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DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL PROTECTION

Capitol Complex
333 W. Nye Lane
Carson City, Nevada 89710

September 19, 1994

Commanding Officer
Public Works/Environmental
Code 187
NAS Fallon
Fallon, Nevada 89406

Attn: Mr. Douglas Bonham

Re: IRP Issues

Dear Mr. Bonham:

The following decisions were made during the Installation Restoration Program (IRP) technical meeting held at the base on August 25 and 26, 1994.

NAS Fallon Bombing Ranges

At the conclusion of our discussion with Mr. John Warner, Fallon Range Analyst/Maintenance Supervisor, it was agreed that base environmental is prepared to address the issues raised in my letter of July 8, 1994. A aerial photography survey is still required. Please submit a written response to the July 8th letter by October 20, 1994.

Site 1

Figure 6, page 18, of the "Tank Removal Activities Report" dated June 1994, indicates that there is soil contamination in the former above-ground storage tank area. This was confirmed during our site tour of August 25th. It was agreed that the vertical and horizontal extent of soil contamination in the former tanks area would be delineated and, if necessary, remediated.

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Site 2

Evidence indicating an on-going leak in the fueling system was discussed. NAS Fallon and the Department of Defense are responsible for fueling utilities located on base property. We look forward to discussing the results of the leak detection efforts being conducted by the base and Santa Fe Pacific Pipeline, Inc.

It was agreed during the meeting that free product thickness measurements and thickness maps, estimates of volumes of free product existing at each plume, and quarterly/cumulative volumes of extracted product would be generated quarterly for all of the IRP sites where free product has been detected. Please include this data quarterly, starting with the third quarter report.

We look forward to working with you to assess the need for soil remediation at Site 2.

Site 3

The Decision Document for Site 3 must include a numerical explanation of why soil and groundwater contamination at Site 3 is not expected to reach the Lower Diagonal Drain, the base boundary, or a receptor, and must include groundwater sampling to confirm this explanation. The base-wide Groundwater Monitoring Plan that is being developed could fulfill this monitoring requirement.

Site 6

It was agreed that soil samples from the unsaturated (vadose) zone would be collected during extraction well installation, and analyzed by EPA Methods 8015 and 8240.

Sites 13, and 14, and 16

The contamination detected in the vadose zone at these sites must be addressed. It was agreed that the base would propose a plan to monitor natural attenuation of this contamination as a first step.

Site 17

No further actions are required at this time.

Site 18

Please include the aerial photograph of this site in the final draft of the Remedial Investigation Report.

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Site 20

The soil cover thickness, grading, and vegetation at this former landfill appear to be adequate (NDEP site inspection August 26, 1994). Groundwater monitoring for this site will be proposed in the base-wide Groundwater Monitoring Plan due to be completed by May 1, 1995.

Sites 21 and 22 (includes Sites 6 and 7)

Surface depressions observed during my August 26th inspection appeared to have allowed ponding of surface water. Although Federal landfill closure regulations do not apply to these sites, State landfill regulations, that were effective when these landfills stopped receiving waste, do apply. These surface depressions must be covered and graded according to Nevada Administrative Code 444.688, effective September 1977 (enclosed).

Diagonal Drain Sampling

Based on the lack of contamination detected during diagonal drain sampling events, it was agreed that the sampling frequency could be changed from quarterly to annually. Annual sampling will be conducted in March of each year. Results are due to the Division May 1st of each year.

Field Work and Document Submittal Schedule

Enclosure (4) of the NAS Fallon letter of July 13, 1994, is a proposed schedule for field work and document submittals. During our meeting, it was agreed that the following changes would be made to the schedule.

- 1) Following the interim sampling event of January 1995, groundwater sampling rounds will be conducted annually starting in September 1995. Please submit a workplan for the January 1995 sampling event by November 10, 1994.
- 2) Items (12) and (14) of the proposed field work schedule will be combined and submitted by May 1, 1995, so that the September 1995 sampling event will include newly installed wells.
- 3) The submittal date for the GTI recovery well workplan was changed to September 30, 1994. GTI field work is expected to begin October 30, 1994.
- 4) The submittal date for the final draft of the Remedial Investigation Report was changed to November 1, 1994.

Mr. Tolson
Washington, D.C.
October 19, 1954

Dear Mr. Tolson:

I am writing to you regarding the information that has been furnished to me by the FBI regarding the activities of the Communist Party in the United States.

If you have any further information regarding this matter, please let me know.

Sincerely,
[Signature]

[Name]

cc: Dave [Name]
John [Name]
Tom [Name]

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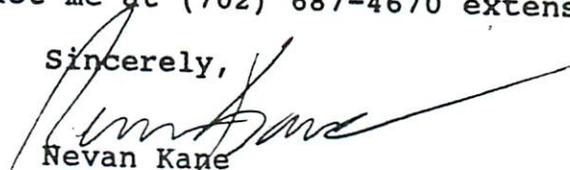
Commanding Officer
Attn: Mr. Douglas Bonham
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Community Relations

Public relations requirements will be met prior to implementation of remedial activities. The Restoration Advisory Board (RAB) meetings could function as public hearings.

If you have any questions or comments regarding these decisions, please contact me at (702) 687-4670 extension 3030.

Sincerely,

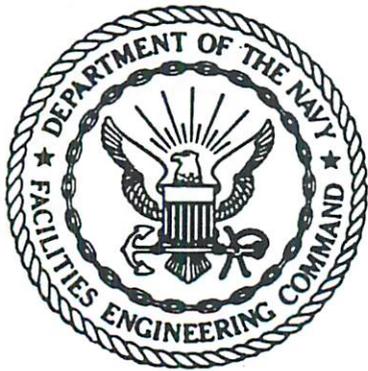


Nevan Kane
Hydrogeologist, C.E.M.
Department of Defense Branch
Bureau of Federal Facilities

TNK:db

Enclosures

cc: Dave Minedew, NDEP
John Dirickson, NAS Fallon
Troy Stewart, NAS Fallon



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OCT 20 1994

ENVIRONMENTAL PROTECTION

Naval Air Station Fallon
Remedial Investigation
Remedial Investigation Report,
Final

Volume I

September 1994



EXECUTIVE SUMMARY

This report presents the results of the remedial investigation (RI) at 21 potentially contaminated sites at Naval Air Station Fallon (NAS Fallon), Nevada, conducted August 1989 through April 1992. A listing and description of these sites is included in this Executive Summary. The results are from site-characterization activities associated with Phase II of the Installation Restoration Program (IR Program).

Introduction of contaminants to the environment has resulted from disposal activities, accidental spills, and leaks associated with past operations at NAS Fallon. Site-characterization results indicate that the vast majority of contaminants of concern are petroleum hydrocarbon-related. These contaminants include JP-5 jet fuel, leaded gasoline, diesel fuel, heating oil, waste oils and lubricants, hydraulic fluids, and solvents. Indeed, areas of contiguous petroleum hydrocarbon contamination can be associated with eleven of the 21 IR Program sites at NAS Fallon. Five sites (Sites 1, 2, 6, 14, & 16) have free-phase product on the ground water and require removal actions under Nevada Division of Environmental Protection regulations (NAC 459.9973 to 459.9979).

The principal exposure pathways of concern associated with NAS Fallon contaminants are the surface flows and shallow drainage systems to which the base contributes. Data indicate, however, that contaminants at NAS Fallon IR Program sites are contained in a relatively immobile state in the shallow subsurface with little or no migration off site.

A summary and interpretation of the site-characterization results are presented for each site. These results, along with the baseline risk assessment, were used to make one of the following remedial recommendations for each site: (1) take no further action (decision document required), (2) initiate a monitoring plan (decision document required), or (3) initiate preparation of engineering plans and specifications for removal of contamination (removal action). The recommendations are made on both a site-specific and media-specific basis. Thus, soils are considered separately from ground water at each site. The recommendations are summarized on the following pages.

