG 1989).

2.1.1 Previous Investigations

The IRP at the Base was initiated with a PA that was conducted June 6 through June 10, 1988, and reported January 1989 (ASG 1989). Based on the results of the PA, the ANGRC decided that environmental data must be collected to confirm and quantify any contamination that may have an adverse impact on public health or the environment.

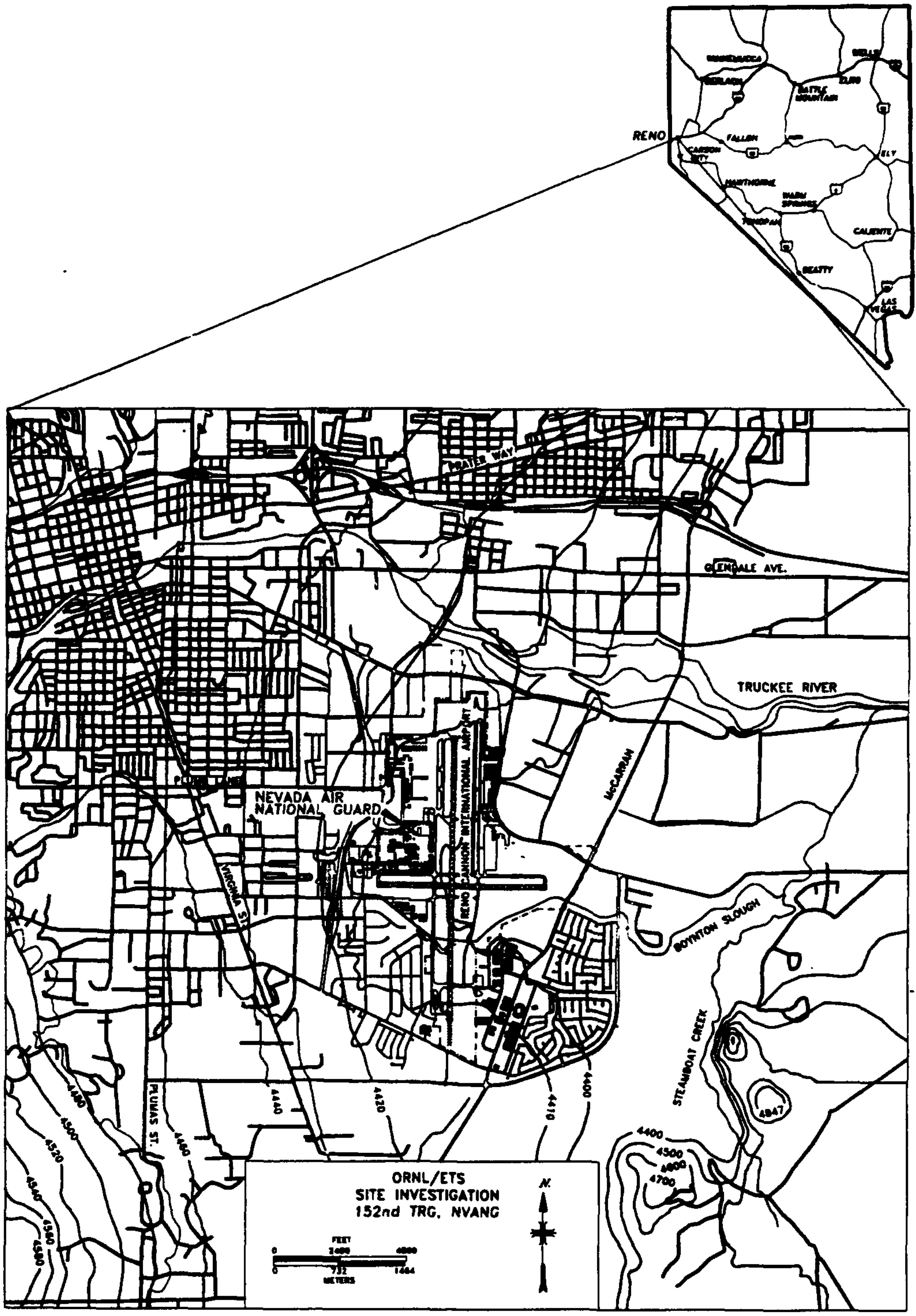

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Fig. 2.1. Location map of Nevada Air National Guard, Reno Cannon International Airport, Reno, Nev.

A kickoff meeting for the SI was held at the site in February 1991 with ANGRC, 152nd TRG, HAZWRAP, and ORNL/ETS personnel in attendance. Representatives from the Federal Facilities Bureau of the Nevada Division of Environmental Protection (NDEP), Washoe County District Health Department (WCDHD), and city of Reno were also present. Environmental information in addition to that presented in the PA report was collected by ORNL/ETS during and after the kickoff meeting, and the investigative approaches to be employed during the SI were determined.

2.2 Site Descriptions

The PA indicates that past waste management and facility operations may have contaminated the surface soils and shallow alluvial aquifer at 7 sites located on the Base and Reno Cannon International Airport property (ASG 1989). These sites, as identified in the PA, are listed below:

- Site 1, Fire Training Area (FTA) No. 1
- Site 2, FTA No. 2
- Site 3, FTA No. 3
- Site 4, FTA No. 4
- Site 5, FTA No. 5
- Site 6, FTA No. 6
- Site 7, Petroleum, Oil, and Lubricant (POL) Storage Facility

As previously discussed, Base personnel identified seven additional sites where past waste management and Base operations may have contaminated surface soils and the shallow alluvial aquifer. These sites are:

- Site 8, 3000-gal Heating Oil Tank No. 76
- Site 9, 1500-gal Heating Oil Tank No. 2

- Site 10, 3000-gal Heating Oil Tank No. 82
- Site 11, 4000-gal Heating Oil Tank No. 84
- Site 12, Fuel Oil Spills on Apron
- Site 13, Storm Drains at the Aerospace Ground Equipment (AGE) Storage Lot
- Site 14, Oil Water Separator (OWS) at Building 82

Sites 8 through 12 were investigated under the RRI and are not addressed by the SI. As previously discussed, Sites 1 and 6 were investigated by the AAWC under an MOU with the ANG and are not addressed by the SI. Therefore, the sites covered by this SI are: Site 2, Site 3, Site 4, Site 5, Site 7, Site 13, and Site 14.

The PA also indicates that there are no active water wells, past or present landfills, radioactive burial sites, or sludge burial sites located on Base property. Drinking water supplies are provided by publicly owned facilities, and the Base sanitary sewage is connected to publicly owned treatment works.

According to the PA, the major Base operations that have used and disposed of hazardous materials include aircraft maintenance, AGE maintenance, ground vehicle maintenance, POL management and distribution, and air weapons control. These operations involve such activities as corrosion control, nondestructive inspection, fuel cell maintenance, hydraulics maintenance, structural repair, and wheel and tire maintenance. Waste oils, recovered fuels, paint wastes, spent cleaners, acids, strippers, and solvents are generated and disposed of by these activities. Table 5 in the PA summarizes the major operations associated with each activity, provides estimates of the quantities of waste generated by these operations, and describes the past and present disposal methods for these wastes.

The location of the sites investigated are shown in Fig. 2.2.

2.2.1 Site 2, FTA No. 2

Site 2 is located on land leased or owned by the Base in an area east of Bldg. 1 and under parking area A2 of the present aircraft parking apron. The Base was the sole

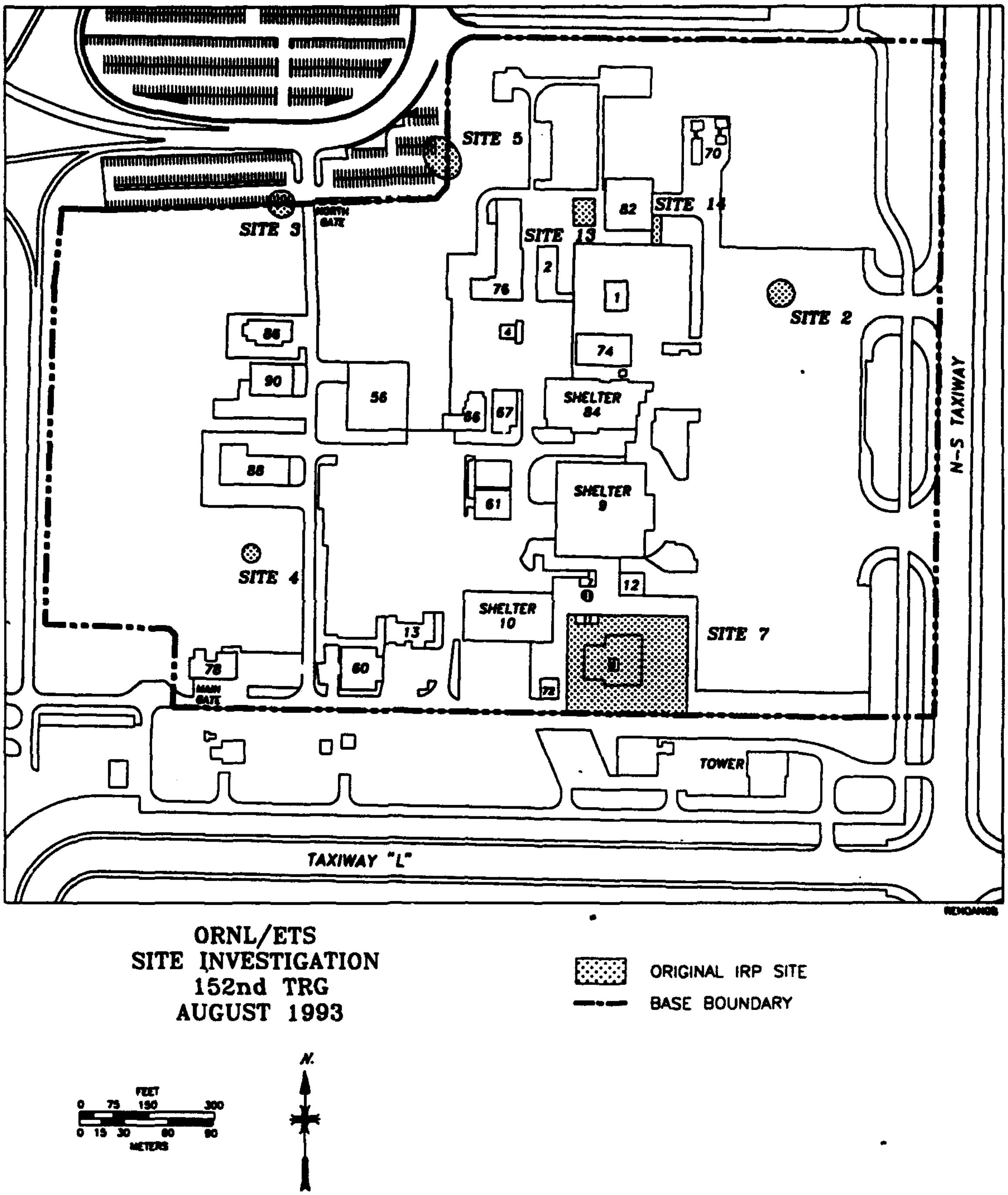


Fig. 2.2. Location of Sites 2, 3, 4, 5, 7, 13, and 14.

operator of this FTA. The training area consisted of an unlined, slightly bermed, open earthen area, with a depth of 12 to 18 in. to contain the flammable liquids used during training.

Spent solvents, waste oils, "slop wastes", and other flammable liquids in addition to JP-4 fuel were the primary fuels burned in the training exercises. A water base was applied to the FTA prior to each burn.

Training was generally performed on an "as needed" basis with an estimated 10 burns per year using 150 gal of flammable liquids per burn. On this basis, it is estimated that 1500 gal/year of flammable liquids were used. Assuming 70% of the flammable liquids released during the training exercises were destroyed, an estimated 450 gal/year remained to evaporate or infiltrate the ground. A potential total of 1800 gal may have infiltrated the ground during the 4-year period that this FTA was in use (ASG 1989).

2.2.2 Site 3, FTA No. 3

Site 3 is located on land previously leased by the Base approximately 50 ft west of the north gate entrance to the Base and under the present AAWC parking lot. In 1985, the Base transferred this portion of land to the AAWC. Thus, this FTA is now off Base property and is under the jurisdictional control of the AAWC. The Base used this FTA between 1964 and 1971 and was the sole operator. This FTA was a flat, slightly bermed, open earthen area, with a depth of 12 in. to contain flammable liquids used during training exercises. Two aircraft and/or mockup models were used as training aids in this area.

Spent solvents, waste oils, "slop wastes", JP-4 fuel, and other flammable liquids were burned during training exercises in this area. During every exercise except one, a water base was applied prior to each burn. During one training exercise in 1971, no water base was applied prior to ignition, resulting in a very poor burn.

Training exercises were conducted on a quarterly basis with multiple burns per exercise. Using two fire training exercises per quarter as a basis and 150 gal of flammable liquids per exercise, twice per day, it is estimated that 2400 gal/year of flammable liquids were used. Assuming 70% of the flammable liquids released during training exercises were destroyed, an estimated 720 gal/year of flammable liquids remained to evaporate or infiltrate the ground. One fire training exercise conducted in 1971 involved 2500 gal of JP-4 fuel with no water base applied to the FTA prior to ignition. The Base Fire Chief estimated that 200 gal of JP-4 fuel infiltrated the ground and was not burned. A potential total of 6300 gal of flammable liquids may have infiltrated the ground during the 6-year period this FTA was in use (ASG 1989).

2.2.3 Site 4, FTA No. 4

Site 4 is located on land leased by the Base south of Bldg. 88 and under the present training field. The Base was the sole operator of this area and used this area in conjunction with Site 5 (FTA No. 5) from 1970 to 1973. FTA No. 4 was a flat, open earthen area, slightly bermed to contain the flammable liquids used during training exercises.

Spent solvents, waste oils, "slop wastes", JP-4 fuel, and other flammable liquids were burned during training exercises in this area. A water base was applied to the FTA prior to each burn.

Training exercises were conducted on an "as needed" basis, estimated at once or twice a year. An estimated 150 gal of flammable liquids per burn were used. On the basis of two burns per year, it is estimated that 300 gal/year of flammable liquids were used. Assuming 70% of the flammable liquids used were destroyed during training exercises, an estimated 90 gal of flammable liquids remained to evaporate or infiltrate the ground. A potential total of 270 gal of flammable liquids may have infiltrated the ground during the 3-year period that this FTA was in use (ASG 1989).

2.2.4 Site 5, FTA No. 5

Site 5 is located between the northwest corner of Bldg. 76 and the southeast corner of the AAWC parking lot on land leased by the Base. The Base was the sole operator of this FTA and used this area in conjunction with Site 4, as described above, from 1970 to 1977. This FTA consisted of a flat, unlined, open earthy area, slightly depressed, and bermed around the edges to contain the flammable liquids used during training exercises. A mock-up model of an aircraft was used during training at this site.

Spent solvents, waste oils, "slop wastes", JP-4 fuel, and other flammable liquids were used during joint training exercises with the AAWC, the Base supplying the flammable liquids for the burns. A water base was applied to the FTA prior to ignition of each burn.

An estimated ten fire training exercises per year were conducted at this FTA. An estimated 150 gal of flammable liquids per burn were used. Using ten burns per year, it is estimated that 1500 gal/year of flammable liquids were used. Assuming that 70% of the flammable liquids released at the FTA were destroyed, an estimated 450 gal/year of flammable liquids remained to evaporate or infiltrate the ground. A potential total of 3200 gal of flammable liquids may have infiltrated the ground during the 7-year period that this FTA was in use (ASG 1989).

2.2.5 Site 7, POL Storage Facility

Site 7 surrounds Bldg. 6 and consists of four 25,000-gal underground storage tanks holding JP-4 fuel for flight line operations and ancillary equipment. These JP-4 fuel tanks have been in the ground for over 30 years (ASG 1989, Appendix F). Visual inspections have been made periodically, the last one in April 1986, to ascertain the condition of these tanks. The inspections revealed medium rusting with light pitting on the interior surfaces of the tanks. These tanks have never been hydraulically static tested for leaks.

Numerous small JP-4 fuel spills have occurred around the refueling stand area of Bldg. 42. Most of the spills occurred between 1973 to 1985 when the fuel trucks were top-loading vehicles. On several occasions, JP-4 fuel spills of up to 1000 gal have occurred in this area. A fuel spill of up to 300 gal occurred in June 1986 when a bottom-loading shutoff valve on a refueling unit failed to operate properly. Other smaller spills of up to

100 gal have occurred during defueling of fuel trucks. Up until the early 1980s, most of these spills were flushed into the soil/graveled areas surrounding the refueling stand (ASG 1989).

2.2.6 Site 13, Storm Drains at the AGE Storage Lot

Although Site 13 was not included in the PA, Base personnel identified the site in May 1991 as a former spill area and possible waste-oil-disposal area. Site 13 includes two storm drains located northeast of the AGE storage lot which is east of Bldg. 2. Both drains are connected to a larger storm drain east of Bldg. 82. The first drain was used as a vehicle wash area for approximately 20 years (1966 to 1986). No estimate of the volume of oil, grease, and hydraulic fluid that may have been washed down this drain is available. Small quantities of oil (5 gal or less) were spilled onto the soil surrounding the second drain on three or four occasions. Additionally, the second drain has received runoff from the AGE storage lot for more than 20 years. An estimate of the volume of oil and other wastes that may have reached this drain is unavailable. Base personnel have indicated that the soil surrounding the drain may have absorbed much of the wastes. No visible stained area or obvious contamination is present today. According to Base personnel, both drains are still functional and have not been used for waste disposal and vehicle washing since 1986.

2.2.7 Site 14, OWS at Building 82

Although Site 14 was not included in the PA, Base personnel discovered the spill area in May 1991 when the 1,000-gal OWS adjacent to Bldg. 82 exceeded its holding capacity, causing the trough system to back up and overflow. Site 14 consists of an unprotected soil area at the southeast corner of Bldg. 82 that receives the overflow, which is JP-4 fuel. Base personnel estimate that approximately 25 to 50 gal have spilled onto the soil area once or twice a year since 1975. Consequently, as much as 1600 gal of JP-4 fuel may have reached the soil area.

3. ENVIRONMENTAL SETTING

The environmental setting at the Reno Cannon International Airport is presented here to establish a reference for describing site-specific work performed during this investigation.

3.1 Meteorology

The annual mean temperature for Reno, Nev., is 49.9 °F with a maximum monthly average of 91.3 °F occurring in July and a minimum monthly average of 18.9 °F occurring in December. The average daily temperature change is 35 °F with a maximum daily temperature change of 43.5 °F occurring in July and August (ASG 1989).

National Oceanic and Atmospheric Administration Station No. 26-6779, located at Reno Cannon International Airport, records an average annual precipitation of 7.49 in. for the Reno area. According to the *Water Atlas of the United States* Plate 12, the average annual evaporation from open water surfaces is 43 in. (ASG 1989). Using the method outlined in the *Federal Register* (47 FR 31224, July 1982), the annual net precipitation for the Base is -35.51 in. (ASG 1989). Rainfall intensity based on the 1-year, 24-h rainfall is calculated to be 1.5 in. (ASG 1989).

3.2 Geology

The majority of the information presented in the following sections was obtained from Cohen and Loeltz (1964), Bingler (1975), and the PA (ASG 1989), which contains information derived from the Nevada Bureau of Mines and Geology Report #25 (Bateman and Sheibach 1975).

The average elevation of the Base is 4400 ft above mean sea level (amsl). The area around Truckee Meadows is generally flat with a gentle slope to the west, although topographic relief is substantial in the surrounding mountain ranges (ASG 1989).

Geologic maps of the Reno and Mt. Rose quadrangles show that the northern portion of the Base lies on a Quaternary deposit termed "floodplain and lacustrine deposits" consisting of interbedded gray to pale grayish-yellow silt and fine-grained sand with thin lenses of peat. These are fluvial and lacustrine deposits up to 23 ft thick with little or no soil development (entisol) (Bonham and Rogers 1983). The southern portion of the airfield is underlain by deposits known as "alluvial Bajada deposits" consisting of thin, sheet-like aprons of fine- to medium-grained sand with intercalated muddy, medium-pebble gravel. These deposits result from low gradient streams that have reworked older gravelly outwash and alluvial fan deposits. They are weakly weathered and largely undissected, with little or no soil development (entisol) (Bonham and Rogers 1983). A generalized stratigraphy underlying the Base is presented in Table 3.1.

The general geology of the Reno area, shown in Fig. 3.1, consists of a north-trending basin known as the Truckee Meadows. This basin is located at the western margin of the Basin and Range physiographic province just east of the Sierra Nevada. Bingler (1975) describes the Truckee Meadows as a structural depression (graben) bounded on the west by the Carson Range, the Virginia Range on the east, Steamboat Hills to the south, and the eastern part of the Peavine Mountain block to the north. These marginal blocks consist of Mesozoic metavolcanic and plutonic rocks overlain by a thick sequence of Tertiary volcanic and epiclastic rocks. The Tertiary rocks are predominantly andesite and andesite porphyry flow rock, hypabyssal intrusives, and minor siliceous welded tuff, which are commonly represented by the Kate Peak and Alta Formations. The foothill and mountain drainages that rim the basin contain large exposures of altered volcanic rock. Along the western margin of the basin and to the north and west along the Truckee River drainage basin, tilted beds of Miocene to upper Pliocene Hunter Creek Sandstone (composed of conglomerate, sandstone, and diatomite) are exposed, marking the start of

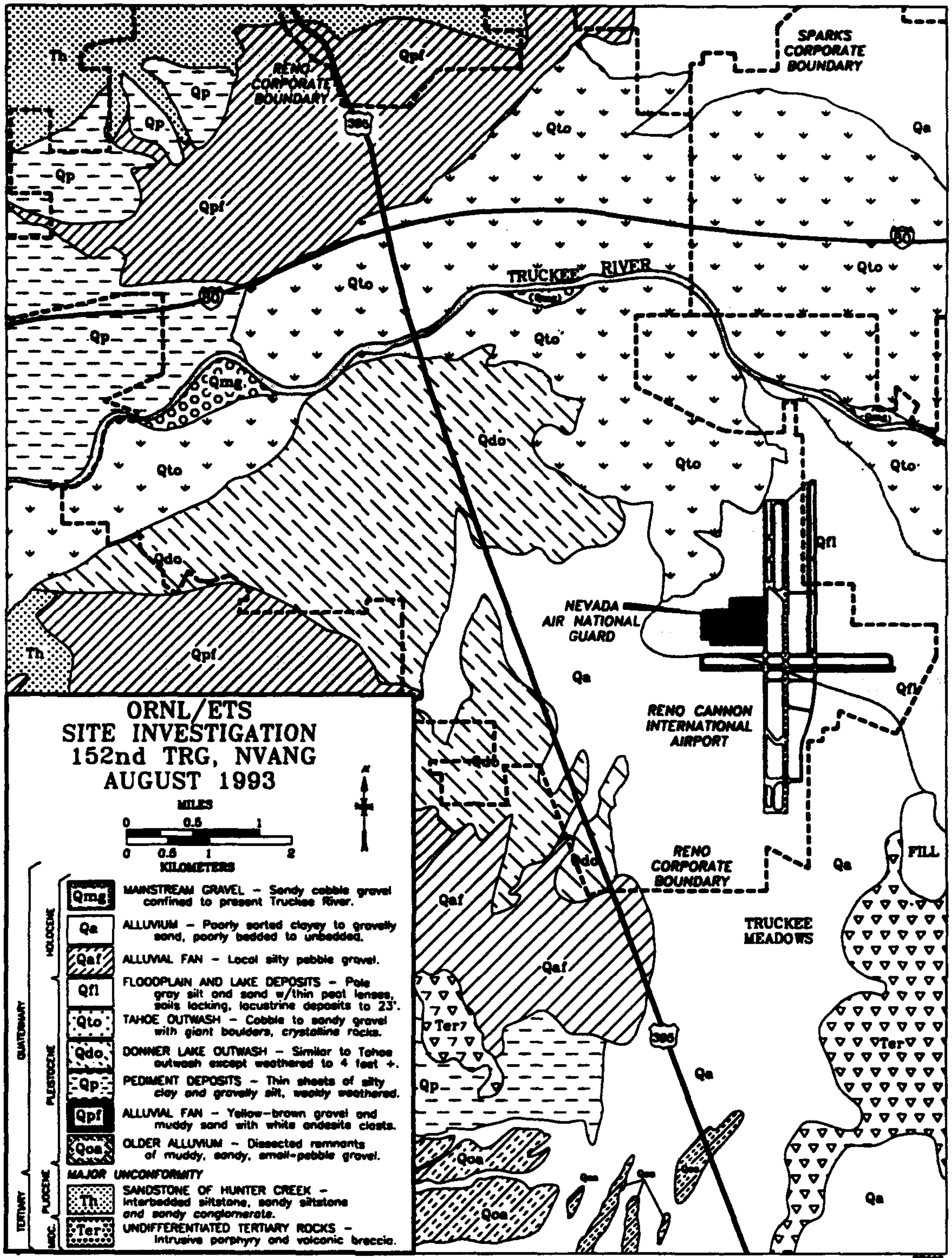
Table 3.1. Generalized stratigraphy underlying the Base

Lithology[a]	Thickness, ft	Depth from surface to bottom of layer, ft
Sandy clay	18	18
Sand[b]	8	26
Clay	8	34
Sand[b]	9	43
Clay	16	59
Sand and gravel[c]	8	67

[a] The lithology presented in this table is a composite of two well logs located within 3000 ft south of the Base. The well logs were obtained from the state of Nevada's Division of Water Resources in Carson City, Nev. The above table was modified from Table 2 presented in the preliminary assessment (ASG 1989).

[b] Water-bearing layer.

[c] Main water-bearing layer.



SOURCE: MODIFIED FROM BONHAM & BINGLER, 1973; BONHAM & ROGERS, 1983

Fig. 3.1. Geologic map of the Reno, Nev., area.

early basin-sediment accumulation. The continuation of long-established patterns of basin-sediment accumulation is represented by the extensive Quaternary deposits exposed in the Truckee Meadows. A generalized stratigraphic column of the Truckee Meadows and surrounding area is presented in Table 3.2.

Bingler (1975) divided the Quaternary deposits into three major categories:

1. main stream gravel deposits of the Truckee River represented by bouldery outwash from glacial activity,
2. a long and complex history of alluvial fan deposition along the margins of the Truckee Meadows that extends in time from the Pleistocene into the Holocene,
3. reworked older deposits and deposition of fine-grained clastic debris throughout the central part of the Truckee Meadows by low gradient streams during the Holocene and continuing into the present.

Geothermal activity in Truckee Meadows is found in two major areas known as Steamboat Springs and Moana. These activities are theorized to be due to the cooling of an intrusive body at depth that may be connected to groundwater resources throughout fault systems near these areas. Geothermal activity has a profound effect on groundwater chemistry by means of hydrothermal alteration of volcanic rocks underlying Truckee Meadows.

3.3 Soils

The locations of the two general soil types are found at the Base are shown in Fig. 3.2. The following abbreviated soil descriptions were derived from the *Soil Survey of Washoe County, Nevada, South Part* (Baumer 1983). The Truckee sandy loam, gravelly substratum covers the northern half of the airport and all of the Base property (Baumer 1983, Map Index No. 805). This very deep, somewhat poorly drained soil is on flood

Table 3.2. Generalized stratigraphy for the Truckee Meadows and surrounding area

Age	Deposit/Formation	Lithologic description
QUATERNARY	Floodplain & lake deposits (Qfl)	Qfl: thin sheet of medium- to thin-bedded clayey silt and sand with discontinuous layers of silt and peat.
	Alluvial Bajada deposits (Qa)	Qa: Poorly sorted thin, sheet-like aprons of clayey to silty gravelly sand, poorly bedded.
	Tahoe Outwash (Qto)	Qto: Glacial outwash stream deposits of volcanic and granitic composition. Boulder to cobble gravel, sandy gravel, and gravelly sand.
	Donner Lake Outwash (Qdo)	Qdo: Deposits similar to Qto except weathered to depths of 4 ft or more.
TERTIARY	Sandstone of Hunter Creek (Th)	Th: Pale brown to gray brown and greenish brown, predominantly bedded interlayered siltstone, silty sandstone, and sandy conglomerate. Some areas are white to yellowish-white diatomite and diatomaceous sandstone.
	Kate Peak Formation (Tk)	Tk: Gray, porphyritic, hornblende-biotite andesite flow containing phenocrysts of plagioclase, biotite, and hornblende. Sometimes occurs as an intrusive rock.
	Alta Formation (Ta)	Ta: Dark-brown pyroxene andesite flows, flow breccia, and laharic breccia. Commonly altered tan rock composed of quartz, sericite, and clay minerals. Hydrothermally altered to gray-green rock containing chlorite, calcite, albite, epidote, and clay minerals.

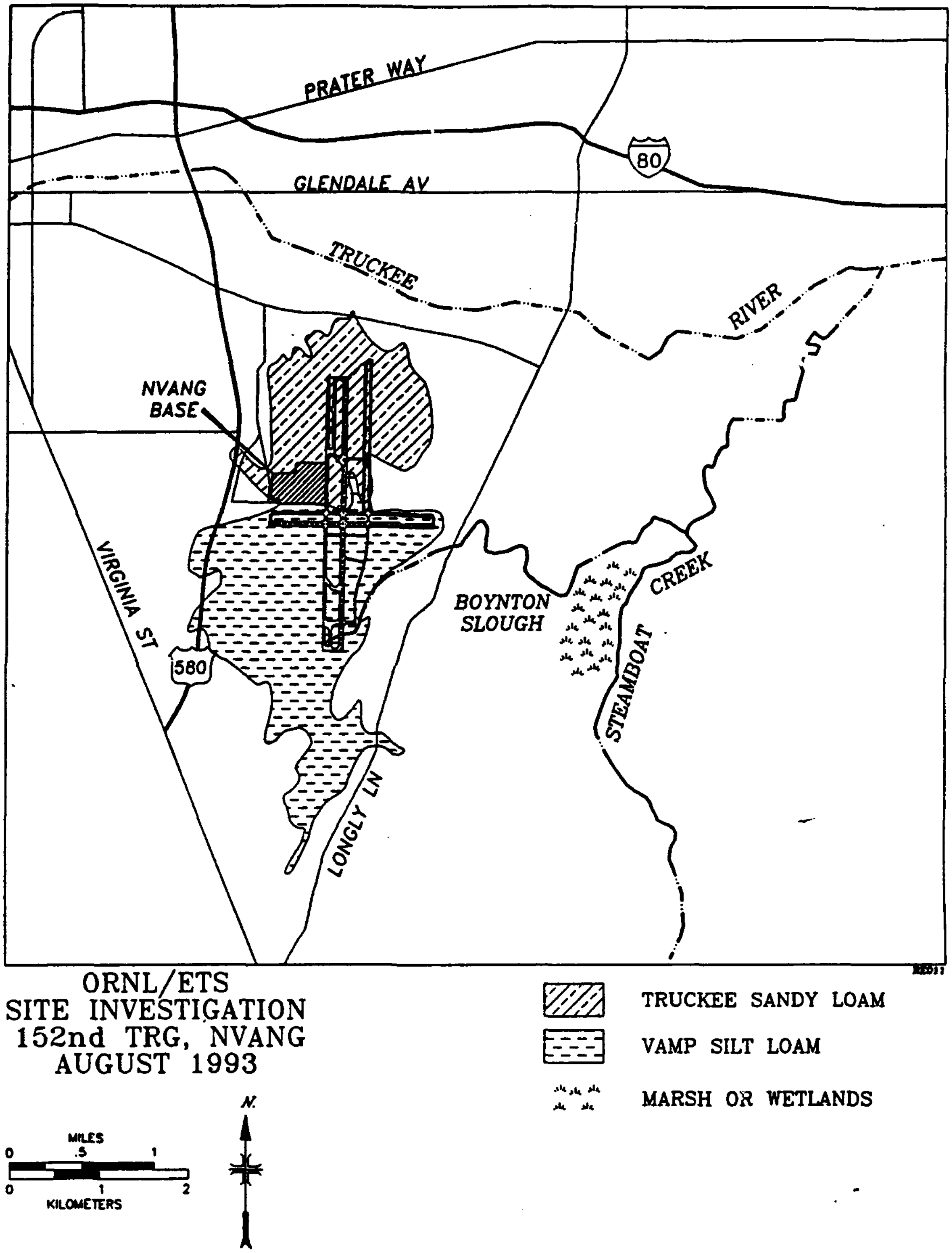


Fig. 3.2. Generalized soils map for the Base.

plains and is formed in alluvium derived from mixed rock sources. Typically, the surface layer is gray sandy loam about 12 in. thick. The upper 18 in. of the underlying material is gray, stratified sandy loam through silty clay loam. The lower part, to a depth of 60 in., is a pale-brown, stratified gravelly sand through very gravelly sandy loam. Depth to the gravelly material ranges from 30 to 40 in. Permeability of the Truckee soil is moderately slow in the upper part of the underlying material and rapid in the lower part. The Vamp silt loam, strongly saline-alkali, covers the southern half of the airport and adjacent areas (Baumer 1983, Map Index No. 911). This is a moderately deep, somewhat poorly drained soil found on flood plains and terraces that is formed in alluvium derived from mixed rock sources. Typically, the surface layer is grayish-brown silt loam about 3 in. thick. Below this is a layer of light grayish-brown and pale-brown, stratified, fine sandy loam and loam about 33 in. thick. The next layer is white, strongly-cemented hardpan about 6 in. thick that is underlain to a depth of 60 in. by yellowish-brown and light olive-gray, stratified loam, sandy loam, and loamy sand. Depth to the hardpan ranges from 20 to 40 in. Permeability of the Vamp soil is moderate. A seasonal high water table is at depth of 30 to 40 in. in spring and early summer.

Channeling and deposition are common along stream banks in both soil units. The risk of corrosion is high for uncoated steel and concrete structures because both soil units are strongly saline and alkaline-affected. Both soil units are subject to seasonal flooding that has been controlled around the Base by deepened drainage ditches. The main limitation to use of the Truckee soil unit for septic tank absorption fields is the moderately slow permeability in the upper part of the stratum. Both of the soil units are also susceptible to frost heaving, a limiting factor in their use for roads, which require drainage provisions and the addition of suitable material for an adequate wearing surface.

3.4 Hydrology

3.4.1 Surface Water

Surface water around the Base occurs in both open and covered drainage ditches. Irrigation ditches fed by diversion dams on the Truckee River pass by the Base just east of the airfield. There are drainage ditches along the north and south sides of the Base (Fig. 3.3) that conduct water to the east, across the airfield, and into Boynton Slough, which drains into Steamboat Creek (ASG 1989).

The Truckee Meadows is drained by the Truckee River, which flows from west to east through the meadows (Fig. 3.4) The Base lies 1.5 miles south of the river channel at its closest point. Steamboat Creek, the major tributary to the Truckee River within the Meadows, enters the Meadows through Pleasant Valley to the south and flows north to the Truckee River. Other streams in this area flow mainly during spring run off (ASG 1989).

The Truckee River supplies 85% (68,000 acre-ft) of the water used in the Reno-Sparks area. The remaining water demand (12,000 acre-ft) is supplied by several wells in the Truckee Meadows (ASG 1989).

3.4.2 Groundwater

The potentiometric surface at the base can be as high as 3 ft below the land surface. The fine-grained nature of the upper sediments compared with the more permeable lower sediments may result in confined conditions across the base. The proximity of the groundwater surface to the land surface is due to the area's function as a groundwater discharge point for the Truckee Meadows. Much of the Base and airport lie on former swampland that was filled in and drained with ditches that receive the current groundwater discharge. Cohen and Loeltz (1964) estimated the total groundwater discharge into the drainage ditches, drains, and sloughs east of the airport to be 6500 acre-ft per year (acre-ft/year)

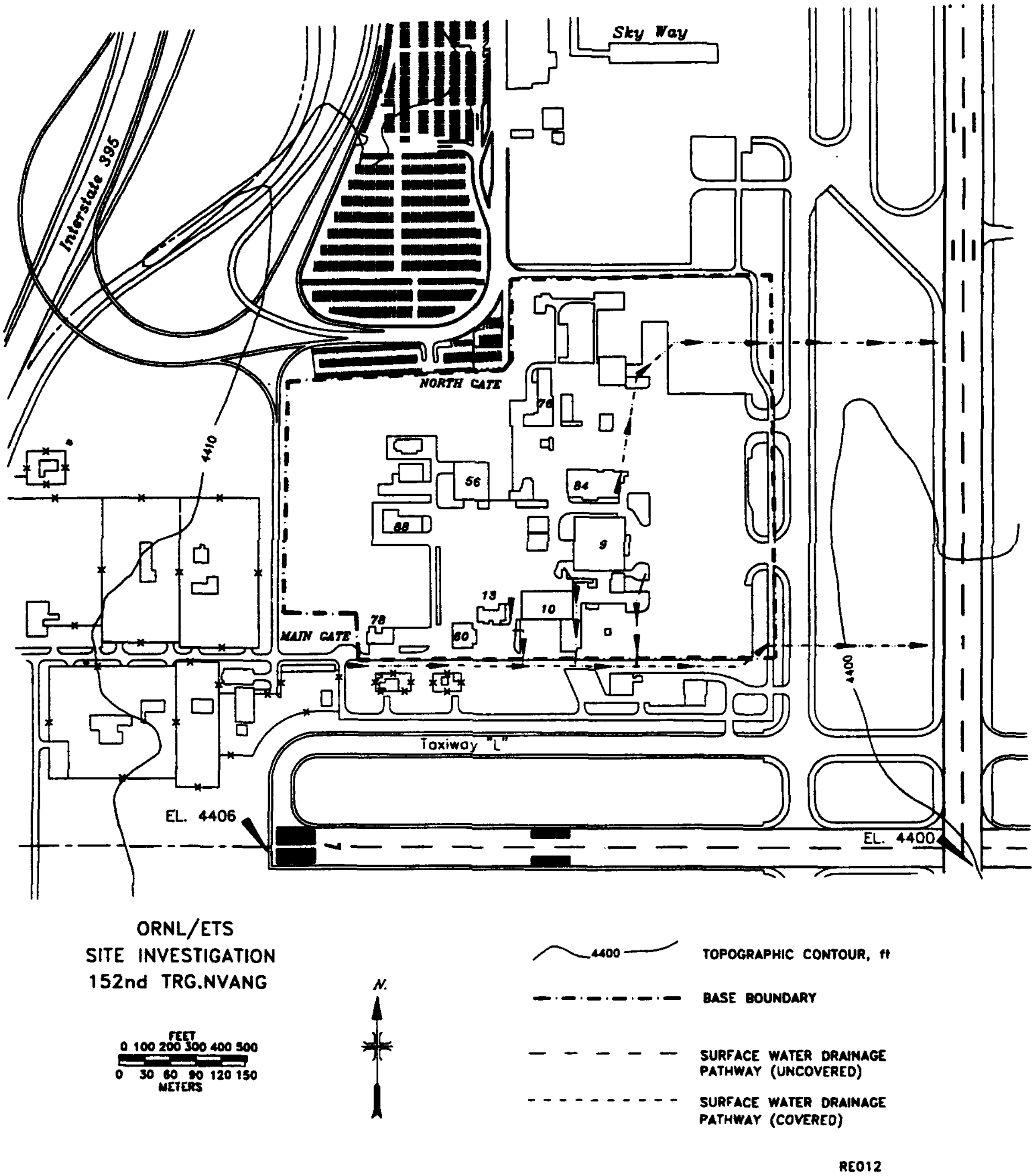


Fig. 3.3. Surface water drainage map for the Base.