Summary of remedial recommendations for IR Program sites

Location	Soil Recommendation	Ground Water Recommendation
Site 1, Crash Crew Training Area	Removal action	Removal action
Site 3, Hanger 300 Area	No action	No action
Site 20, Checkerboard Landfill	No action	No action
Site 24, Road Oiling Area	No action	No action
Group I		
Site 2, New Fuel Farm	Removal action	Removal action
Site 4, Transportation Yard	No action	No action
Group II		
Site 6, Defuel Disposal Area	No action	Removal action
Site 7, Napalm Burn Pit	No action	No action
Site 21, Receiver Site Landfill	No action	No action
Site 22, NE Runway Landfill	No action	No action
Group III		
Site 9, Wastewater Treatment Plant	No action	No action
Site 18, SE Runway Landfill	No action	No action
Group IV		
Site 10, GATAR Compound	No action	No action
Site 11, Paint Shop	No action	No action
Site 12, Pest Control Shop	No action	No action
Site 13, Boiler Plant Tanks	Removal action	No action
Site 14, Old Vehicle Maintenance Shop	No action	Removal action
Site 16, Old Fuel Farm	Removal action	Removal action
Site 17, Hanger 5	No action	No action
Site 19, Post-WW II Burial Site	No action	No action
Site 23, Shipping/Receiving Disposal	No action	No action

Description of NAS Fallon IR Program sites under investigation

Site Number and Name	Site Description	Period of Operation	Suspected Waste Types
1 Crash Crew Training Area	Burn pit, stained soils and tanks	mid 1950s to 1982	Avgas, JP-4, JP-5, waste oil, hydraulic fluid, napalm solvents (probably including carbon tetrachloride, trichloroethene, methyl ethyl ketone, PD-680, stoddard) wood debris
		1982 to 1988	Off-specification JP-5
2 New Fuel Farm	Top-off rack spill	1985	JP-5
	Tank bottom disposal area	late 1950s to 1981	JP-5, JP-4, avgas, diesel fuel, gasoline
	Oil/water separator leachfield	1981 to present	JP-5, JP-4, avgas, diesel fuel, gasoline
	Daily truck-drainage area	late 1950s to 1981	JP-5, JP-4, avgas, diesel fuel, gasoline
	Truck leakage area	late 1950s to present	JP-5, JP-4, avgas, diesel fuel, gasoline
	Weed control area	late 1950s to 1981	JP-5, JP-5, avgas, diesel fuel, gasoline
	Tank #204-C leak	early 1960s	JP-5
3 Hangar 300 Area	North aircraft fluid disposal area (North AFD area)	1960 to 1981	JP-5, hydraulic fluid, lube oil, solvents (including carbon tetra-chloride, TCE, PD-680)
	South aircraft fluid disposal area	1960 to 1981	(same as North AFD area)
	Bowser disposal	1960 to 1984	(same as North AFD area)
	Oil/water separator	1960 to 1986	(same as North AFD area plus Turco)
	Wells air start building area	1978 to 1987	Lube oil
	GSE storage and maintenance areas	1960 to 1987	Hydraulic fluid, lube oil, waste oil, Turco, PD-680, TCE
4 Transportation Yard	Building 378 drain	1971 to 1981	Radiator coolant, probably vehicle fluids and paint waste
	Outdoor vehicle	1971 to 1986	Waste oil, hydraulic fluid, gasoline and diesel fuel, transmission oil
6 Defuel Disposal Area	2 defuel disposal sites	1966 to 1972	JP-4, JP-5
7 Napalm Burn Pit	Napalm burn pit	early 1960s to 1983	Napalm M-2, Napalm A & B, diesel fuels

Description of NAS Fallon Program sites under investigation (continued)

Site Number and Name	Site Description	Period of Operation	Suspected Waste Types
9 Wastewater Treatment Plant	Grit chamber disposal pits	1961 to 1985	Heavy solids, probably including metals
	Imhoff tank sludge disposal pit	1980	Imhoff tank floating sludge, probably including oils
	Settling pond sludge disposal	1943 to 1985	Settling pond sludge, probably including metals, oils, paint waste
	Settling pond seepage	1943 to 1985	Effluent seepage to ground water, probably including metals, oils, paint waste
	Underground diesel fuel tank	1961 to 1986 (removed 1985)	Diesel fuel
10 GATAR Compound	Reported burial of PCB cans	1984	PCB oils in containers
	PCB transformer storage and leakage?	1982 to 1983	PCB oils
	Asbestos burial	1982	Asbestos
11 Paint Shop	Paint waste disposal at Bldg. 15	1976 to 1985	Waste paint, paint thinner
12 Pest Control Shop	2 leachfields near pest control	Pre-1974	DDT, DDD
		1974 to present	Malathion, pyrethrin, diazion, 2,4,-D
13 Boiler Plant Tanks	Underground fuel tanks	1943 to 1986 (removed 1992)	No. 6 fuel oil, waste lube oil, hydraulic fluid, JP-5, diesel fuel
14 Old Vehicle Maintenance Shop	2 underground tanks	1943 to 1973 (removed 1989)	Gasoline
	Lube pits and drain	1943 to 1973	Lube oil, hydraulic fluid, coolant
16 Old Fuel Farm	4 underground tanks	1943 to 1962 (dead storage 1963 to 1985, removed 1992)	Avgas, JP-4, JP-5, diesel fuel, gasoline, No. 6 fuel oil
17 Hangar 5	Surface runoff from aircraft maintenance	1943 to 1946,	Wash solvents (Turco), lube oil, hydraulic fluid, grease, avgas,
		1952 to present	JP-4, JP-5, MEK, isopropyl alcohol, PD-680
18 Southeast Runway Landfill	Landfill	1943 to 1946	Municipal refuse, industrial trash
19 Post-WWII Burial Site	Burial trenches	1946 to 1949	Trash, vehicles, wood, solvents, possible paints, thinners

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5/1/5 1965-1991

Description of NAS Fallon Program sites under investigation (continued)

Site Number and Name	Site Description	Period of Operation	Suspected Waste Types
20 Checkerboard Landfill	Landfill	1951 to 1965	Wet garbage, trash, rubble, avgas, waste oil, JP-4, JP-5, gasoline, diesel fuel, hydraulic fluid
21 Receiver Site Landfill	Landfill	1965 to 1975	Wet garbage, trash, rubble, JP-5, gasoline, diesel fuel, waste oils, hydraulic fluid
22 Northeast Runway Landfill	Landfill	1980 to mid-1987	Trash
23 Shipping and Receiving Disposal	Disposal trenches	1968	Junk, debris, metal, rubble, waste liquids (paints, thinners, lubricants, oils)
		1984	Asbestos
	Aircraft burial area	1977	DC-3 airplane (avgas or JP-5, lube oil, hydraulic fluid)
24 Road Oiling Area	Road oiling/unpaved perimeter roads	1943 to 1946	Waste oils, hydraulic fluid, anti-freeze, leaded gasoline, carbon tetrachloride
		1975 to 1981	Waste oils, hydraulic fluids, antifreeze, mogas, JP-5, TCA, PD-680

Source: Dames and Moore. 1988. *Preliminary Assessment/Site Inspection (PA/SI) Naval Air Station, Fallon, Nevada*. Prepared for Naval Energy and Environmental Support Activity, Port Hueneme, Calif.

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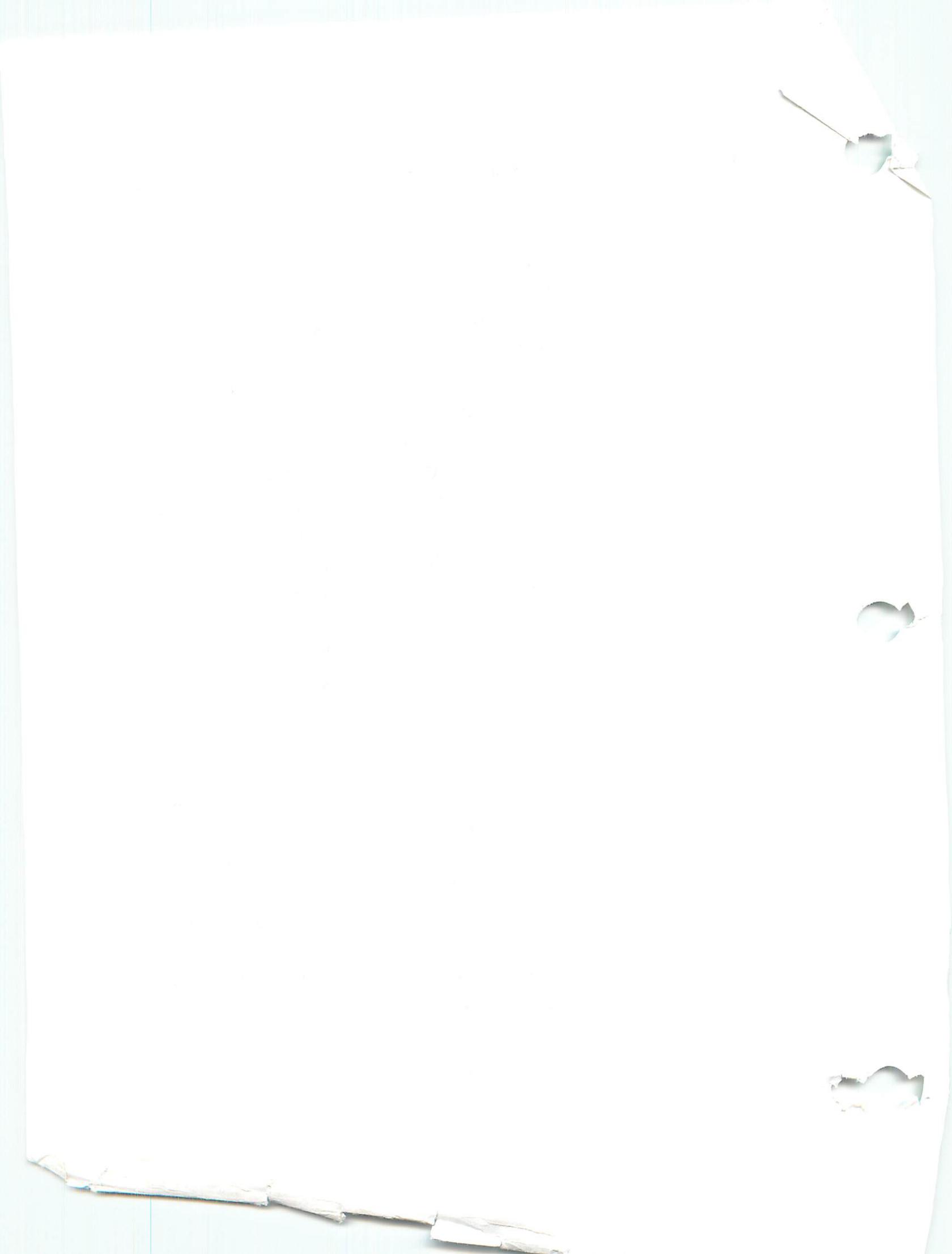
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ACRONYMS, ABBREVIATIONS, and INITIALS

ARARs	--	applicable or relevant and appropriate requirements
ASL	--	above sea level
ASTM	--	American Society for Testing and Materials
avgas	--	aviation gasoline
AWQC	--	ambient water quality criteria
BGL	--	below ground level
BGS	--	below ground surface
BHC	--	benzene hexachloride
BNAs	--	base/neutral and acid extractable semivolatile organics
BQL	--	below quantitation limits
BRA	--	baseline risk assessment
CCD	--	charge-coupled device
CERCLA	--	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	--	cubic feet per second
CLEAN	--	Comprehensive Long-Term Environmental Action Navy (program)
CWA	--	Clean Water Act
d	--	day
1,2-DCA	--	1,2-dichloroethane
1,1-DCE	--	1,1-dichloroethene
1,2-DCE	--	1,2-dichloroethene
DDD	--	dichlorodiphenyldichloroethane
DDE	--	dichlorodiphenyldichloroethene
DDT	--	dichlorodiphenyltrichloroethane
DNAPL	--	dense non-aqueous-phase liquid
DOD	--	Department of Defense
DON	--	U.S. Department of the Navy

EE/CA	--	engineering evaluation/cost analysis
EM	--	electromagnetic
EPA	--	U.S. Environmental Protection Agency
eV	--	electron volts
FS	--	feasibility study
ft	--	feet
GATAR	--	Ground to Air Transmitting and Receiving
GC	--	gas chromatograph
GJ	--	Grand Junction, Colo.
gpm	--	gallons per minute
GSE	--	ground-support equipment
GSI	--	Groundwater Technology Government Services, Inc.
h	--	hours
H&S	--	health and safety
HAZWRAP	--	Hazardous Waste Remedial Actions Program
HBPHCs	--	high-boiling point petroleum hydrocarbons
HI	--	hazard index
IR Program	--	Installation Restoration Program
LBPHCs	--	low-boiling point petroleum hydrocarbons
LD	--	Lower Diagonal (Drain)
LD #1	--	Lower Diagonal No. 1 (Drain)
MCLs	--	maximum contaminant levels
MCLGs	--	maximum contaminant level goals
MEK	--	methylethyl ketone
$\mu\text{g/L}$	--	micrograms per liter
$\mu\text{mhos/cm}$	--	micromhos per centimeter
mg/kg	--	milligrams per kilogram
mg/L	--	milligrams per liter
min	--	minute
mogas	--	motor vehicle gasoline
MYBP	--	million years before the present

NAAQS	--	National Ambient Air Quality Standards
NAAS	--	Naval Air Auxiliary Station
NAC	--	Nevada Administrative Code
NAS Fallon	--	Naval Air Station Fallon
NAVFAC	--	Naval Facilities Engineering Command
NDEP	--	Nevada Division of Environmental Protection
NDWS	--	National Drinking Water Standards
NEESA	--	Naval Energy and Environmental Support Activity
NPL	--	National Priorities List
NRS	--	Nevada Revised Statutes
o.d.	--	outside diameter
ORNL/GJ	--	Oak Ridge National Laboratory/Grand Junction office
ORNL/PAG	--	Oak Ridge National Laboratory/Pollutant Assessments Group
OSWER	--	Office of Solid Waste and Emergency Response
OVA	--	organic vapor analyzer
O/WS	--	oil/water separator
PAG	--	Pollutant Assessments Group
PA/SI	--	preliminary assessment/site investigation
PC	--	personal computer
PCB	--	polychlorinated biphenyl
PCBs/pest	--	polychlorinated biphenyls/pesticides
PHC	--	petroleum hydrocarbon
PID	--	photoionization detector
PP	--	priority pollutant (metals)
ppb	--	parts per billion
ppb/v	--	parts per billion by volume
PSCS	--	Preliminary Site Characterization Summary
psi	--	pounds per square inch
PVC	--	polyvinyl chloride
QA	--	quality assurance

QAPP	--	quality assurance project plan
QA/QC	--	quality assurance/quality control
QC	--	quality control
RF	--	radio frequency
RI	--	remedial investigation
s	--	seconds
SARA	--	Superfund Amendments and Reauthorization Act
SCS	--	Soil Conservation Service
SDWA	--	Safe Drinking Water Act
SVOC	--	semivolatile organic compound
1,1,1-TCA	--	1,1,1-trichloroethane
TCE	--	trichloroethene
TCLP	--	toxicity characteristics leaching procedure
TDS	--	total dissolved solids
TICs	--	tentatively identified compounds
TOC	--	top of casing
TPH	--	total petroleum hydrocarbon
TSP	--	total suspended particulates
USDA	--	U.S. Department of Agriculture
USRADS	--	ultrasonic ranging and data collection system
UST	--	underground storage tank
VHS	--	video home system
VOCs	--	volatile organic compounds

1. INTRODUCTION

This remedial investigation (RI) report has been prepared as part of Phase II of the Installation Restoration Program (IR Program) currently underway at Naval Air Station Fallon (NAS Fallon), Nevada. The purpose of the Department of the Navy (DON) IR Program is to identify, assess, characterize, and clean up or control contamination from past hazardous waste disposal operations and hazardous material spills at Navy operations (DON 1992).