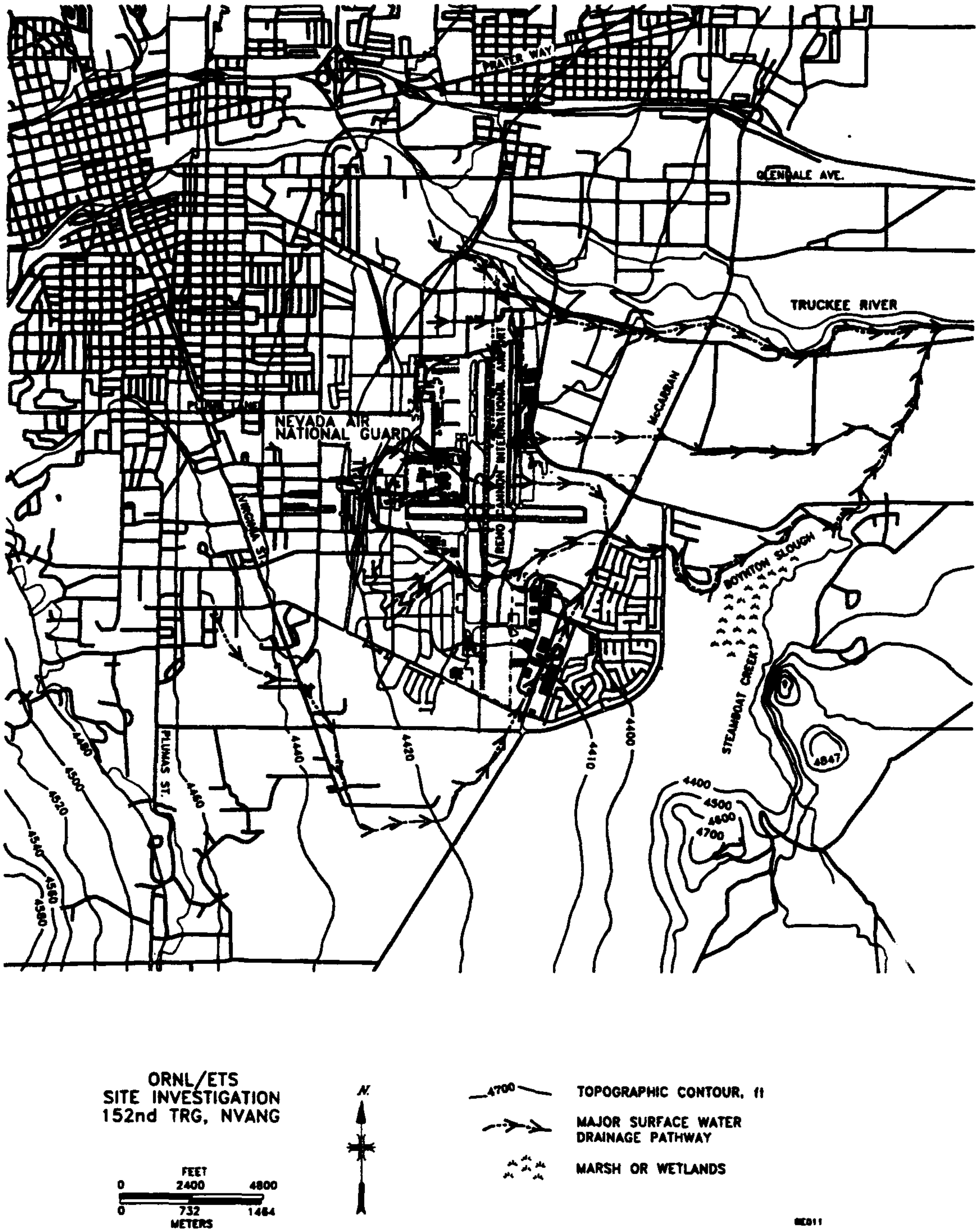


Fig. 3.4. Surface water drainage map for the Reno, Nev., area.

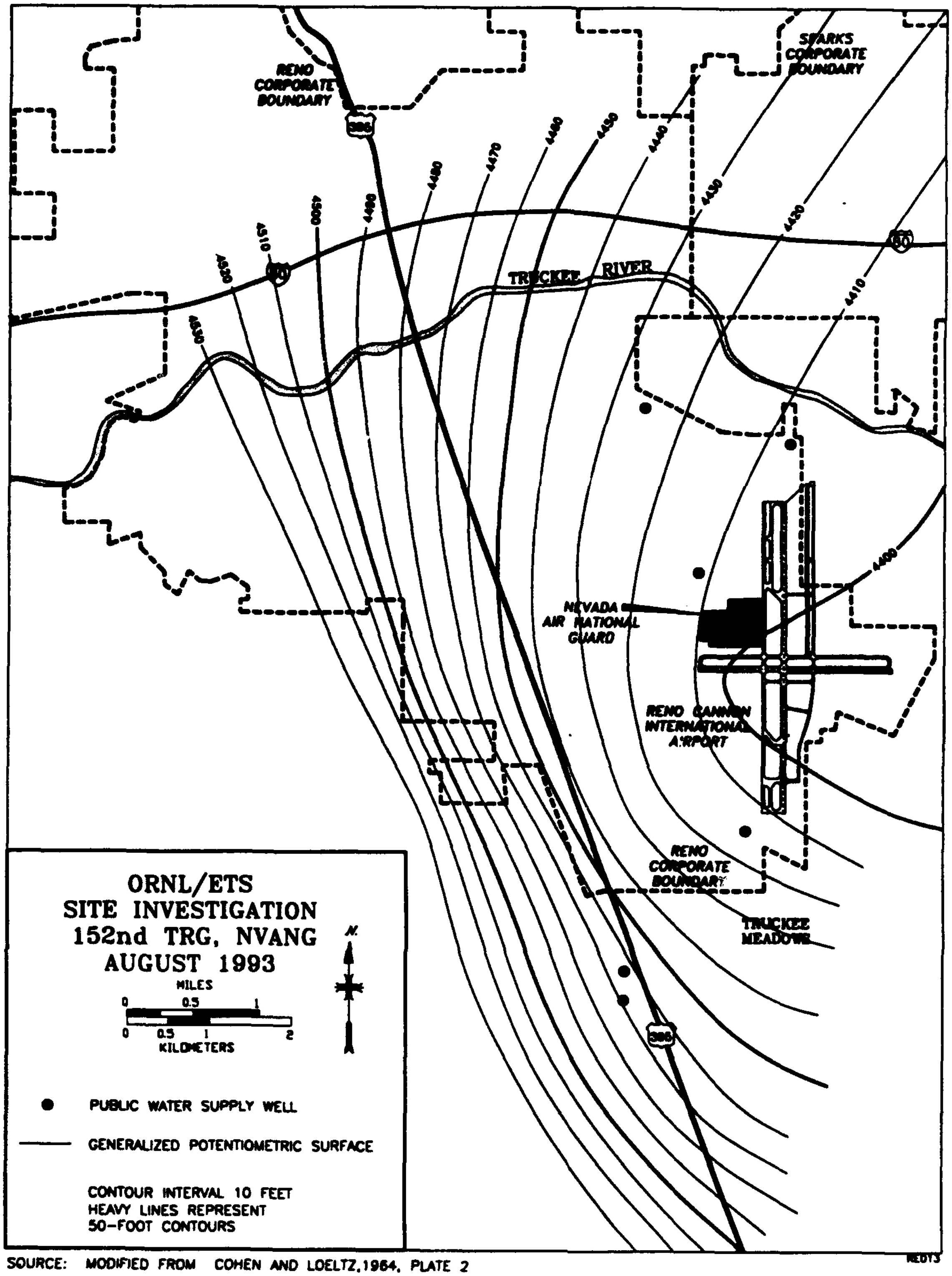
with an additional 2200 acre-ft/year discharged to drains immediately north of the airfield. Today, the only remaining swamp-land, located east of the Base, is found south of the confluence of Boynton Slough and Steamboat Creek.

Groundwater in the Truckee Meadows occurs under both artesian and water table conditions in the unconsolidated and partially consolidated younger and older alluvium of the valley fill. Artesian heads in the meadows area commonly are less than 20 ft above the land surface (Cohen and Loeltz 1964). Depths to the groundwater vary considerably due to the intertonguing nature of the valley-fill deposits. Several public water-supply wells located in the meadows are screened at depths ranging from 274 to more than 800 ft (Fig. 3.5). Commonly, wells located several yards apart will tap water bearing deposits at different depths. This trend becomes more pronounced in the area of the Truckee River where channel shifts have left discontinuous and sinuous gravels (ASG 1989).

Review of Nevada Department of Water Resources drilling records, stored by the United States Geological Survey Water Resources Division in Carson City, Nevada, indicate that there are 90 monitoring wells within a 1-mile radius of the NVANG. None of these wells are considered private supply wells as they are less than 30 ft deep and constructed as monitoring wells related to environmental site assessments in the airport area. Because shallow groundwater in this area is not used for drinking water due to high concentrations of naturally occurring inorganic compounds, there are no known private drinking water wells near the NVANG.

Cohen and Loeltz (1964) suggest that 70% of the recharge to the groundwater in the Truckee Meadows is from infiltration by crop irrigation practices and 30% can be attributed to the infiltration of streamflow and underflow from tributary valleys. Increasing urbanization in the meadows, however, has decreased the use of crop irrigation, thus, decreasing the rate of recharge and consequently lowering water levels. The state engineer's office in Carson City estimates the present annual groundwater recharge to the Truckee Meadows at 20,000 to 25,000 acre-ft.

Basic groundwater flow gradients and flow direction in the Truckee Meadows and vicinity of the Base are illustrated in Fig. 3.5.



SOURCE: MODIFIED FROM COHEN AND LOELTZ, 1964, PLATE 2

Fig. 3.5. Potentiometric map of the Reno area.

4. FIELD PROGRAM

4.1 Summary

This section describes the activities conducted for site investigations at the Base. The results of these investigations are presented and discussed in Sect. 5. A summary of the field activities and dates is provided in Table 4.1.

Field investigations at each site were performed as two activities. First, the field-screening activities were designed to gather preliminary information regarding the nature and extent of contamination at each site. The screening data were used to develop a detailed plan for the second activity: confirmation and delineation. The latter activities were designed to confirm the information gained during the field-screening activities and to provide data of sufficient quality to support recommendations for additional activities or recommendations for no further action. Field activities at each site consisted of the following:

1. groundwater screening: field screening to delineate the areas most likely to contain residual wastes,
2. piezometer installation: field screening to determine the direction of groundwater flow for the proper placement of monitoring wells,
3. soil borings: to obtain soil samples at various depths for field screening with field analytical instruments and for shipment to an analytical laboratory for confirmation analyses,
4. monitoring well construction: to obtain groundwater samples for shipment to an analytical laboratory for confirmation analyses.

In addition to the above activities, the following were conducted at specific sites listed below:

1. sediment/surface water sampling: to obtain background and base wide data on sediments and surface water from drainage ditches at the Base,

Table 4.1. Summary of field activities during site investigation

Activity	Dates
Groundwater screening & monitoring	Sep. 8 to 21, 1992 Oct. 5 to 15, 1992 Nov. 5 to 10, 1992
Piezometer installation	Oct. 16 to 22, 1992
Surveying and mapping	Nov. 2 to 4, 1992 Dec. 1 to 8, 1992
Monitoring well installation	Nov. 10 to Dec 3, 1992
Soil boring/soil sampling	Dec. 2 to 6, 1992
Monitoring well development	Nov. 17 to 25, 1992 Nov. 29 to Dec. 4, 1992
Groundwater sampling	Dec. 3 to 8, 1992 Mar. 3 to 8, 1993

2. single well pumping tests: to obtain hydraulic conductivity data across the Base. A total of six single tests were performed.

In general, field activities were carried out as described in the work plan. Deviations from the work plan are presented in Sect. 4.4.

4.2 Geologic and Hydrologic Investigations

The various techniques used to determine geologic and hydrologic conditions consisted of the field screening and confirmation activities previously discussed. Specifically, piezometers, soil borings, and monitoring wells were used to determine the geology and hydrogeology at the Base. A piezometer network was installed to determine the groundwater-flow direction. Soil borings were used to determine lithologic properties and obtain analytical data on the soil matrix. Monitoring wells were installed to obtain groundwater quality information, enhance flow directions information, and obtain hydraulic conductivity data. A description of each of these techniques is presented in Sect. 4.5 and Sect. 4.6.

4.3 Background

Background conditions at the Base were determined through the use of screening and confirmation activities. Regional groundwater information was used to determine the upgradient boundary of the Base. Field-screening activities such as the groundwater screening method (GSM) and piezometer installations were used to assess background groundwater quality and general groundwater-flow directions. These screening data were then used to locate two background soil borings that were subsequently completed as monitoring wells. Additionally, background sediment samples and a surface water sample were collected from ditches.

4.4 Deviations from the Work Plan

Significant base-wide deviations from the work plan are summarized below. Relevant field change forms are presented in Appendix A.

1. The investigations of Sites 1 and 6 were performed by the AAWC under a MOU with the ANGRC. Therefore, none of the activities described in the work plan were performed at these sites by ORNL/ETS.
2. Refinements in the GSM allowed the 4-in. screened augers to be replaced with a 1-in.-diameter hollow drill steel probe equipped with disposable steel points. This allowed the collection of groundwater samples for headspace screening directly into the sample bottle with a Waterra foot valve and eliminated pouring the sample from the augers. The net result is less volatilization of groundwater samples and no generation of auger cuttings.
3. Due to the extensive GSM survey performed at each site before piezometer construction, screening of groundwater samples during piezometer installation was not required. The work plan had called for the installation of piezometers as the first screening activity, but the order was changed so that GSM surveys were performed first. This allowed for the location of piezometers outside areas of suspected contamination.
4. Collection of rinsate blanks was changed from daily collection to 10% of the total samples. This change resulted from changes made to HAZWRAP guidelines regarding the collection of rinsate blanks (HAZWRAP 1990).

4.5 Field Screening Activities

4.5.1 Groundwater Screening Method

The GSM was the first screening tool used at the Base to aid in the characterization of contamination. This type of screening is very useful as a qualitative tool to determine the presence and extent of contamination by volatile organic compounds (VOCs). GSM data can then be used in effectively locating soil borings, piezometers, and monitoring wells.

The first step in the GSM survey was the establishment of a grid system over each site and along the upgradient edge of the Base. Grid spacings varied from 25 to 100 ft depending on the size of the site. Each grid was laid out with a measuring tape and a compass and each grid node was marked with a wooden stake or fluorescent orange paint. At least one point on the grid was surveyed so the grid could be tied into the Base map. Final utility clearance was provided by Base personnel before any sampling occurred.

The GSM procedure consists of hydraulically driven, 1-in.-outside-diameter (OD) hollow drill steel probes equipped with disposable steel points. The probes were pushed and/or hammered to penetrate the top foot of the water table aquifer that ranges in depth from 3 to 9 ft below ground surface (bgs). The probe assembly was then retracted approximately 1 ft to disengage the drive point and allow fluid to flow into the hollow drill steel probe. Then a ⅝-in-diameter, stainless steel, Waterra foot valve on the end of polyethylene tubing was lowered through the hollow probes to collect a water sample. The foot valve, which works on a ball cock mechanism similar to a bailer, was activated through and oscillating up-and-down movement of the tubing at the surface. Within several minutes, water reached the surface and was collected into 40-mL septum vials for headspace analysis with a field gas chromatograph (GC). Due to the heterogeneity of the sediments and the varying amounts of fill present at the Base, the time required for a GSM boring to fill with groundwater varied from several minutes to 12 h. In the latter case, the probes were left in the hole overnight so that water could seep into the annulus.

After collection, the samples were analyzed with a Photovac model 10S50 GC equipped with a CapSil 5CB (0.52 mm inner diameter (ID) × 10 m) capillary column. The detector was a 10.6 eV photoionization detector that is sensitive to a wide range of volatile organic compounds. The carrier gas used was ultra-pure, zero-grade air. All samples were analyzed on the day of collection, usually within 4 h.

The GC was initially calibrated by injecting three different volumes of a known standard. The standard was a commercially available mixture of benzene, toluene, ethylbenzene, *o*-xylene, *m*-xylene, *p*-xylene, 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), 1,1,1-trichloroethane (1,1,1-TCA), and trichloroethene (TCE). The standard was certified by the manufacturer to contain 1 part per million (ppm) of each constituent. Therefore, injecting different volumes of the same standard produced a mass-based calibration curve. After the initial calibration, the instrument was calibrated daily with standard injections at only one volume. All sample runs were bracketed by standard injections. Routine start-up procedures included warming up of the instrument and running syringe blanks to gauge instrument stability, carrier gas flow, and column contamination.

Headspace sample collection from the 40-mL vial containing the groundwater sample was performed in several steps. First, the vial was shaken vigorously for several minutes so that volatile compounds in the water could partition into the headspace of the vial. A 10 or 50 µL syringe was then used to collect the headspace sample and inject it into the GC.

Sample chromatograms were compared with standard chromatograms that bracketed the run. Compound identification, by comparison of the relative retention times between the sample and the standards proved to be a very inexact procedure with tenuous results at best. This was primarily because of the relatively high number of unknown compounds for which no standards were available. In very few cases was compound identification made with any degree of certainty. Therefore, rather than incorrectly identify compounds and calculate meaningless concentrations, a different approach was taken. The chromatographic data was used as a measure of relative contamination, and a system designed to categorize the data as positive or negative was devised. Essentially, a "negative" GC decision was assigned to GC data with little or no evidence of contamination. A "positive" GC decision was assigned when obvious or moderate evidence of contamination was found. Additionally, an HNU model 101 photoionization detector (PID) was used to screen the GSM open boreholes for VOCs. Using the GC and PID information, suspected areas of soil and groundwater contamination were delineated for further characterization by the confirmation activities. Thus, the main objective of the GSM survey, which was to determine areas of potential contamination, was accomplished in spite of the difficulties with the GC analysis. A summary of the GSM results appear in the site-specific discussions in Sect. 5.

4.5.2 Piezometers

The direction of groundwater flow at the Base and at each site was evaluated through the installation of a temporary piezometer network during screening activities. Five piezometers were installed at various points on the Base and were used with 15 additional site-specific piezometers to capture groundwater flow direction and gradient information.

Hollow stem auger drilling methods were used to drill 8-in.-diameter boreholes for piezometer installation. During drilling, auger cuttings were screened with an HNU model 101 to determine the appropriate disposal practice for the soil. Approximately 10 ft of precleaned, 1.66-in.-OD schedule 40 polyvinyl chloride (PVC) riser casing was attached to a 5-ft length of 0.010-in. slotted screen and inserted into the hollow stem augers. Screened intervals were sand packed with 12/20 grade silica sand to 24 in. above the uppermost screen slot and sealed with 24 in. of bentonite. All annular materials were added through the augers. The augers were then removed from the boring and the remaining annular space backfilled with native cuttings to approximately 12 in. bgs. The PVC risers were covered with slip-on PVC caps and finished with ground-level, 6-in.- diameter, traffic-rated vaults. In undeveloped areas, a concrete apron was installed around the vault to provide mechanical stability and prevent surface infiltration. An elevational and locational survey of the piezometer casings was performed by ORNL/ETS personnel. Static water levels were recorded, and the piezometric surface of the water table aquifer was determined.

Although lithologic sampling was not performed during piezometer drilling, a construction record for each piezometer is presented in Appendix B.

The temporary piezometers were abandoned in April 1993 according to NDEP protocols.

4.6 Confirmation Activities

4.6.1 Soil Borings

Soil borings were drilled to collect soil samples for confirmation chemical analysis from each site under investigation. Additionally, soil samples were collected from two background borings that were subsequently completed as monitoring wells. The borings were drilled and sampled to the top of the water table in order to evaluate the extent of contamination in the soil. The location and number of borings were determined by analyzing data from the GSM survey. The borings were placed to intercept the areas of highest suspected contamination as well as peripheral areas of potential contamination. The results of soil-screening activities are discussed in Sects. 5.2 through 5.9.

The borings were drilled using a hollow stem auger method. Generally, a 6-in. boring was drilled and soil samples collected with a 30 × 3-in.-OD moss sampler equipped with five 6-in. brass sleeves. Upon removal from the borehole, soil samples were screened in the sleeves for VOCs with an HNU PID by separating the sleeves enough to insert the HNU probe between the sleeves. The sample sleeve exhibiting the highest VOC concentrations was then capped with Teflon®-lined plastic caps, sealed with silicone tape, and placed in a cooler with Blue Ice to be shipped to an analytical laboratory. Soil from the adjacent sleeve was then placed in a 40-mL vial with approximately 10 mL of deionized water and submitted for headspace screening by the field GC. If visible contamination was evident, GC screening was omitted to prevent gross column contamination. The fifth or uppermost sleeve was always discarded since it represented potential slough material. The remaining sleeves were used for lithologic evaluation. If results of the GC screening did not suggest the presence of VOCs, sample selection criteria for confirmation analysis were based on the depth of the sample relative to the depth of the water table. Generally, three samples from each boring were submitted for confirmation analyses.

Table 4.2 summarizes the analytical sampling performed during the entire investigation. Included are the analytical methods used, the number and types of samples collected at each site, associated quality assurance/quality control (QA/QC) samples, and total samples by matrix.

The GC instrument and protocols used for headspace screening were the same as those used for the GSM survey described in Sect. 4.5.1. As with the GC data collected during the GSM survey, the identification of compounds from the sample chromatograms proved tentative at best. In some cases, certain compounds were identified with relative certainty. Results of the headspace screening data are presented in Sect. 5.

Lithologic logs and observations for each soil boring were recorded by the ORNL/ETS geologist and are presented in Appendix B.

4.6.2 Monitoring Wells

The bulk of the confirmation activities consisted of monitoring well installations in the water table aquifer. Background or baseline characteristics for groundwater quality were established with the installation of two background monitoring wells along the west Six of the seven sites under investigation received an upgradient monitoring well to establish baseline conditions at each site. This was not done at Site 14 due to its proximity to Site 13. Two additional monitoring wells were installed at each site: one located within the area of suspected contamination and one immediately downgradient of it. The monitoring well locations were based on GSM-survey and piezometer data. Due to the presence of floating product at Site 7, a total of five monitoring wells were installed.

Table 4.2 Summary of sampling activities

Matrix Analysis	Method[a]	Environmental Samples									Field QA/QC[1] Samples				Total Samples	
		Sampling Location														
		Back-ground	Site 2	Site 3	Site 4	Site 5	Site 7	Site 13	Site 14	Sub total	Field Dup[2]	Equip Rinse[3]	Trip Blanks[4]	Field Blanks[5]	Soil	Water
Borehole Soils																
GC/MS for VOCs [b]	CLP	7	8	12	12	12	14	12	14	91	7	4	9	2	98	15
GC/MS for BNAs [c]	CLP	7	8	12	12	12	14	12	14	91	7	4	-	2	98	13
Total Petroleum Hydrocarbons	LUFT	7	8	12	12	12	14	12	14	91	7	4	-	2	98	13
Metals	CLP	7	8	12	12	12	14	12	14	91	7	4	-	2	98	13
Sediments																
GC/MS for VOCs	CLP	4	-	-	-	-	-	-	-	4	-	-	1	-	4	1
GC/MS for BNAs	CLP	4	-	-	-	-	-	-	-	4	-	-	-	-	4	-
Total Petroleum Hydrocarbons	LUFT	4	-	-	-	-	-	-	-	4	-	-	-	-	4	-
Metals	CLP	4	-	-	-	-	-	-	-	4	-	-	-	-	4	-
Surface Water																
GC/MS for VOCs	CLP	1	-	-	-	-	-	-	-	1	-	-	1	-	-	1
GC/MS for BNAs	CLP	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Total Petroleum Hydrocarbons	LUFT	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Metals, dissolved[6]	CLP	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Groundwater (2 rounds)																
GC/MS for VOCs	CLP	4	6	6	6	6	12	6	4	50	6	6	12	2	-	76
GC/MS for BNAs	CLP	4	6	6	6	6	12	6	4	50	6	6	-	2	-	64
Total Petroleum Hydrocarbons	LUFT	4	6	6	6	6	12	6	4	50	6	6	-	2	-	64
Metals, dissolved[6]	CLP	4	6	6	6	6	1	6	-	35	6	6	-	2	-	49
Containerized Groundwater (2 tanks)																
GC/MS for VOCs	CLP	2	-	-	-	-	-	-	-	2	-	-	1	-	-	3
GC/MS for BNAs	CLP	2	-	-	-	-	-	-	-	2	-	-	-	-	-	2
Total Petroleum Hydrocarbons	LUFT	2	-	-	-	-	-	-	-	2	-	-	-	-	-	2
Metals, dissolved[6]	CLP	2	-	-	-	-	-	-	-	2	-	-	-	-	-	2

[1] QA/QC: quality assurance/quality control.
[2] Field Duplicates: collected at a frequency of 10% per matrix per event except soils.
[3] Equipment Rinsates: collected at a frequemcy of 10% of total samples.
[4] Trip Blanks: one per cooler with samples for volatile organic compounds analysis.
[5] Field Blanks: one per water type (deionized and potable) per field episode per analyte.
[6] Water samples for laboratory metals analysis were filtered (0.45 μm)

[a] CLP: U.S.EPA 1990 and 1991.
LUFT: CSWRCB 1987.
[b] Gas chromatography/mass spectrometer analysis for volatile organic compounds.
[c] Gas chromatography/mass spectrometer analysis for base nuetral acid extractable compounds.

Hollow stem auger drilling methods were used to drill the monitoring wells. Continuous samples were collected during drilling to obtain accurate lithologic descriptions and identification of saturated conditions. Precleaned well screen and casing consisting of 2.375-in.-OD schedule 40 PVC with flush-threaded joints were used in all well construction. Well screens with 0.010 in.-slots were positioned in the water table aquifer with 3 ft of screen above and 7 ft of screen below the static water level as determined by lithologic characteristics. All screened intervals were sand packed (size 8/12 well rounded silica sand) to 24 in. above the screen and sealed with 24 in. of bentonite pellets. The remaining annular space to within 1 ft bgs was grouted using a cement-bentonite grout mixture. The grout mixture was composed of 1 part bentonite to 6 parts of cement. All annular material was added through the augers. The PVC risers were sealed with expanding lockable plugs and finished with 6-in.-diameter vaults. In undeveloped areas, a concrete apron was installed around the vaults to provide mechanical stability and prevent surface infiltration. An elevational and locational survey of the monitoring wells was performed by ORNL/ETS personnel. This information is presented in Appendix B.

Following well construction, each monitoring well was developed to remove mud and fines from the screen and filter pack by surging and pumping. A 1.75-in.-diameter steel rod attached to a rope was used to surge the well. An electric submersible pump was then placed at the bottom of the well and run until clear water was obtained. The procedure was repeated to ensure that most of the fines had been removed. Wells that were pumped dry were allowed to recover, were surged, and were pumped again. Water discharged from each well was collected in a truck-mounted, 560-gal tank that was then periodically emptied into the larger, 6500-gal, holding tank on site.

Monitoring wells were sampled for chemical analysis on two occasions. The first round of groundwater samples was collected in December 1992. A minimum of three well volumes was purged from each well before sampling. During purging, pH, conductivity, and temperature were measured with a YSI model 3000 meter. These measurements were recorded in the sample log book. The YSI meter was calibrated daily using standard solutions and following the manufacturer's specifications.

Groundwater samples were obtained using a decontaminated Teflon® bailer. Water samples for metals analysis were obtained with a peristaltic pump using new tubing at each location. The metals samples were passed through a 0.45 μm filter, leaving the dissolved phase of the metals. A sample label was attached to each bottle that identified the project name, sample location, date and time of sample collection, analyses requested, method of preservation, and sampler's initials. The bottles were packaged in a cooler with Blue Ice and shipped to the laboratory via overnight courier.

A second round of groundwater samples was collected in March 1993. The monitoring wells were purged and sampled using the same procedures described above.

4.6.3 Hydraulic Testing

To obtain hydraulic conductivity and transmissivity values for the assessment of potential contaminant dispersion in the water table aquifer, single well pumping tests were performed on selected monitoring wells following methods described by Heath (1989). These tests are described as single well pumping tests and consist of pumping a single well at a constant rate over a specified time period. Drawdown data was analyzed using the Cooper Jacob equation:

$$T = \frac{2.3Q}{4\Pi \Delta h}$$

where: T = transmissivity
Q = pumping rate
Δh = drawdown per log cycle.

At the Base, single well pumping tests were performed by pumping a monitoring well at a constant rate between 3 and 6 gallons per minute (gpm) with a 1.75-in.-OD submersible electric pump. Initially, short-term tests (5 to 10 min) were conducted on each well to ascertain the optimum pumping rate the well could maintain while still experiencing measurable drawdown. The pump was placed in the well and the water level allowed to reach equilibrium. The pump was then engaged, and water levels were recorded every 15 s until no difference in two consecutive measurements was noted. Water-level measurements were then recorded at 30-s intervals, 60-s intervals, and 120-s intervals until there was no measurable drawdown. Water-level measurements were made with the same hand-held water-level indicator.

In two cases, water-level-recovery tests were conducted on an adjacent well and piezometers. Recovery tests were conducted following methods described by Heath (1989). After the pumping well was disengaged, water levels in the observation wells were recorded in the same manner as previously described. Results of hydraulic testing are described in Sect. 5.2. Drawdown data and graphs showing time versus drawdown are presented in Appendix C.

4.6.4 Sediment and Surface Water

To establish baseline conditions across the Base, surface water and sediment samples were collected during the confirmation activities. Four sediment and one surface water sample were collected and submitted for Level C QC (HAZWRAP 1990). The selection criteria for sediment/surface water sampling locations were based on storm-water-outfall locations and the occurrence of surface water. Sediment and surface water sample results are discussed further in Sect. 5.2.

4.7 Field Methods

All field work, including drilling; well installation; soil and groundwater sampling; documentation; equipment operation; sampling equipment decontamination; and sample shipping, handling, and preservation were done in accordance with appropriate procedures unless otherwise stated in the report. Specific procedures are explained in the Pollutant Assessments Group Procedures Manual (ORNL 1990).

4.8 Investigation-Derived Waste

Wastes generated during the SI field investigation consisted of soil cuttings from drilling operations, well development water, decontamination fluids, and miscellaneous solid wastes (gloves, paper towels, and plastic sheeting).

Soil cuttings from drilling operations were monitored with a HNU PID for the presence of VOCs. Soils with PID values below 100 ppm were used to backfill soil borings or were spread out in undeveloped areas. All soils exhibiting PID reading in excess of 100 ppm were segregated and transported to the designated holding area north of Bldg. 84. Soils used in the GC headspace screening that were potentially contaminated were also added to this pile. These soils were covered with 6-mm plastic sheeting that was secured with rocks to maintain its integrity and to avoid additional volatilization to the atmosphere. The soil was scheduled to be sampled for waste characteristics upon the conclusion of field activities in March. However, when ORNL/ETS personnel went to collect the samples, the pile was no longer in its original location. Discussion with Base personnel revealed the pile had inadvertently been moved and consolidated it with a much larger mound of soil produced during adjacent construction activities. Base personnel reported the incident to Mr. Nevan Kane with NDEP on March 22, 1993 (personal communication from Captain John C. Peck, NVANG, Reno, Nev., to F. G. Gardner, ORNL, Grand Junction, Colo., March 22, 1993). Due to the relatively small amount of potentially contaminated soil (~1 yd^3) and the potentially low levels of contamination present, Mr. Kane decided that no waste-characteristic sampling would be necessary.

Well development water and decontamination fluids generated between September and December 1992 were contained in a 6500-gal cylindrical polyethylene (PE) tank located in the decontamination area north of Bldg. 84. At the conclusion of the first round of groundwater sampling, the tank contents were sampled with a decontaminated Teflon® bailer. Analysis for VOCs, base neutral acid extractables (BNAs), petroleum hydrocarbons (PHCs), and metals indicated that benzene at 8 µg/L was the only constituent of concern. After reviewing the analytical data, officials with the city of Reno agreed to a one-time discharge of the tank to the sanitary sewer system without requiring any special permitting or additional engineering analyses. The tank contents were pumped through a 20-µm bag filter and discharged to the sanitary sewer on February 2, 1993, in the presence of the city of Reno Environmental Control Officer, Mr. Gil Ellis.

Additional well water and decontamination fluids generated during hydraulic testing in January 1993 and the second round of groundwater sampling in March 1993 were contained in a 560-gal PE tank located adjacent to the decontamination area. Well water was initially pumped into a truck-mounted, 560-gal tank and then transported to the 560-gal holding tank described above. Upon conclusion of field activities in March 1993, the holding tank was sampled with a decontaminated Teflon® bailer for the parameters previously mentioned. Again, benzene at 10 µg/L was the only constituent of concern. Permission to discharge the tank to the ground surface in an area where no storm drains exist was granted by NDEP's Water Pollution Control Branch (letter from James B. Williams, Jr., Water Pollution Control, NDEP, Carson City, Nev., to Frank Gardner, ORNL/ETS, Grand Junction, Colo., May 11, 1993) (Appendix A).

Solid waste was disposed of with regular Base trash.

5. INVESTIGATION FINDINGS

5.1 Introduction

This section presents the results of the investigations at each site, makes a preliminary evaluation of the significance of the results, and identifies any data gaps. Overall results and significance of findings form the basis of the conclusions and recommendations presented in Sect. 6.

5.2 Geology and Hydrogeology

The investigation of the seven sites at the Base produced data that are in general agreement with the hydrogeologic information presented in Sect. 3. Information from drilling activities confirmed that the near-surface geology consists of Quaternary lacustrine silty clay underlain by alluvial sand and gravel. The fence diagram presented in Fig. 5.1 presents some interesting aspects about these deposits. On the western side of the Base, the silty clay is underlain by fine-grained sand with varying amounts of silt that progressively thins from west to east. The silt content in this unit diminishes as the unit thins to the east. The fine-grained sand is underlain by a well-graded gravelly sand with varying amounts of gravel and cobbles. The overlying fine-grained sand unit thins to the east, and the well-graded gravelly sand then underlies the silty clay in the central and eastern portions of the Base. The top of the gravelly sand unit is typically encountered at depths of 5 to 10 ft bgs and is the most hydrologically significant unit at the Base as determined by the hydrologic testing, the results of which are discussed below. The regional hardpan discussed in Sect. 3.3 was not encountered under the base.

Water-level measurements presented in Table 5.1 were collected in December 1992 and again in February and March 1993. Potentiometric maps for each of the measurement dates are presented as Figs. 5.2, 5.3, and 5.4. On the December map (Fig. 5.2), the general direction of groundwater flow is to the east with a progressive southeastern component. The potentiometric maps for February (Fig. 5.3) and March (Fig. 5.4) suggest

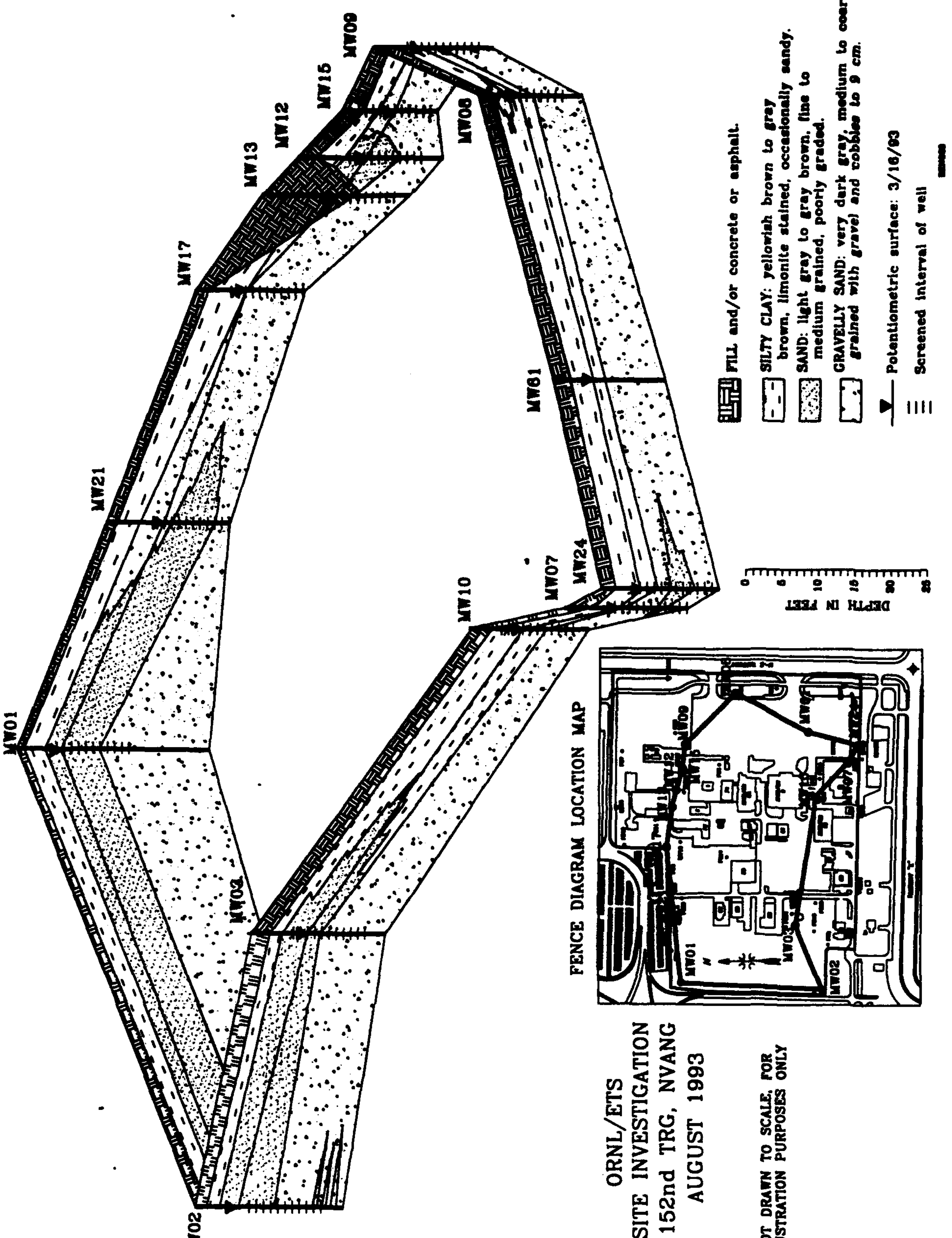


Fig. 5.1. Fence diagram of the Base.

Table 5.1. Water-level data for December 1992, February 1993, and March 1993

Well Number	Measurement Date	Water Level, ft bcl[1]	Water Table, ft amsl[2]
MW01	12/04/92	11.12	4394.99
	02/02/93	9.03	4397.08
	03/16/93	8.86	4397.25
MW02	12/04/92	7.06	4397.56
	02/02/93	—	NT
	03/16/93	5.36	4399.26
MW03	12/04/92	9.08	4395.30
	02/02/93	6.82	4397.56
	03/16/93	7.54	4396.84
MW04	12/04/92	8.58	4395.11
	02/02/93	6.82	4396.87
	03/16/93	7.39	4396.30
MW05	12/04/92	8.46	4395.15
	02/02/93	6.72	4396.89
	03/16/93	7.25	4396.36
MW06	12/04/92	4.74	4393.95
	02/02/93	4.61	4394.08
	03/16/93	4.38	4394.31
MW07	12/04/92	4.40	4393.50
	02/02/93	4.01	4393.89
	03/16/93	4.23	4393.67
MW08	12/04/92	5.34	4393.87
	02/02/93	4.94	4394.27
	03/16/93	4.91	4394.30
MW09	12/04/92	7.40	4394.57
	02/02/93	6.79	4395.18
	03/16/93	6.86	4395.11
MW10	12/04/92	6.50	4394.29
	02/02/93	6.17	4394.62
	03/16/93	5.99	4394.80
MW11	12/04/92	5.92	4394.17
	02/02/93	5.52	4394.57
	03/16/93	5.43	4394.66
MW12	12/04/92	7.62	4394.88
	02/02/93	7.31	4395.19
	03/16/93	7.11	4395.39
MW13	12/04/92	7.57	4394.91
	02/02/93	7.25	4395.23
	03/16/93	7.04	4395.44
MW14	12/04/92	7.09	4395.04
	02/02/93	6.97	4395.16
	03/16/93	6.78	4395.35
MW15	12/04/92	8.03	4394.74
	02/02/93	7.65	4395.12
	03/16/93	7.50	4395.27

Table 5.1. (continued)

Well Number	Measurement Date	Water Level, ft bcl[1]	Water Table, ft amsl[2]
MW16	12/04/92 02/02/93 03/19/93	9.06 8.83 8.63	4395.11 4395.34 4395.54
MW17	12/04/92 02/02/93 03/16/93	7.34 7.07 6.86	4395.16 4395.43 4395.64
MW18	12/04/92 02/02/93 03/16/93	8.01 0.00 7.25	4394.75 destroyed 4395.51
MW19	12/04/92 02/02/93 03/16/93	8.83 8.55 8.29	4395.28 4395.56 4395.82
MW20	12/04/92 02/02/93	7.73 7.28	4395.32 4395.77
MW21	12/04/92 02/02/93 03/16/93	7.57 7.09 7.02	4395.72 4396.20 4396.27
MW22	12/04/92 02/02/93 03/16/93	9.02 8.58 8.41	4395.63 4396.07 4396.24
MW23	12/04/92 02/02/93 03/16/93	5.92 5.34 5.23	4393.48 4394.06 4394.17
MW24	12/04/92 02/02/93 03/16/93	5.24 4.68 4.65	4393.43 4393.99 4394.02
MW25	02/02/93 03/16/93	3.61 3.56	4394.17 4394.22
PZ01	12/04/92 02/02/93 03/16/93	9.36 8.88 8.76	4396.13 4396.61 4396.73
PZ02	12/04/92 02/02/93 03/16/93	6.52 6.12 6.02	4394.60 4395.00 4395.10
PZ03	12/04/92 02/02/93 03/16/93	4.78 4.38 4.30	4493.84 4494.24 4494.32
PZ04	12/04/92 03/16/93	6.41 5.98	4394.68 4395.11
PZ05	12/04/92 02/02/93 03/16/93	4.16 3.52 3.54	4393.12 4393.76 4393.74
PZ06	12/04/92 02/02/93 03/16/93	3.84 3.44 3.33	4393.39 4393.79 4393.90

Table 5.1. (continued)

Well Number	Measurement Date	Water Level, ft bcl[1]	Water Table, ft amsl[2]
PZ07	12/04/92	8.65	4394.88
	02/02/93	8.21	4395.32
	03/16/93	8.05	4395.48
PZ08	12/04/92	8.08	4396.36
	02/02/93	5.80	4398.64
	03/16/93	6.44	4398.00
PZ09	12/04/92	8.04	4395.24
	03/16/93	7.61	4395.67
PZ10	12/04/92	8.68	4395.20
	02/02/93	8.28	4395.60
	03/16/93	8.10	4395.78
PZ11	12/04/92	8.95	4395.05
	02/02/93	8.59	4395.41
	03/16/93	8.41	4395.59
PZ12	12/04/92	9.35	4395.30
	02/02/93	9.07	4395.58
	03/16/93	8.81	4395.84
PZ13	12/04/92	8.56	4397.16
	02/02/93	6.45	4399.27
	03/16/93	5.27	4400.45
PZ14	12/04/92	8.63	4395.22
	02/02/93	6.84	4397.01
	03/16/93	7.25	4396.60
PZ15	12/04/92	5.74	4393.84
	02/02/93	0.00	destroyed
	03/16/93	0.00	destroyed
PZ16	12/04/92	6.04	4394.09
	02/02/93	5.76	4394.37
	03/16/93	5.53	4394.60
PZ17	12/04/92	8.50	4395.04
	02/02/93	8.28	4395.26
	03/16/93	8.06	4395.48
PZ18	12/04/92	8.54	4395.06
	02/02/93	6.48	4397.12
	03/16/93	0.00	destroyed
PZ19	12/04/92	8.93	4395.48
	02/02/93	6.19	4398.22
	03/16/93	7.15	4397.26
PZ20	12/04/92	8.94	4395.31
	02/02/93	8.57	4395.68
	03/16/93	8.42	4395.83

[1] feet below casing level.
[2] feet above mean sea level.

NT = measurement not take; well was under water.

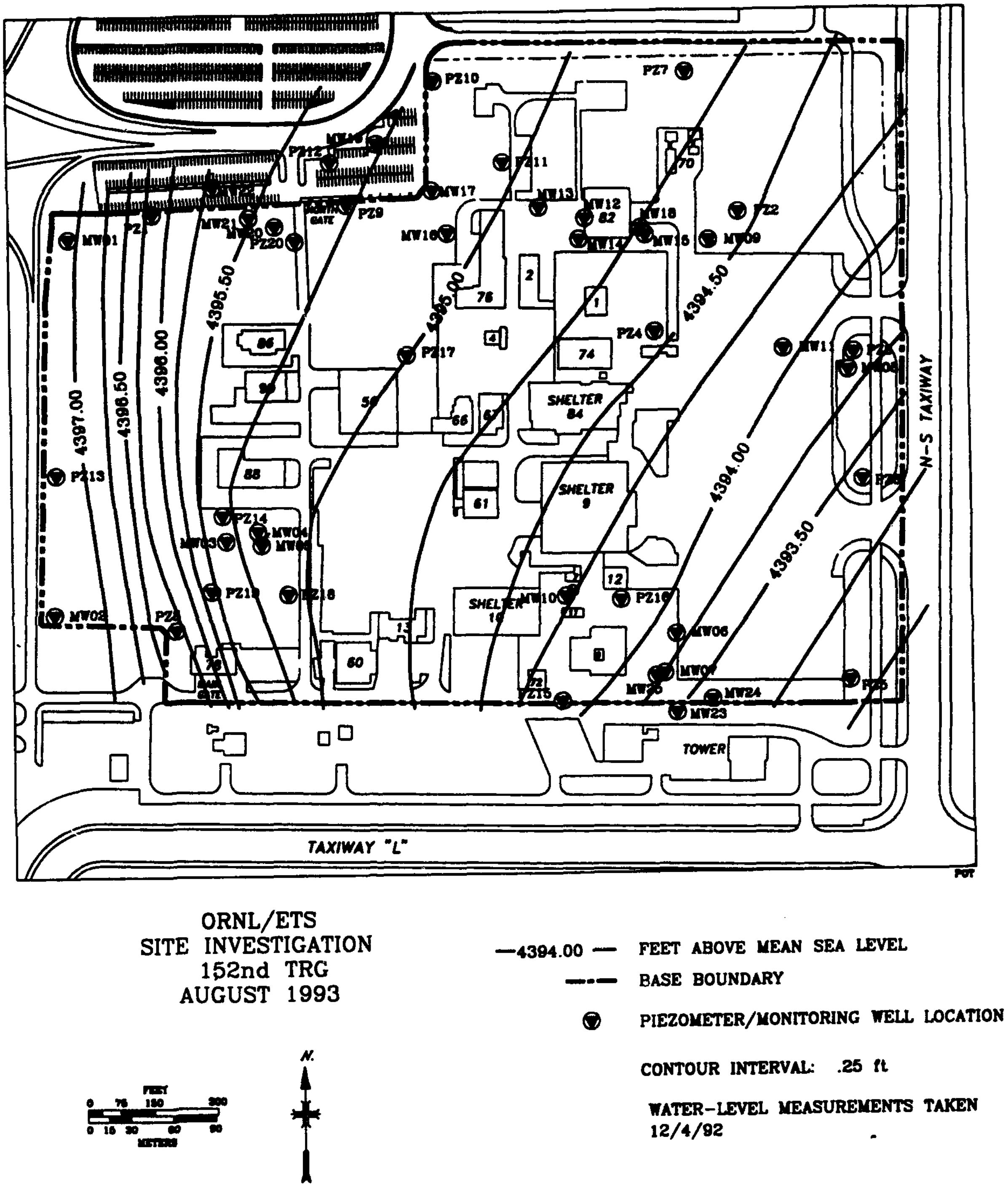


Fig. 5.2. Potentiometric surface, December 1992.

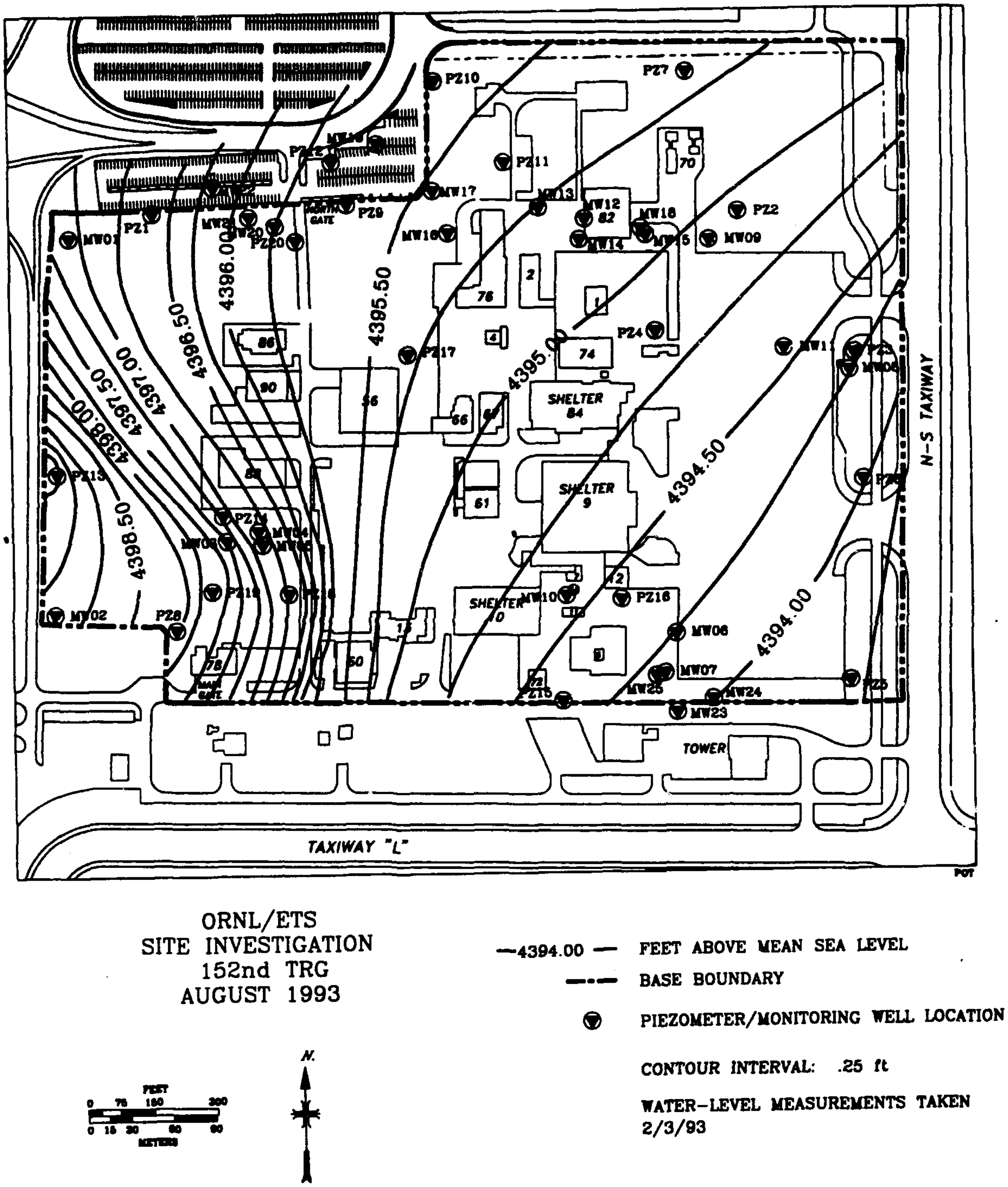


Fig. 5.3. Potentiometric surface, February 1993.

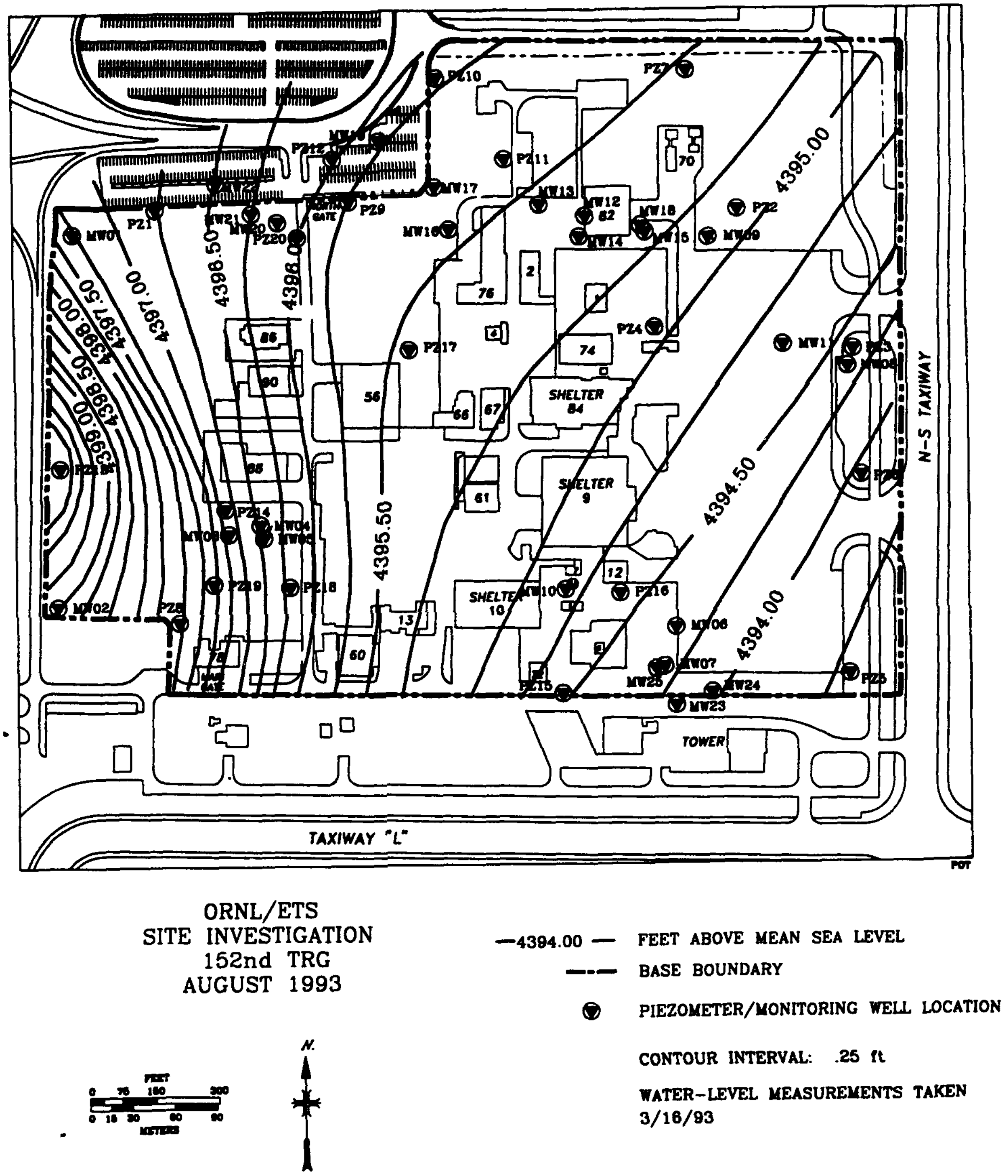


Fig. 5.4. Potentiometric surface, March 1993.

a slight northeastern component resulting from a perched zone in the southwestern corner of the Base. The noticeably steeper gradient along the western side of the Base, which is apparent on all three maps, likely results from the progressive eastward thinning of the fine-grained sand unit previously discussed. As this unit thins to the east, the gradient becomes less pronounced due to increased permeability of the well-graded gravelly sand, and the flow direction shifts slightly to the southeast. Typically, the water table surface is near the bottom of the fine-grained sand. However, as this unit thins to the east, the water table shifts into the overlying silty clay unit. Wherever the silty clay unit overlies the water table, the vertical migration of contaminants into the groundwater has apparently been reduced. An example of this is provided by MW18 at Site 14, where soil contamination is high but the groundwater remains uncontaminated. Conversely, when the silty clay unit lies within the water table, its effectiveness in reducing vertical contaminant migration is limited.

Hydraulic testing was performed at various sites to determine overall hydraulic properties of the aquifer. Results of the hydraulic tests are discussed in this section to maintain continuity in the discussion, which would be affected by breaking it up into site-specific discussions. Single well pumping tests were performed on MW02, MW03, MW08, MW09, MW21, and MW23. Additionally, recovery tests were conducted on PZ03 after pumping MW08, and on MW20 after pumping MW21. The locations of the aforementioned wells and piezometer are shown in Fig. 5.5. The specific hydraulic testing methods are discussed in Sect 4.6.3, and drawdown and recovery data are presented in Appendix C.

Hydraulic conductivity values reported in Table 5.2 range from 4 to 479 ft/d. Typically, wells screened in silty clay and poorly graded sand or silty sand (such as MW02, MW03, and MW23) exhibit much lower values than those wells screened in the well-graded gravelly sand (such as MW08, PZ03, MW09, MW20, and MW21). The lithologic logs presented in Appendix B present a good correlation between measured hydraulic conductivity values and lithology. Additionally, the recovery test results from PZ03 and MW20 show transmissivity values nearly twice those of the associated pumping wells. This is not surprising since recovery test results are not influenced by the condition of the

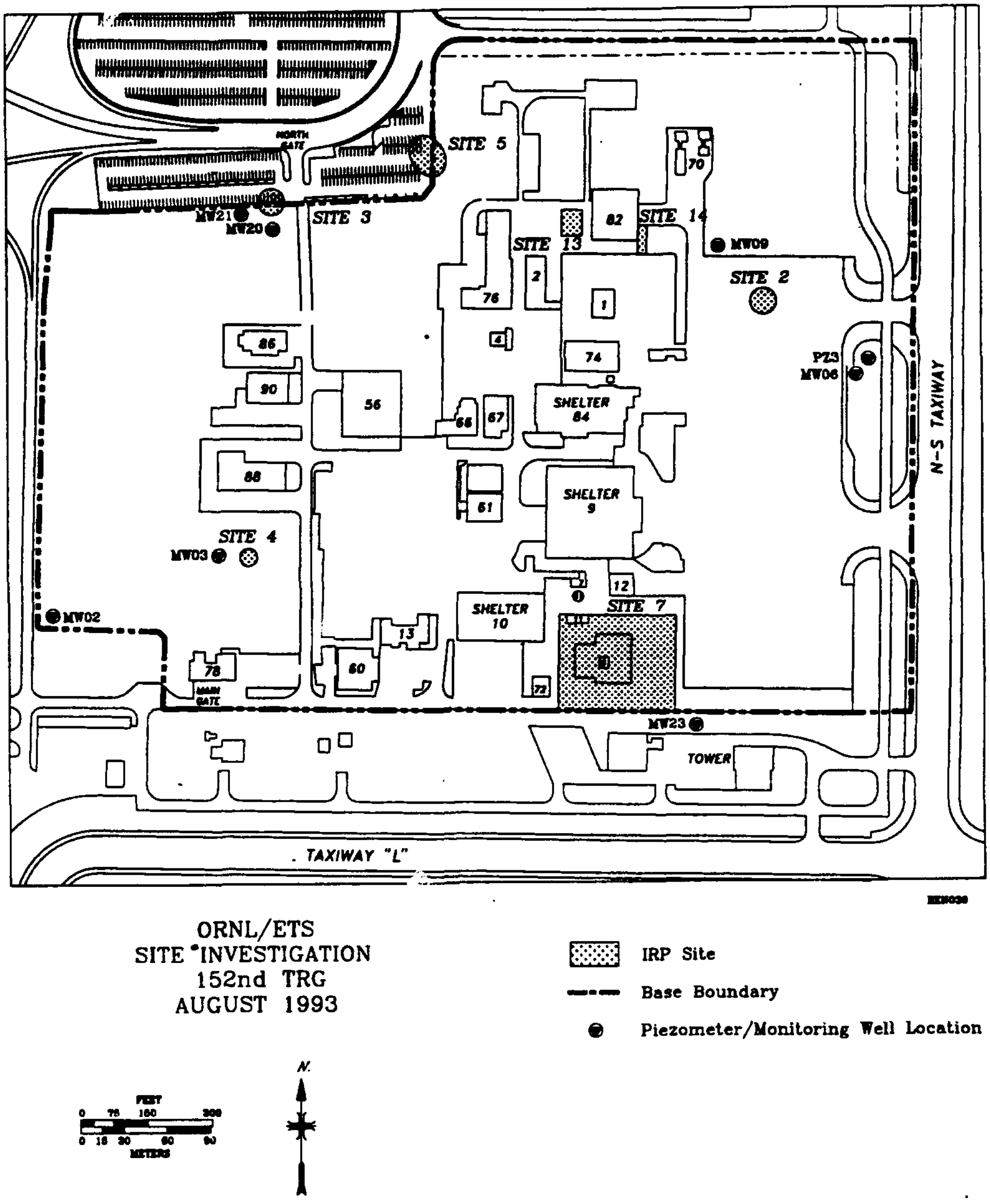


Fig. 5.5. Aquifer testing locations.

Table 5.2 Hydraulic conductivity and transmissivity values

Test Location	Screened aquifer thickness, ft*	Transmissivity, ft^2/d	Hydraulic conductivity, ft/d
MW02	9.8	39	4
MW03	9.0	61	6.7
MW08	7.0	1628	232
MW09	7.5	2265	302
MW20	6.5	3110	479
MW21	6.5	1816	285
MW23	6.5	250	38
PZ03	7.0	2774	396

* Only the permeable portions of the aquifer adjacent to the well screen were considered. For example, if the upper three feet of a ten foot well screen is adjacent to a silty clay and the lower seven feet is adjacent to a sandy gravel unit, then the aquifer thickness for hydraulic conductivity conversions was assumed to be seven feet.

pumping well, and, therefore, conductivity values are typically higher. If MW08 and MW21 had been designed and developed for aquifer testing, the difference in conductivity values would be less obvious.

Hydraulic testing results suggest that the water table aquifer is very heterogenous, which will have a significant effect on the transport of contaminants. Additionally, the pump test data suggest that the well-graded gravelly sand unit has a hydraulic conductivity that is generally one order of magnitude higher than that of the fine-grained sand unit.

Using an average hydraulic conductivity value based on observation well pumping tests of 500 ft/d, a hydraulic gradient of 0.001 based on the site potentiometric map, and an assumed effective porosity of 0.2 for a fine to coarse sand (de Marsily, 1986), the average linear groundwater velocity for the site would be 2.5 ft/d. This estimate is based on the equation for average linear velocity (V) of

$$V=\frac{Ki}{n}$$

where: K = hydraulic conductivity
i = hydraulic gradient
n = porosity.

5.3 Background Screening and Confirmation Results

5.3.1 Screening Results

Screening activities for background concentrations of VOCs were performed along the western boundary (upgradient edge) of the Base due to previously identified soil contamination existing adjacent to the Base. The western Base boundary was determined to be the upgradient edge of the Base from regional potentiometric data presented in

Sect 3.4.2. Therefore, a GSM survey on a 300 × 1000-ft grid with 200-ft spacing was performed to establish optimum locations for background monitoring wells and soil borings. Due to the proximity of several potential groundwater contamination sources to the southwest corner of the Base, the grid spacing was tightened up to a 100-ft spacing. The locations of GSM survey points is presented in Fig. 5.6. Results of the field GC analysis and GSM borehole screening with an HNU PID, presented in Table 5.3, suggest that no VOC contamination exists along the upgradient boundary.

5.3.2 Confirmation Results

Two background soil borings that were subsequently completed as monitoring wells MW01 and MW02 were drilled to determine background concentrations. Four soil samples were collected from MW01 at depths of 2, 4, 6, and 8 ft. Three soil samples were collected from MW02 at depths of 4, 6, and 8 ft. All soil samples from the background soil borings were screened with the field GC with no contaminants detected. The soil samples were submitted for confirmation analysis so that sufficient baseline information would be available for data evaluation and comparison with the seven sites under investigation. The locations of MW01 and MW02 are presented in Fig. 5.7.

The background soil samples were collected in areas that reportedly have never been used for waste management activities Moreover, according to piezometer data, the background areas are upgradient of the seven sites under investigation.

As part of the background investigation, four sediment samples and one surface water sample were collected from the drainage ditches located on or near the Base. These sampling locations, denoted as SD05, SW05, SD06, SD07, and SD08 and illustrated in Fig. 5.7, were selected to obtain baseline data relative to surface water and ditch sediments. All of the sediment sampling locations are representative of surface water out fall points with the exception of SD05/SW05. The latter location represents the point at which the only ephemeral stream in the area enters the Base.

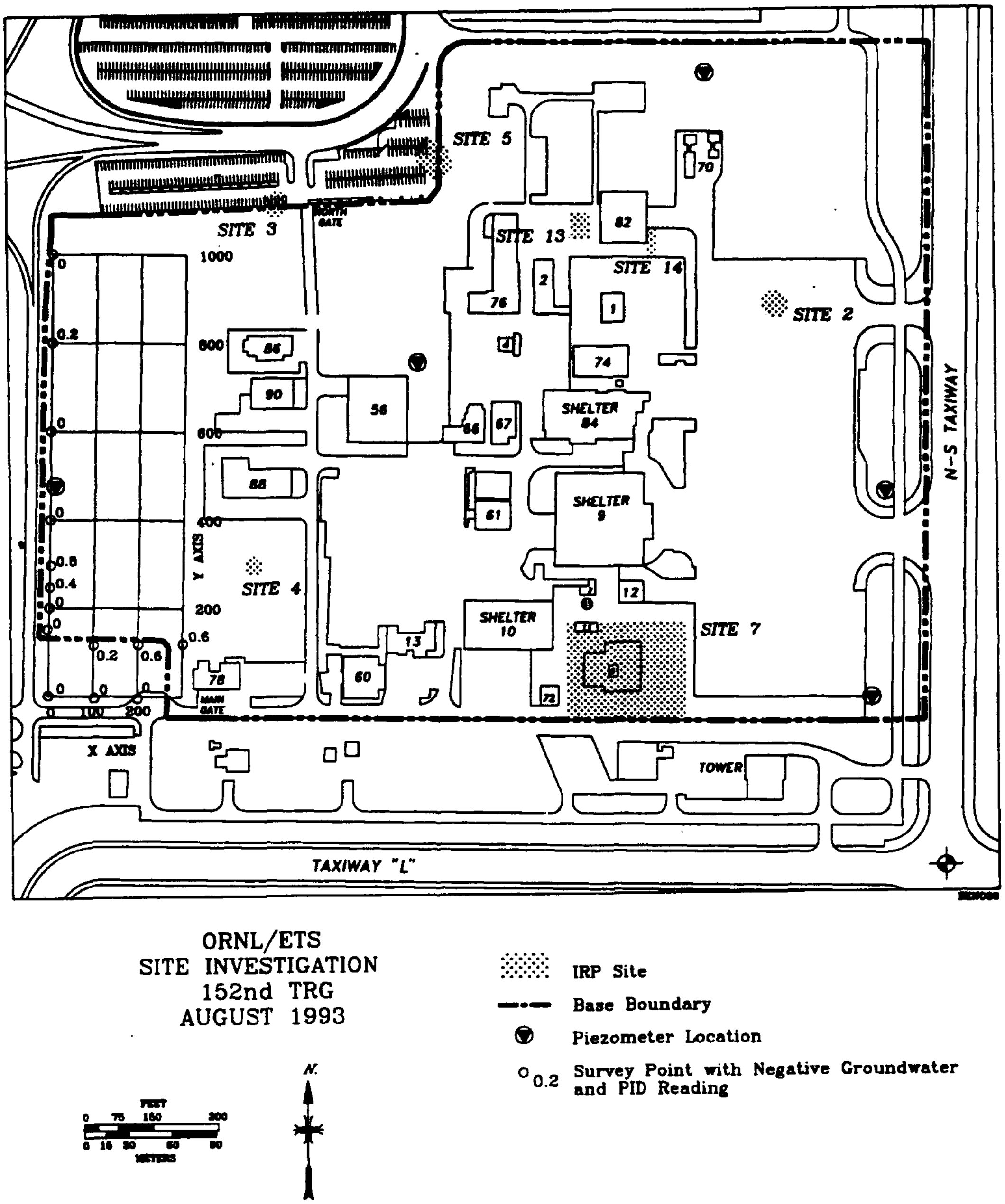


Fig. 5.6. GSM survey locations along the western Base boundary.

Table 5.3. GSM survey results for background concentrations

GSM Location	Grid coordinates, x,y	PID, ppm	GC Decision
BW01	0,200	0	Negative
BW02	0,400	0	Negative
BW03	0,600	0	Negative
BW04	0,800	0.2	Negative
BW05	0,1000	0	Negative
BW06	0,0	0	Negative
BW07	0,150	0	Negative
BW08	0,250	0.4	Negative
BW09	0,300	0.8	Negative
BW10	100,120	0.2	Negative
BW11	200,120	0.6	Negative
BW12	300,120	0.6	Negative
BW13	100,-7	0.6	Negative
BW14	120,-7	0	Negative

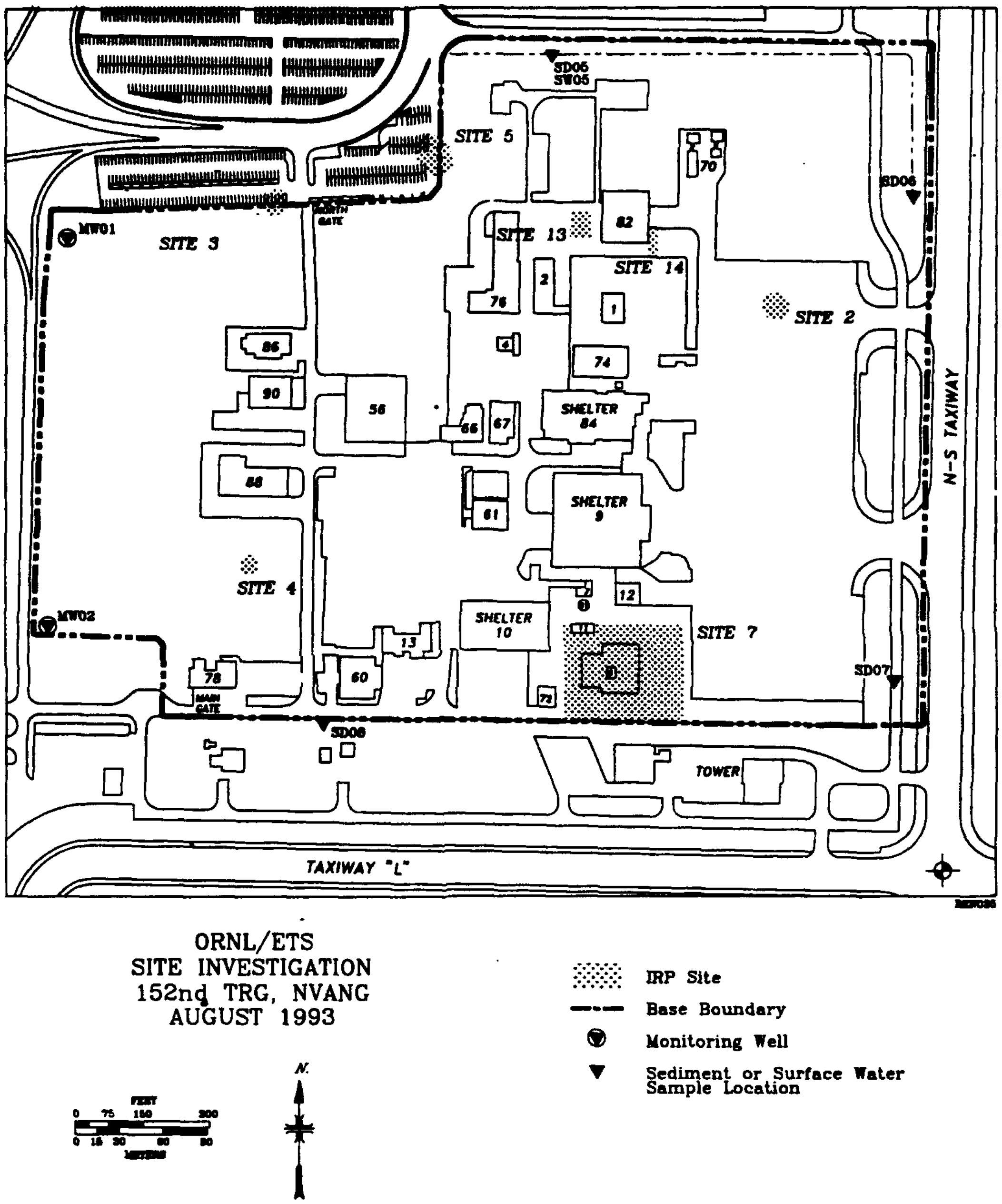


Fig. 5.7. Background sampling locations.

Significant analytical data from the base wide investigation and associated QA/QC samples are presented in Appendix D, which is divided into four tables: Table D-1 contains site-specific data beginning with the base wide or background results and continuing through Site 14; Table D-2 contains results from equipment rinsates, field blanks, trip blanks, and waste characteristics of SI-derived waste; Table D-3 contains analytes detected in laboratory method blanks for all of the analyses; and Table D-4 lists the target compounds and metals along with the analytical methods and detection limits.

The listing of many analytes shown in Appendix D, may not indicate that the contaminants are present at the site investigated. For example, methylene chloride, chloroform, and acetone, common laboratory solvents, are often detected due to contamination introduced to the sample in the laboratory. These solvents are extensively used as extraction or cleaning agents. Other contaminants that are commonly introduced during sample collection and/or analysis are phthalates. Di-*n*-butyl phthalate and *bis*-(2-ethylhexyl) phthalate, which are ubiquitous in samples and blanks, originate from plastic materials such as PVC gloves, which are worn during sampling and analysis. Based on the methodology presented in the HAZWRAP guidance document for evaluating laboratory analyses (HAZWRAP 1990), a constituent such as a common laboratory solvent may be present at a level 10 times more than the concentration of that solvent in any associated blank and not be considered significant. The 10-times-more criterion is applicable to common laboratory solvents but is reduced to 5-times-more for target compound list (TCL) constituents.

When common laboratory solvents are detected, they are usually estimated values as indicated by a "J" qualifier and/or present in associated laboratory blanks as indicated by a "BR" qualifier. The estimated values are below EPA contract required detection limits (CRDLs) but above the method detection limit. Thus, a J qualifier denotes positive identification of a compound with a certain degree of uncertainty associated with the quantity of the compound. The BR qualifier indicates that the compound was detected in the laboratory method blank (B) and was therefore flagged unusable (R) during data validation. The complete data validation report is presented in Appendix F.

A number of inorganic compounds were detected in the background samples. The compounds detected, the concentration ranges found, and the average values are presented in Table 5.4. The crustal abundance average for each compound (Taylor 1964) is also provided. With the exception of antimony, arsenic, lead, mercury, and zinc, all of the inorganic compounds detected in the background samples do not exceed the referenced crustal abundance averages. The antimony and mercury results are suspect because their occurrence in other soil samples is rare. Although the arsenic levels reported in the background samples exceed the crustal abundance average significantly, they are not alarming. Arsenic commonly occurs in high concentrations in basin-fill deposits of alluvial-lacustrine origin, particularly in semiarid areas (Welch et al. 1988). Although the mean background concentrations for lead and zinc exceed their respective crustal abundance averages, the concentrations are relatively close, and thus, the differences are not significant. In fact, previous investigators in the region have concluded that natural geochemical reactions appear to be a primary factor responsible for the presence of inorganic constituents at high concentrations (Welch et. al. 1989). Review of the inorganic soil data from each of the sites in Appendix D suggests that no significantly elevated levels for heavy metals exists. Therefore, the discussion of inorganic results from each site will be limited to any anomalous results or potentially significant data.

Complete results of the organic compound analyses of soil samples from background locations (MW01, MW02, SD05, SD06, SD07, and SD08) are presented Table D-1, Appendix D. Significant data from Table D-1 has been summarized in Table 5.5 where data are presented by boring number and depth. For example, MW01-8 refers to the sample collected 8 ft bgs in MW01. Analytical data from four equipment rinsates associated with the soil sampling activity are presented in Table D-2 in Appendix D. There are no significant analyte concentrations in these samples (sample numbers 1007, 1108, 1109, and 1110).

Three VOCs were detected in background soil. Chloroform was reported at very low concentrations in MW01-2 and MW01-8 and is not considered significant. Although acetone and methylene chloride are reported at significant estimated concentrations not

Table 5.4. Comparison of inorganic compounds in soils at Nevada ANG with crustal abundance averages

Element	Background Values at Nevada ANG, mg/kg			Crustal Abundance Average Value[1], mg/kg
	High	Low	Mean	
Aluminum	25,500	2010	12,900	82,300
Antimony	16.3	16.3	16.3	0.2
Arsenic	94.8	10.0	41.53	1.8
Barium	211	97.4	152.99	425
Beryllium	0.78	0.57	0.69	2.8
Calcium	43,500	2730	10,750	41,500
Cadmium	ND	ND	ND	5.4
Chromium	15.4	7.3	11.18	100
Cobalt	17.0	6.9	10.16	25
Copper	33.5	16.1	23.9	55
Iron	25,800	14,200	19,691	56,300
Lead	57.8	7.2	17.9	12.5
Magnesium	14,300	2470	5358.2	23,300
Manganese	874	130	477.63	950
Mercury	0.12	0.12	0.12	0.08
Nickel	18.4	10.7	14.2	75
Potassium	5290	1570	2973.3	20,900
Selenium	ND	ND	ND	22
Silver	ND	ND	ND	0.07
Sodium	2700	589	1383	23,600
Thallium	ND	ND	ND	9.6
Vanadium	55.5	35	46.7	135
Zinc	171	39.6	93.74	70

[1] *Source:* Taylor 1964.

ND = not detected.

Table 5.5. Organic chemical constituents detected in background soil

Chemical	MW01-2	MW01-4	MW01-6	MW01-8	SD05	SD06	SD07	SD08
VOCs, µg/kg								
Chloroform	2.0			2.0				
Acetone				4400.0 J				
Methylene chloride				200.0 J				
BNAs, µg/kg								
4-Methylphenol						96.0 J		
Di-*n*-octyl phthalate						270.0 J		280.0 J
4-Nitrophenol			43.0 J					
bis(2-Ethylhexyl) phthalate	46.0 J	44.0	46.0	69.0	930.0	1700.0		1400.0
Benzo[*a*]anthracene					320.0 J	380.0 J	190.0 J	520.0
Benzo[*a*]pyrene					310.0 J	420.0 J	170.0 J	210.0 J
Benzo[*b*]fluoranthene					670.0	1200.0	550.0	730.0
Benzo[*g,h,i*]perylene					180.0 J	250.0 J		150.0 J
Benzo[*k*]fluoranthene					670.0	1200.0	550.0	730.0
Butylbenzyl phthalate					52.0 J	460.0 J		73.0 J
Carbazole						110.0 J		61.0 J
Chrysene					360.0 J	490.0 J	210.0 J	390.0 J
Dibenz[*a,h*]anthracene					62.0 J	120.0 J		
Fluoranthene					620.0	1000.0	410.0 J	790.0
Indeno(1,2,3-CD)pyrene					150.0 J	210.0 J		210.0 J
Phenanthrene					230.0 J	310.0 J	87.0 J	330.0 J
Phenol						120.0 J		
Pyrene					510.0	630.0	250.0 J	660.0

Blank space indicates compound was undetected or flagged unusable during data validation.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

excluded by the 10-times-more rule previously discussed, their presence is suspect and not considered significant because of their use as laboratory solvents.

Two BNA compounds were detected in soil from MW01. *Bis*(2-ethylhexyl) phthalate was reported at low concentrations ranging from 44 to 69 μg/kg in MW01. This compound is both ubiquitous to the environment and a frequent result of laboratory contamination. An estimated value (43 μg/kg) for 4-nitrophenol was also reported in MW01-6. This compound is used in industry as fungicide for leather and in organic synthesis. This compound is not associated with jet fuel or aircraft operations and will not be discussed further in the report.

Eighteen BNA compounds were detected in the sediment samples. These compounds consists of phthalates, phenolics, and polynuclear aromatic hydrocarbons (PAHs). The presence of phthalates is not considered significant due to their ubiquity as previously discussed. The phenolic compounds such as phenol and 4-methylphenol are commonly associated with automobile exhaust (Verschueren 1983). Carbazole was reported in low estimated quantities in two samples. This compound is a common constituent of coal tar and can be derived from anthracenes and phenanthrene (Sax and Lewis 1987). Consequently, its possible presence is related to the PAHs. The latter group of compounds are common in the environment and result from sources such as wood burning and leaching of asphalt surfaces (Freeman and Cattell 1990, Takada et. al. 1991). Indeed, street dusts commonly contain several thousand μg/g of PAHs (Takada et. al. 1991, Menzie and Potocki 1992), which is within the range reported in Table 5.5.

Complete analytical results from background surface-water and groundwater samples collected from SW05, MW01 and MW02 respectively, are presented in Table D-1, Appendix D. Significant data from the analyses are summarized in Table 5.6. Two rounds of groundwater samples were collected from the monitoring wells and are indicated as 1st and 2nd in the column headings. Nevada drinking water standards are presented in Table 5.7. The presence of chloroform, toluene, and carbon disulfide at very low levels are not considered significant as these are common laboratory solvents. Similarly, the presence of phthalates is not considered significant due their ubiquity.