The IR Program at NAS Fallon was initiated through a Phase I preliminary assessment/site inspection (PA/SI). Phase I utilized employee interviews, site inspections, record searches, and limited analytical testing to determine areas where environmental contamination was present. Potentially contaminated sites were identified and recommended for inclusion in Phase II of the IR Program, the RI. Phase I activities were completed for NAS Fallon in April 1988. The resulting report concluded that 21 sites at NAS Fallon were potentially contaminated and recommended these sites for inclusion in Phase II activities (Dames and Moore 1988).

Phase II activities commenced at NAS Fallon in September 1988. The objectives of the Phase II investigation were to further assess contamination at the 21 sites of interest and to recommend appropriate remedial measures. This RI report includes the confirmation and quantification of contamination, as well as a recommendation, for each site. Phase II work also included performing a baseline risk assessment (BRA) through a systematic evaluation of the available characterization data. The characterization data and risk assessment are utilized in selecting preferred remedial alternatives capable of providing environmental protection from the contaminants confirmed to be present.

The assessment of potential environmental risks at a specific site requires an understanding of: 1) the nature, extent, and magnitude of contaminants present; and 2) the mobility, transport pathways, exposure points, and receptors associated with contaminants. Because these items are all dependent upon past activities in and around the site, a knowledge of site history is also required.

Final

This RI satisfies three critical categories of information needs: 1) verification of contamination; 2) characterization of the extent and concentration of contaminants; and 3) assessment of potential for migration of contaminants away from the site in ground water, surface water, or other media of concern at levels harmful to human health or the environment. Iterations of field investigations and data evaluation were generally required to satisfy these information needs.

Now that RI field activities are completed, the resulting characterization summaries have been assimilated into this activity-wide RI report. The removal actions required by the Nevada Division of Environmental Protection (NDEP) will be implemented and will constitute the final remedial actions for the IR Program sites.

Investigative activities covered by this report include field work performed in August and September 1989, field screening and surface water sampling; May, June, and July 1990, installing and sampling monitoring wells at Site 2; October and November 1990, drilling soil borings, well surveying and sampling, and geophysical survey; March and April 1991, drilling soil borings, installing wells, and sampling wells for the remaining sites; August 1991, sampling monitoring wells; November and December 1991, drilling soil borings, installing and sampling additional monitoring wells; and March and April 1992, aquifer testing and well surveying and sampling. Table 1.1, p. 1-3, summarizes the field investigations performed through April 1992 on a site-specific basis.

1.1 SITE BACKGROUND

1.1.1 Site Description

NAS Fallon is located within the jurisdictional boundary of Churchill County, Nevada, approximately six miles southeast of the town of Fallon and sixty miles east of the city of Reno. Fallon is the county seat for Churchill County. The majority of the county's population lives within a 10-mile radius of the main station of NAS Fallon.

Table 1.1. Summary of facility-wide IR Program activities through April 1992

Activity Summary		
Site number or description	Sampling method or screening technique	Number of locations or samples
Site 1	Geophysical survey	1
	Ground-water test holes	65
	Soil borings	8
	Monitoring wells	13
	Piezometers	10
Site 3	Ground-water test holes	12
	Soil borings	8
	Sediment samples	3
	Monitoring wells	12
Site 20	Ground-water test holes	36
	Monitoring wells	6
Site 24	Ground-water test holes	25
	Soil borings	5
Group I Sites: Site 2 Site 4	Soil-gas survey	225
	Soil borings	15
	Ground-water test holes	105
	Monitoring wells	19
	Piezometers	7
	Geophysical survey	1
Group II Sites: Sites 6, 7, 21, & 22	Ground-water test holes	88
	Monitoring wells	11
	Piezometers	15
Group III Sites: Sites 9 & 18	Ground-water test holes	10
	Soil borings	8
	Monitoring wells	2
	Piezometers	1
Group IV Sites: Sites 10, 11, 12, 13, 14, 16, 17, 19, & 23	Geophysical survey	2
	Ground-water test holes	202
	Soil borings	29
	Monitoring wells	25
	Piezometers	19
Lower Diagonal #1 Drain	Surface water/sediment	4
	Staff gauges	6
Lower Diagonal Drain	Surface water/sediment	4
	Staff gauges	1

The main station comprises 7,982 acres and is located in the central part of the Carson Desert, commonly referred to as the Lahontan Valley. It includes airfield and appurtenant maintenance facilities, public works and supply facilities, and housing facilities. An additional 14 parcels (four of which are used as aerial weapons training ranges) totaling approximately 148,000 acres are located in the general vicinity of the main station (Dames and Moore 1988; NAVFAC 1982). However, only the main station contains sites recommended for inclusion in Phase II of the IR Program (Fig. 1.1, p. 1-5). Thus, mention of NAS Fallon throughout this document refers to the main station only.

1.1.2 Site History

NAS Fallon was originally established as a military facility in 1942, when the Civil Aviation Administration and Army Air Corps constructed four airfields in Nevada as part of the Western Defense Program. In 1943, the Navy assumed control of the still-uncompleted facility, and on June 10, 1944, Naval Air Auxiliary Station (NAAS) Fallon was commissioned. The newly commissioned facility provided training, servicing, and support to air groups sent to the facility for combat training. From 1946 to 1951, NAAS Fallon experienced varying but reduced operational status and was eventually turned over to Churchill County and the Bureau of Indian Service.

In 1951, Fallon was used as an auxiliary landing field for NAS Alameda, Calif., and on October 1, 1953, NAAS Fallon was re-established. From 1945 to 1975, the Air Force also occupied part of the station as part of an early warning radar network. From 1958 to 1972, the station was designated Van Voorhies Field, named after a Fallon Medal of Honor recipient. On January 1, 1972, NAAS Fallon was upgraded to its current status of NAS Fallon. NAS Fallon serves primarily as an aircraft weapons delivery and tactical air combat training facility. With the construction of a new runway and additional aircraft maintenance facilities, NAS Fallon's training mission is expected to continue to expand.