Table 5.6. Chemical constituents detected in background surface water and groundwater

Chemical	MW01 - 1st	MW01 - 2nd	MW02 -1st	MW02 - 2nd	SW05
VOCs, μg/L					
Chloroform	2.0 J				
Toluene	1.0 J				
Carbon disulfide				9.0	
BNAs, μg/L					
Di-*n*-butyl phthalate	2.0 J			1.0	
Butylbenzyl phthalate				1.0	
Diethyl phthalate				1.0	
Inorganic Analytes, μg/L					
Aluminum	314.0		568.0		305.0
Arsenic	84.5 J	88.6 J	152.0 J	137.0 J	
Barium	36.7	39.4	31.2	17.7	38.9
Calcium	22,400.0	25,800.0	47,400.0	34,600.0	18,600.0
Copper	11.9	7.1	9.4	6.6	
Iron	360.0		55.9 J		67.9 J
Magnesium	5530.0	6250.0	040.0	3900.0	6880.0
Manganese	172.0	15.6	164.0	79.4	36.0
Potassium	8550.0	7090.0	14,500.0	11,800.0	2850.0
Selenium	4.7	5.5	4.2		
Sodium	236,000.0	258,000.0	443,000.0	364,000.0	16,500.0
Vanadium	15.0	13.0	13.0	12.5	
Zinc			3.8		4.2

Blank space indicates compound was undetected or was flagged unusable during data validation.

J = reported value is below the contract required detection limit but above the instrument detection limit for VOCs and BNAs. For inorganics the reported value is estimated because the associated matrix spike was out of control limits. Values are estimated quantities.

Table 5.7. Nevada drinking water standards

Constituent	Maximum contaminant level, ug/L MCL[1]	Secondary maximum contaminant level, ug/L SMCL[2]	Secondary preferred standard, ug/L SPS[3]
Inorganic Analyses			
Arsenic	50.0		
Barium	2000.0		
Cadmium	5.0		
Chromium	100.0		
Copper		1000.0	1000.0
Iron		300.0	300.0
Lead	50.0		
Magnesium		150,000.0	125,000.0
Manganese		50.0	50.0
Mercury	2.0		
Selenium	50.0		
Silver	100.0		
Zinc		5000.0	5000.0
pH		6.5 - 8.5	6.5 - 8.5
Organic Compounds			
Benzene	5.0		
Benzo[*a*]pyrene	0.2		
Butylbenzyl phthalate	100.0*		
Carbon tetrachloride	5.0		
Chloroform	100.0		
Ethylbenzene	700.0	30.0*	
Methylene chloride	5.0		
Toluene	1000.0	40.0*	
Trichloroethene	5.0		
Trihalomethanes (total)	100.0		
1,2-Dichloroethane	5.0		

Table 5.7. (continued)

Constituent	Maximum contaminant level, ug/L MCL[1]	Secondary maximum contaminant level, ug/L SMCL[2]	Secondary preferred standard, ug/L SPS[3]
cis-1,2-dichloroethene	70.0		
trans-1,2-dichloroethene	100.0		
1,1-Dichloroethene	7.0		
1,4-Dichlorobenzene	75.0	5.0*	
1,2-Dichlorobenzene	600.0	10.0*	
1,1,1-Trichloroethane	200.0		
Xylenes (total)	10,000.0	20.0	

[1] Maximum contaminant levels (MCLs) are health related and federally mandated. MCLs are adopted from the National Drinking Water Regulations.

[2] Secondary maximum contaminant levels (SMCLs) are based on esthetic qualities and enforceable by the state. SMCLs except that for magnesium are adopted from the National Drinking Water Regulations.

[3] Secondary preferred standards (SPSs) must be met unless water of that quality is not available, in which case the SMCLs must be met if they exist.

* Proposed levels.

Source: EPA 1993.

Results of the inorganic analyses indicate levels of cations and metals that are within the range found by Welch et. al. (1989). The major cations present in background groundwater in order of abundance are sodium, calcium, potassium, and magnesium. High iron and manganese concentrations also are common in the hydrographic region (Welch et al. 1989). The only inorganic constituent exceeding an MCL is arsenic, which is expected given the levels found in background soils (Table 5.4). Even though the estimated arsenic values in Table 5.6 exceed the MCL, the occurrence of high concentrations of this element in groundwater results from geochemical processes rather than introduction of pollutants by man (Welch et. al. 1989).

5.4 Site 2, FTA No. 2

5.4.1 Screening Activity Results

GSM Survey

The results of the GSM survey are presented in Fig. 5.8 and Table 5.8. Samples were collected from 15 locations on a 200 × 250-ft grid with 50-ft spacing. The grid was located to surround the suspected location of the former FTA identified in aerial photographs.

Although the GSM survey suggested the trace presence of several chlorinated and fuel-related compounds in the groundwater (TCE, 1,2-DCE, 1,1-DCE, benzene, toluene, ethylbenzene, and xylenes), the coexistence of numerous unknown compounds interfered with definitive compound identification during GC headspace analysis. As previously discussed in Sect. 4.5.1, the GC data were used as a measure of relative contamination. Points with little or no apparent groundwater contamination were deemed negative, and those with moderate to high apparent groundwater contamination were classified positive. Thus, all of the points within the shaded area of Fig. 5.8, which represents the suspected area of groundwater contamination, are positive. Also reported in Fig. 5.8 and Table 5.8

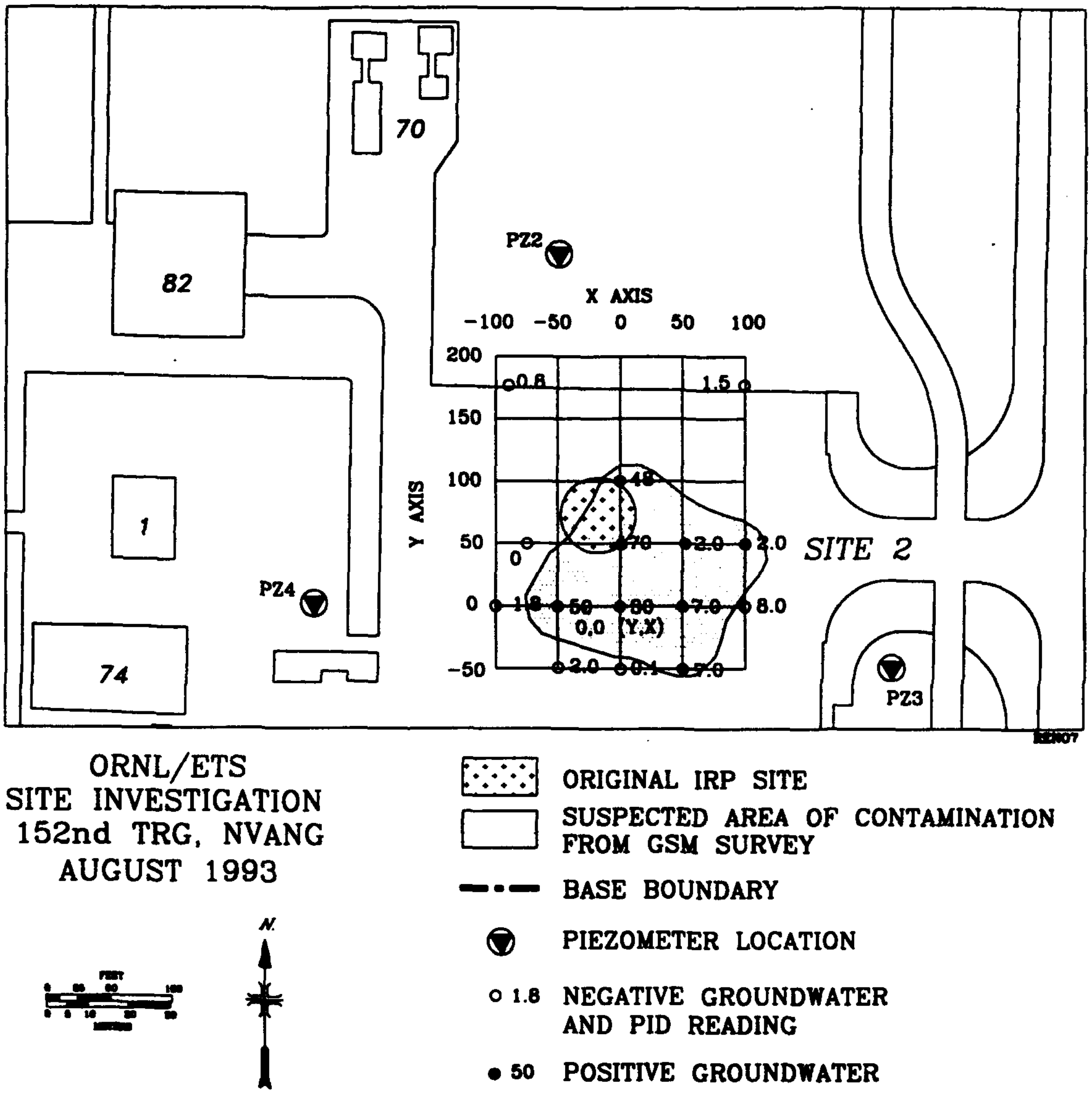


Fig. 5.8. Site 2 GSM survey locations.

Table 5.8. GSM survey results from Site 2

Location	Grid coordinates, x,y	PID, ppm	GC Decision
S201	0,0	30	Positive
S202	0,-50	0.1	Negative
S203	50,0	7.0	Positive
S204	-50,0	50	Positive
S205	0,50	70	Positive
S206	0,0	8	Negative
S207	50,50	2	Positive
S208	50,-50	7	Positive
S209	0,100	48	Positive
S210	-50,-50	2	Negative
S211	100,50	2	Negative
S212	-75,50	0	Negative
S213	-100,0	1.8	Negative
S214	100,175	1.5	Negative
S215	-45,175	0.8	Negative

are the PID readings recorded at each hole, which are indicative of VOCs in the soil. Consequently, a positive GC decision may be paired with a relatively low PID reading suggesting potential groundwater contamination without any associated soil contamination. Conversely, a relatively high PID reading may be paired with a negative GC decision, suggesting potential soil contamination without any associated groundwater contamination.

The GSM at Site 2 was limited in scope due to contamination from apron activities. Site 2 has subsequently been incorporated into Site 12 and will undergo investigation as part of the Site 12 RI/FS.

Piezometer Levels

Three piezometers (PZ02, PZ03, and PZ04) were installed around Site 2 in order to determine the optimum placement of downgradient monitoring wells. Construction records for the piezometers are presented in Appendix B. The potentiometric surface map for Site 2 (Fig. 5.9) indicates that groundwater flows to the southeast. Groundwater flow direction is discussed in Sect. 5.4.3.

5.4.2 Confirmation and Delineation Activities

Three monitoring wells and three soil borings were drilled to support characterization of Site 2. Eight soil samples, collected from the soil borings, and six groundwater samples, collected from the monitoring wells, were submitted for laboratory analysis. Soil and groundwater samples were analyzed for VOCs, BNAs, PHCs, and metals.

Soil Sampling

Complete analytical results for the soil samples are presented in Table D-1 of Appendix D. Significant results from the organic analyses are presented in Table 5.9. The data are presented by boring number and depth. For example, BH32-3 refers to the

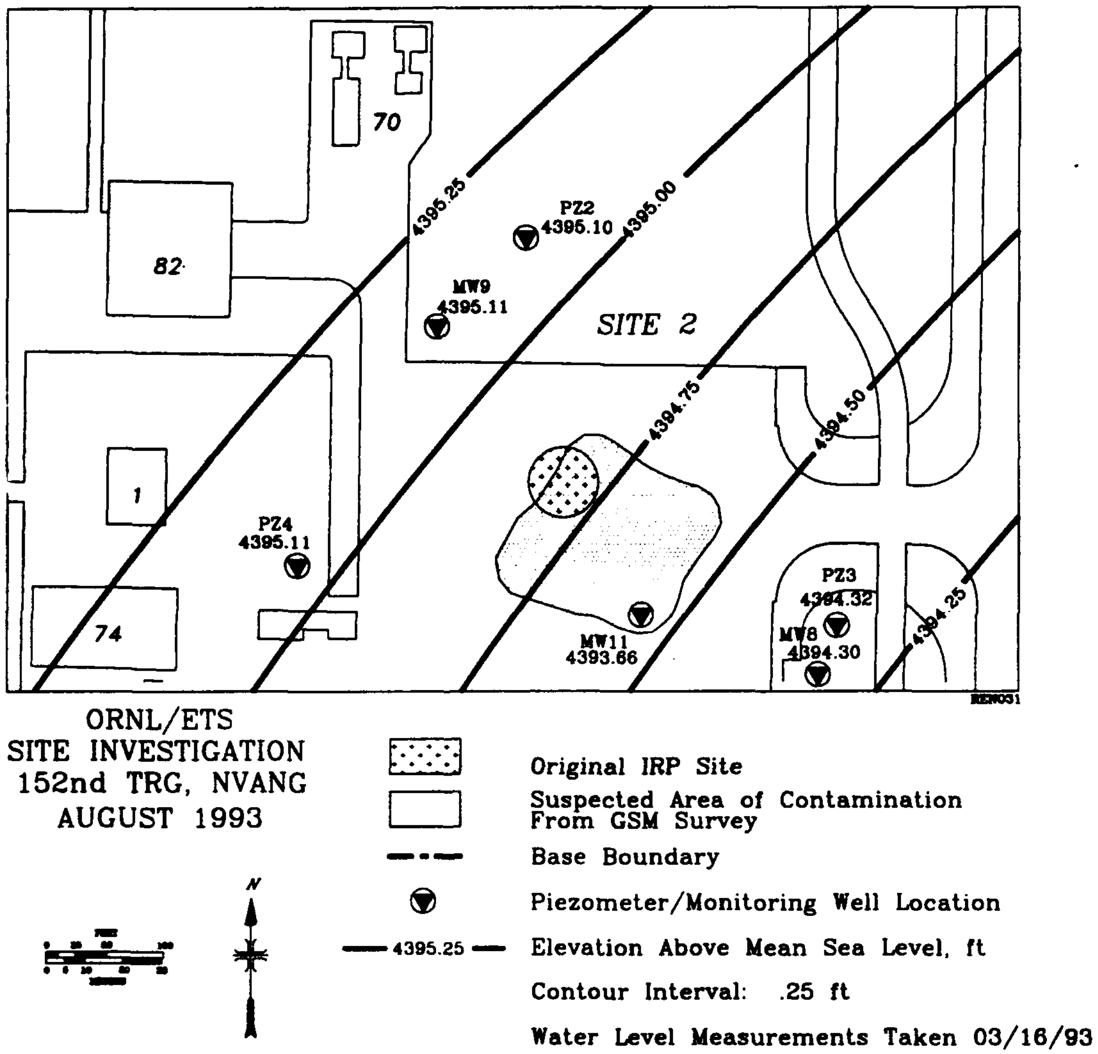


Fig. 5.9. Potentiometric surface for Site 2.

Table 5.9. Organic chemical constituents detected in Site 2 soil

Chemical	BH32-3	BH32-5	BH32-7	BH33-3	BH33-5	BH33-7	BH34-3	BH34-5
VOCs, μg/kg								
Chloroform	1.0 J	1.0 J	1.0 J		2.0 J	2.0 J		1.0 J
2-Butanone		12.0 J		4400.0 J			9.0 J	
1,2-Dichloroethene				200.0 J	8.0 J	48.0		
Ethylbenzene					17.0	12.0 J		
Xylenes					13.0			
BNAs, μg/kg								
bis(2-Ethylhexyl) phthalate	88.0 J	55.0 J	50.0 J	89.0 J	42.0 J	40.0 J	79.0 J	120.0 J
2-Methylnaphthalene					84.0 J	91.0 J		
Naphthalene					52.0 J	110.0 J		
PHCs, mg/kg								
Total petroleum hydrocarbons	84.69	1.83	1.17		12.43	0.12	0.17	

Blank space indicates compound was undetected or was flagged unusable during data validation.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

sample collected 3 ft bgs in borehole 32. All of the inorganic results for the soil samples are within the background ranges reported in Table 5.4 and are, therefore, not considered significant. The soil boring locations are presented in Fig. 5.10.

Several VOCs were detected in the soil at Site 2. These compounds include chloroform (1.0 to 2.0 μg/kg, J), 2-butanone (12 to 4400 μg/kg, J), 1,2-DCE (8.0 to 200 μg/kg, J), ethylbenzene (12 to 17 μg/kg), and total xylenes (13 μg/kg).

BNAs reported include *bis*(2-ethylhexyl) phthalate (40 to 120 μg/kg, J), 2-methylnaphthalene (84 to 91 μg/kg, J), and naphthalene (52 to 110 μg/kg, J).

PHCs, reported as total petroleum hydrocarbons (TPH), ranged from 0.12 to 85 mg/kg at Site 2.

Groundwater Sampling

Groundwater samples were collected in December 1992 and March 1993 from the wells shown in Fig. 5.10. Complete analytical results are presented in Table D-1 of Appendix D. Significant groundwater data from Site 2 are presented in Table 5.10 where the data is presented by well number and sampling round (1st or 2nd). Field measurements made during sampling are presented in Tables 5.11 and 5.12.

Two VOCs were detected in MW08: TCE was detected in both rounds at concentrations ranging from 2.0 (J) to 6 μg/L while 1,2-DCE was detected in the second round only (18 μg/L) in MW08.

Estimated concentrations of three BNAs were found in all three wells but not in both rounds of sampling. These compounds consist of two phthalates and pentachlorophenol. Due to their low and sporadic concentrations, these compounds are not considered significant.

None of the inorganic compounds presented in Table 5.10 exceed any of the applicable standards presented in Table 5.7.

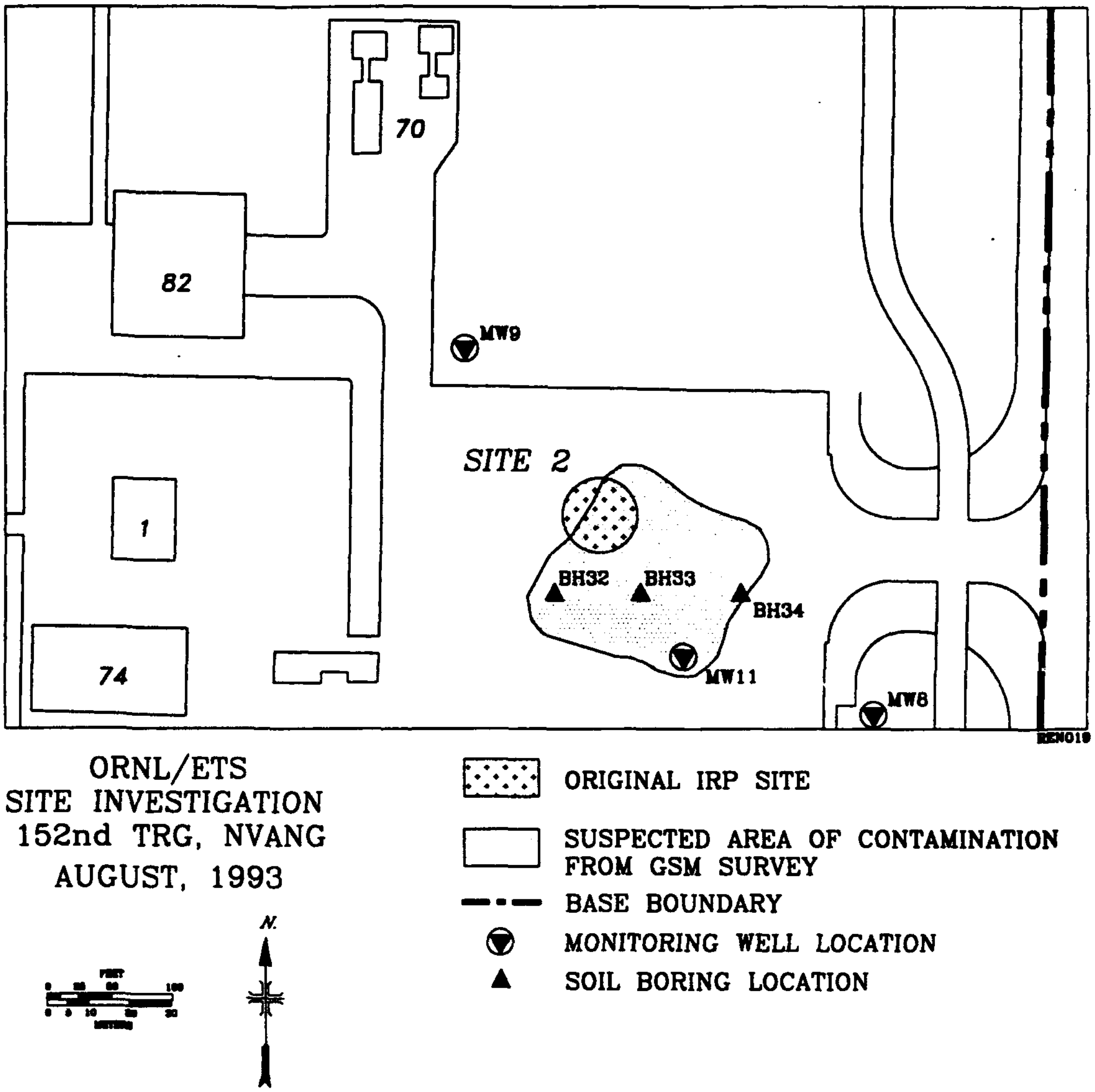


Fig. 5.10. Site 2 soil-boring and monitoring well locations.

Table 5.10. Chemical constituents detected in Site 2 groundwater

Chemical	MW08 - 1st	MW08 - 2nd	MW09 -1st	MW09 - 2nd	MW11 - 1st	MW11 - 2nd
VOCs, μg/L						
Trichloroethene	6.0	2.0 J				
1,2-Dichloroethene		18.0				
BNAs, μg/L						
Di-*n*-butyl phthalate					1.0 J	
Diethyl phthalate		1.0 J				
Pentachlorophenol		1.0 J		2.0 J		
Inorganic Analyte, μg/L						
Aluminum	389.0		366.0		392	
Antimony						36.2
Arsenic	43.4 J	50.0	26.8 J	29.5	45.2 J	49.8
Barium	95.5	41.7	50.2	23.5	64.2	92.2
Calcium	61,600.0	85,400.0	43,200.0	74,300.0	66,000.0	53,500.0
Copper					11.3	
Iron	35.9 J	65.5		21.7		262.0
Magnesium	12,400.0	17,000.0	8300.0	15,800.0	21,100.0	24,700.0
Manganese	248.0	127.0	111.0	93.6	1350.0	3030.0
Potassium	12,400.0	10,600.0 J	8820.0	9130.0 J	17,200.0	15,800.0 J
Sodium	150,000.0	157,000.0	98,700.0	132,000.0	132,000.0	81,100.0
Vanadium	13.5	11.0	11.9	17.7	6.9	
Zinc	5.3	5.2	5.3		4.9	8.7

Blank space indicates compound was undetected or was flagged unusable during data validation.

J = reported value is below the contract required detection limit but above the instrument detection limit for VOCs and BNAs. For inorganics the reported value is estimated because the associated matrix spike has out of control limits. Values are estimated quantities.

Table 5.11. Groundwater field measurements, Round 1 sampling

Well Number	Water level[1] bcl, ft	Water table elev, ft amsl[2] 12/04/92	pH	Temp, °C	Conductivity, µmhos
MW01	11.12	4394.99	7.92	14.7	1030
MW02	7.06	4397.56	8.32	18.2	2240
MW03	9.08	4395.30	7.60	13.5	2130
MW04	8.58	4395.11	7.57	15.5	2160
MW05	8.46	4395.15	7.37	16.1	1950
MW06	4.74	4393.95	7.11	19.6	892
MW07	4.40	4393.50	7.14	19.0	1283
MW08	5.34	4393.87	7.18	19.2	911
MW09	7.40	4394.57	7.06	17.6	616
MW10	6.50	4394.29	7.34	15.2	1135
MW11	5.92	4394.17	7.33	19.0	1068
MW12	7.62	4394.88	7.05	17.2	784
MW13	7.57	4394.91	7.08	17.5	616
MW14	7.09	4395.04	6.94	18.9	880
MW15	8.03	4394.74	7.18	17.4	786
MW16	9.06	4395.11	7.22	15.3	699
MW17	7.34	4395.16	6.99	17.1	746
MW18	8.01	4394.75	7.34	17.1	786
MW19	8.83	4395.28	7.24	18.7	545
MW20	7.73	4395.32	6.89	15.9	1484
MW21	7.57	4395.72	6.90	15.4	1216
MW22	9.02	4395.63	6.99	19.2	1560
MW23	5.92	4393.48	6.18	17.1	1232
MW24	5.24	4393.43	7.41	17.8	984
MW25	3.61	4394.17	7.02	15.2	1680

[1] water level in ft below casing level.

[2] water table elevation in ft above mean sea level.

Table 5.12. Groundwater field measurements, Round 2 sampling

Well Number	Water level[1] bcl, ft	Water table elev, ft amsl[2] 03/16/93	pH	Temp, °C	Conductivity, μmhos
MW001	8.86	4397.25	ND	ND	ND
MW002	5.36	4399.26	7.18	14.7	1760
MW003	7.54	4396.84	7.29	11.7	2340
MW004	7.39	4396.30	7.22	13.6	1980
MW005	7.25	4396.36	7.33	11.5	1600
MW006	4.38	4394.31	7.17	15.6	950
MW007	4.23	4393.67	6.74	16.5	2540
MW008	4.91	4394.30	7.10	12.9	1290
MW009	6.86	4395.11	7.10	14.9	850
MW010	5.99	4394.80	6.80	12.7	1620
MW011	5.43	4394.66	7.13	13.5	794
MW012	7.11	4395.39	6.54	15.5	600
MW013	7.04	4395.44	6.74	15.8	610
MW014	6.78	4395.35	7.04	15.1	980
MW015	7.50	4395.27	6.46	15.4	1070
MW016	8.63	4395.54	7.07	14.9	812
MW017	6.86	4395.64	7.08	13.9	660
MW018	7.25	4395.51	6.88	14.0	980
MW019	8.29	4395.82	7.75	16.9	647
MW020	7.28	4395.77	6.62	14.9	1570
MW021	7.02	4396.27	6.92	14.9	1310
MW022	8.41	4396.24	7.13	16.4	1620
MW023	5.23	4394.17	7.39	15.0	1178
MW024	4.65	4394.02	6.80	15.4	1150
MW025	3.56	4394.22	6.80	16.3	1590

[1] water level in ft below casing level.
[2] water table elevation in ft above mean sea level.

ND = non detect

Comparison of Screening Results with Confirmation Results

The results of the GSM survey compare favorably with the confirmation data. The GC headspace analysis of groundwater samples collected from the water table suggested the trace presence of VOC groundwater contamination within the shaded area in Fig. 5.10. Similarly, the PID values listed are a relative measure of VOC soil contamination. Soil contamination was confirmed by soil boring results, presented in Table 5.9. However, the lack of VOC contamination in MW11 suggests this well may have been located south of the actual groundwater flow path, which may be passing it on the north side. Although 1,2-DCE was found in the soil at Site 2, no TCE was confirmed, which suggests the origin of the latter solvent in groundwater at MW08 may be related to activities that have taken place on the aircraft parking apron after Site 2 was covered with concrete. Therefore, the presence of TCE in MW08 may be related to Site 2 but cannot be confirmed without an additional data point.

5.4.3 Geologic and Hydrogeologic Investigation Results

The subsurface encountered at Site 2 is comprised of fill material: yellowish-brown to gray silty clay; and very dark gray, well-graded sandy gravel with occasional cobbles. The geologic cross section presented in Fig. 5.11 was constructed using lithologic data from MW08, MW09, and MW11. Well construction data are presented in Appendix B.

The fill material, which thickens from 2 ft at the northwest end to 10 ft at the southeast end, is present across the entire site. The underlying silty clay is approximately 4 ft thick across most the site but pinches out at the southeast end. Thickness of the water-bearing well-graded sand was not determined because none of the monitoring wells penetrate through it completely.

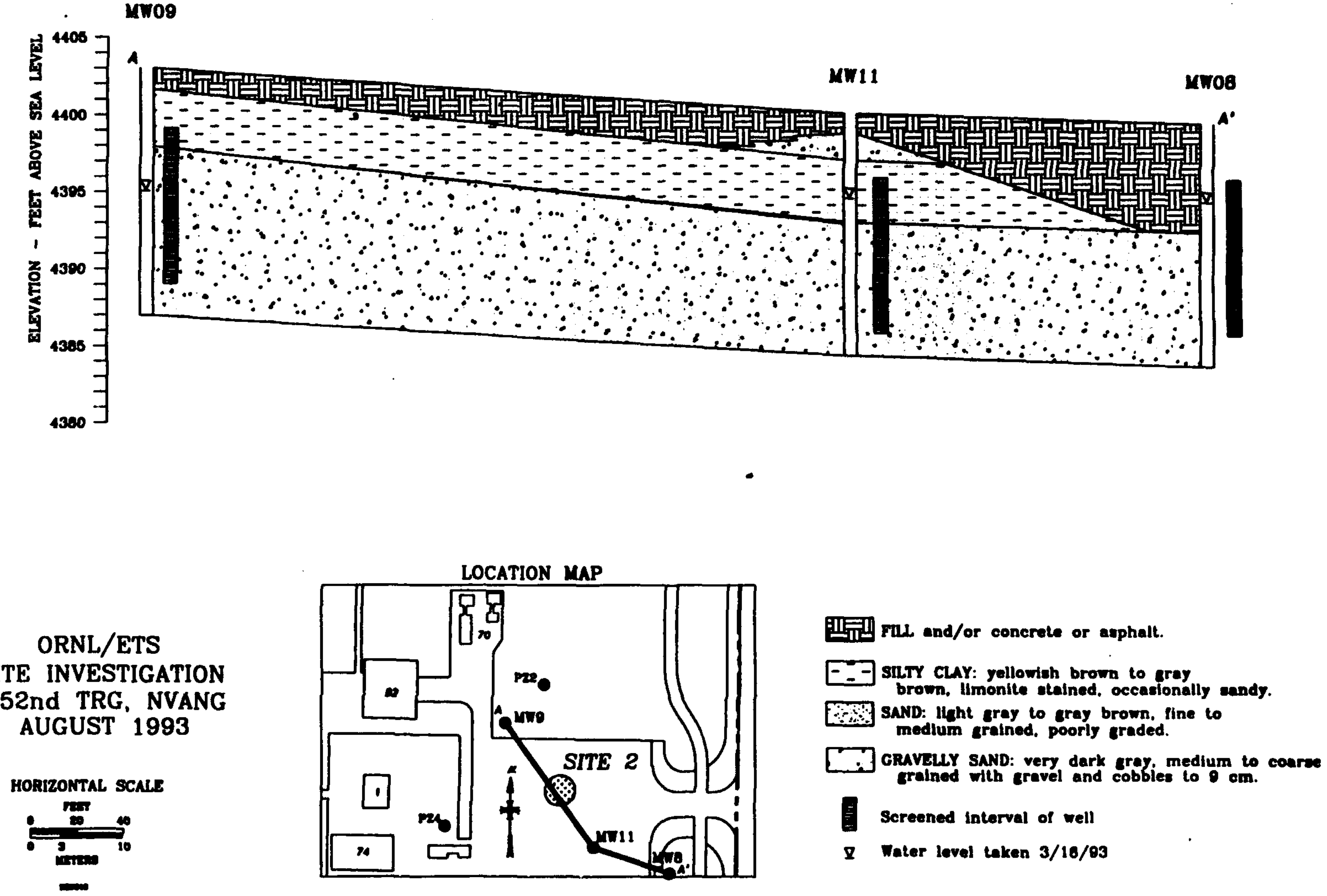


Fig. 5.11. Geologic cross section of Site 2.

Piezometer data were evaluated, and the groundwater flow direction was determined to be to the southeast. An upgradient monitoring well (MW09) and two downgradient monitoring wells were installed (MW08 and MW11). A final round of water-level measurements was used to construct the potentiometric map presented in Fig. 5.9. The average hydraulic gradient for Site 2 is approximately 3.6 ft/mile. Based on the hydraulic testing results discussed in Sect. 5.2, the hydraulic conductivity ranges from 232 to 396 ft/d at Site 2. Both the gradient and conductivity values correlate well with the predominantly coarser and more-permeable lithology of the aquifer at Site 2.

5.4.4 Conclusions

As discussed in Sect. 2.2.1, this site consists of a former FTA that has been covered with concrete during expansion of the aircraft parking apron. Results of the investigation at Site 2 indicate the presence of low levels of chlorinated solvents and fuel-related compounds in the soil. The highest VOC contamination in soil was found in BH33-5 and BH33-7. The highest PHC contamination was found in BH32-3 and BH33-5. The presence of chloroform, 2-butanone, *bis*(2-ethylhexyl) phthalate, diethyl phthalate, and pentachlorophenol at low concentrations in the soil is not considered significant for reasons previously discussed.

Results of the groundwater samples and groundwater levels indicate that MW11 may be located outside (south) of the contaminated groundwater flow path affecting MW08. While MW11 has no observed contamination, MW08 located downgradient shows low levels of TCE and 1-2,DCE. The groundwater flow direction indicated by the potentiometric map (Fig. 5.9) also suggests that MW11 is located south of the flow path containing the solvent-contaminated groundwater. Although the respective maximum concentration limits (MCLs) for TCE were exceeded on separate occasions, this contamination is located downgradient of the site and may result from activities not associated with Site 2. Currently Site 2 has been incorporated into Site 12 (Apron Area) which is undergoing investigation. Results of the investigation may provide sufficient information to delineate the contamination contribution from Site 2.

5.5 Site 3, FTA No. 3

5.5.1 Screening Activity Results

GSM Survey

The results of the GSM survey are presented in Fig. 5.12 and Table 5.13. Samples were collected from 21 locations on a 200 × 200-ft grid with 50-ft spacing. The grid was located to surround the suspected location of the former FTA identified in aerial photographs.

Although the GSM survey suggested trace levels of several chlorinated and fuel-related compounds in the groundwater (TCE, 1,2-DCE, benzene, and toluene), the coexistence of numerous unknown compounds interfered with definitive compound identification during GC headspace analysis. As previously discussed in Sect. 4.5.1, the GC data were used as a measure of relative contamination. Points with little or no apparent groundwater contamination were deemed negative, and those with moderate to high apparent groundwater contamination were classified positive. Thus, all of the points within the suspected contamination area, indicated by shading in Fig. 5.12, are positive. Also reported in Fig 5.12 and Table 5.13 are the PID values recorded at each hole, which are indicative of VOCs in soil. Consequently, a positive GC decision may be paired with a relatively low PID reading suggesting potential groundwater contamination without any associated soil contamination. Conversely, a relatively high PID reading may be paired with a negative GC decision, suggesting potential soil contamination without any associated groundwater contamination.

Piezometer Levels

Three piezometers (PZ01, PZ12, and PZ20) were installed around Site 3 in order to determine the optimum placement of monitoring wells. Construction data on the piezometers are presented in Appendix B. The potentiometric surface map for Site 3

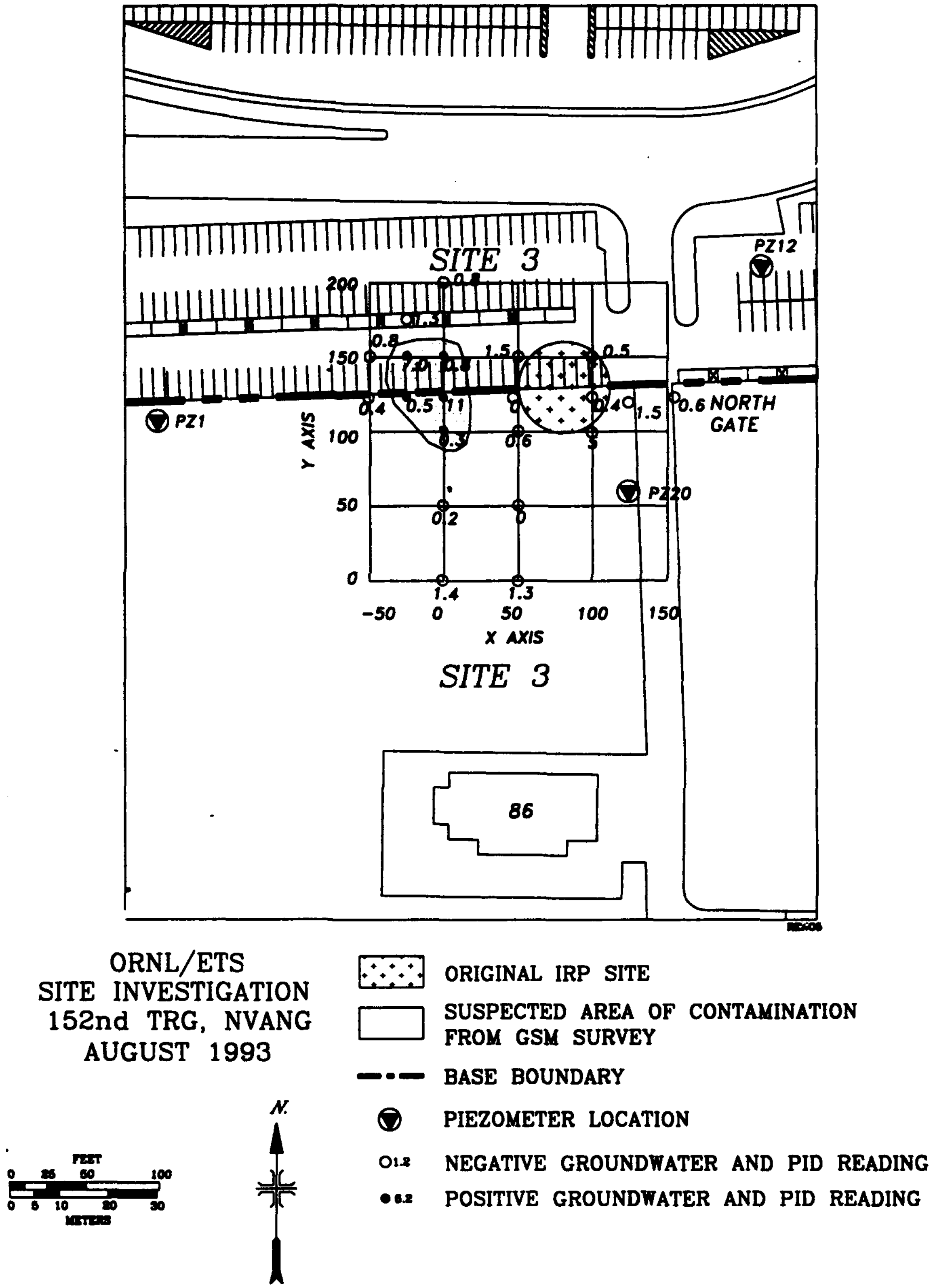


Fig. 5.12. Site 3 GSM survey locations.

Table 5.13. GSM survey results from Site 3

Location	Grid coordinates, x,y	PID, ppm	GC Decision
S301	0,0	1.4	Negative
S302	0,50	0.2	Negative
S303	0,100	0.3	Positive
S304	0,122	11	Positive
S305	-50,122	0.4	Negative
S306	50,0	1.3	Negative
S307	50,50	0	Negative
S308	100,100	5	Negative
S309	50,122	0	Negative
S310	50,100	0.6	Negative
S311	100,122	0.4	Negative
S312	-25,122	0.5	Positive
S313	124,119	1.5	Negative
S314	155,122	0.6	Negative
S315	100,150	0.5	Negative
S316	50,150	1.5	Negative
S317	0,150	0.8	Positive
S318	-25,150	7	Positive
S319	-50,150	0.8	Negative
S320	-25,175	1.3	Negative
S321	0,200	0.8	Negative

(Fig. 5.13) indicates that groundwater flows to the east-southeast. Groundwater flow direction is discussed in Sect. 5.5.3.

5.5.2 Confirmation and Delineation Activities

Three monitoring wells and five soil borings were drilled to support characterization of Site 3. Twelve soil samples, collected from the soil borings, and six groundwater samples, collected from the monitoring wells, were submitted for laboratory analysis. Two duplicate groundwater samples were also collected. Soil and groundwater samples were analyzed for VOCs, BNAs, PHCs, and metals.

Soil Sampling

Complete analytical results for the soil samples are presented in Table D-1 of Appendix D. Significant results from the organic analyses are presented in Table 5.14. The data are presented by boring number and depth. For example, BH03-6 refers to the sample collected 6 ft bgs in borehole 3. All of the inorganic results for the soil samples are within the background ranges reported in Table 5.4 and, therefore, are not considered significant. The soil boring locations are presented in Fig. 5.14.

Chloroform at very low estimated levels (1.0 to 2.0 μg/kg, J) was the only VOC detected in the soil at Site 3. *Bis*(2-ethylhexyl) phthalate (63 to 84 μg/kg, J) was the only BNA compound detected in the soil at Site 3.

Groundwater Sampling

Groundwater samples were collected in December 1992 and March 1993 from the wells shown in Fig. 5.14. Complete analytical results are presented in Table D-1 of Appendix D. Significant groundwater data from Site 3 are presented in Table 5.15. Field measurements made during sampling are presented in Tables 5.11 and 5.12.

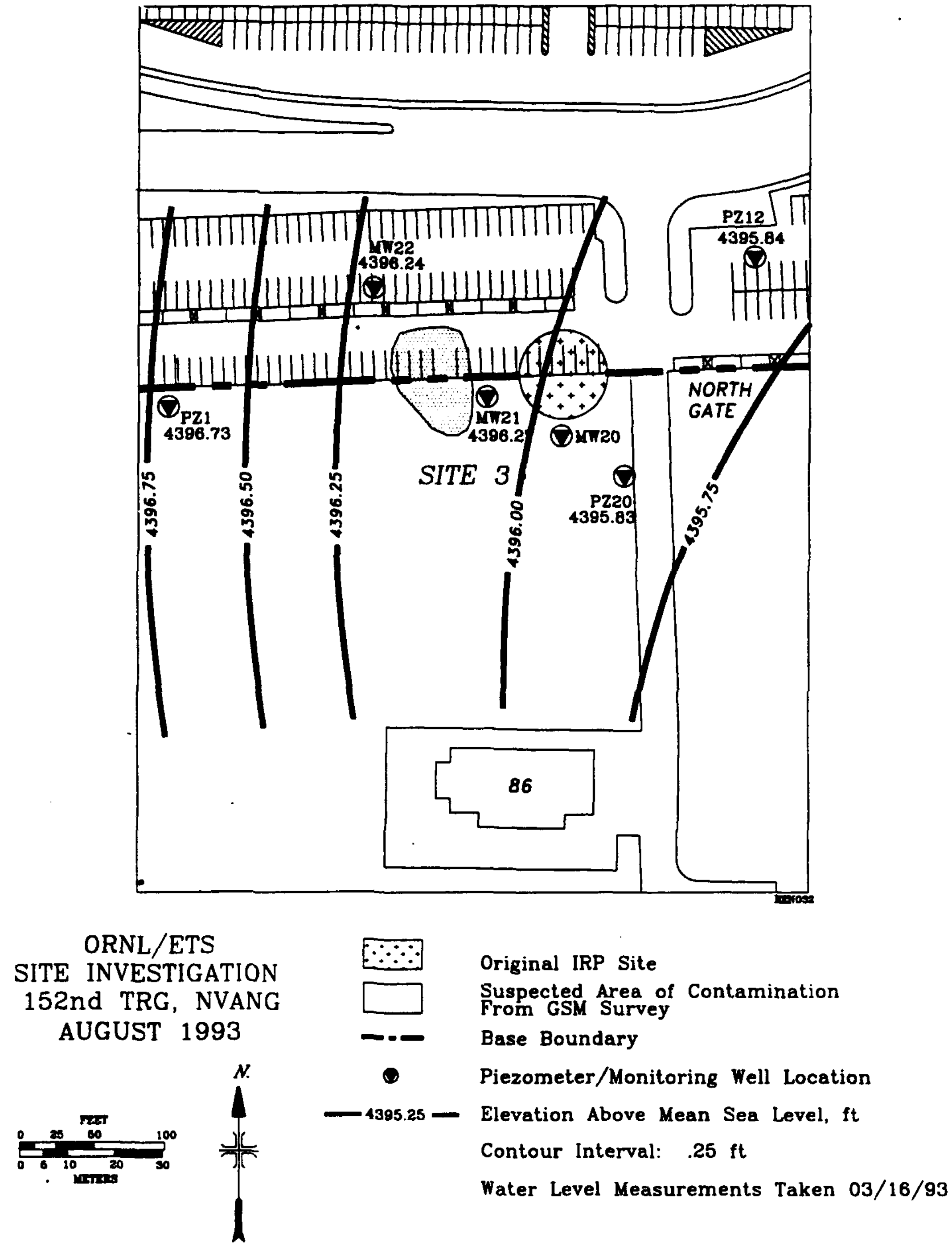


Fig. 5.13. Potentiometric surface for Site 3.

Table 5.14. Organic chemical constituents detected in Site 3 soil

Chemical	BH03-6	BH03-8	BH04-4	BH04-6	BH05-6	BH05-7
VOCs, μg/kg						
Chloroform	2.0 J	2.0 J	1.0 J			
BNAs, μg/kg						
bis(2-Ethylhexyl) phthalate			84.0 J		63.0 J	83.0 J

Blank spaces indicates compound was undetected or was flagged unusable during data validation.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

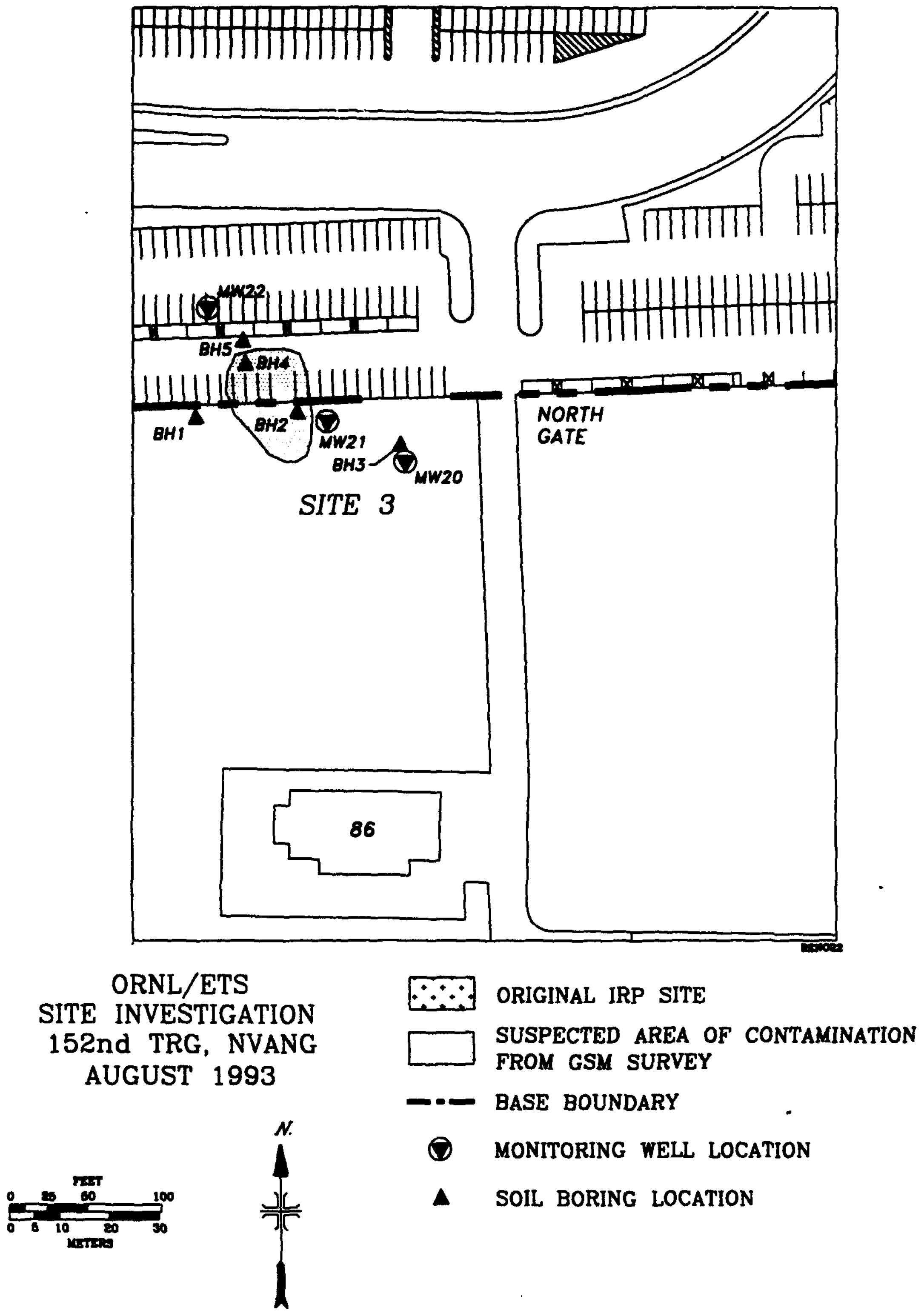


Fig. 5.14. Site 3 soil-boring and monitoring well locations.

Table 5.15. Chemical constituents detected in Site 3 groundwater

Chemical	MW20-1st	MW20-2nd	MW21-1st	MW21-1st D	MW21-2nd	MW21-2nd D	MW22-1st	MW22-2nd
VOCs, μg/L								
Toluene							2.0 J	
BNAs, μg/L								
Diethyl phthalate					1.0			
Di-*n*-butyl phthalate			1.0 J					
Inorganics Analytes, μg/L								
Aluminum	194.0		178.0	202.0			196.0	
Antimony		30.0						
Arsenic	37.9 J	38.7 J	39.0 J	32.0 J	30.3 J	26.7	23.2 J	15.8
Barium	53.2	83.6	43.7	44.1	52.4	50.4	66.5	63.1
Beryllium		1.0						
Cadmium		5.0						
Calcium	45,400	47,535	44,100	43,700	490,00	48,900	57,400	62,900
Chromium		6.0						
Cobalt		9.0						
Copper	8.2	4.0		9.6	6.2		11.0	
Iron	75.2						75.2	
Magnesium	16,000	15,178	12,800	12,800	14,100	14,000	18,100	17,900
Manganese	258.0	239.8	27.0	26.4	17.1	15.3	328.0	236.0

Table 5.15. (continued)

Chemical	MW20-1st	MW20-2nd	MW21-1st	MW21-1st D	MW21-2nd	MW21-2nd D	MW22-1st	MW22-2nd
Mercury		0.2 J						
Nickel		13.0						
Potassium	11,000	7,997	9030	10,300	9330	8460	14,800	11,700
Selenium		3.0						
Silver		5.0						
Sodium	297,000	268,990	221,000	223,000	233,000	227,000	304,000	280,000
Thallium		3.0						
Vanadium	9.7	8.28	10.6	10.3	7.3	9.2	6.7	6.2
Zinc	7.0		4.8	5.6			4.2	

Blank space indicates compound was undetected or was flagged unusable during data validation.
D indicates duplicate sample.

J = reported value is below the contract required detection limit, but above the instrument detection limit for VOCs and BNAs. For inorganics the reported value is estimated because the associated matrix spike nas out of control limits. Values are estimated quantities.

Toluene was reported at 2 μg/L (J), in the first round sample from MW22. Estimated levels (1 μg/L, J) of diethyl phthalate and di-*n*-butyl phthalate were reported in MW21 but not in the duplicate samples or in both rounds.

None of the compounds presented in Table 5.15 exceed any of the applicable standards presented in Table 5.7.

Comparison of Screening Results with Confirmation Results

The GSM survey suggested the presence of trace levels of organic contamination within the shaded area in Fig. 5.14. However, the lack of contamination in the confirmation data suggests the low levels of organics indicated by the GSM survey were below the CLP method detection limits of the confirmation samples.

5.5.3 Geologic and Hydrogeologic Investigation Results

The subsurface encountered at Site 3 is comprised of fill material: pale-gray to olive-brown silt; fine to medium-grained, light-gray to gray-brown sand; and very dark gray, well-graded sandy gravel with occasional cobbles. The geologic cross section presented in Fig. 5.15 was constructed using lithologic data from MW20, MW21, and MW22. Well construction data are presented in Appendix B.

Approximately 2 to 3 ft of fill material are present across the entire site. The underlying silt is 2 to 4 ft thick, uniformly calcareous, and increasingly clayey in MW22. Immediately underneath the silt is the well-graded sand, which is divided by a thin silt stringer and a slightly thicker, fine-grained sand stringer. The facies change depicted in the cross section is typical of depositional characteristics observed in fluvial and lacustrine environments. Thickness of the water-bearing well-graded sand was not determined because ıe of monitoring wells penetrate through it completely.

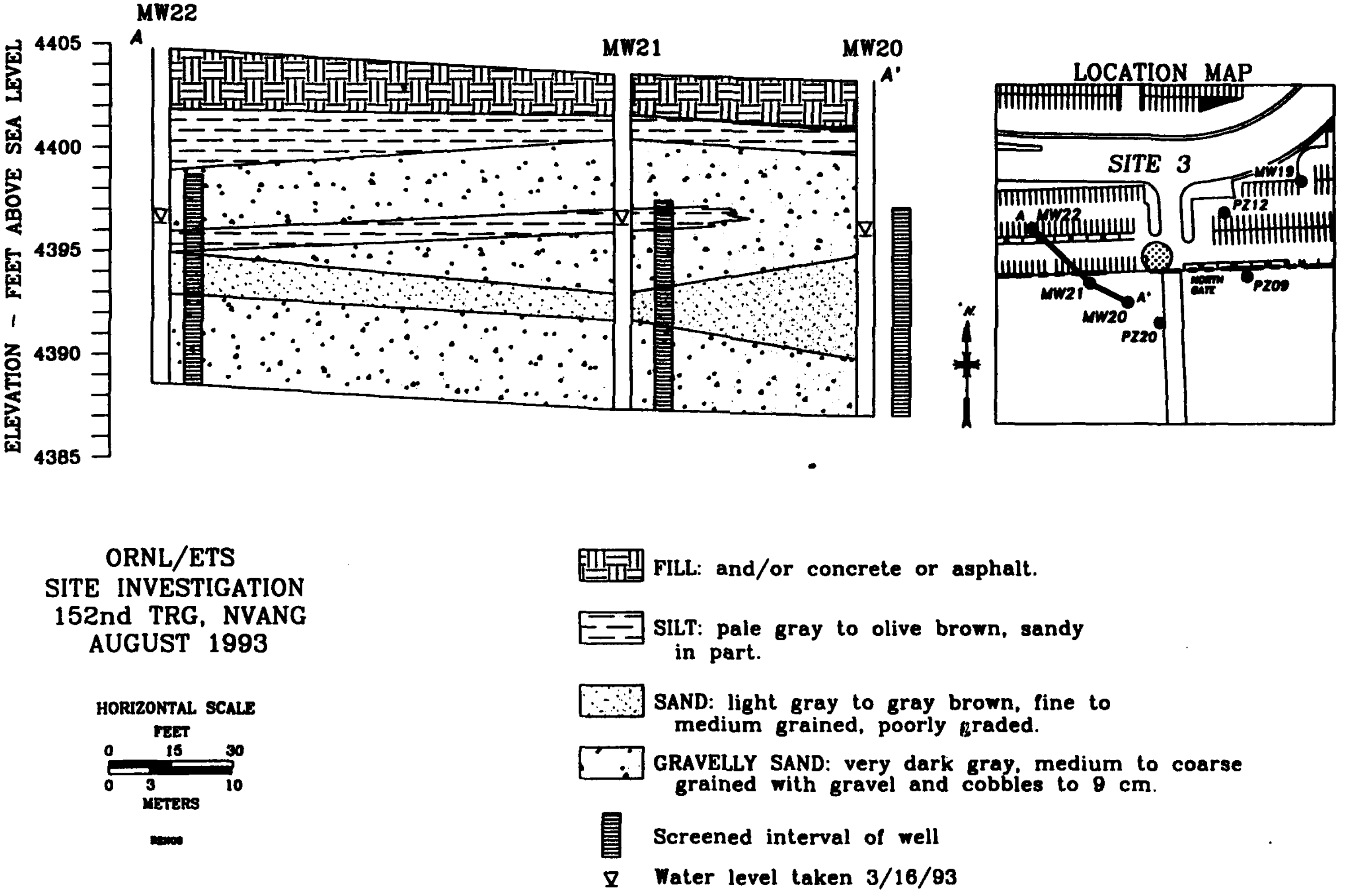


Fig. 5.15. Geologic cross section of Site 3.

Piezometer data were evaluated, and the groundwater flow direction was determined to be east to southeast. An upgradient monitoring well (MW22) and two downgradient monitoring wells were installed (MW20 and MW21). A final round of water-level measurements was used to construct the potentiometric map presented in Fig. 5.13. The average hydraulic gradient for Site 3 is approximately 7.8 ft/mile. Based on the hydraulic testing results discussed in Sect. 5.2, the hydraulic conductivity ranges between 285 and 479 ft/d at Site 3. Both the gradient and conductivity values correlate well with the coarser, more-permeable aquifer lithology found at Site 3.

5.5.4 Conclusions

- Results of the investigation at Site 3 indicate that there are no confirmable levels of contaminants in the soil or groundwater. Although the screening data suggested that trace levels of organics were present, none were indicated by the confirmation sampling. Therefore, former activities at Site 3 have apparently not impacted soil or groundwater quality.

5.6 Site 4, FTA No. 4

5.6.1 Screening Activity Results

GSM Survey

The results of the GSM survey are presented in Fig. 5.16 and Table 5.16. Samples were collected from 21 locations on a 100 × 200-ft grid with 50-ft spacing. The grid was located to surround the suspected location of the former FTA identified in aerial photographs.

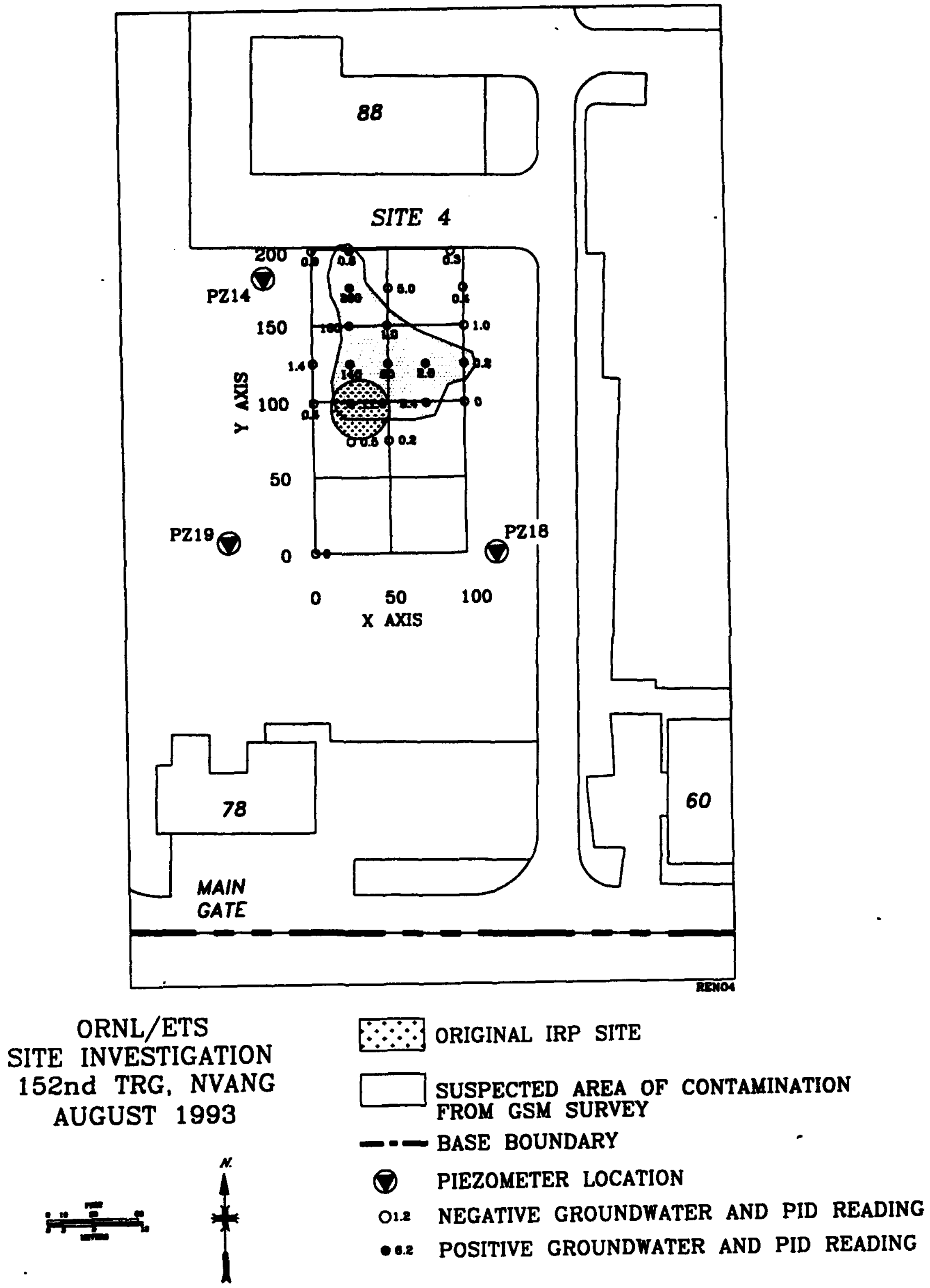


Fig. 5.16. Site 4 GSM survey locations.

Table 5.16. GSM survey results from Site 4

GSM Location	Grid coordinates, x,y	PID, ppm	GC Decision
S401	0,0	0	Negative
S402	0,100	0.4	Negative
S403	0,200	0.9	Negative
S404	90,200	0.3	Negative
S405	100,100	0	Negative
S406	25,100	11.6	Positive
S407	50,150	1.0	Positive
S408	100,150	1.0	Negative
S409	75,100	9.4	Positive
S410	50,75	0.0	Negative
S411	25,125	140	Positive
S412	25,75	0.5	Negative
S413	50,125	60	Positive
S414	0,125	1.4	Negative
S415	25,150	160	Positive
S416	25,175	260	Positive
S417	25,200	0.6	Positive
S418	50,175	5	Negative
S419	100,175	0.4	Negative
S420	75,125	2	Positive
S421	100,125	0.2	Positive

Although the GSM survey suggested the presence of several chlorinated and fuel related compounds in the groundwater (TCE, 1,2-DCE, 1,1-DCE, benzene, toluene, ethylbenzene, and xylenes), the coexistence of numerous unknown compounds interfered with definitive compound identification during GC headspace analysis. As previously discussed in Sect. 4.5.1, the GC data were used as a measure of relative contamination. Points with little or no apparent groundwater contamination were deemed negative, and those with moderate to high apparent groundwater contamination were classified positive. Thus, all of the points within the shaded area of Fig. 5.16, which represents the suspected area of groundwater contamination, are positive. Also reported in Fig. 5.16 and Table 5.16 are the PID readings recorded at each hole, which are indicative of VOCs in the soil. Consequently, a positive GC decision may be paired with a relatively low PID reading, suggesting potential groundwater contamination without any associated soil contamination. Conversely, a relatively high PID reading may be paired with a negative GC decision, suggesting potential soil contamination without any associated groundwater contamination.

Piezometer Levels

Three piezometers (PZ14, PZ18, and PZ19) were installed around Site 4 in order to determine the optimum placement of monitoring wells. Construction data on the piezometers are presented in Appendix B. The potentiometric surface map for Site 4 (Fig. 5.17) indicates that groundwater flows to the east. Groundwater flow direction is discussed in Sect. 5.6.3.

5.6.2 Confirmation and Delineation Activities

Three monitoring wells and five soil borings were drilled to support characterization of Site 4. Twelve soil samples, collected from the soil borings, and six groundwater samples plus two duplicate groundwater samples, collected from the monitoring wells, were submitted for laboratory analysis. Soil and groundwater samples were analyzed for VOCs, BNAs, PHCs, and metals.

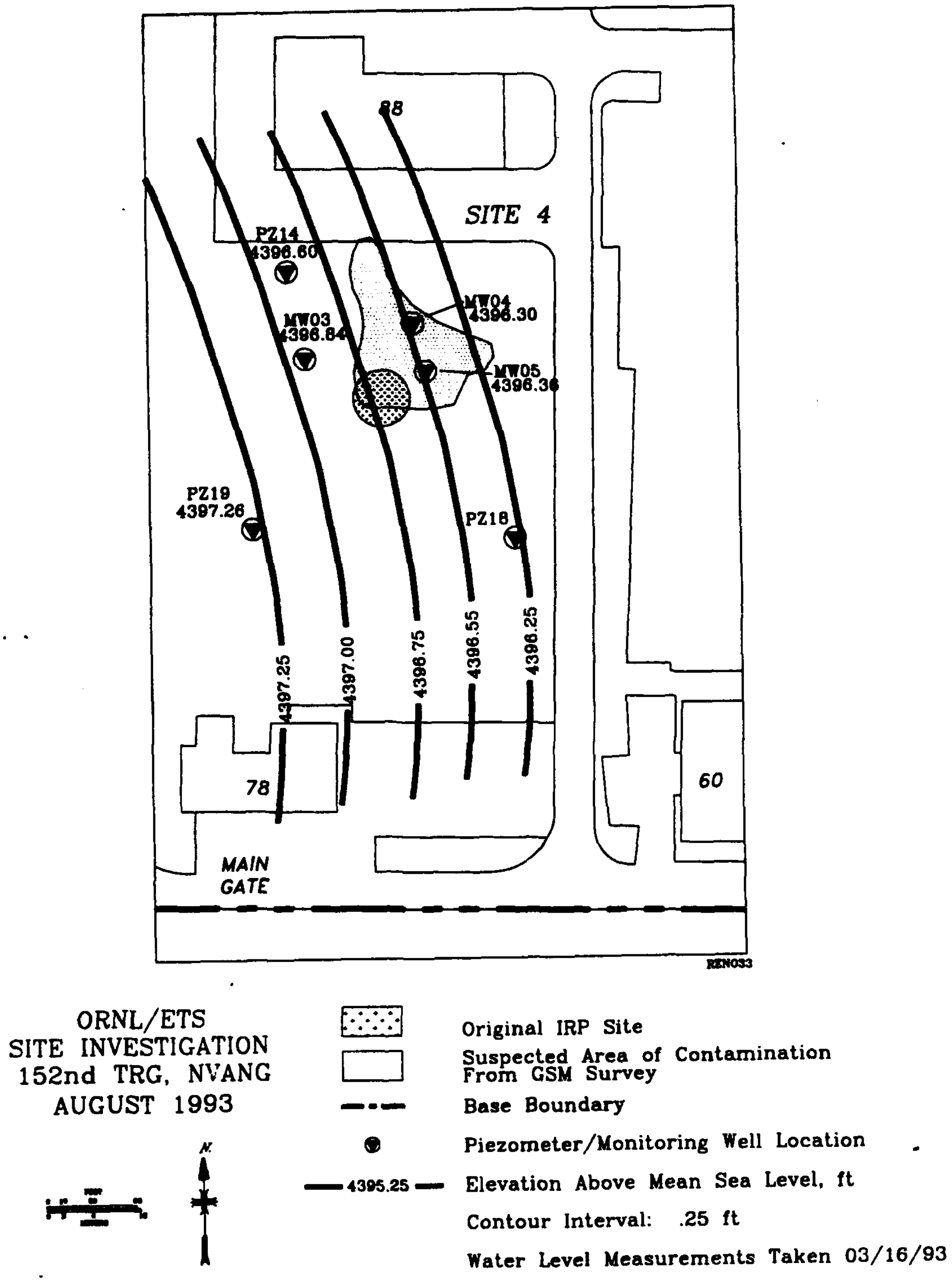


Fig. 5.17. Potentiometric surface for Site 4.

Soil Sampling

Complete analytical results for the soil samples are presented in Table D-1 of Appendix D. Significant results from the organic analyses are presented in Table 5.17. The data are presented by boring number and depth. For example, BH12-2 refers to the sample collected 2 ft bgs in borehole 12. All of the inorganic results for the soil samples are within the background ranges reported in Table 5.4 and are, therefore, not considered significant. The soil boring locations are presented in Fig. 5.18.

Several VOCs were detected in the soil at Site 4. These compounds include chloroform (1.0 to 2.0 μg/kg, J), acetone (1800 μg/kg, J), methylene chloride (1900 μg/kg, J), benzene (5 μg/kg, J), ethylbenzene (72 to 1300 μg/kg, J), and total xylenes (2.o (J) to 4600 μg/kg).

BNAs reported include *bis*(2-ethylhexyl) phthalate (73 (J) to 590 μg/kg), 2-methylnaphthalene (910 to 1200 μg/kg), naphthalene (1500 to 2100 μg/kg), pyrene (45 μg/kg, J), and phenol (52 μg/kg, J).

All of the inorganic results reported in Table D-1 of Appendix D are within the background ranges reported in Table 5.4.

PHCs, reported as TPH, ranged from 0.01 (J) to 3800 mg/kg at Site 4.

Groundwater Sampling

Groundwater samples were collected in December 1992 and March 1993 from the wells shown in Fig. 5.18. Complete analytical results are presented in Table D-1 of Appendix D. Significant groundwater data from Site 4 are presented in Table 5.18. Field measurements made during sampling are presented in Tables 5.11 and 5.12.

Table 5.17. Organic chemical constituents detected in Site 4 soil

Chemical	BH12-2	BH12-6	BH12-8	BH13-2	BH13-4	BH13-8	BH14-4	BH14-6	BH14-8	BH15-2	BH15-6	BH15-6D
VOCs, μg/kg												
Ethylbenzene			1300 J						400 J	72		
Methylene chloride			1900 J									
Xylenes			4600						1000 J	170	2 J	
Chloroform							1 J	2 J				
Acetone									1800 J			
Benzene										5 J		
BNAs, μg/kg												
bis(2-Ethylhexyl) phthalate	170 J	180 J	590 J	230 J	190 J	120 J	330 J	73 J	500	97 J	83 J	590
2-Methylnaphthalene			910						1200			
Naphthalene			1500						2100			
Pyrene										45 J		
Phenol												52 J
PHCs, mg/kg												
Total Petroleum Hydrocarbons	0.01 J		630			120	0.10 J		3800	9.20	0.39 J	250

Blank space indicates compound was undetected or was flagged unusable during data validation.
D indicates duplicate sample.

J = Reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

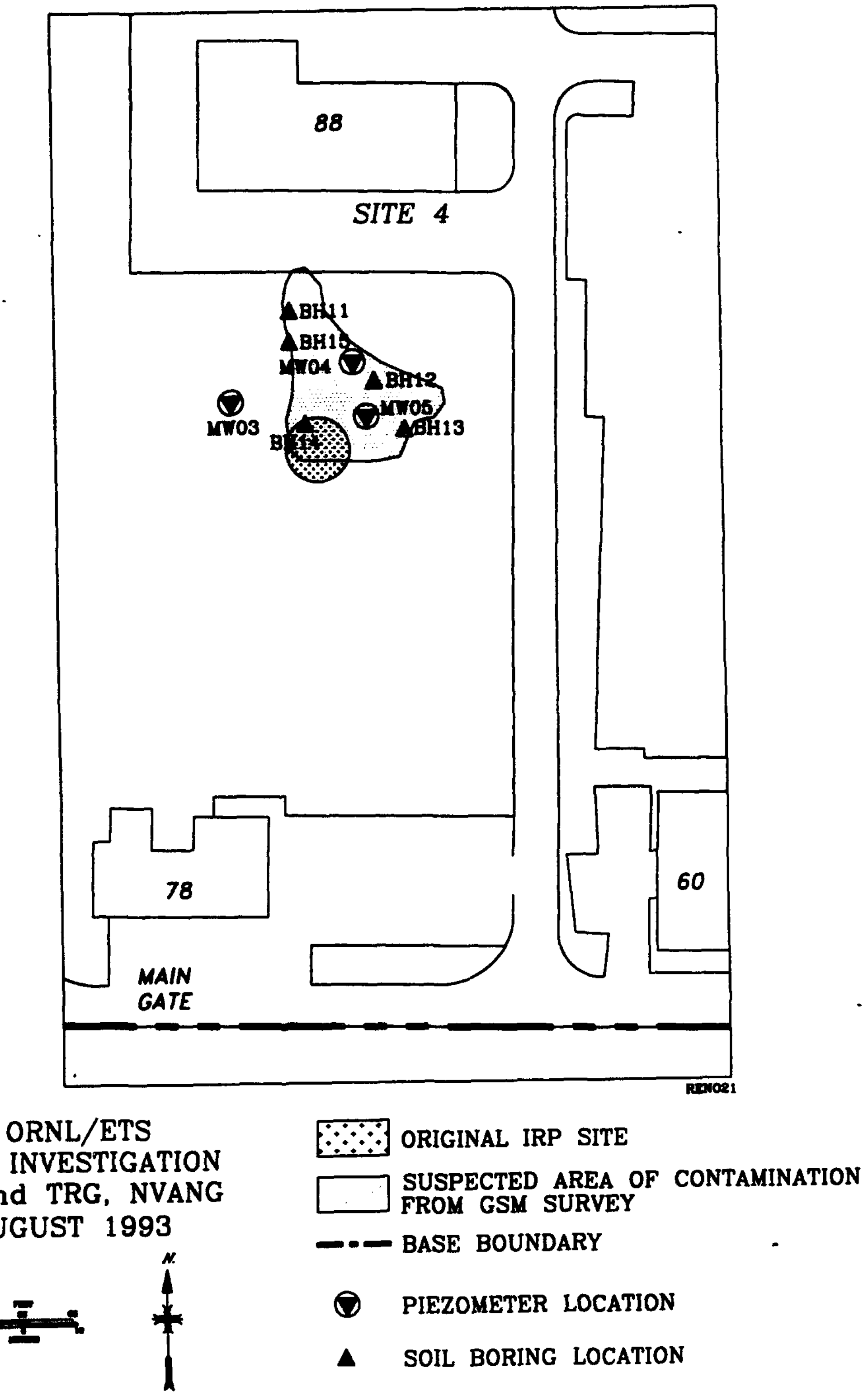


Fig. 5.18. Site 4 soil-boring and monitoring well locations.

Table 5.18. Chemical constituents detected in Site 4 groundwater

Chemical	MW03-1st	MW03-2nd	MW04-1st	MW04-2nd	MW05-1st	MW05-1st D	MW05-2nd	MW05-2nd D
VOCs, *µg/L*								
Benzene					18.0	17.0	24.0	23.0
Ethylbenzene					17.0	12.0	27.0	24.0
Toluene					24.0	21.0	37.0	33.0
Trichloroethene					20.0	14.0	8.0	9.0
Xylenes					210.0	200.0	450.0	450.0
Actone				2.0 J				
Methylene chloride				3.0				
BNAs, *µg/L*								
1,2-Dichlorobenzene					1.0	2.0	5.0	11.0
1,3-Dichlorobenzene							2.0	3.0
1,4-Dichlorobenzene							2.0	4.0
2-Methylnaphthalene							2.0	4.0
2,4-Dimethylphenol					2.0	1.0		
bis(2-Ethylhexyl) phthalate						58.0 J		
Butylbenzyl phthalate								2.0
Di-*n*-butyl phthalate								2.0
Naphthalene					8.0	6.0	9.0	17.0
PHCs, mg/L								
Total Petroleum Hydrocarbons					1.2	0.74	2.4	0.74

Table 5.18. (continued)

Chemical	MW03-1st	MW03-2nd	MW04-1st	MW04-2nd	MW05-1st	MW05-1st D	MW05-2nd	MW05-2nd D
Inorganic Analytes *µg/L*								
Aluminum	512.0		490.0		449	498.0		
Arsenic	116.0 J	121.0 J	55.4 J	73.0 J	58.6 J	57.1 J	116 J	116.0 J
Barium	95.0	79.0	106.0	68.7	397.0	363.0	237	218.0
Calcium	66,900	88,700	96,400	90,900	83,200	82,100	72,500	64,600
Cobalt					15.3	13.9		
Copper	10.5	15.8	13.4	12.9	109.0	104.0	12.4	15.3
Iron	43.8 J	21.4 J	43.9 J		34.3 J			
Magnesium	18,600	26,500	24,100	23,800	22,900	22,600	18,300	16,300
Manganese	384.0	448.0	152.0	100.0	4660.0	4080.0	845	814
Mercury							0.21 J	
Nickel					11.6	12.8		
Potassium	12,100	14,200	16,000	15,100	17,200	15,700	15,700	14,700
Selenium	4.9	4.8					5.5	
Sodium	394,000	421,000	371,000	368,000	371,000	361,000	285,000	254,000
Vanadium	7.1	9.0	17.9	17.5	6.2		11.3	10.6
Zinc	4.6		13.8		22.6	6.9		

Blank space indicates compound was undetected.
D indicates duplicate sample.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

Several VOCs were detected in groundwater samples and duplicates from both rounds in MW05: TCE (8 to 20 μg/L), benzene (17 to 24 μg/L), ethylbenzene (12 to 27 μg/L), toluene (21 to 37 μg/L), and total xylenes (200 to 450 μg/L). Low levels of methylene chloride and acetone were reported in the second round sample from MW04, suggesting spurious laboratory contamination.

Nine BNA compounds are listed in Table 5.18 under MW05. The values listed for the three phthalates are inconsistent in appearance and indicative of laboratory and/or sampling contamination. With the exception of 1,2-dichlorobenzene and naphthalene, which were reported at concentrations below 20 μg/L, none of the remaining BNAs were detected in both rounds.

PHCs reported as TPH were found in samples from both rounds and duplicates from MW05 at levels ranging from 0.74 to 2.4 mg/L. PHCs were not detected in MW03 or MW04. None of the inorganic compounds presented in Table 5.18 exceed any of the applicable standards presented in Table 5.7.

Comparison of Screening Results with Confirmation Results

The results of the GSM survey compare favorably with the confirmation data. The GSM survey suggested the presence of organic contamination within the shaded area in Fig. 5.18, which was confirmed by analytical results presented in Tables 5.17 and 5.18. However, the lack of contamination in MW04 suggests this well may be located down-gradient of an uncontaminated zone within the suspected area of contamination or subtle hydrogeological parameters may be affecting groundwater flow in the immediate vicinity of the well. At this time, this anomaly remains unexplained.

5.6.3 Geologic and Hydrogeologic Investigation Results

The subsurface lithology encountered at Site 4 is comprised of fill material: yellowish-brown to gray silty clay with occasional sand; light-gray to gray-brown fine to medium-grained, poorly graded sand; and very dark gray, well-graded sandy gravel with occasional cobbles. The geologic cross section presented in Fig. 5.19 was constructed using lithologic data from MW02, MW03, and MW04. Well construction data are presented in Appendix B.

Approximately 2 ft of fill material are present across the entire site. The underlying silty clay is approximately 2 ft thick across most the site but thickens to 5 ft in MW04 on the eastern edge of the site. The underlying poorly graded sand averages about 4 ft in thickness at Site 4 and gradually thickens to the southwest. Thickness of the water-bearing, well-graded sand was not determined because none of monitoring wells penetrated through it completely.

Piezometer data were evaluated, and the groundwater flow direction was determined to be to the east. An upgradient monitoring well (MW03) was installed west of the site and two wells (MW04 and MW05) were located downgradient of the area with the most apparent contamination as indicated by the GSM survey. A final round of water-level measurements were used to construct the potentiometric map presented in Fig. 5.17. The average hydraulic gradient for Site 4 is approximately 27 ft/mile, which represents the steepest gradient identified during the investigation. Based on the hydraulic testing results discussed in Sect. 5.2, the hydraulic conductivity averages 6.7 ft/d at Site 4. Both the gradient and conductivity values correlate well with the predominantly fine-grained, less-permeable lithology of the aquifer at Site 4.