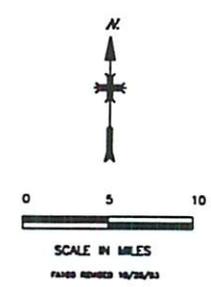
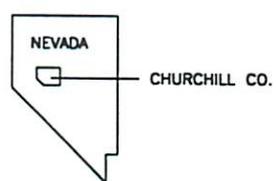
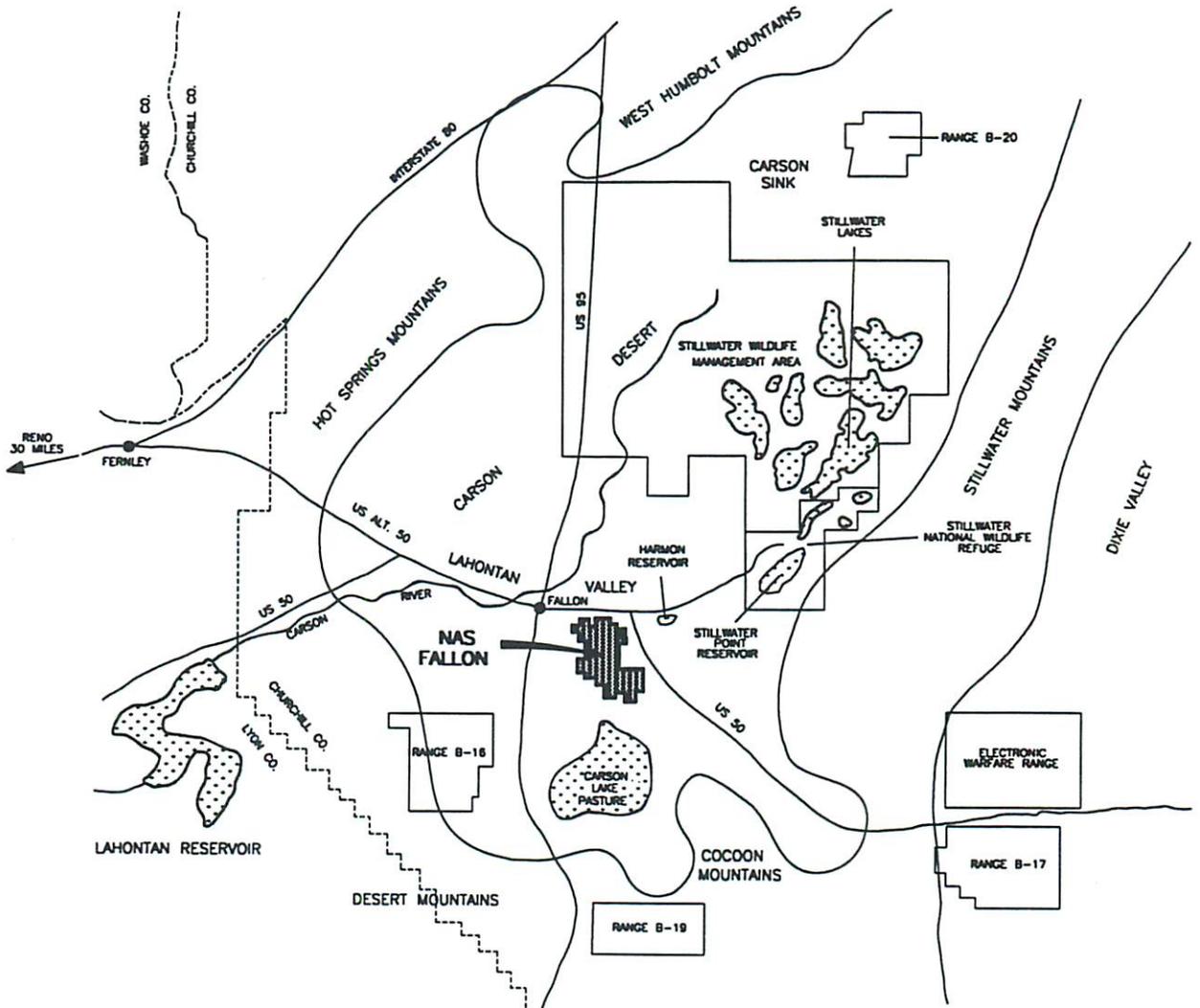


Fig. 1.1. Regional location map of NAS Fallon.

Since its inception in 1942, various kinds of hazardous materials have been routinely used and/or disposed of at NAS Fallon. These include jet fuel (JP-4 and JP-5), oil, avgas (aviation gasoline), gasoline, antifreeze, hydraulic fluid, solvents, paint, pesticides, and industrial and municipal garbage. These substances may have been introduced into the environment during: aircraft refueling, maintenance, and washing; vehicle maintenance; off-specification fuel disposal; fire training exercises; tank cleaning; sewage disposal; pest and weed control; landfilling; and accidental leaks and spills. Currently, the facility actively implements comprehensive waste management practices to control environmental pollutants.

1.1.3 Previous Investigations

The following sections summarize environmental investigations that took place at NAS Fallon prior to, or external of, RI Phase II activities.

1.1.3.1 Site 2 Investigations

The discovery of fuel on the water table at the New Fuel Farm (Site 2) prompted the issuance of a *Finding of Alleged Violation* and an *Order to Comply* by NDEP on August 26, 1986. These actions were issued in accordance with Nevada Revised Statutes (NRS) 445.221, which prohibit the unlawful discharge of pollutants without a permit. The *Order to Comply* required that NAS Fallon submit data on the extent of contamination and implement an approved plan to clean up the site to the satisfaction of NDEP.

As a result of the legal actions by NDEP, NAS Fallon began a program to install wells and assess the extent of contamination at the New Fuel Farm (Site 2). Base personnel installed six wells using a backhoe and subsequently contracted with ERM-West of Walnut Creek, Calif., to conduct a site investigation. This work proceeded under Delivery Order #0061, Naval Air Station, Fallon, Nevada, Hydrocarbon Contamination, dated October 28, 1987 (ERM-West 1988).

ERM-West performed a soil-gas survey, drilled several soil borings, and installed eight wells. All of the downgradient wells were contaminated. The ERM-West final report contains information on the subsurface geology, results of ground-water and soil sampling, and recommendations for further action at the site. One recommendation was to design an interim extraction system to begin removal of free product from the shallow ground water. The base subsequently initiated a program to pump product from two of the previously installed wells as an interim clean-up measure. The program was discontinued when the Phase II IR Program began, the rationale being that the Phase II RI would address the site along with the other sites recommended for further investigation in Phase II (ORNL 1991).

In March 1989, a notice of violation from NDEP resulted in discontinuing use of the fuel farm oil/water separator (O/WS) by NAS Fallon. The separator was repaired and is presently in service. In February 1990, another NDEP action concerned the investigation of an alleged fuel spill in January/February, 1988 (NDEP 1990). The investigation concluded that a 1,000 to 5,000-gal release of JP-5 jet fuel did occur at the facility on February 22, 1988. Cleanup of this JP-5 spill was initiated by the fuel farm contractor at the time. As a result of this investigation, NDEP recommended further investigation into the scope and magnitude of subsurface contamination and ordered that identified environmental problems be remedied. NDEP also recommended leak testing of the fuel storage facilities and associated piping. This leak testing was conducted in addition to the testing completed in July 1990 required by Naval Facilities Engineering Command (NAVFAC) Manual No. 230, *Maintenance and Operation of Petroleum Fuel Facilities*, (NAVFAC 1990).

All aboveground and underground bulk storage tanks are inspected and cleaned per *Military Standard Handbook 457B* (DOD 1989). Bottom samples are taken monthly and visually checked for sediment, water, and microbiological growth. Tanks are cleaned and inspected at least every 8 years, depending upon results of the monthly bottom samples. Most recently, all fuel farm tanks were cleaned and inspected in April and May 1993. The pipelines are pressure-tested annually.

1.1.3.2 Underground Storage Tank Removal Program

An underground storage tank (UST) removal program was conducted at NAS Fallon during the period of March through September 1992. The program was managed by PRC Environmental Management, Inc., under the Comprehensive Long-Term Environmental Action Navy (CLEAN) program. The objective of the removals was to prevent or mitigate the release of contaminants into the environment (PRC 1992). USTs were removed from three IR Program sites: Site 2, the New Fuel Farm; Site 13, the Boiler Plant Tanks; and Site 16, the Old Fuel Farm. Removal activities are summarized in the site-specific sections of this report.

1.2 REPORT ORGANIZATION

This RI report follows the format suggested in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S.EPA 1988a). To facilitate ease in referencing and in developing location maps, Phase II activities reference the 21 sites as four individual sites and four groupings (encompassing seventeen sites). Grouping is based on proximity of sites to one another and/or similarity of contaminants. In order to maintain consistency throughout Phase II activities, reference to individual sites in this report is the same as that developed in the previous Phase II documents. The 21 sites and associated groupings under investigation are shown in Table 1.2, p. 1-9, and on Fig. 1.2, p. 1-10. An aerial photograph of the main station is presented in Fig. 1.3, p. 1-11.