5.6.4 Conclusions

As discussed in Sect. 2.2.3, this site consists of a former FTA that has been covered with fill material during the construction of a recreation area. Results of the investigation at Site 4 indicate the presence of significant levels of fuel-related compounds (benzene, ethylbenzene, and xylenes) in the soil. Additionally, significant levels of PHCs reported as TPH were reported in the soil. The highest fuel-related VOC concentrations were found in BH14-8, BH12-8, and BH13-8. PHC concentrations, reported from highest to lowest,

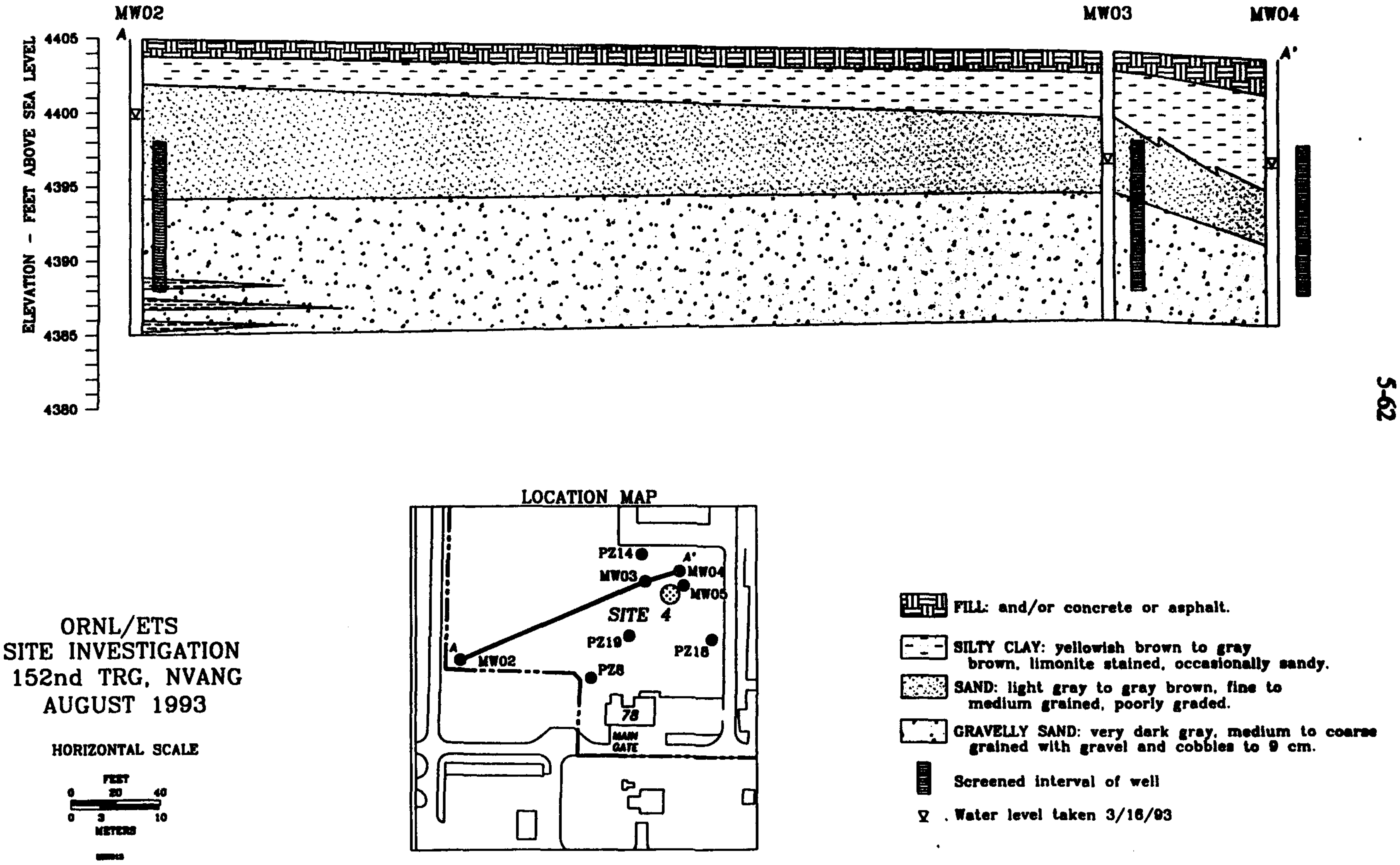


Fig. 5.19. Geologic cross section of Site 4.

were found in BH14-8, BH12-8, BH15-6D, and BH13-8. Although acetone and methylene chloride are reported at significant but estimated levels, their sporadic occurrence is likely related to spurious laboratory contamination rather than actual environmental contamination. Similarly, the sporadic low levels of chloroform and *bis*(2-ethylhexyl) phthalate are not considered significant for reasons previously discussed.

Results of the groundwater samples indicate VOC groundwater contamination at Site 4. Compounds detected include acetone and methylene chloride in MW04; and benzene, ethylbenzene, toluene, xylenes, and TCE in MW05. Of these, only benzene and TCE are reported at levels exceeding the current MCLs presented in Table 5.7. Duplicate VOC samples collected during both rounds of groundwater sampling are in good agreement.

Several BNA compounds were also seen in the groundwater samples. The presence of *bis*(2-ethylhexyl) phthalate is not considered significant due the relatively low levels reported and the compound's ubiquity in the environment and analytical laboratory. The remainder of the BNAs reported consists of PAHs that were inconsistently detected at very low levels that do not exceed applicable MCLs.

Therefore, the presence of groundwater contamination by VOCs at Site 4 has been confirmed.

5.7 Site 5, FTA No. 5

5.7.1 Screening Activity Results

GSM Survey

The results of the GSM survey are presented in Fig. 5.20 and Table 5.19. Samples were collected from 19 locations on a 125 × 125-ft grid with 25-ft spacing. The grid was located to overlie the suspected location of the former FTA identified in aerial photographs.

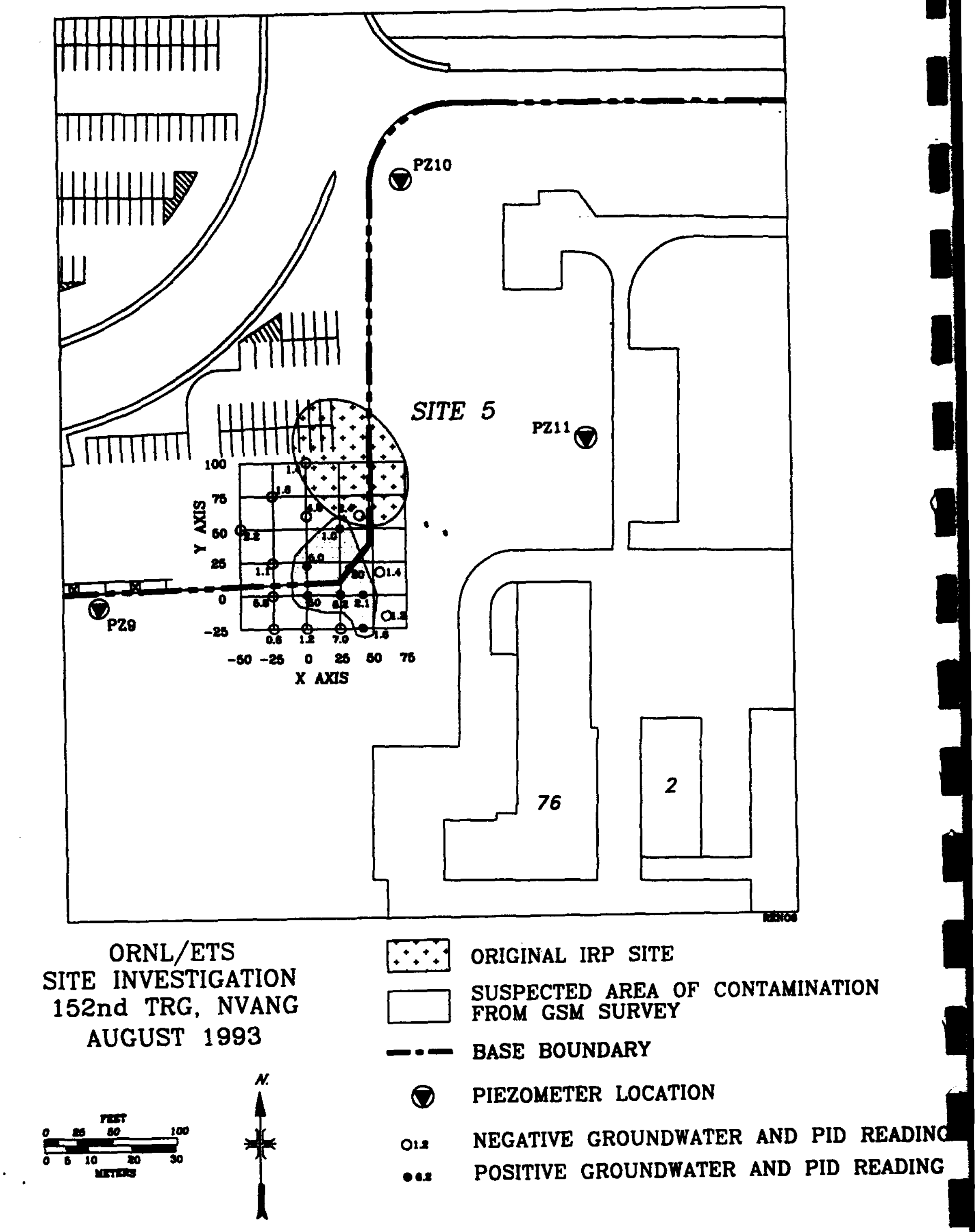


Fig. 5.20. Site 5 GSM survey locations.

Table 5.19. GSM survey results from Site 5

Location	Grid coordinates, x,y	PID, ppm	GC Decision
S501	0,60	4.8	Negative
S502	-50,50	2.2	Negative
S503	40,60	2.4	Negative
S504	0,100	1.4	Negative
S505	0,22	5.0	Positive
S506	25,50	1.0	Positive
S507	-25,75	1.6	Negative
S508	0,0	50.0	Positive
S509	25,0	5.8	Negative
S510	0,-25	1.2	Negative
S511	25,0	6.2	Positive
S512	25,-25	7.0	Negative
S513	42,0	2.1	Positive
S514	-25,-25	0.8	Negative
S515	42,-25	1.6	Negative
S516	60,-15	1.2	Negative
S517	55,18	1.4	Negative
S518	32,20	80.0	Positive
S519	-250,25	1.1	Negative

Although the GSM survey suggested the presence of several chlorinated and fuel related compounds in the groundwater (TCE, 1,2-DCE, 1,1-DCE, benzene, toluene, ethylbenzene, and xylenes), the coexistence of numerous unknown compounds interfered with definitive compound identification during GC headspace analysis. As previously discussed in Sect. 4.5.1, the GC data were used as a measure of relative contamination. Points with little or no apparent groundwater contamination were deemed negative, and those with moderate to high apparent groundwater contamination were classified positive. Thus, all of the points within the shaded area of Fig. 5.20, which represents the suspected area of groundwater contamination, are positive. Also reported in Fig. 5.20 and Table 5.19 are the PID readings recorded at each hole, which are indicative of VOCs in the soil. Consequently, a positive GC decision may be paired with a relatively low PID reading, suggesting potential groundwater contamination without any associated soil contamination. Conversely, a relatively high PID reading may be paired with a negative GC decision, suggesting potential soil contamination without any associated groundwater contamination.

Piezometer Levels

Three piezometers (PZ09, PZ10, and PZ11) were installed around Site 5 in order to determine the optimum placement of downgradient monitoring wells. Construction data on the piezometers are presented in Appendix B. The potentiometric surface map for Site 5 (Fig. 5.21) indicates that groundwater flows to the southeast. Groundwater flow direction is discussed in Sect. 5.7.3.

5.7.2 Confirmation and Delineation Activities

Three monitoring wells and three soil borings were drilled to support the characterization of Site 5. Twelve soil samples, collected from the soil borings, and six groundwater samples plus two duplicate groundwater samples, collected from the monitoring wells,

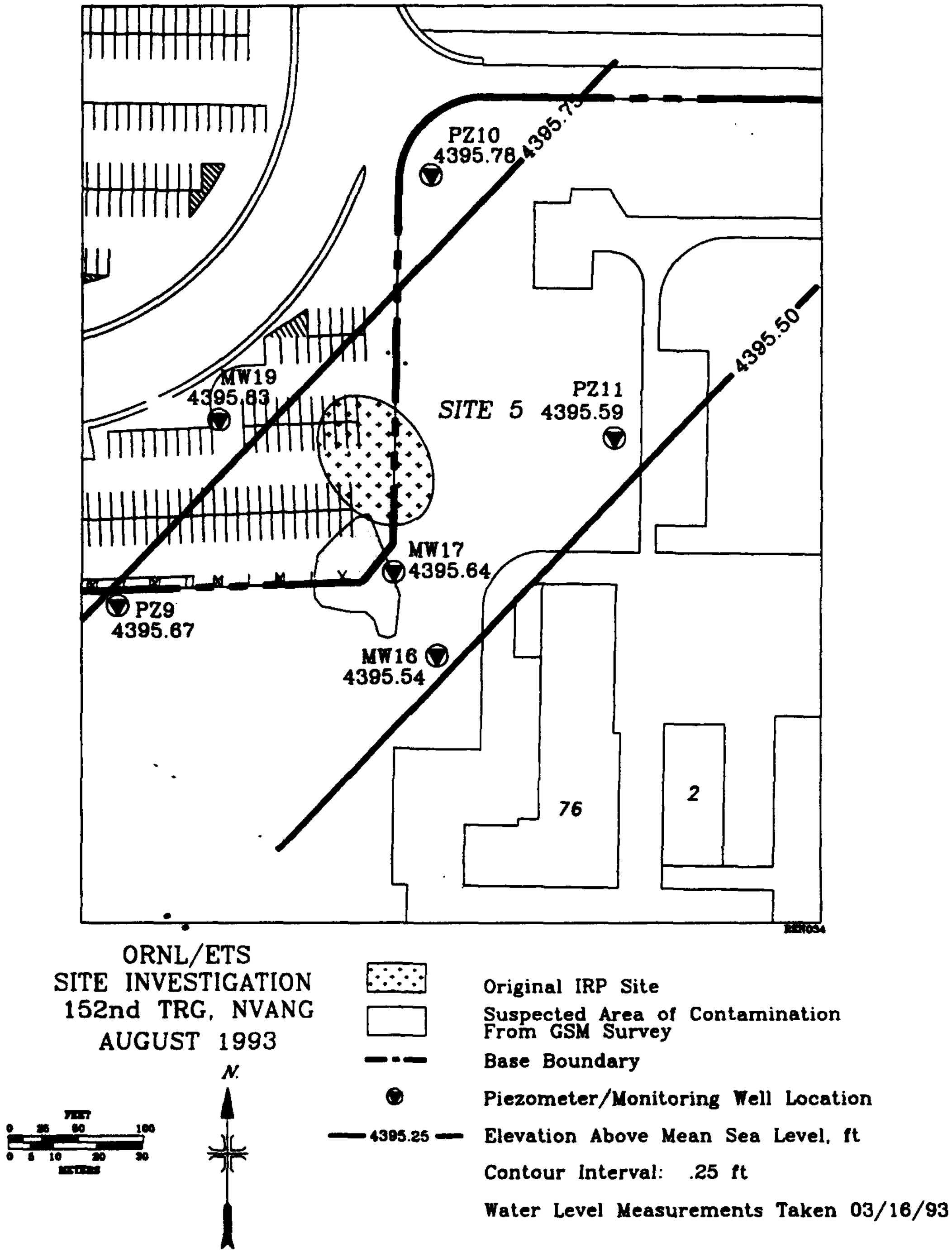


Fig. 5.21. Potentiometric surface for Site 5.

were submitted for laboratory analysis. Additionally, an equipment rinsate sample, associated with the second-round groundwater sample from MW17, was collected for analysis. Soil and groundwater samples were analyzed for VOCs, BNAs, PHCs, and metals.

Soil Sampling

Complete analytical results for the soil samples are presented in Table D-1 of Appendix D. Significant results from the organic analyses are presented in Table 5.20. The data are presented by boring number and depth. For example, BH06-2 refers to the sample collected 2 ft bgs in borehole 6. All of the inorganic results for the soil samples are within the background ranges reported in Table 5.4 and are, therefore, not considered significant. The soil boring locations are presented in Fig. 5.22. The relative proximity of BH07 and BH08 to one another was brought about by sampler refusal in BH07 at 3 ft bgs. The drilling rig was moved a few feet, and BH08 was drilled to obtain the soil samples.

Several VOCs were detected in the soil at Site 5. These compounds include chloroform (1.0 to 2.0 μg/kg, J), acetone (12 to 1900 μg/kg, J), methylene chloride (4200 μg/kg, J), ethylbenzene (1800 μg/kg, J), and total xylenes (9700 μg/kg).

Sixteen compounds were detected by the BNA analysis. These compounds consist of one phthalate and fifteen PAHs, which range in concentration from nondetectable levels to 3300 μg/kg.

All of the inorganic results for Site 5 soils reported in Table D-1 of Appendix D are within the background ranges reported in Table 5.4.

PHCs, reported as TPH, ranged from 0.08 (J) to 2200 mg/kg at Site 5.

Groundwater Sampling

Groundwater samples were collected in December 1992 and March 1993 from the wells shown in Fig. 5.22. Complete analytical results are presented in Table D-1 of Appendix D. Significant groundwater data from Site 5 are presented in Table 5.21. Field measurements made during sampling are presented in Tables 5.11 and 5.12.

Table 5.20. Organic chemical constituents detected in Site 5 soil

Chemical	BH06-2	BH06-4	BH06-6	BH07-2	BH08-6	BH08-7	BH09-2	BH09-6	BH09-7	BH10-2	BH10-8	BH10-9
VOCs, µg/kg												
Chloroform				1.0 J					2.0 J			
Acetone			1900 J		14 J	12 J						
Methylene chloride			4200 J									
Ethylbenzene			1800 J									
Xylenes			9700									
BNAs, µg/kg												
2-Methylnaphthalene			3300									
Fluorene			110 J									
Naphthalene			2400									
bis(2-Ethylhexl) phthalate	62 J	180 J	500 J	250 J	230 J	220 J	190 J	210 J	200 J		260 J	250 J
Benzo[*a*]anthracene	52 J	41 J										
Benzo[*a*]pyrene	52 J											
Benzo[*b*]fluoranthene	96 J	63 J										
Benzo[*g,h,i*]perylene	88 J											
Benzo[*k*]fluoranthene	96 J											
Chrysene	48 J											
Dibenz[*a,h*]anthracene		41 J										
Fluoranthene	94 J		96 J									
Indeno[*1,2,3-cd*]pyrene	39 J											
Phenanthrene	58 J											
Pyrene	73 J	70 J	68 J									
PHCs, mg/kg												
Total petroleum hydrocarbons			2166.45					19	0.08 J	9.9		0.02 J

Blank space indicates compound was undetected or was flagged unusable during data validation.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

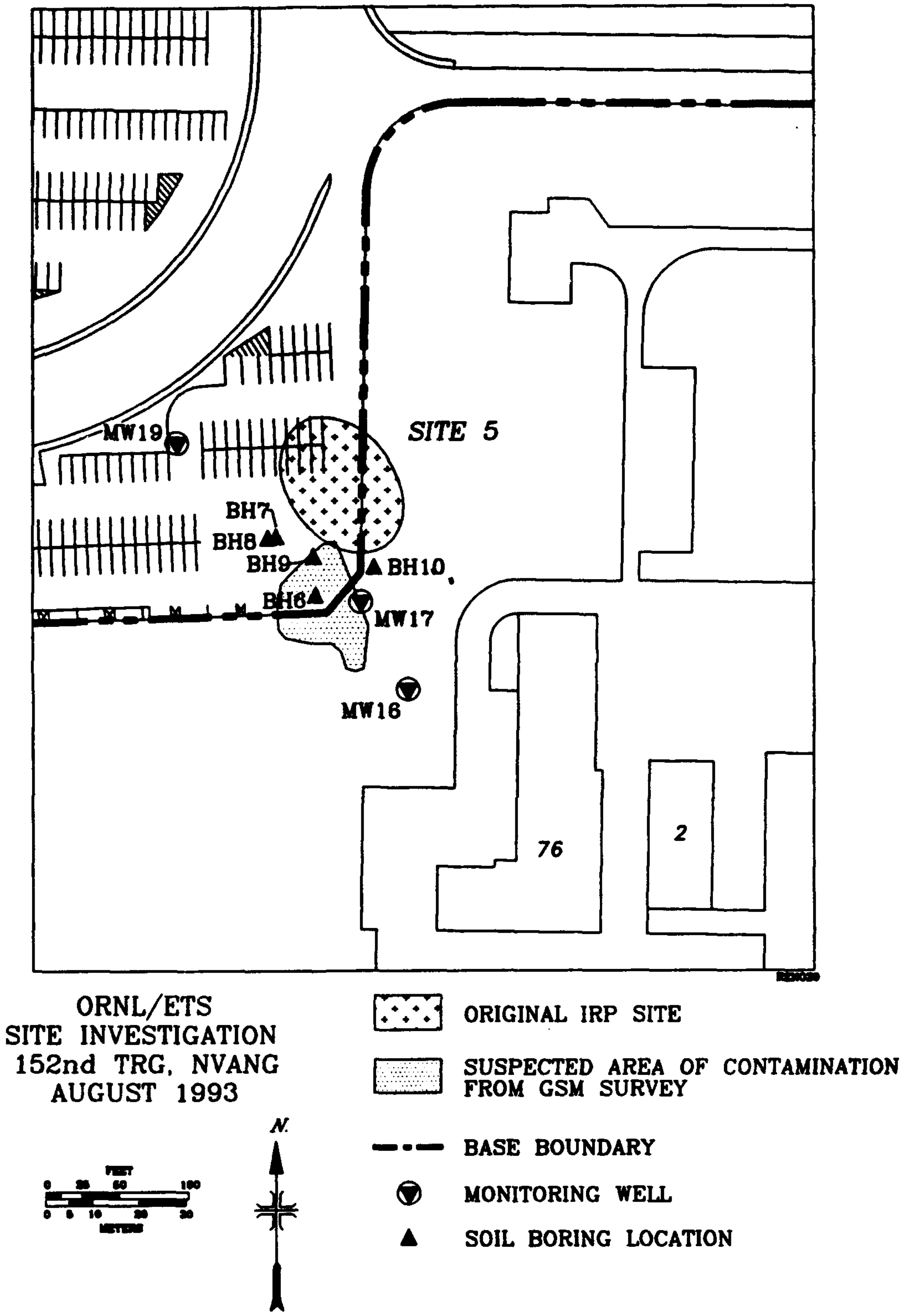


Fig. 5.22. Site 5 soil-boring and monitoring well locations.

Table 5.21. Chemical constituents detected in Site 5 groundwater

Chemical	MW16-1st	MW16-1st D	MW16-2nd	MW16-2nd D	MW17-1st	MW17-2nd	MW19-1st	MW19-2nd
VOCs, µg/mL								
Acetone								
Benzene	1.0 J	1.0 J			2.0 J	15.0		
Ethylbenzene					4.0 J	24.0		
Xylenes					12.0	7.0 J		
Toluene					7.0 J	1.0 J		
1,2-Dichloroethene					2.0 J	4.0 J		
BNAs, µg/L								
bis(2-Ethylhexyl) phthalate	1.0 J	1.0 J				20.0 J		
Naphthalene						1.0 J		
PHCs (mg/L)								
Total petroleum hydrocarbons					0.1	0.15		
Inorganic Analytes, µg/L								
Aluminum	194	185			295		35	
Antimony						30.0		
Arsenic	61.6 J	54.2 J	34.1 J	33.2 J	58.2 J	32.42	19.6 J	11.5
Barium	27.6	27.8	25.4	24.2	83.5	68.76	27.6	24.0
Beryllium						1.0		
Cadmium						5.0		
Calcium	42,600	47,700	50,200	48,400	66,000	64,759	47,000	46,900
Chromium						6.0		

Table 5.21. (continued)

Chemical	MW16-1st	MW16-1st D	MW16-2nd	MW16-2nd D	MW17-1st	MW17-2nd	MW19-1st	MW19-2nd
Cobalt						9.0		
Copper		10.5	5.3			7.68	13.8	21.8
Iron	125	50.1			49.8 J	164.0		
Lead						2.0		
Magnesium	10,400	10,500	11,000	10,500	14,300	14,031	10,000	9250
Manganese	218	220	228	229	335	444.4	90.8	43.8
Mercury						0.2		
Nickel						13.0		
Potassium	8040	9450	8450	7520	9310	9523.3 J	9480	7070
Selenium						3.0		
Silver						5.0		
Sodium	98,300	102,000	109,000	104,000	69,000	67,168	56,500	58,600
Thallium						3.0		
Vanadium						4.0	5.5	6.1
Zinc	7.2	3.8			3.3	5.19		

Blank space indicates compound was undetected.
D indicates duplicate sample.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

Several VOCs were detected in the groundwater at Site 5. Benzene was detected at 1.0 μg/L, J, in MW16 in the first round sample and duplicate sample but was not confirmed by the second round sample or duplicate. Data from both sampling rounds in MW17 indicate the presence of benzene (1.0 (J) to 15 μg/L), ethylbenzene (4.0 (J) to 24 μg/L), total xylenes (7.0 to 12 μg/L), toluene (1.0 to 7.0 μg/L, J), and 1,2-DCE (2.0 to 4 μg/L, J).

Two BNAs were detected and are listed in Table 5.21. Naphthalene and *bis*(2-ethylhexyl) phthalate were reported at very low estimated concentrations but do not consistently appear in both rounds of sample data.

PHCs reported as TPH were found in samples from both rounds from MW17 at levels ranging from 0.10 to 0.15 mg/L.

None of the inorganic compounds presented in Table 5.21 exceed any of the applicable standards presented in Table 5.7.

Results of the equipment rinsate sample (#1572) associated with MW07 March 1993 sampling round are presented in Table D-2, Appendix D. Sample 1572 has no significant detectable compounds.

Comparison of Screening Results with Confirmation Results

The results of the GSM survey compare favorably with the confirmation data. The GSM survey suggested the presence of organic contamination within the shaded area in Fig. 5.22, which was confirmed by analytical results presented in Tables 5.20 and 5.21. The only significant soil contamination was found in BH06, and the only significant groundwater contamination was found in MW17, which is located downgradient of BH06.

5.7.3 Geologic and Hydrogeologic Investigation Results

The subsurface encountered at Site 5 is comprised of fill material: yellowish-brown to gray-brown silty clay with occasional sand; light-gray to gray-brown, fine to medium-grained, poorly graded sand; and very dark gray, well-graded sandy gravel with occasional cobbles and pale-gray to olive-brown sandy silt streaks. The geologic cross section presented in Fig. 5.23 was constructed using lithologic data from MW16, MW17, and MW19. Well construction data are presented in Appendix B.

Between 3 and 10 ft of fill material are present at Site 5. The underlying silty clay reaches a maximum thickness of 6 ft in MW17. In MW16 and MW17, the underlying well-graded sandy gravel is upwardly fining. In MW19, the silty clay is underlain by 6 ft of well-graded gravelly sand that contains a 2-ft-thick silt lens. Underlying the gravelly sand is another 6 ft of poorly graded, fine-grained, dark-olive sand. Actual thickness of the water-bearing, well-graded sand was not determined because none of monitoring wells penetrated through it completely.

Piezometer data were evaluated, and the groundwater flow direction was determined to be to the southeast. An upgradient monitoring well (MW19) was installed northwest of the site, and two wells (MW16 and MW17) were located downgradient of the area with the most apparent contamination as indicated by the GSM survey (Fig. 5.22). A final round of water-level measurements was used to construct the potentiometric map presented in Fig. 5.21. The average hydraulic gradient for Site 5 is approximately 4.8 ft/mile, which correlates well with the predominantly coarser and more-permeable lithology of the aquifer. Although no hydraulic testing was performed at Site 5, the general lithologic sequence in MW16 and MW17 is similar to that encountered in MW08 and MW09 at Site 2. Based on the results of the hydraulic test performed on the latter two wells that was presented in Sect. 5.2, the hydraulic conductivity would range from 230 to 330 ft/d at Site 5. Both the gradient and conductivity values correlated well with the predominantly coarse-grained, more-permeable lithology of the aquifer at Site 5.

5.7.4 Conclusions

As discussed in Sect. 2.2.4, this site consists of a former FTA that has been covered with fill material during the expansion of a parking area north of the Base. Results of the investigation at Site 5 indicate the presence of significant levels of fuel-related compounds (ethylbenzene and xylenes) in the soil. Additionally, significant levels of PHCs reported as

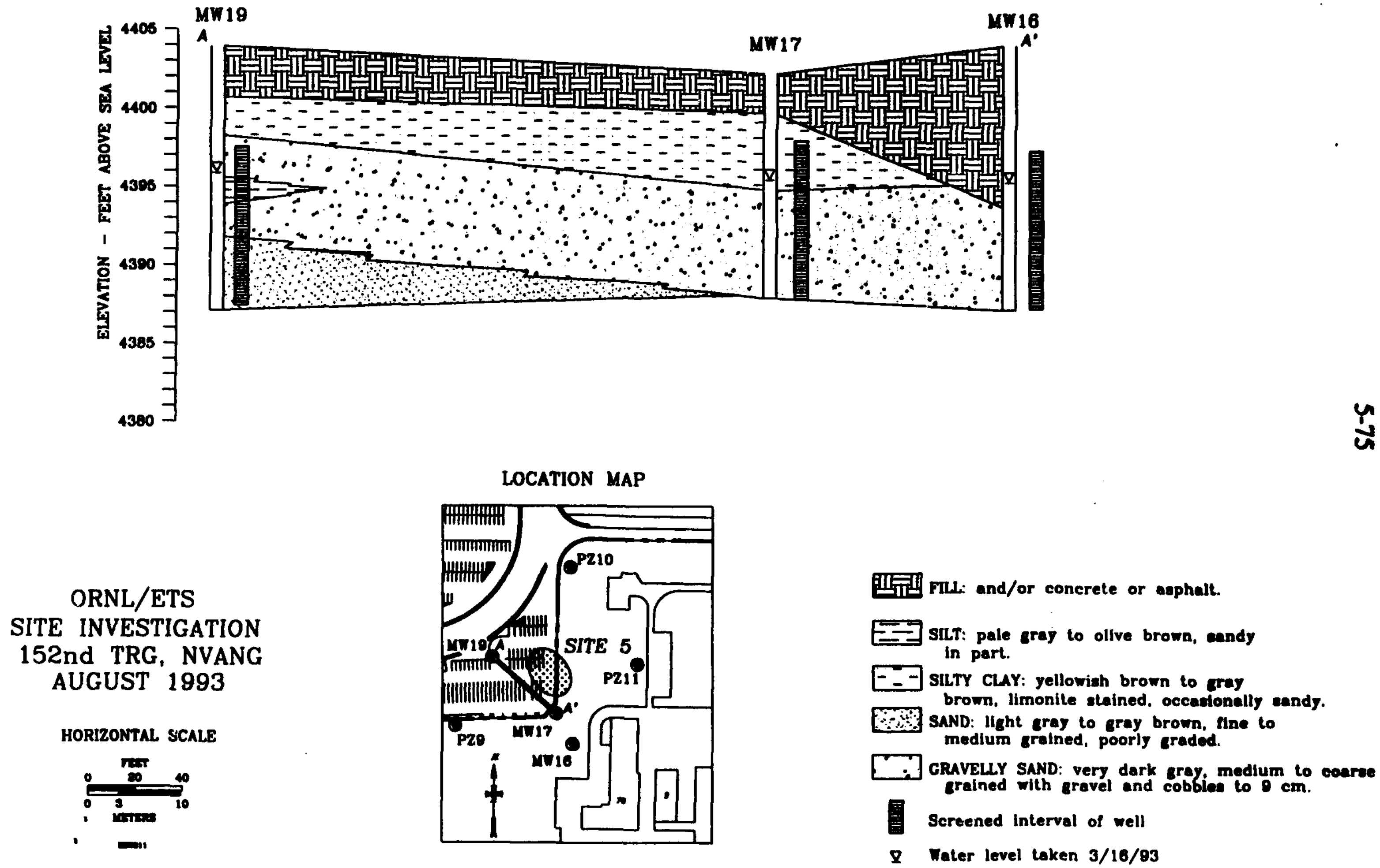


Fig. 5.23. Geologic cross section of Site 5.

TPH were detected in the soil. The highest fuel-related VOC concentration was found in BH06-6. PHC concentrations, reported from highest to lowest, were found in BH06-6, BH09-6, and BH10-2. Although acetone and methylene chloride are reported at significant but estimated levels, their sporadic occurrence is likely related to spurious laboratory contamination rather than actual environmental contamination. Similarly, the sporadic, low levels of chloroform and *bis*(2-ethylhexyl) phthalate are not considered significant for reasons previously discussed. The occurrence of a number of PAHs at relatively low levels is also not considered significant for reasons discussed in Sect. 5.3.2.

Results of the groundwater samples indicate low level VOC groundwater contamination at Site 5. Compounds detected include benzene, ethylbenzene, toluene, xylenes, and 1,2-DCE in MW17. Of these, only benzene is reported at levels exceeding the current MCLs presented in Table 5.7. Duplicate VOC samples collected during both rounds of groundwater sampling from MW16 are in good agreement.

Two BNA compounds were also seen in the groundwater samples. The presence of *bis*(2-ethylhexyl) phthalate is not considered significant due the relatively low levels reported and the compound's ubiquity in the environment and analytical laboratory. The presence of naphthalene is insignificant due to its low estimated level.

Therefore, the presence of groundwater contamination by VOCs at Site 5 has been confirmed.

5.8 Site 7, POL Storage Facility

5.8.1 Screening Activity Results

GSM Survey

The results of the GSM survey are presented in Fig. 5.24 and Table 5.22. Samples were collected from 34 locations on a 300 × 300-ft grid with 50-ft spacing. The grid was laid over the Site 7 area.

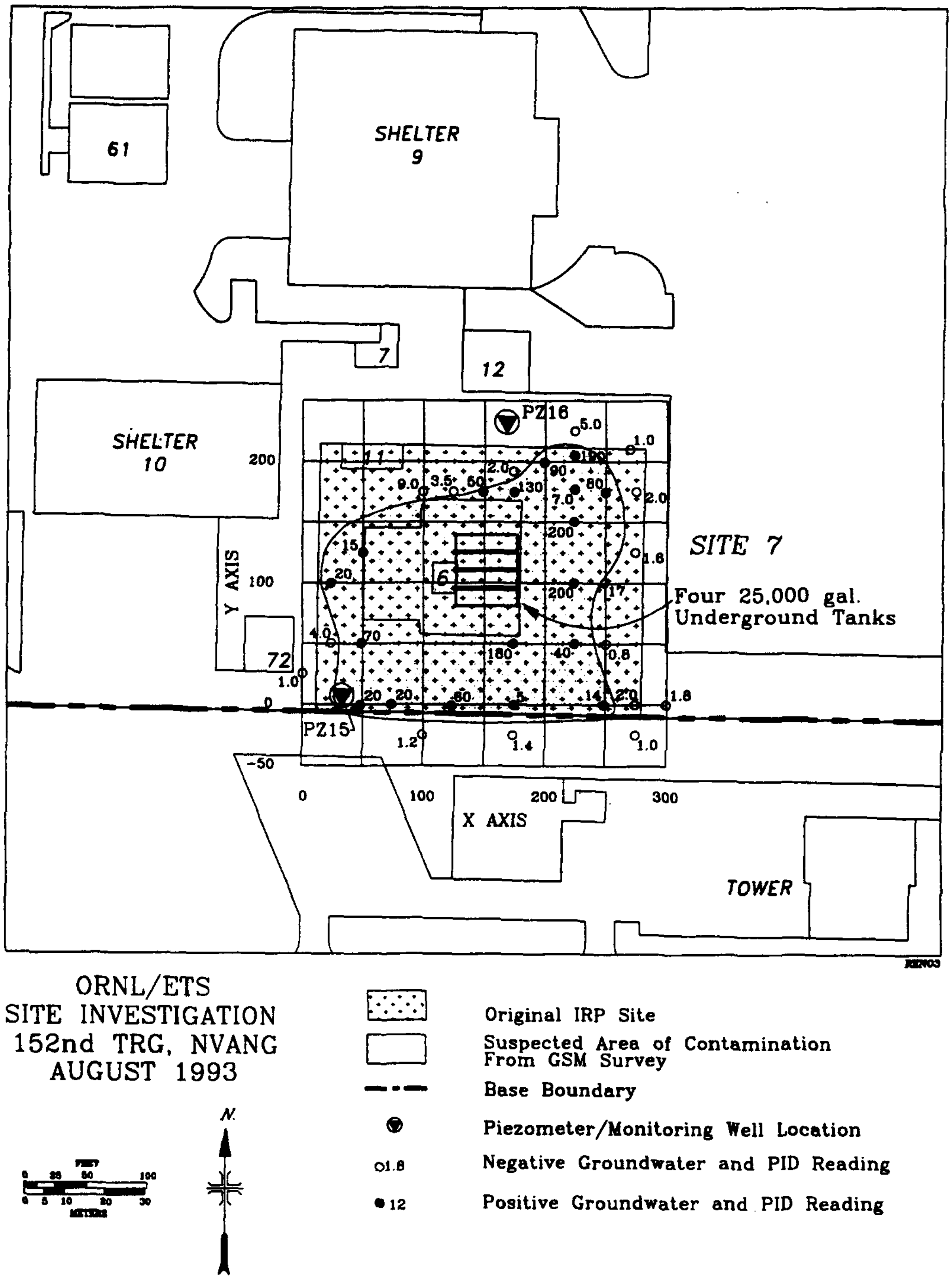


Fig. 5.24. Site 7 GSM survey locations.

Table 5.22. GSM survey results from Site 7

Location	Grid coordinates, x,y	PID, ppm	GC Decision
S701	75,50	180.0	Positive
S702	175,0	5.0	Positive
S703	250,0	14.0	Positive
S704	300,0	1.8	Negative
S705	275,0	2.0	Negative
S706	225,50	40.0	Positive
S707	250,50	0.8	Negative
S708	225,100	200.0	Positive
S709	250,100	17.0	Positive
S710	225,150	200.0	Positive
S711	225,175	7.0	Negative
S712	220,175	80.0	Positive
S713	275,175	2.0	Negative
S714	275,125	1.6	Negative
S715	225,205	190.0	Positive
S716	175,175	130.0	Positive
S717	175,192	2.0	Negative
S718	100,175	9.0	Negative
S719	125,175	3.5	Negative
S720	150,175	50.0	Negative
S721	200,200	90.0	Positive
S722	225,225	5.0	Negative
S723	270,210	1.0	Negative
S724	125,0	60.0	Positive
S725	75,0	20.0	Positive
S726	50,0	20.0	Positive
S727	50,50	70.0	Positive
S728	2,25	1.0	Positive
S729	25,50	4.0	Negative
S730	25,100	20.0	Positive
S731	50,150	15.0	Positive
S732	175,-25	1.4	Negative
S733	275,-25	1.0	Negative
S734	100,-25	1.2	Negative

Although the GSM survey suggested the presence of several chlorinated and fuel related compounds in the groundwater (TCE, 1,2-DCE, 1,1-DCE, benzene, toluene, ethylbenzene, and xylenes), the coexistence of numerous unknown compounds interfered with definitive compound identification during GC headspace analysis. As previously discussed in Sect. 4.5.1, the GC data were used as a measure of relative contamination. Points with little or no apparent groundwater contamination were deemed negative, and those with moderate to high apparent groundwater contamination were classified positive. Thus, all of the points within the shaded area of Fig. 5.24, which represents the suspected area of groundwater contamination, are positive. Also reported in Fig. 5.24 and Table 5.22, are the PID readings recorded at each hole, which are indicative of VOCs in the soil. Consequently, a positive GC decision may be paired with a relatively low PID reading, suggesting potential groundwater contamination without any associated soil contamination. Conversely, a relatively high PID reading may be paired with a negative GC decision, suggesting potential soil contamination without any associated groundwater contamination.

Piezometer Levels

Two piezometers (PZ15 and PZ16) installed around Site 7 were used in conjunction with one of the base wide piezometers (PZ05 in Fig. 5.6) to determine the optimum placement of monitoring wells. Construction data on the piezometers are presented in Appendix B. The potentiometric surface map for Site 7 (Fig. 5.25) indicates that groundwater flows to the southeast. Groundwater flow direction is discussed in Sect. 5.8.3.

5.8.2 Confirmation and Delineation Activities

Six monitoring wells and four soil borings were drilled to support characterization of Site 7. Fourteen soil samples plus three duplicate soil samples, collected from the soil borings, and twelve groundwater samples, collected from the monitoring wells, were submitted for laboratory analysis. Additionally, an equipment rinsate sample, associated

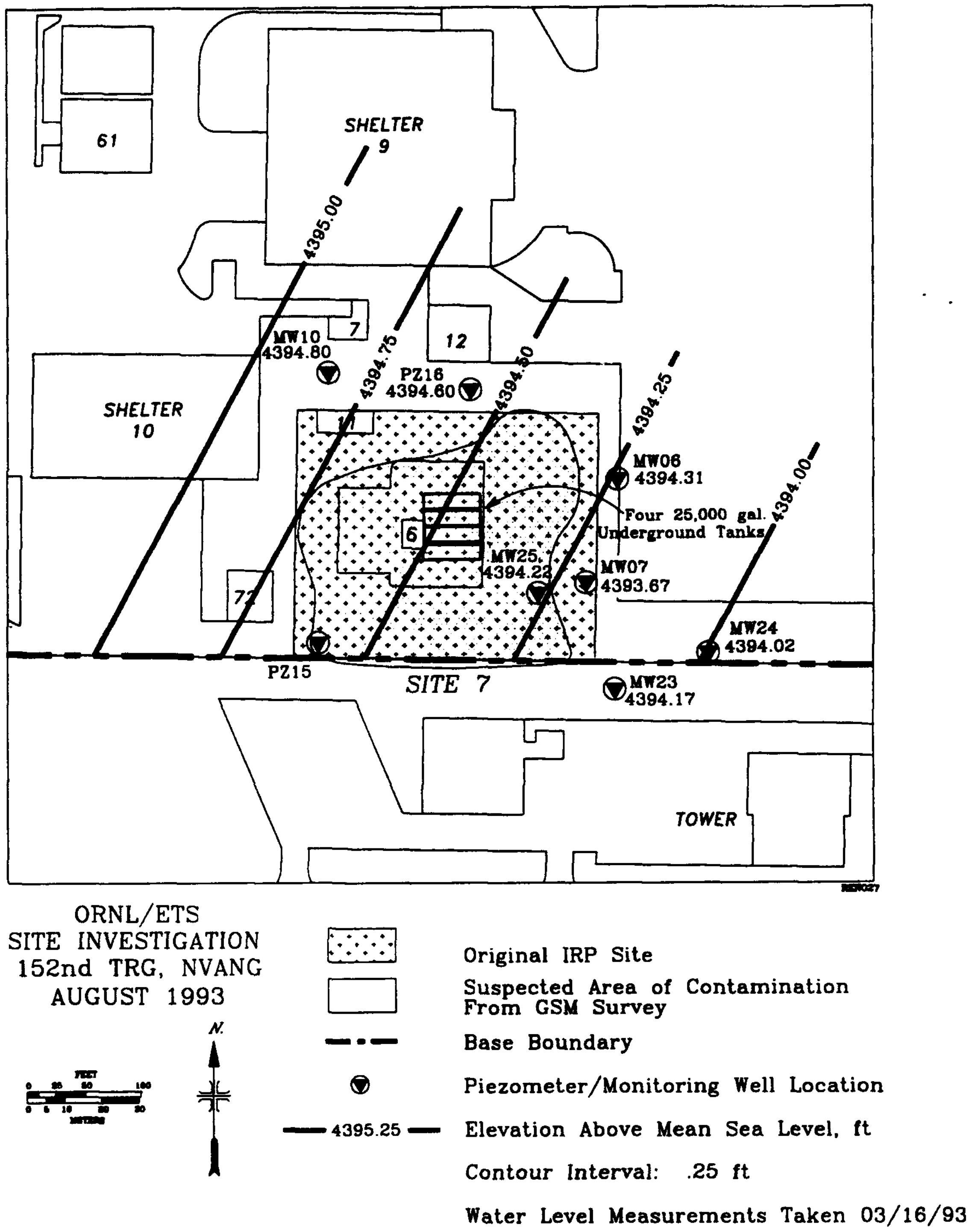


Fig. 5.25. Potentiometric surface for Site 7.

with the second round sampling of MW07, was collected for chemical analysis. All of the soil and groundwater samples were analyzed for VOCs, BNAs, and PHCs. Although no metals analysis was planned, one groundwater sample and all of the soil samples were inadvertently analyzed for metals.

Field observations made during the drilling of BH27 suggested the presence of free product in the soil. Therefore, the boring was completed as a monitoring well (MW25). Thus, all of the soil sampling data are related to BH27 while all of the groundwater data are related to MW25.

Soil Sampling

Complete analytical results for the soil samples are presented in Table D-1 of Appendix D. Significant results from the organic analyses are presented in Table 5.23. The data are presented by boring number and depth. For example, BH27-2 refers to the sample collected 2 ft bgs in borehole 27. All of the inorganic results for the soil samples are within the background ranges reported in Table 5.4 and are, therefore, not considered significant. The soil boring locations are presented in Fig. 5.26.

Several VOCs were detected in the soil at Site 7. These compounds include chloroform (2.0 (J) to 4.0 μg/kg, J), acetone (38 to 120 μg/kg, J), ethylbenzene (8.0 (J) to 24,000 μg/kg), toluene (7.0 (J) to 3900 μg/kg) and xylenes (5.0 (J) to 82,000 μg/kg).

Twenty-one compounds were detected by the BNA analysis. These compounds consist of one phthalate and nineteen PAHs, which range in concentration from nondetectable levels to 20,000 μg/kg. The vast majority of the PAH compounds exhibit levels that exceed background concentrations.

All of the inorganic results for Site 7 soils reported in Table D-1 of Appendix D are within the background ranges reported in Table 5.4.

PHCs, reported as TPH, ranged from 0.06 (J) to 2800 mg/kg at Site 7.

Table 5.23. Organic chemical constituents detected in Site 7 soil

Chemical	BH27-2	BH27-5	BH27-5D	BH28-2	BH28-5	BH28-8	BH29-2	BH29-5	BH29-5D	BH29-7	BH30-2	BH30-5	BH30-8	BH31-2	BH31-5	BH31-5D	BH31-8
VOCs, µg/kg																	
2-Butanone				8.0 J		1100 J						1300 J			1200 J		
Acetone					78 J			38 J			120 J						
Benzene		3.0 J	2.0 J	19.0	14 J						4.0 J					670 J	230 J
Chloroform		4.0 J	2.0 J	3.0 J	4 J				2.0 J								
Ethylbenzene		50	120	94	320	1100 J					8.0 J	2300			630 J	24,000	
Xylenes	44,000	280	420	200	1500	5600					56	8200	5 J		2600	82,000	1400 J
Toluene		7.0 J		39	140	520 J										3900	
Dibenzofuran				485													
BNAs, µg/kg																	
2-Methylnaphthalene	13,000	480	600	180 J	950	2000 J					1600	240 J			1300	20,000 J	1300
4-Methylphenol					120 J												
Benzo[*a*]anthracene	5200 J	85 J	73 J	580	110 J		40 J	44 J				66 J					
Benzo[*a*]pyrene	4600 J	58 J	47 J	580													
Benzo[*b*]fluoranthene	9000	110 J	110 J	850	110 J		57 J					120 J					
Benzo[*g,h,i*]perylene	2600 J			310 J													
Benzo[*k*]fluoranthene	9000 J	110 J	110 J	850 J	110 J		57 J					120 J					
bis(2-Ethylhexyl) phthalate		570	520	380 J	110 J		100 J	150 J	120 J	110 J	91 J	88 J	100 J	110 J			
Carbazole	1700 J			82 J	52 J												
Chrysene	6300 J	70 J	73 J	660	130 J		52 J					67 J					
Dibenzofuran				48 J													
Fluoranthene	13,000	130 J	150 J	800	210 J	300 J	110 J	96 J		49 J		130 J					
Fluorene	1000 J			99 J													

Table 5.23. (continued)

Chemical	BH27-2	BH27-5	BH27-5D	BH28-2	BH28-5	BH28-8	BH29-2	BH29-5	BH29-5D	BH29-7	BH30-2	BH30-5	BH30-8	BH31-2	BH31-5	BH31-5D	BH31-8
Indeno[*1,2,3-cd*]pyrene	2700 J			300 J													
Naphthalene	11,000	320 J	500	200 J	670	1700 J					1300	190 J			1100	13,000 J	930
Phenanthrene	11,000	160 J	230 J	580	260 J	410 J	130 J	120 J	47 J	54 J		90 J					
Phenol		45 J	86 J	77 J	220 J	350 J									98 J		150 J
Pyrene	16,000	250 J	250 J	1500	280 J	430 J	110 J	99 J				120 J					
Acenaphthene	1300 J			100 J	62 J						54 J					350 J	
Anthracene	2000 J			130 J	72 J												
2,4-Dimethylphenol															180 J	190 J	210 J
PHCs, mg/kg																	
Total petroleum hydrocarbons	2500	87	33	9.6 J	590	1600	2.0			0.06 J	5.8	570	3.1 J				2800

Blank space indicates compound was undetected.
D indicates duplicate sample.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

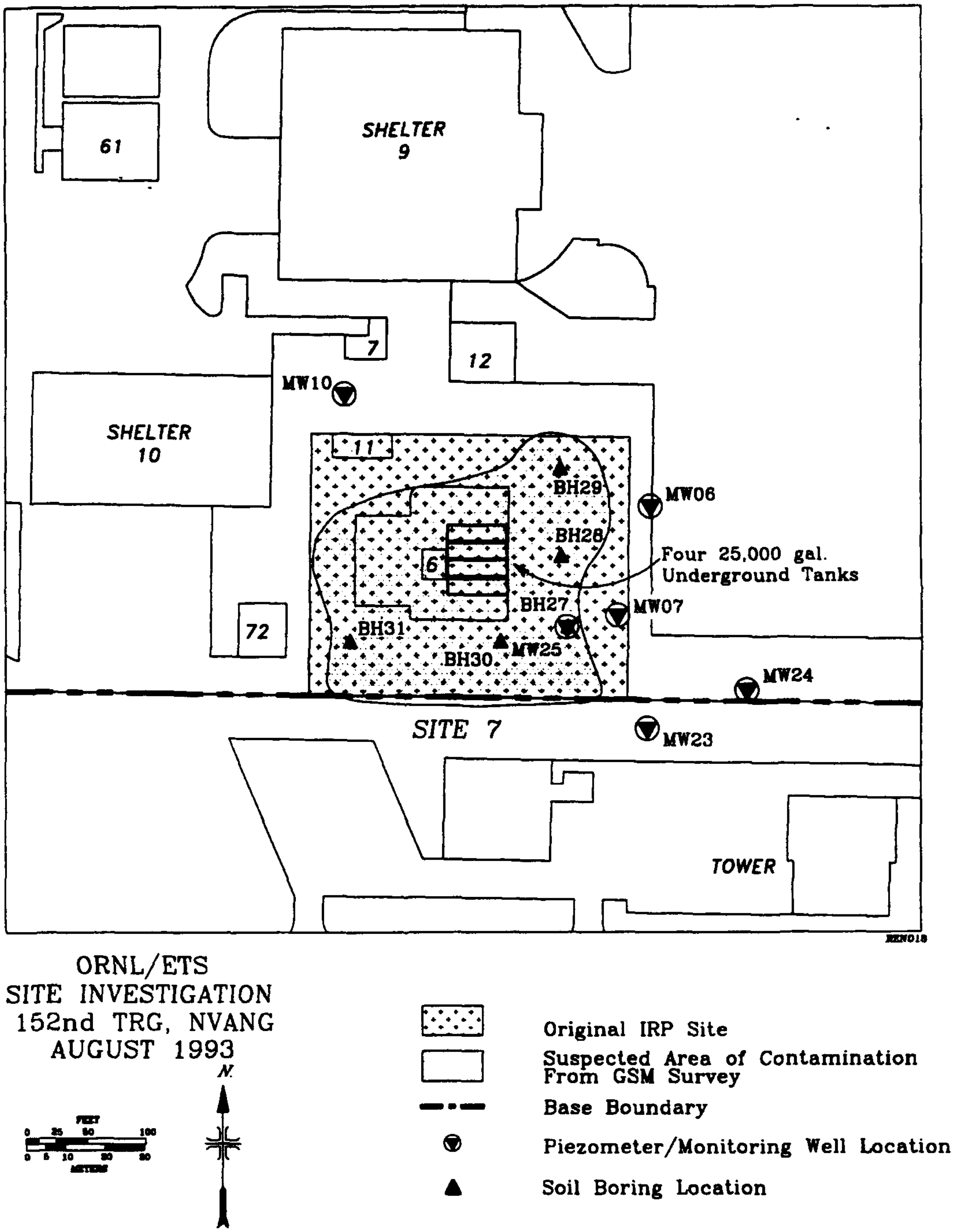


Fig. 5.26. Site 7 soil-boring and monitoring well locations.

Groundwater Sampling

Groundwater samples were collected in December 1992 and March 1993 from the wells shown in Fig. 5.26. Complete analytical results are presented in Table D-1 of Appendix D. Significant groundwater data from Site 7 are presented in Table 5.24. Field measurements made during sampling are presented in Tables 5.11 and 5.12. It should be noted that apparently decaying floating-phase fuel product was encountered in MW07. Product thickness, as measured in the well, varied from 0.25 to 3 in. A summary of free product thickness measurements and product volume removed from MW07 by Base personnel is presented in Table 5.25. Approximately 1.3 L of free product were removed with a bailer between March 1993 and March 1994.

Significant VOC levels were found in the groundwater at Site 7. Benzene was consistently detected in three wells (MW06, MW07, and MW25) at levels ranging from 21 to 2300 μg/L. Xylenes were also found consistently in the same three wells at levels ranging from 59 to 1400 μg/L. Ethylbenzene was consistently detected in MW07 (480 μg/L) and sporadically in MW06 and MW25 (14 J to 55 μg/L). Toluene was consistently detected in MW06 and MW25 at estimated levels ranging from 1 to 8 μg/L, J. 1,2-DCE was detected twice in MW10 at estimated concentrations ranging from 2.0 to 5.0 (J) μg/L. Traces (1.0 to 2.0 μg/L) of TCE, 1,2-dichloroethane (1,2-DCA), and chloroform were detected once in MW06. Methylene chloride was reported twice in MW07 at concentrations ranging from 51 to 76 μg/L, J.

Nineteen BNA compounds were detected in groundwater at Site 7 and are listed in Table 5.24. Of these compounds, two are phthalates and the rest are PAHs or derivative compounds. The most significant concentrations among the reported PAHs are 2-methylnaphthalene (3.0 (J) to 96,000 μg/L) and naphthalene (6.0 (J) to 6900 μg/L). The bulk of the PAHs are reported at estimated concentrations and do not consistently appear in both rounds of sample data.

PHCs reported as TPH were found in samples of both rounds from MW06, MW07, and MW25 at levels ranging from 0.05 to 28 mg/L.

Table 5.24. Chemical constituents detected in Site 7 groundwater

Chemical	MW06-1st	MW06-2nd	MW07-1st	MW07-2nd	MW10-1st	MW10-2nd	MW23-1st	MW23-2nd	MW24-1st	MW24-2nd	MW25-1st	MW25-2nd
VOCs, μg/L												
Acetone												
Benzene	21	67	2300	2100							620	380
Carbazole											4.0 J	3.0 J
Chloroform		1.0 J								1.0 J		
Ethylbenzene		55	480	480								14 J
Methylene chloride			76 J	51 J								
Xylenes	63	73	1400	1000							92	59
Toluene	6.0 J	1.0 J					2.0 J		2.0 J		7.0 J	8.0 J
Trichloroethene	1.0 J											
1,2-Dichloroethane	2.0 J											
1,2-Dichloroethene					5.0 J	2.0 J						
Phenol	2.0 J											
BNAs, μg/L												
Acenophthene				330 J							1.0 J	2.0 J
Anthracene				260 J							1.0 J	
2-Methylnaphthalene		3.0 J	960	9600							5.0 J	8.0 J
Fluoranthene			76 J	700 J							1.0 J	
Fluorene				300 J								1.0 J
2,4-Dimethylphenol		1.0 J									5.0 J	3.0 J
bis(2-ethylhexyl) phthalate	17 J			190 J			1.0 J		3.0 J		19.0 J	
Benzo[*a*]anthracene				330 J								
Benzo[*a*]pyrene				190 J								
Benzo[*b*]fluoranthene				320 J								
Benzo[*k*]fluoranthene				320 J								
Chrysene				380 J								

Table 5.24. (continued)

Chemical	MW06-1st	MW06-2nd	MW07-1st	MW07-2nd	MW10-1st	MW10-2nd	MW23-1st	MW23-2nd	MW24-1st	MW24-2nd	MW25-1st	MW25-2nd
Diethylphthalate							1.0 J		1.0 J			
Dibenzofuran				180 J							2.0 J	1.0 J
Phenol		4.0 J									22	32
Di-*n*-butylphthalate	2.0 J										1.0 J	
Naphthalene		6.0 J	840	6900							6.0 J	12.0
Phenanthrene			83 J	760 J							3.0 J	2.0 J
Pentachlorophenol												
Pyrene			96 J	780 J								
PHCs, mg/L												
Total petroleum hydrocarbons	0.56	1.6	28	14.0		0.05 J					2.6	1.8
Inorganic Analytes, µg/L												
Aluminum											235	
Arsenic											258 J	
Barium											140	
Calcium											152,000	
Iron											1450	
Magnesium											39,500	
Manganese											2580	
Potassium											18,600	
Sodium											184,000	
Zinc											4.7	

Blank space indicates compound was undetected.

J = reported value is,below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

Table 5.25 Summary of product thickness measurements and volumes removed from MW07

Date	Water Level, ft amsl[a]	Product thickness, in./cm	Volume removed, oz./L
03/26/93	4394.21	2.75/6.99	5.0/0.15
04/15/93	4394.32	1.50/3.81	3.0/0.09
04/29/93	4394.23	1.25/3.18	3.0/0.09
05/13/93	4394.28	1.00/2.54	2.0/0.06
05/27/93	4394.15	1.25/3.18	3.0/0.09
06/10/93	4394.07	2.50/6.35	5.0/0.15
06/24/93	4394.32	1.00/2.54	2.0/0.06
07/08/93	4394.23	2.00/5.08	4.0/0.12
07/26/93	4394.15	1.00/2.54	2.0/0.06
08/05/93	4394.19	2.00/5.08	4.0/0.12
08/19/93	4394.40	3.00/7.62	6.0/0.18
09/02/93	4394.32	0.50/1.27	0/0
09/20/93	4394.32	0.50/1.27	0/0
09/30/93	4394.28	0.50/1.27	0/0
10/14/93	4394.23	0.50/1.27	0/0
10/28/93	4394.32	0.75/1.91	1.0/0.03
11/15/93	4394.28	1.00/2.54	2.0/0.06
11/29/93	4394.23	0.75/1.91	1.0/0.03
12/09/93	4394.15	0.50/1.27	1.0/0.03
12/23/93	4394.32	0.50/1.27	1.0/0.03
01/06/94	4394.40	0.25/0.64	0/0
01/20/94	4394.40	0.25/0.64	0/0
02/03/94	4394.32	0.25/0.64	0/0
02/17/94	4394.23	0.25/0.64	0/0
03/03/94	4394.32	0.25/0.64	0/0
03/17/94	4394.36	0.25/0.64	0/0

[a] ft/amst = feet above mean sea level

None of the inorganic compounds presented in Table 5.24 exceed any of the applicable standards presented in Table 5.7.

Results of the equipment rinsate sample (#1582) associated with the MW07 March 1993 sampling round are presented in Table D-2, Appendix D. Sample 1582 shows 1 μg/L diethyl phthalate as the only detectable compound.

Comparison of Screening Results with Confirmation Results

The results of the GSM survey compare favorably with the confirmation data. The GSM survey suggested the presence of organic contamination within the shaded area in Fig. 5.26, which was confirmed by analytical results presented in Tables 5.23 and 5.24. Significant soil contamination was found in BH27, BH28, BH30, and BH31. Significant groundwater contamination was consistently reported in MW06, MW07, MW25, which are located downgradient of the identified soil contamination. Traces of toluene and chloroform were reported in downgradient wells MW23 and MW24 but only at very low, estimated and inconsistent levels. Estimated levels of 1,2-DCE were reported in MW10, which is located upgradient of Site 7. Estimated levels of 1,2-DCA (2.0 μg/L (J)) were reported in MW06. This is the only reported occurrence of 1,2-DCA in any sample collected during the investigation.

The occurrence of floating product in MW07 is apparently related to isolated spills since no GSM points between this well and the JP-4 fuel tanks found any signs of floating product. Additionally, observations of fuel-stained soil during drilling of MW25 and MW07 suggest that the source of the floating product observed in MW07 is limited to the immediate area.

5.8.3 Geologic and Hydrogeologic Investigation Results

The subsurface encountered at Site 7 is comprised of fill material: yellowish-brown to gray-brown silty clay with occasional sand; light-gray to gray-brown, fine to medium-grained poorly graded sand; and very dark gray, well-graded sandy gravel with occasional cobbles. The geologic cross section presented in Fig. 5.27 was constructed using lithologic data from MW10, MW06, MW07, MW23, and MW24. Well construction data are presented in Appendix B.

Up to 4 ft of fill material are present at Site 7. The underlying silty clay reaches a maximum thickness of 8 ft in MW10. In MW23, the silty clay contains a lens of poorly graded sand. Generally, the silty clay is underlain by well-graded, sandy gravel that contains a lens of poorly graded sand between MW07 and MW24. Actual thickness of the water-bearing, well-graded sand was not determined because none of the monitoring wells penetrated through it completely.

Piezometer data were evaluated, and the groundwater flow direction was determined to be to the southeast. An upgradient monitoring well (MW10) was installed northwest of the site, and three wells (MW06, MW07 and MW25) were installed at the downgradient edge of the suspected contamination as indicated in Fig. 5.26. Due to the presence of floating product in MW07, two additional downgradient wells (MW23 and MW24) were installed 50 to 100 ft beyond the downgradient edge of the suspected contaminated area as indicated by the GSM survey (Fig. 5.26). A final round of water-level measurements was used to construct the potentiometric map presented in Fig. 5.25. The average hydraulic gradient for Site 7 is approximately 8.4 ft/mile, which correlates well with the predominantly coarser and more-permeable lithology of the aquifer. Based on the results of the hydraulic testing performed in MW23 (presented in Sect. 5.2), an estimated hydraulic conductivity of 38 ft/d is found at Site 7. The conductivity value is representative of the fine-grained, poorly graded sand found in MW23. Based on the predominantly coarse-grained lithology of the aquifer at Site 7, a higher conductivity could be inferred.

5.8.4 Conclusions

As discussed in Sect. 2.2.5, this site consists of a POL storage area. Results of the investigation at Site 7 indicate the presence of significant levels of fuel-related compounds

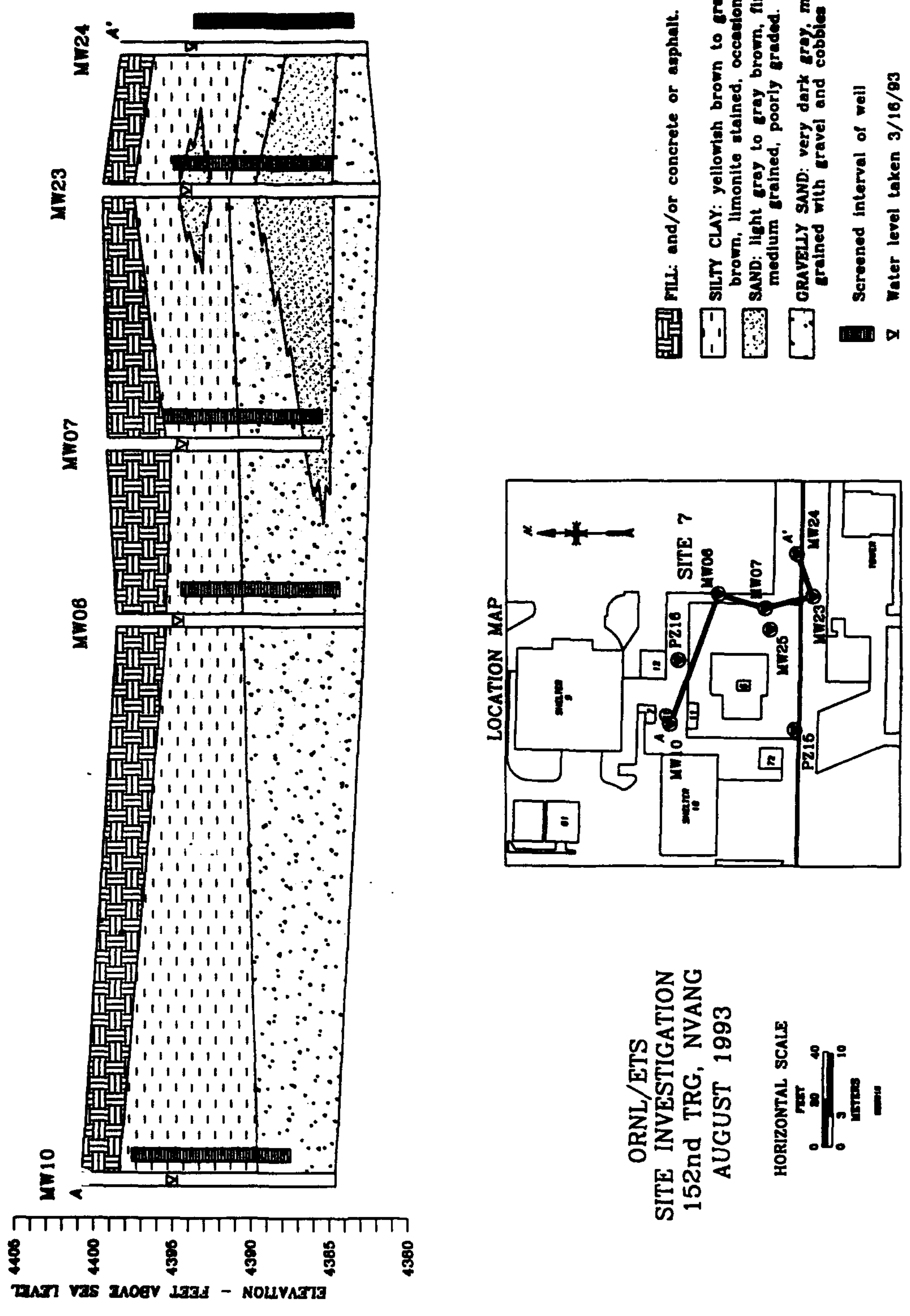


Fig. 5.27. Geologic cross section of Site 7.

(benzene, ethylbenzene, toluene, and xylenes) in the soil. Additionally, significant levels of PHCs reported as TPH were detected in the soil. The highest concentrations of fuel-related VOC contamination in soil were found in BH27, BH28, BH30, and BH31. The highest PHC concentrations in soil were found in BH31, BH30, BH27, and BH28. Although acetone and chloroform are reported at estimated levels, their sporadic occurrence is likely related to spurious laboratory contamination rather than actual environmental contamination. Similarly, the sporadic occurrence of *bis*(2-ethylhexyl) phthalate is not considered significant for reasons previously discussed. The occurrence of numerous PAHs suggest these compounds are derived from the identified fuel contamination.

Results of the groundwater samples indicate significant VOC contamination at Site 7, most of which is related to the floating product in MW07. The source of the floating product appears to be limited to the immediate area and not related to the upgradient JP-4 fuel tanks. Product thickness in MW07 (Table 5.25) has averaged less than 2 in., which, when converted to actual thickness on the water table using the four-times-less approach, would not exceed the NDEP removal-action guideline of ½ in. actual thickness. To mitigate the floating-product situation in MW07, periodic product-thickness measurement and bailing are being performed by Base personnel.

Compounds detected include benzene, ethylbenzene, toluene, xylenes, 1,2-DCE, 1-2-DCA, chloroform, and methylene chloride. Of these, only benzene is reported at levels exceeding the current MCLs presented in Table 5.7.

The presence of PAHs in the groundwater suggest that the source of these compounds is fuel related. With the exception of benzo[*a*]pyrene, none of the PAHs reported in Site 7 groundwater have current or proposed MCLs. This compound, which was reported at 190 $\mu g/L$, J, in MW07, exceeds its proposed MCL of 0.2 $\mu g/L$ listed in Table 5.7.

Therefore, the presence of groundwater contamination by VOCs and BNAs at Site 7 has been confirmed.

5.9 Site 13, Storm Drains at the AGE Storage Lot

5.9.1 Screening Activity Results

GSM Survey

The results of the GSM survey are presented in Fig. 5.28 and Table 5.26. Samples were collected from 26 locations on a 125 × 225-ft grid with 25-ft spacing. The grid was laid over the suspect storm drains.

Although the GSM survey suggested the trace presence of several chlorinated and fuel-related compounds in the groundwater (TCE, 1,2-DCE, TCA, benzene, toluene, ethylbenzene, and xylenes), the coexistence of numerous unknown compounds interfered with definitive compound identification during GC headspace analysis. As previously discussed in Sect. 4.5.1, the GC data were used as a measure of relative contamination. Points with little or no apparent groundwater contamination were deemed negative, and those with moderate to high apparent groundwater contamination were classified positive. Thus all of the points within the shaded area of Fig. 5.28, which represent the suspected area of groundwater contamination, are positive. Also reported in Fig. 5.28 and Table 5.26 are the PID readings recorded at each hole, which are indicative of VOCs in the soil. Consequently, a positive GC decision may be paired with a relatively low PID reading, suggesting potential groundwater contamination without any associated soil contamination. Conversely, a relatively high PID reading may be paired with a negative GC decision, suggesting potential soil contamination without any associated groundwater contamination.

Piezometer Levels

The potentiometric surface for Site 13 is the same as that for Site 14 due to their relative proximity to one another. This potentiometric surface was established using one

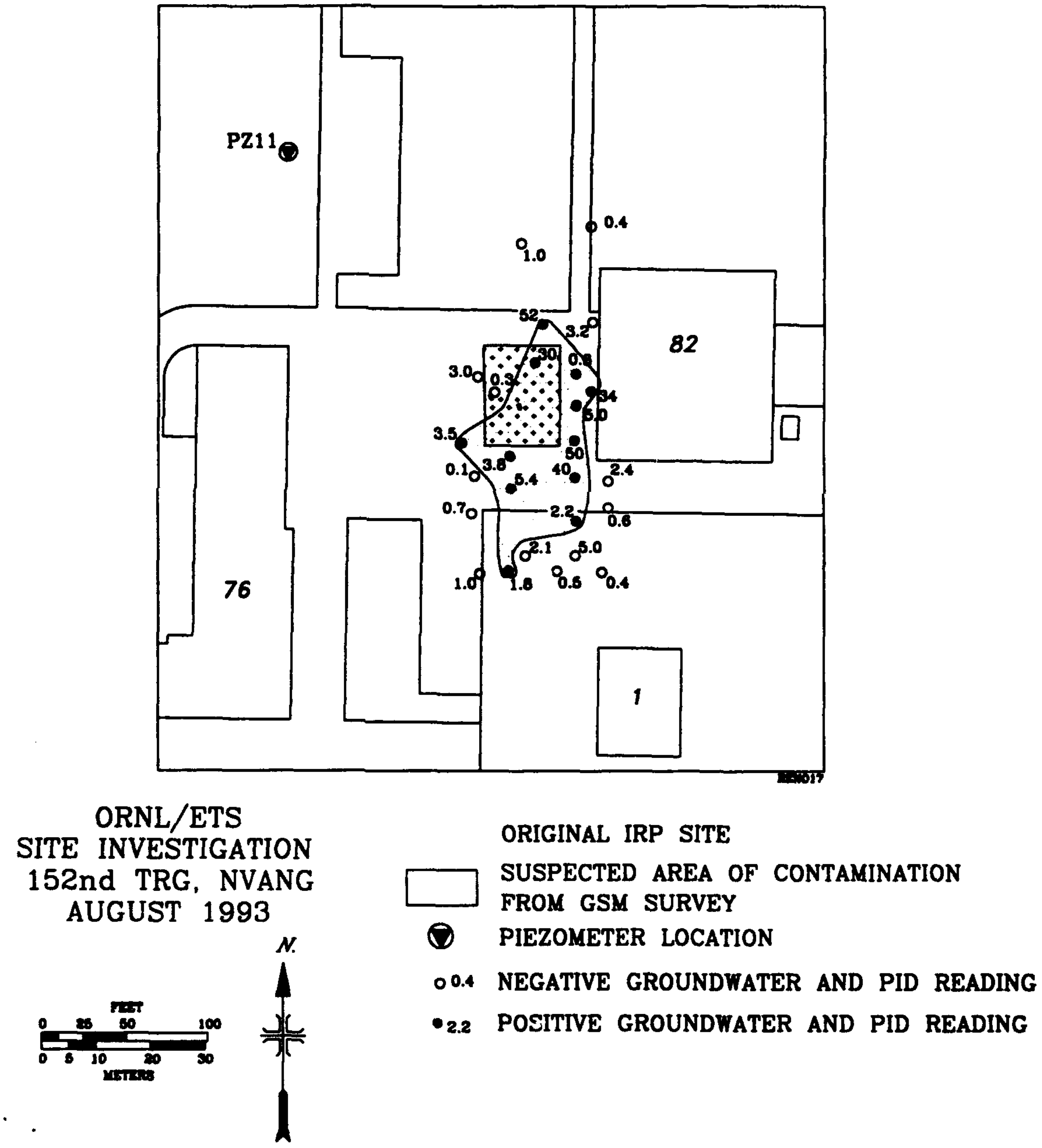


Fig. 5.28. Site 12 GSM survey locations.

Table 5.26. GSM survey results from Site 13

Location	Grid coordinates, x,y	PID, ppm	GC Decision
S1301	0,0	1.8	Positive
S1302	30,0	0.5	Negative
S1303	56,0	0.4	Negative
S1304	10,10	2.1	Negative
S1305	40,10	5.0	Negative
S1306	40,120	0.8	Positive
S1307	-20,120	3.0	Negative
S1308	405,100	5.0	Positive
S1309	40,80	50.0	Positive
S1310	40,57	40.00	Positive
S1311	40,30	2.2	Positive
S1312	-20,60	0.1	Negative
S1313	0,70	3.8	Positive
S1314	-10,110	0.3	Negative
S1315	16,127	30.0	Positive
S1316	20,150	52.0	Positive
S1317	-30,80	3.5	Positive
S1318	0,50	5.4	Positive
S1319	60,40	0.6	Negative
S1320	60,55	2.4	Negative
S1321	50,110	34.0	Positive
S1322	50,150	3.2	Negative
S1323	10,190	1.0	Negative
S1324	50,210	0.4	Negative
S1325	-20,-5	1.0	Negative
S1326	-23,35	0.7	Negative

base wide piezometer (PZ07) and three piezometers (PZ11, PZ04, and PZ02) installed at adjacent sites (Site 5 and Site 2). Piezometer levels in PZ11, PZ07, PZ04, and PZ02 were used to determine the optimum placement of monitoring wells at Sites 13 and 14. Construction data on the piezometers are presented in Appendix B. The potentiometric surface map for Site 13 (Fig. 5.29) indicates that groundwater flows to the southeast. Groundwater flow direction is discussed in Sect. 5.9.3.

5.9.2 Confirmation and Delineation Activities

Three monitoring wells and five soil borings were drilled to support the characterization of Site 13. Twelve soil samples plus three duplicate soil samples, collected from the soil borings, and six groundwater samples, collected from the monitoring wells, were submitted for laboratory analysis. Additionally, an equipment rinsate sample, associated with the second round sampling of MW12, was collected for chemical analysis. All of the soil and groundwater samples were analyzed for VOCs, BNAs, PHCs, and metals.

Soil Sampling

Complete analytical results for the soil samples are presented in Table D-1 of Appendix D. Significant results from the organic analyses are presented in Table 5.27. The data are presented by boring number and depth. For example, BH16-4 refers to the sample collected 4 ft bgs in borehole 16. All of the inorganic results for the soil samples are within the background ranges reported in Table 5.4 and are therefore, not considered significant. The soil boring locations are presented in Fig. 5.30. The relative proximity of BH19 and BH20 to one another was brought about by sampler refusal in BH19 at 3 ft bgs. The drilling rig was moved a few feet and BH20 was drilled to obtain the soil samples.

Two VOCs were detected in the soil at Site 13. These compounds include chloroform (1.0 μg/kg, J) and 2-butanone (16 μg/kg).

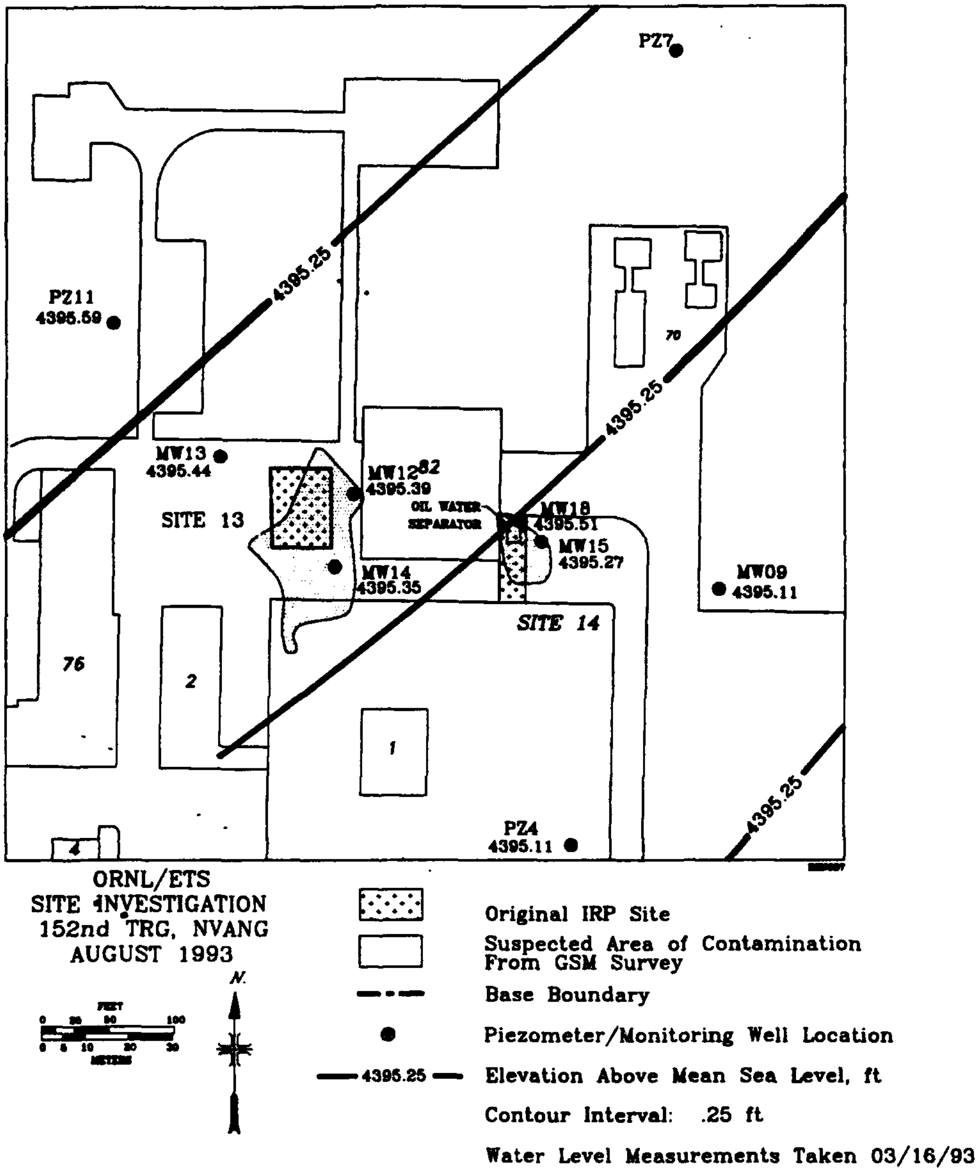


Fig. 5.29. Potentiometric surface for Sites 13 and 14.