The RI report consists of three volumes. Volume I is the text describing RI activities and is comprised of twelve sections. Sections 1 and 2 of Volume I provide an introduction and describe the general site characteristics of the base. Sections 3 through 10 describe the site investigation and results for each potentially contaminated IR Program site or group of sites. Each site- or group-specific section concludes with a summary

**Table 1.2. Phase II investigation sites
and associated groupings for NAS Fallon**

SITE	GROUPING
Site 1 - Crash Crew Training Area	Stand alone
Site 3 - Hangar 300 Area	Stand alone
Site 20 - Checkerboard Landfill	Stand alone
Site 24 - Road Oiling Area	Stand alone
Site 2 - New Fuel Farm	Group I
Site 4 - Transportation Yard	Group I
Site 6 - Defuel Disposal Area	Group II
Site 7 - Napalm Burn Pit	Group II
Site 21 - Receiver Site Landfill	Group II
Site 22 - Northeast Runway Landfill	Group II
Site 9 - Wastewater Treatment Plant	Group III
Site 18 - Southeast Runway Landfill	Group III
Site 10 - Ground to Air Transmitting and Receiving (GATAR) Compound	Group IV
Site 11 - Paint Shop	Group IV
Site 12 - Pest Control Shop	Group IV
Site 13 - Boiler Plant Tanks	Group IV
Site 14 - Old Vehicle Maintenance Shop	Group IV
Site 16 - Old Fuel Farm	Group IV
Site 17 - Hangar 5	Group IV
Site 19 - Post-World War II Burial Site	Group IV
Site 23 - Shipping and Receiving Disposal	Group IV

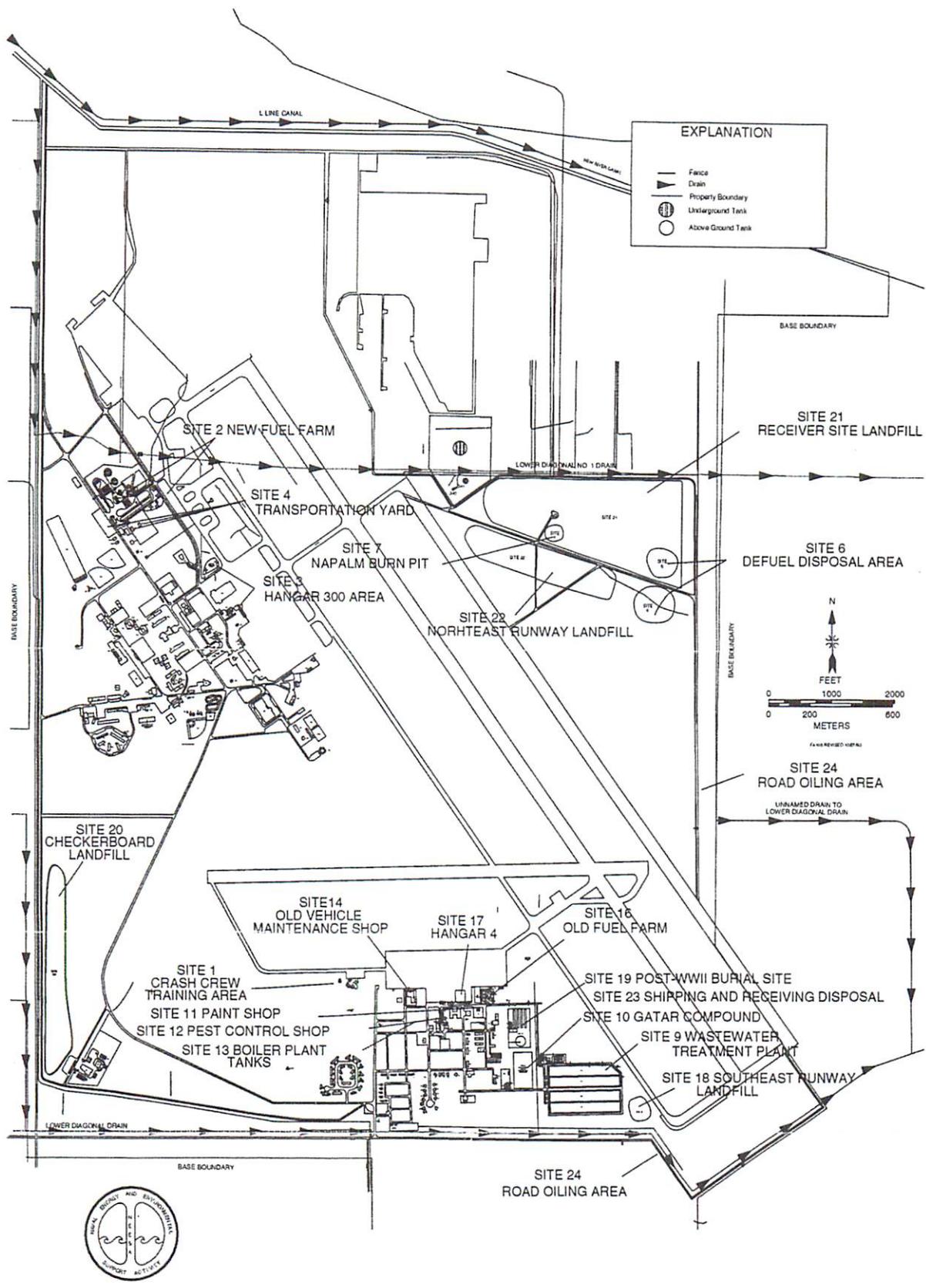


Fig. 1.2. Map of the 21 sites under investigation.

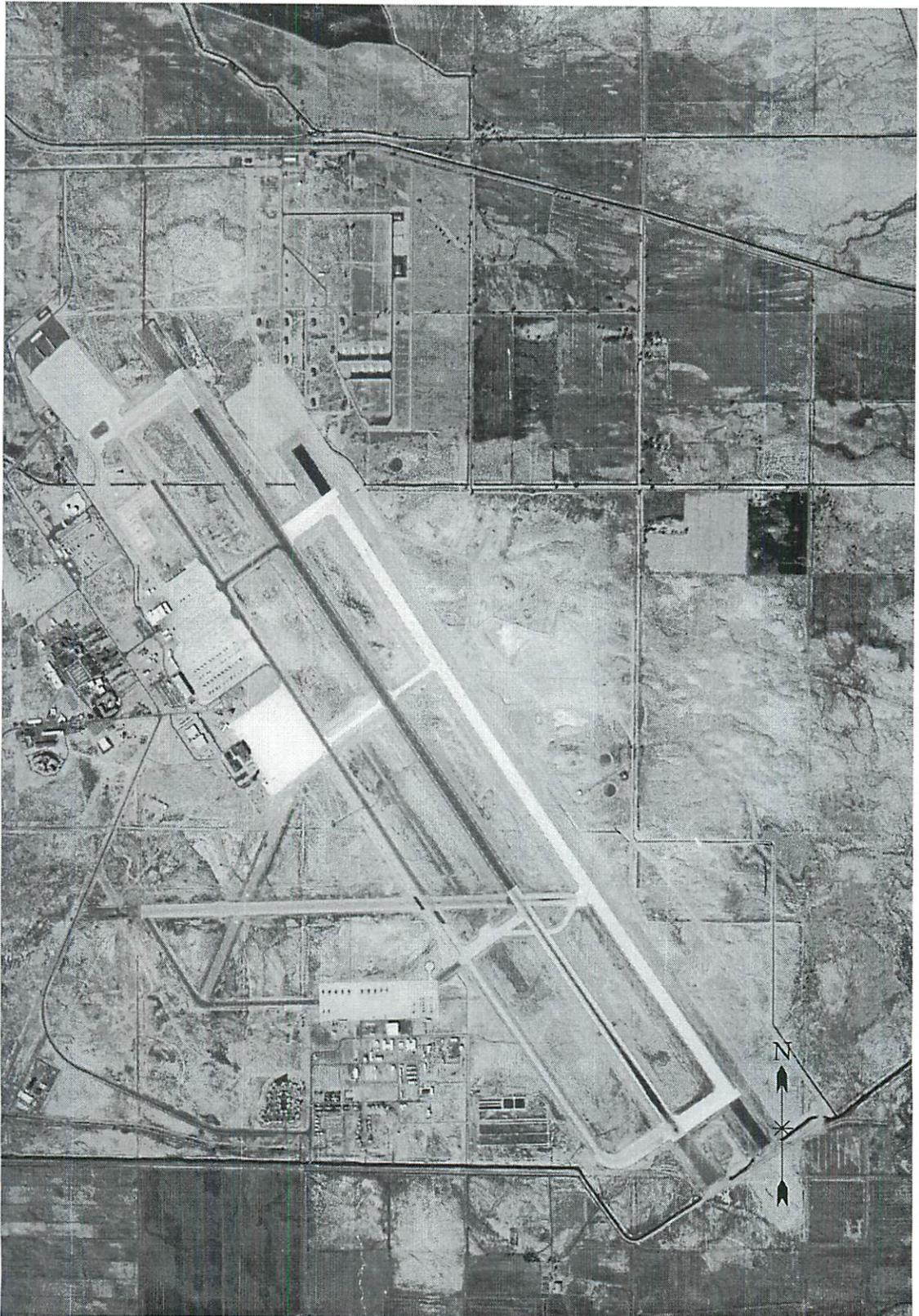


Fig. 1.3. Aerial view of NAS Fallon.

and one of the following recommendations: (1) take no further action (decision document required), (2) initiate a monitoring plan (decision document required), or (3) initiate preparation of engineering plans and specifications for removal of contamination (removal action). The recommendations are made both on a site-specific and media-specific basis. Thus, soils are considered separately from ground water at each site. Section 11 addresses the surface water on and near the base, and Sect. 12 summarizes the conclusions and recommendations for each site. Volume II of the RI report is comprised of the report appendices. Volume III is the BRA (ASG 1993).

1.3 BASELINE RISK ASSESSMENT EXPOSURE SCENARIOS

The following potential exposure scenarios were used in the BRA for the various media for current and future land use as NAS Fallon IR Program sites.

1.3.1 Soils/Sediments

Inside Guarded Flightline Area (Current and Future). If the site is situated within a security zone and is inaccessible to the public, a worker exposure scenario is appropriate. For example, workers might be exposed to soil contamination while repairing underground utilities. Such workers may be required to wear protective clothing in areas of significant contamination. No such construction activities are underway at the present time. The worker scenario, however, represents a reasonable conservative scenario.

The exposure pathways considered were dermal contact, incidental ingestion, inhalation of volatilized organic compounds, and inhalation of fugitive dust. The standard default worker exposure factors were used in the calculation, with the exception that a worker was assumed to spend only 10% of his time at a contaminated site. Current and future scenarios are identical.

Outside Flightline Area (Current). In general for sites located outside the guarded flightline area, both a trespasser exposure scenario as well as a worker exposure scenario are appropriate. Because of on-base housing, a trespasser may be able to gain access to these areas. For purposes of conservativeness, the trespasser is defined as an older child (14 years old) and is assumed to have limited access to sites even though they may be currently in use and/or fenced (e.g., pesticide shop and wastewater treatment plant). If a contaminated area is covered with clean overburden or has only subsurface contamination, only the worker scenario is used, assuming exposure while excavating. The exposure pathways for the trespasser or worker were dermal contact, incidental ingestion, inhalation of volatilized organic compounds, and inhalation of fugitive dust. Landfills that are covered with clean overburden are considered to present no complete pathways since routine excavation is precluded.

Outside Flightline Area (Future). If on-base housing were to expand in the future or if portions of the base were to be closed and made available to the public, a residential scenario would be an appropriate conservative scenario for the area. Therefore, all areas currently outside secured zones, with the exception of areas covered with overburden or having only subsurface contamination, were evaluated based on a future residential scenario. The standard default exposure factors for residential use, were used for this scenario. The default parameters assume that a person resides at the location for 30 years. This is very conservative assumption for NAS Fallon on-base housing. Exposure pathways considered were ingestion, dermal contact, and inhalation.

1.3.2 Ground Water

On Base (Future). There is no potential for current exposure to contaminated ground water from any of the ground-water plumes on the base because the ground water is not used for any purpose. Because the ground water is of poor quality (salty), it is not likely to be used on the base in the future, and it will not be considered a pathway of concern on base.

Off Base (Future). In the absence of remediation, the existing ground-water plumes may migrate to areas not currently impacted. Therefore, future risk associated with off-base residency was evaluated. Pathways evaluated include inhalation of organics, dermal contact, and ingestion of irrigated produce and/or watered livestock. However, human ingestion of ground water is not a pathway because the upper aquifer contains non-potable (salty) ground water.

1.3.3 Surface Water

On Base and Off Base (Current and Future). Currently, the surface-water bodies include the LD Drain and the LD #1 Drain. These drains have limited recreational potential. Some fishing and waterfowl hunting has occurred off Base in the past, but hunting and fishing does not occur on Base. The majority of fish species in the drains are not typically consumed, and with local availability of more plentiful fishing areas, the likelihood of fishing in the drains is low. Following irrigation season, major portions of the drains are dry; the survival of fish becomes problematic at best.

Contaminated ground water may reach these drains in the future, but contaminant levels would be significantly lower than those observed at the source area due to the considerable transport distance. Surface-water risk was not evaluated quantitatively; however, risk potential is addressed in Chapter 11 of the RI report.

1.4 SITE-SPECIFIC INVESTIGATION RESULTS

Site-specific analytical data are presented in table format. The tables are separated into results for water samples and results for soil samples. Tables for both water sample and soil sample results for organic analyses are divided into columns showing the method-

specific results for each sample. Each row of sample data may include results for petroleum hydrocarbon (PHC) analyses, polychlorinated biphenyl (PCB) and pesticide analyses, semivolatile organic compounds analyses, and volatile organic compounds (VOCs) analyses. The PHC data are reported as either results for EPA method 418.1, which was the analytical method used for samples collected prior to November 1990, or as results for modified EPA method 8015/8020, which was required by NDEP as of September 1990. Total petroleum hydrocarbon (TPH) results from EPA method 8015/8020 were often reported as a value for diesel, gasoline, JP-5, or motor oil. This indicates which standard the analyst thought most closely matched the sample result but does not positively fingerprint the nature of the sample. In addition, the laboratory did not consistently report the closest standard match. Thus, some TPH values consist only of a concentration without an identifier.

The tables also include the data quality flags that resulted from data validation based on U.S. EPA guidelines (Marty et al. 1993). These flags are explained for each table; however, there are some consistent flags that appear throughout the data. For instance, *J indicates an estimated value, and ** indicates unusable data resulting from associated blank contamination. The *J flag is used when certain quality assurance (QA) criteria are exceeded during initial or continuing calibration or during blank analysis. For example, if a compound has a percent difference of >25 during continuing calibration, positive results for that compound are flagged as estimated. Likewise, a low surrogate recovery for a compound during blank analysis results in the data being flagged. Also, the *J flag may be assigned by the laboratory when a compound concentration is found at or below the contract required detection limit, but is above the instrument detection limit. The ** flag indicates that these compounds were detected during the instrument method blank analysis, signifying that they are laboratory contaminants. For example, bis(2-ethylhexyl) phthalate, methylene chloride, chloroform, and acetone are often identified as laboratory contaminants. However, in several instances, these compounds were reported as both positive results and laboratory contaminants for samples from the same site. Thus, due to the fact

that these compounds are common laboratory contaminants, positive sample results for these compounds have been footnoted in the data tables with " a - suspected laboratory contaminant." It should be emphasized that this footnote is not associated with the data validation process. A data validation summary is presented in Appendix I.