Table 5.27. Organic chemical constituents detected in Site 13 soil

Chemical	BH16-4	BH16-6	BH16-6D	BH16-8	BH17-4	BH17-4D	BH17-6	BH17-8	BH18-3	BH19-2	BH20-6	BH20-6D
VOCs, μg/kg												
2-Butanone										16.0		
Chloroform				1.0 J							1.0 J	
BNAs, μg/kg												
Benzo[*a*]anthracene										88 J		
Benzo[*a*]yrene										70 J		
Benzo[*b*]fluoranthene										140 J		
Benzo[*k*]fluoranthene										140 J		
bis(2-Ethylhexyl) phthalate	88.0 J	77.0 J	88.0 J	66.0 J	62.0 J	94.0 J	74.0 J	220 J	200 J			
Chrysene										75 J		
Fluoranthene										160 J		
Phenanthrene										65 J		
Pyrene										130 J		
PHCs, mg/kg												
Total petroleum hydrocarbons	39.0	0.21					2.8		34			

Blank space indicates compound was undetected.
D indicates duplicate sample.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

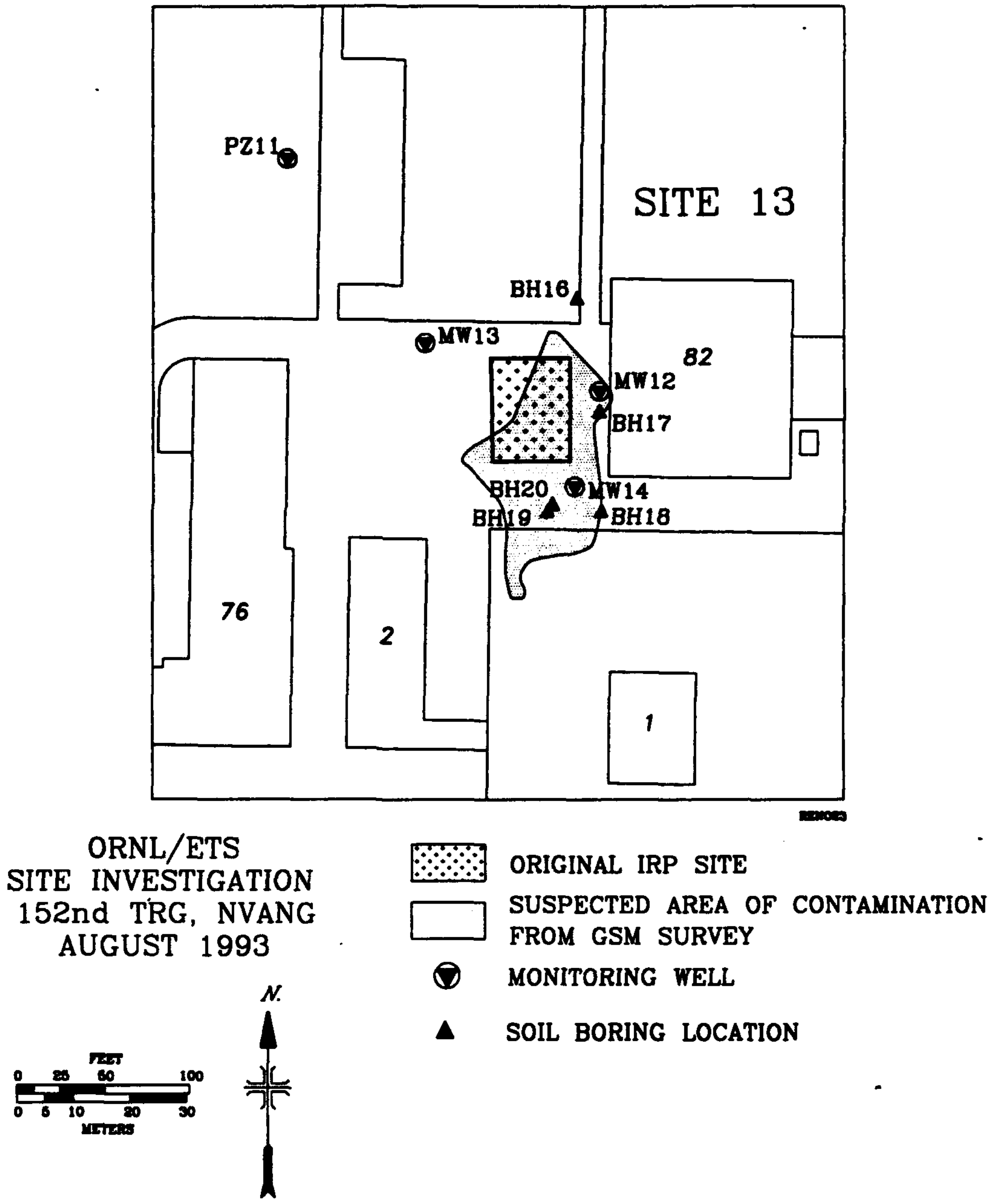


Fig. 5.30. Site 13 soil-boring and monitoring well locations.

Nine compounds were detected by the BNA analysis. These compounds consist of one phthalate and eight PAHs, which range in concentration from 65 to 220 $\mu g/kg$, J. All of the BNA compounds exhibit levels that are within background concentrations.

All of the inorganic results for Site 13 soils reported in Table D-1 of Appendix D are within the background ranges reported in Table 5.4.

PHCs, reported as TPH, ranged from 0.21 to 39 mg/kg at Site 13.

Groundwater Sampling

Groundwater samples were collected in December 1992 and March 1993 from the wells shown in Fig. 5.30. Complete analytical results are presented in Table D-1 of Appendix D. Significant groundwater data from Site 13 are presented in Table 5.28. Field measurements made during sampling are presented in Tables 5.11 and 5.12.

No significant VOC levels were found in the groundwater at Site 13. Carbon disulfide was detected intermittently in MW13 and MW14 at levels ranging from 1.0 to 14 $\mu g/L$.

Three BNA compounds were detected in groundwater at Site 13. All three of these compounds are phthalates at low levels (1.0 to 2.0 $\mu g/L$).

A trace of PHCs reported as TPH (0.02 mg/L) was found in the second round sample from MW12.

None of the inorganic compounds presented in Table 5.28 exceed any of the applicable standards presented in Table 5.7.

Results of the equipment rinsate sample (#1558) associated with the MW12 March 1993 sampling round are presented in Table D-2, Appendix D. Sample 1558 has no significant data to report.

Table 5.28. Chemical constituents detected in Site 13 groundwater

Chemical	MW12-1st	MW12-2nd	MW13-1st	MW13-2nd	MW14-1st	MW14-2nd
VOCs, μg/L						
Carbon disulfide				14.0		1.0
BNAs, μg/L						
bis(2-Ethylhexyl) phthalate	2.0 J		1.0 J			
Butylbenzyl phthalate				2.0		1.0
Diethyl phthalate						1.0
PHCs, mg/L						
Total petroleum hydrocarbons		0.02				
Inorganic Analytes, μg/L						
Aluminum	216		181		213	
Arsenic	16.3 J	25.9	23.2 J	23.6	14.5 J	26.7
Barium	44.2	33.9	40.6	43.3	37.3	40.8
Calcium	59,900	34,700	44,200	40,500	51,400	59,000
Copper	9.6	8.1		10.5	7.8	14.8
Iron	66.9		50.2		75.2	
Magnesium	12,400	6560	8670	7890	10,000	11,300
Manganese	71	15.5	24.1		86.4	73.9
Potassium	12,100	7470	8970	7910	10,300	9840
Sodium	103,000	73,000	96,000	79,100	134,000	153,000
Vanadium	6	5.7	8.7		10.1	7.6
Zinc	5.8		8.4		10.1	

Blank space indicates compound was undetected.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

Comparison of Screening Results with Confirmation Results

The results of the GSM survey compare favorably with the confirmation data. The GSM survey suggested the trace presence of organic contamination within the shaded area of Fig. 5.30, which was apparently below the detection limits of the analytical results presented in Tables 5.27 and 5.28. With the exception of minor TPH contamination detected in BH16-4 and BH18-3, no significant soil or groundwater contamination were found at Site 13. The TPH contamination in BH16-4 and BH18-3 does not appear to be associated with waste disposal activities at the AGE storm drains due to its location north of the site.

5.9.3 Geologic and Hydrogeologic Investigation Results

The subsurface lithology for Sites 13 and 14 is discussed jointly due to their relative proximity to one another and lithologic similarity. The subsurface at Sites 13 and 14 is comprised of fill material: pale-gray to olive-brown sandy silt, yellowish-brown to gray-brown silty clay with occasional sand; light-gray to gray-brown, fine to medium-grained, poorly graded sand; and very dark gray, well-graded sandy gravel with occasional cobbles. The geologic cross section presented in Fig. 5.31 was constructed using lithologic data from MW13, MW12, MW15, and MW09. Well construction data are presented in Appendix B.

Approximately 3 ft of fill material are present across Sites 13 and 14 with the exception of MW13, which has about 10 ft. The underlying silty clay reaches a maximum thickness of about 4 ft and grades into sandy silt between MW15 and MW09. Generally, the silt and silty clay are underlain by well-graded sandy gravel that contains a lens of poorly graded sand on the west end of the cross section. Actual thickness of the water-bearing, well-graded sand was not determined because none of monitoring wells penetrated through it completely.

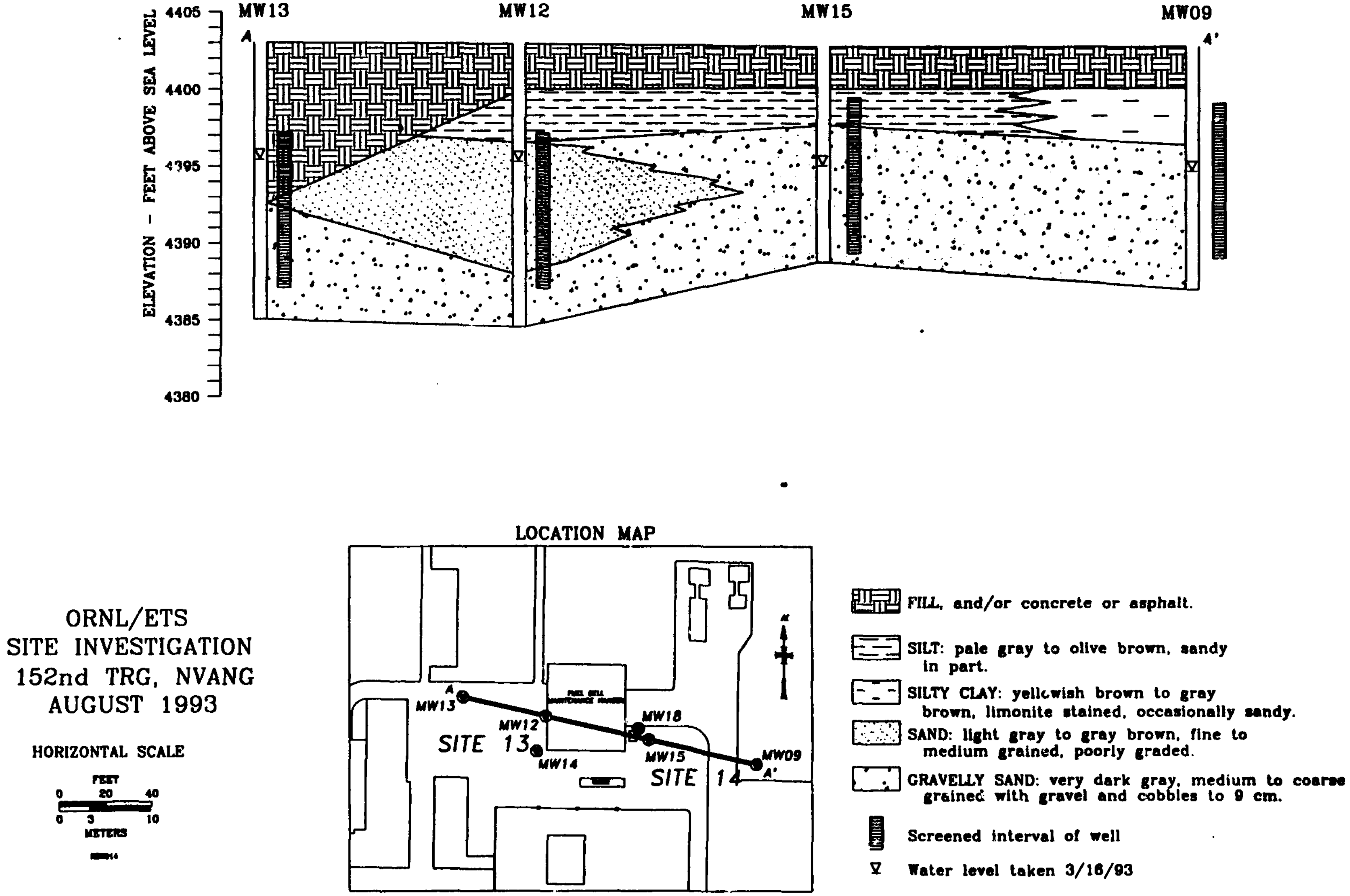


Fig. 5.31. Geologic cross section of Sites 13 and 14.

Piezometer data were evaluated, and the groundwater flow direction was determined to be to the southeast. An upgradient monitoring well (MW13) was installed northwest of the sites, and two additional wells were installed at each site. MW12 and MW14 were installed at the downgradient edge of suspected contamination at Site 13, while MW15 and MW18 were installed at the downgradient edge of suspected contamination at Site 14. A final round of water-level measurements was used to construct the potentiometric map presented in Fig. 5.29. The average hydraulic gradient for Sites 13 and 14 is approximately 4.2 ft/mile, which correlates well with the predominantly coarser and more permeable lithology of the aquifer. Based on the results of the hydraulic testing performed in MW09 (Sect. 5.2), which is located immediately east of Site 14, an estimated hydraulic conductivity of 302 ft/d is calculated in this area. Review of the cross section (Fig. 5.29) suggests the fine-grained lithology and thicker fill material on the west end would yield lower hydraulic conductivity values due to the reduced permeability.

5.9.4 Conclusions

As discussed in Sect. 2.2.6, this site consists of storm drains at the AGE storage lot. Results of the investigation at Site 13 indicate the presence of low TPH levels in the soil in an area north and east of the site. The highest TPH level was found in BH16-4.

Results of the groundwater samples indicate no significant VOC contamination present at Site 13. Carbon disulfide, a common laboratory solvent, was detected at low levels (1.0 to 14 μg/L) on an intermittent basis, suggesting spurious laboratory contamination rather than environmental contamination.

The low-level presence of three phthalates in the groundwater suggest the source of these compounds is related to sampling and/or analytical interferences. Except for the butylbenzyl phthalate, none of the phthalates reported in Site 13 groundwater have current or proposed MCLs. The MCL for butylbenzyl phthalate is 100 μg/L.

Therefore, the presence of no significant soil or groundwater contamination at Site 13 has been confirmed.

5.10 Site 14, OWS at Building 82

5.10.1 Screening Activity Results

GSM Survey

The results of the GSM survey are presented in Fig. 5.32 and Table 5.29. Samples were collected from 15 locations on a 125 × 175-ft grid with 25-ft spacing. The grid was laid over the area suspected to have received overflows from the OWS.

Although the GSM survey suggested the trace presence of fuel-related compounds in the groundwater (benzene, toluene, ethylbenzene, and xylenes), the coexistence of numerous unknown compounds interfered with definitive compound identification during GC headspace analysis. As previously discussed in Sect. 4.5.1, the GC data were used as a measure of relative contamination. Points with little or no apparent groundwater contamination were deemed negative, and those with moderate to high apparent groundwater contamination were classified positive. Thus, all of the points within the shaded area (Fig. 5.32), which represents the suspected area of groundwater contamination, are positive. Also reported in Fig. 5.32 and Table 5.29 are the PID readings recorded at each hole, which are indicative of VOCs in the soil. Consequently, a positive GC decision may be paired with a relatively low PID reading, suggesting potential groundwater contamination without any associated soil contamination. Conversely, a relatively high PID reading may be paired with a negative GC decision, suggesting potential soil contamination without any associated groundwater contamination.

Piezometer Levels

Due to their relative proximity to one another, the discussion of piezometer levels for Site 13 and Site 14 was presented in Sect. 5.9.1. Groundwater flow directions are discussed in Sect. 5.10.3.

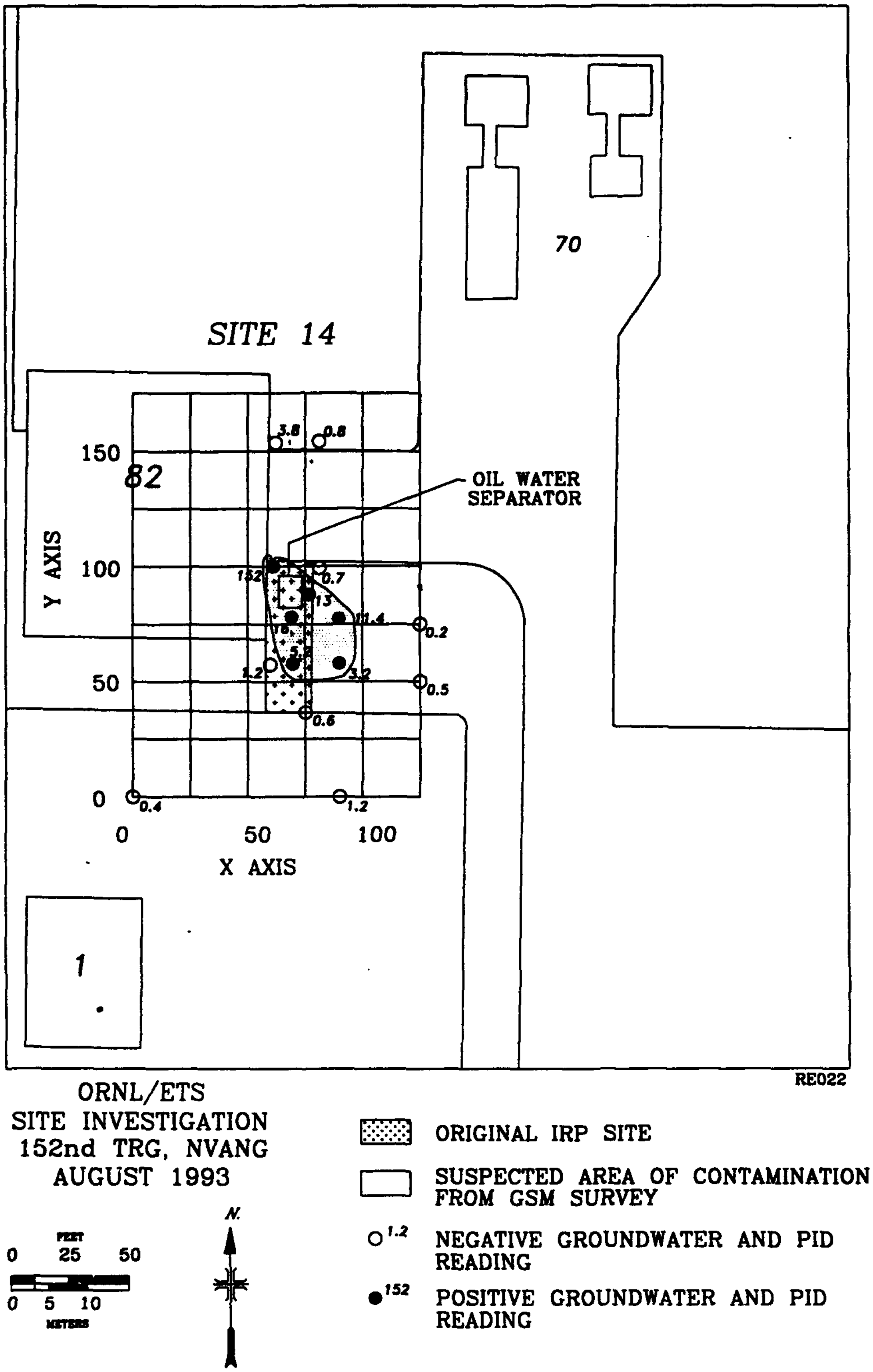


Fig. 5.32. Site 14 GSM survey locations.

Table 5.29 GSM survey results from Site 14

Location	Grid coordinates, x,y	PID, ppm	GC Decision
S1401	0,0	0.4	Negative
S1402	90,0	1.2	Negative
S1403	90,60	3.2	Positive
S1404	90,80	11.4	Positive
S1405	78,87	13.0	Positive
S1406	80,100	0.7	Negative
S1407	60,100	152.0	Positive
S1408	70,80	16.0	Positive
S1409	70,60	5.2	Positive
S1410	60,60	1.2	Negative
S1411	60,155	3.8	Negative
S1412	80,155	0.8	Negative
S1413	125,50	0.5	Negative
S1414	125,75	0.2	Negative
S1415	75,37	0.6	Negative

5.10.2 Confirmation and Delineation Activities

Three monitoring wells and six soil borings were drilled to support characterization of Site 14. Fourteen soil samples plus one duplicate soil sample, collected from the soil borings, and four groundwater samples, collected from the monitoring wells, were submitted for laboratory analysis. All of the soil and groundwater samples were analyzed for VOCs, BNAs, and PHCs. Although no metals analyses were planned, all of the soil samples were inadvertently analyzed for metals.

Soil Sampling

Complete analytical results for the soil samples are presented in Table D-1 of Appendix D. Significant results from the organic analyses are presented in Table 5.30. The data are presented by boring number and depth. For example, BH21-8 refers to the sample collected 8 ft bgs in borehole 16. All of the inorganic results for the soil samples are within the background ranges reported in Table 5.4 and are, therefore, not considered significant. The soil boring locations are presented in Fig. 5.33. The relative proximity of BH25 and BH26 to one another was brought about by sampler refusal in BH25 at 6 ft bgs. The drilling rig was moved a few feet, and BH26 was drilled to obtain the soil samples. BH25 and BH26 were drilled north of the site to confirm or deny historical information about suspected areas of overflow from the oil water separator.

Five VOCs were detected in the soil at Site 14. These compounds include chloroform (1.0 to 2.0 μg/kg, J), 2-butanone (11 μg/kg, J), tetrachloroethene (3.0 μg/kg, J), methylene chloride (2200 to 5100 μg/kg, J), and total xylenes (2.0 to 2500 μg/kg, J).

Five compounds were detected by the BNA analysis for soil. These compounds consist of one phthalate and four PAHs, which range in concentration from 100 μg/kg, J, to 28,000 μg/kg.

All of the inorganic results for Site 14 soils reported in Table D-1 of Appendix D are within the background ranges reported in Table 5.4.

Table 5.30. Organic chemical constituents detected in Site 14 soil

Chemical	BH21-4	BH21-8	BH21-8D	BH22-4	BH22-6	BH22-8	BH23-4	BH23-6	BH23-8	BH24-4	BH24-8	BH25-6	BH26-8
VOCs, µg/kg													
Tetrachloroethene		3.0 J				3.0 J							
2-Butanone							11.0 J						
Chloroform				2.0 J								1.0 J	2.0 J
Methylene chloride								2200 J	5100 J				
Xylenes		13							2500 J				2.0 J
BNAs, µg/kg													
2-Methylnaphthalene		28,000						2200	27,000				
bis(2-Ethylhexyl) phthalate												210 J	100 J
Dibenzofuran		210 J											
Naphthalene		14,000						920 J	16,000				
Acenaphthene		210 J											
PHCs, mg/kg													
Total petroleum hydrocarbons	0.11	2600	110		4.1	1700	0.075	330	4809	91.36	0.07 J		

Blank space indicates compound was undetected.
D indicate duplicate sample.

J = reported value is below the contract required detection limit but above the instrument detection limit. Values are estimated quantities.

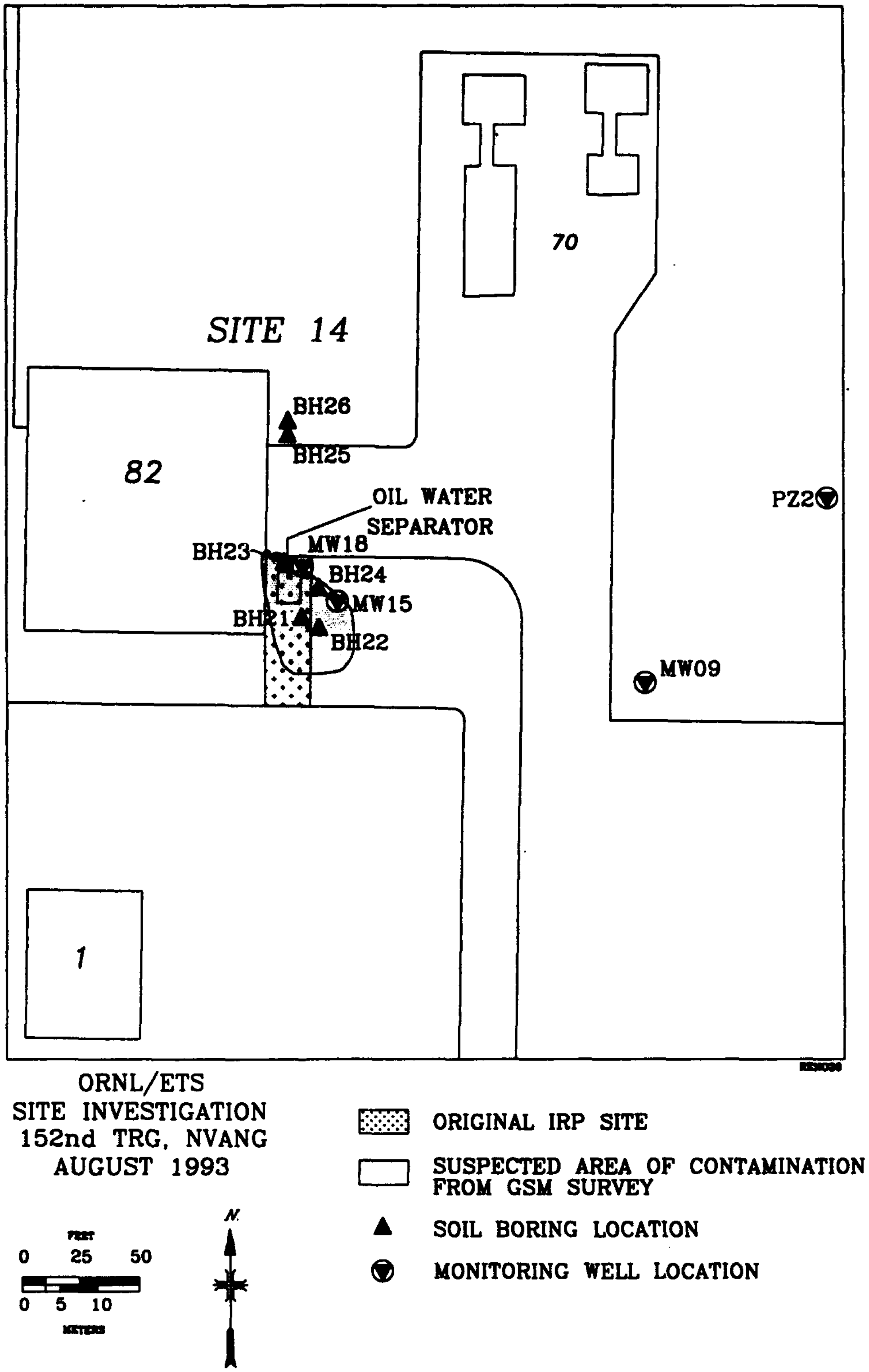


Fig. 5.33. Site 14 soil-boring and monitoring well locations.

PHCs, reported as TPH, ranged from 0.11 to 4800 mg/kg at Site 14.

Groundwater Sampling

Groundwater samples were collected in December 1992 and March 1993 from the wells shown in Fig. 5.33. Complete analytical results are presented in Table D-1 of Appendix D. Significant groundwater data from Site 14 are presented in Table 5.31. Field measurements made during sampling are presented in Tables 5.11 and 5.12.

No significant VOC levels were found in the groundwater at Site 14. Carbon disulfide was detected on one occasion in MW18 at a level of 2 μg/L.

Two BNA compounds were detected in groundwater at Site 14. Both of these compounds are phthalates at low levels (1 μg/L).

No PHCs were reported in the groundwater at Site 14.

Comparison of Screening Results with Confirmation Results

The results of the GSM survey compare favorably with the confirmation data. The GC headspace analysis of groundwater samples collected from the water table suggested the trace presence of VOC contamination within the shaded area of Fig. 5.33. Similarly, the PID values listed are a relative measure of VOC contaminants in soil. The soil contamination was confirmed by soil boring results, presented in Table 5.30, where significant PHC contamination is reported between 6 and 8 ft bgs. Although GC head-space analysis of water table samples suggested trace organic contamination, the groundwater analytical results presented in Table 5.31 indicate that the groundwater quality has not been affected by the overlying PHC contamination. This suggests that the contaminants have not accumulated sufficient mass to significantly penetrate the water table, or they have been left behind by a locally declining water table.

Table 5.31. Chemical constituents detected in Site 14 groundwater

Chemical	MW18-1st	MW18-2nd	MW15-1st	MW15-2nd
VOCs, μg/L				
Carbon disulfide		2.0		
BNAs, μg/L				
Butylbenzyl phthalate		1.0		1.0
Di-*n*-butyl phthalate		1.0		

Blank space indicates compound was undetected.

5.10.3 Geologic and Hydrogeologic Investigation Results

The subsurface lithology of Sites 13 and 14 is discussed jointly due to their relative proximity and lithologic similarity. This discussion is presented in Sect. 5.9.3.

5.10.4 Conclusions

As discussed in Sect. 2.2.6, this site consists of an unprotected area adjacent to the OWS that receives occasional overflows of JP-4 fuel. Results of the investigation at Site 14 indicate the presence of high PHC levels in the soil in the area around the OWS. The highest concentrations of PHCs were found in BH24, BH21, BH22, and BH23 at depths of 6 to 8 ft bgs.

Results of the groundwater samples indicate no significant VOC contamination present at Site 14. Carbon disulfide, a common laboratory solvent, was detected once at a concentration of 2 μg/L, suggesting spurious laboratory contamination rather than environmental contamination.

The low levels of phthalate compounds is most likely related to sampling and/or analytical interferences. Of the phthalates reported in Site 14 groundwater, only butylbenzyl phthalate has a proposed MCL of 100 μg/L.

Although significant soil contamination was confirmed at Site 14, no significant groundwater contamination has been confirmed.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Field investigations were conducted at seven potentially contaminated sites at the 152nd TRG, Reno, Nev. Five of these sites were originally identified in the PA and two additional sites were subsequently identified by Base personnel. At each site, soil and groundwater screening surveys were conducted, piezometers were constructed, soil borings were drilled and sampled, and monitoring wells were constructed and sampled. In addition, background sediment, surface water, soil, and groundwater were sampled. Hydraulic testing was performed at various sites to obtain representative conductivity values for the water table aquifer.

Investigation results are described in detail in the preceding sections and are summarized in Table 6.1.

6.2 Conclusions

6.2.1 Data Gaps

Data gaps consist of missing data that must be collected before decisions regarding progression to the next step can be made. Only one data gap was identified during this investigation. As discussed in Sect. 6.2.2, groundwater level data at Site 2 indicate that an additional monitoring well is needed at that site to ensure that samples are taken directly downgradient from the contaminated area of Site 2.

The only significant planned activity described in the work plan that was not fully executed was the identification and quantification of compounds by the GSM survey at the Base. As discussed in Sect. 4.5.1, the presence of numerous unknown compounds prevented accurate compound identification or quantification. However, as explained in Sect. 4.5.1, the main of objective of the GSM survey was met because the GSM data were used as a relative measure of contamination that served to delineate areas of suspected contamination.

Table 6.1. Comparison of contamination levels at each site with remediation standards.

Site	Soil	Groundwater
2: FTA No. 2	Below NDEP remediation standards	Exceeds MCL for TCE
3: FTA No. 3	Below NDEP remediation standards	Below MCL for all contaminants
4: FTA No. 4	Exceeds NDEP remediation standards for TPH and generic total VOCs	Exceeds MCL for TCE and benzene
5: FTA No. 5	Exceeds NDEP remediation standards for TPH and generic total VOCs	Exceeds MCL for benzene
7: POL Storage Area	Exceeds NDEP remediation standards for benzene, TPH, and generic total VOCs	Exceeds MCL for benzene, exceeds proposed MCL for benzo[a]pyrene
13: Storm drains at the AGE storage lot	Below NDEP remediation standards	Below MCL for all contaminants
14: OWS at Building 82	Exceeds NDEP remediation standards for TPH, BNAs, and generic total VOCs	Below MCL for all contaminants

6.2.2 Recommendations

Recommendations for the disposition of the each site are based on the remediation standards set forth in *Contaminated Soil and Ground Water Remediation Policy* (NDEP 1992). The standards specific to contaminants identified during this investigation have been tabulated. Table 6.2 presents the soil remediation standards for organic compounds, and Table 6.3 presents the groundwater remediation standards for organic compounds. Due to the high concentrations of naturally occurring inorganic compounds, these remediation standards are not presented. As discussed in Sect. 5.3, inorganic compound levels in background soil and groundwater samples are similar to the levels found at each site, which suggests that former site activities have not impacted inorganic soil and groundwater quality.

As such, the recommendations presented below do not reflect the site-specific attributes considered by a qualitative and/or quantitative risk evaluation. Therefore, it is recommended that the site-specific data be subjected to minimal risk evaluation criteria before carrying out any of the recommendations presented below.

Site 2, FTA No. 2

The analytical data at Site 2 indicate contamination of soil below the NDEP soil remediation criteria with the exception of 2-butanone (a common laboratory contaminant) in one sample that exceeds the generic total VOC limit of 1000 μg/kg. Therefore, a no-decision document for soils is recommended.

The analytical data indicate no contamination of groundwater at the site. Groundwater downgradient of the site contains TCE (2.0 to 6.0 μg/L) at levels that exceed NDEP remediation criteria (MCLs) for TCE (5.0 μg/L). Site 2 is currently under investigation as Site 12 - Aircraft Parking Apron Area. The investigation included a soil gas survey of the entire apron, soil boring samples and the installation of two downgradient monitoring wells. The project will include a Corrective Action Plan. Therefore, a no-further-action decision document for Site 2 is recommended.

Table 6.2. Nevada soil remediation standards for organic compounds

Compound	TCLP Limit, µg/kg[a]	MCL Limit, µg/kg[b]	SMCL Limit, µg/kg[c]	Generic VOC Limit, µg/kg[d]	Generic BNA Limit, µg/kg[e]
Benzene	500	500	----	NA	NA
Benzo[*a*]pyrene	NA	20	----	NA	NA
Butylbenzyl phthalate	NA	10,000	----	NA	NA
Carbon disulfide	NA	NA	NA	1000	NA
Chloroform	NA	10,000	----	NA	NA
1,2-dichlorobenzene	NA	60,000	1000[•]	NA	NA
1,3-dichlorobenzene	NA	NA	NA	NA	10,000
1,4-dichlorobenzene	7500	7500	500[•]	NA	NA
1,1-dichloroethane	NA	NA	NA	1000	NA
1,2-dichloroethane	500	500	----	NA	NA
1,1-dichloroethene	700	700	----	NA	NA
cis-1,2-Dichloroethene	NA	7000	----	NA	NA
trans-1,2-Dichloroethene	NA	10,000	----	NA	NA
Ethylbenzene	NA	70,000	3000[•]	NA	NA
Methylene chloride	NA	500	----	NA	NA
PAHs	NA	NA	NA	NA	10,000
Pentachlorophenol	100,000	NA	NA	NA	NA
Toluene	NA	100,000	4000[•]	NA	NA
Trichloroethene	500	500	----	NA	NA
Xylenes total	NA	1,000,000	2000[•]	NA	NA

[a] TCLP (toxicity characterization leaching procedure) limit refers to the specific concentration criteria under the toxicity characteristics rule (40 CFR Part 261.24). If the compound is regulated under this rule, the toxicity characteristics regulatory limits are applied as the soil remediation standard.

[b] MCL limit refers to federally promulgated maximum contaminant level (MCL). If an MCL exists for a specific compound, the MCL is multiplied by 100 to determine the soil remediation standard.

[c] SMCL limit refers to federally promulgated secondary maximum contaminant level (SMCL). If an SMCL exists for a specific compound, the SMCL is multiplied by 100 to determine the soil remediation standard.

[d] A generic standard of 1000 µg/kg for total volatile organic compounds without applicable TCLP or MCL limits.

[e] A generic standard of 10,000 µg/kg for total base neutral compounds without TCLP or MCL limits.

[•] proposed

PAHs = polynuclear aromatic hydrocarbons
NA = not applicable

Table 6.3 Nevada groundwater remediation standards for organic compounds

Constituent	Maximum Contaminant Level[a], μg/L	Secondary Maximum Contaminant Level[b], μg/L	Secondary Preferred Standard[c], μg/L
Benzene	5.0		
Benzo[*a*]pyrene	0.2		
Butylbenzyl phthalate	100.0*		
Carbon tetrachloride	5.0		
Chloroform	100.0		
Ethylbenzene	700.0	30.0*	
Methylene chloride	5.0		
Toluene	1000.0	40.0*	
Trichloroethene	5.0		
Trihalomethanes (total)	100.0		
1,2-Dichloroethane	5.0		
cis-1,2-Dichloroethene	70.0		
trans-1,2-Dichloroethene	100.0		
1,1-Dichloroethene	7.0		
1,4-Dichlorobenzene	75.0	5.0*	
1,2-Dichlorobenzene	600.0	10.0*	
1,1,1-Trichloroethane	200.0		
Xylenes (total)	10,000.0	20.0	
Copper		1000.0	
Zinc		5000.0	
pH		6.5 to 8.5	

[a] Maximum contaminant levels (MCLs) are health related and federally mandated. MCLs are adopted from the National Drinking Water Regulatior

[b] Secondary maximum contaminant levels (SMCLs) are based on esthetic qualities and enforceable by the state. SMLCs, except that for magnesium, are adopted from the National Drinking Water Regulations.

[c] Secondary preferred standards (SPSs) must be met unless water of that quality is not available, in which case the SMCLs must be met if they exist. SMCLs have not been established for copper, pH, and zinc.

* Proposed levels.

Site 3, FTA No. 3

The analytical data at Site 3 indicate that no contamination of soil or groundwater is present. Therefore, preparation of a no-further-action decision document for soil and groundwater at Site 3 is recommended.

Site 4, FTA No. 4

The analytical data at Site 4 indicate contamination of soil above the NDEP soil remediation criteria for TPH (100 mg/kg) and generic total VOCs (1000 μg/kg) in the form of ethylbenzene, total xylenes, acetone, and methylene chloride. The analytical data indicate contamination of groundwater at levels that exceed NDEP remediation criteria (MCLs) for benzene and TCE. An RI for soils and groundwater is recommended to evaluate the extent of contamination.

Site 5, FTA No. 5

The analytical data at Site 5 indicate contamination of soil above the NDEP soil remediation criteria for TPH (100 mg/kg) and generic total VOCs (1000 μg/kg) in the form of ethylbenzene, total xylenes, acetone, and methylene chloride. The analytical data indicate benzene contamination in groundwater at levels (15 μg/L) that exceed NDEP remediation criteria (MCL) for benzene (5.0 μg/L). An RI for soils and groundwater is recommended to evaluate the extent of contamination.

Site 7, POL Area

The analytical data at Site 7 indicate contamination of soil above the NDEP soil remediation criteria for benzene (500 μg/kg), TPH (100 mg/kg), and generic total VOCs

(1000 μg/kg) in the form of ethylbenzene, total xylenes, 2-butanone, and toluene. Additionally, the NDEP generic total BNA remediation standard of 10,000 μg/kg is also exceeded. The analytical data indicate benzene contamination in groundwater at levels (21 to 2300 μg/L) that exceed current NDEP remediation criteria (MCL) for benzene (5.0 μg/L). Additionally, levels of benzo[*a*]pyrene (190 μg/L) exceed proposed remediation standards (20 μg/L). Groundwater data from two downgradient wells, however, indicate that the extent of contamination is very limited and could be controlled with source removal of a relatively small amount of contaminated soil. An RI for soils and groundwater is recommended to evaluate the extent of contamination.

Site 13, Storm drains at the AGE storage lot

The analytical data at Site 13 indicate that no contamination of soil or groundwater in excess of any remediation standards is present. Therefore, preparation of a no-further-action decision document for soil and groundwater at Site 13 is recommended.

Site 14, OWS at Building 82

The analytical data at Site 14 indicate contamination of soil above the NDEP soil remediation criteria for VOCs, TPH, and BNAs. Levels of methylene chloride (suspected laboratory contamination) in one sample exceed the proposed NDEP remediation standard of 500 μg/kg, TPH levels exceed the 100 mg/kg remediation standard, and total VOCs and BNAs exceed their respective generic 1000 and 10,000 μg/kg remediation standards. An RI for soils is recommended to evaluate the extent of contamination.

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