The analytical laboratory reported all detected compounds, including a variety of tentatively identified compounds (TICs) and unknowns. Some of the TICs are polynuclear aromatic compounds such as naphthalene, acenaphthene, and phenanthrene derivatives. These compounds are found in oil and jet fuel, but are also formed by incomplete combustion of fuels, oils, and even lower molecular weight hydrocarbon mixtures. Thus, they may be found associated with fire training, road dust, and automobile exhaust. TICs that would be expected in jet fuel, oil, or gasoline include octanes, nonanes, and decanes. Some detected compounds, such as hexadecanoic acid and octadecanoic acid, are naturally occurring fatty acids. These could be related to humates, plant material in the soil, or poorly refined fuels and oils. Also, many of the TICs are commonly occurring anthropogenic compounds such as phthalates from plasticizers, siloxanes from grease, and oxirane from antifreeze. TICs are not included in the data tables presented in this report because the compounds are "tentatively identified" and the concentrations are estimated. Also, TICs were not considered in the risk assessment.

1.5 CONTAMINANT ACTION LEVELS AND APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

NDEP statutes and policy are the primary applicable or relevant and appropriate requirements (ARARs) of concern at NAS Fallon IR Program sites. These include the Contaminated Soil and Ground Water Remediation Policy (NDEP 1992) and the Nevada statutes regarding UST release remediation. The latter are the principal ARARs at NAS Fallon due to the nature of contamination (i.e., fuel-related) at the activity. The statutory

basis for UST cleanup is found in NRS 459.832 to 459.834 and Nevada Administrative Code (NAC) 459.993 to 459.998. Table 1.3, p. 1-18, lists the NDEP action levels for hydrocarbon-contaminated soils and ground water. Appendix A gives the full text of NAC 459.9973 to 459.9979.

In addition to the action levels listed in Table 1.3, p. 1-18, the NAC also states that dissolved hydrocarbon product in ground water may require remediation any time benzene, ethylbenzene, xylene, or toluene concentrations are equal to or in excess of U.S. Environmental Protection Agency (EPA) maximum contaminant levels (MCLs) and the maximum contaminant level goals (MCLGs) established by the federal Safe Drinking Water Act (SDWA). However, the code also states that exemptions may be granted if: 1) the ground water affected by the release does not serve as a source of drinking water and is not likely to serve as a source of drinking water in the future because it is economically or technically impractical to: a) recover the water for drinking because of the depth or location of the water or b) render the water fit for human consumption; 2) the total dissolved solids (TDS) in the ground water are more than 10,000 mg/L and the ground water is not reasonably expected to become a supply of drinking water. Thus, EPA MCLs and MCLGs are not considered ARARs for the shallow aquifer underlying NAS Fallon based on the following: 1) the ground water is not presently used for human consumption; 2) the high mineral content and high dissolved solids render the aquifer unfit for human consumption [indeed, the regional water quality data for TDS in ground water range from 12,800 to 70,700 mg/L (Hoffman et al. 1990)]; 3) low well yields make pumping of the aquifer impractical; and 4) due to the poor water quality and low well yields, the aquifer is not reasonably expected to become a source of drinking water in the future.

Other regulatory acts identified as ARARs for NAS Fallon include the Endangered Species Act of 1973, the Migratory Bird Treaty Act of 1972, the Clean Water Act (CWA) Ambient Water Quality Criteria, and the Nevada Water Quality Criteria. These ARARs are described in more detail in Appendix B of the BRA.

Table 1.3. Action levels and ARARS from NAC 459.9973 to 459.9977

Contaminant	NDEP Action Level
Free hydrocarbon product in the formation	greater than 0.5 in.
TPHs in:	
soils	greater than 100 mg/kg
ground water	greater than 1 mg/L when ground water discharges to surface water

TPHs = total petroleum hydrocarbons

2. REMEDIAL INVESTIGATION

2.1 REMEDIAL INVESTIGATION ACTIVITIES

2.1.1 Work Plan

Development of work plans began immediately after a September 1988 coordination meeting. The meeting was attended by personnel from the Naval Energy and Environmental Support Activity (NEESA), Hazardous Waste Remedial Actions Program (HAZWRAP), Oak Ridge National Laboratory/Grand Junction (ORNL/GJ), and the NAS Fallon Environmental Division.

The project work plan for NAS Fallon is comprised of five separate portions bound into four volumes. The first volume contains Part I, the work plan, consisting of the project description and technical approach for performing the remedial investigation at the 21 sites. A summary of the site setting is presented along with the site history. The work plan rationale was based on an evaluation of site conditions, risk considerations, and the data required to perform risk assessments and to evaluate remedial alternatives. Procedures described in OSWER Directive 9355.3-01 (U.S.EPA 1988a) were fundamental in developing the work plan.

Volume two contains the health and safety (H&S) plan, which provides required measures to ensure personnel safety during field activities. It is site specific for NAS Fallon and relies on the ORNL/GJ H&S procedures manual for references (ORNL 1992a).

The third volume contains the sampling and analysis plan, consisting of two parts: Part III, quality assurance project plan (QAPP), and Part IV, field sampling plan.

The QAPP presents requirements for sample collection, preservation, and chemical analysis. It establishes field and laboratory procedures to ensure that data collection is controlled and documented. The field sampling plan contains site-specific tasks for remedial investigation. The investigative tasks proposed for each site were prescribed by site

history and setting, (i.e., suspected waste types, characteristics of the wastes, potential paths of migration, and other risk considerations). The rationale for the field sampling plan tasks is presented in the work plan.

Volume four contains Part V, the community relations plan. The community relations plan describes a course of action to facilitate communication between the Navy and the community at large. It was developed after conducting community interviews and is tailored to meet the concerns of the community.

2.1.2 Site Characterization

A phased approach was used for the site characterization. Soil-gas and ground-water-screening data were used to optimize the locations of planned monitoring wells at the sites.

Table 2.1, p. 2-3, shows a schedule of the field activities. The following sections provide details on individual elements of the site characterization that were not included in the work plan or that are deviations from the work plan.

2.1.2.1 Screening With Soil-Gas Sampling and Ground-Water Test Holes

Soil-gas sampling began at Site 2, the New Fuel Farm. The initial screening method involved driving a hollow steel probe tipped by a loosely held steel point to a depth of 4 to 6 ft and then withdrawing the probe 6 in. to expose the sampling interval. A hand-held vacuum pump attached to the probe purged the sample train; soil gas was then collected through a syringe inserted into a silicon section of the sample tubing. Next, the syringe needle was capped with a piece of silicone and taken directly to a portable gas chromatograph (GC). Although this method was successful in identifying volatile contaminants in the soil, ground-water contamination often went undetected. It is likely that saturation in the capillary fringe and lack of permeability (e.g., clay layers) in the upper alluvium inhibit PHCs from migrating from the ground water toward the surface.

Table 2.1. Schedule of field activities, NAS Fallon, Phase II study

Date	Activity
Sept. 26, 1988	Kick-off meeting held at NAS Fallon; set schedule and methods
Aug. 22 to Aug. 30, 1989	Sample surface water in drains; physical survey of Site 2, New Fuel Farm; geophysical survey
Sept. 5 to Sept. 15, 1989	Soil-gas survey at Site 2, New Fuel Farm
Oct. 10 to Oct. 11, 1989	Surface-water sampling in drains
May 21 to May 25, 1990	Soil-gas survey at Site 2, New Fuel Farm; ground-water screening
June 14 to June 27, 1990	Drill and sample ground-water test holes; install pumping well and monitoring wells at Site 2
July 10 to July 27, 1990	Ground-water sampling, monitoring well drilling, aquifer testing, ground-water-test-hole sampling, land survey: Sites 1, 2, and 4
Oct. 16 to Nov. 15, 1990	Land survey, ground-water test hole sampling, monitoring well sampling, geophysical survey: Sites 1, 2, 3, 9, 10, 12, 14, 16, 18, 22, and 23
March 4 to March 27, 1991	Drill, install, develop monitoring wells, install piezometers, sample ground-water test holes: Sites 1, 3, 4, 6, 9, 11, 12, 13, 14, 16, 18, 20, 21, and 22
April 2 to April 18, 1991	Sample ground-water test holes, sample monitoring wells, conduct aquifer test: Sites 1, 3, 4, 6, 9, 10, 14, 16, 18, 19, 20, 23, and 24
April 22 to May 3, 1991	Land survey
Aug. 6 to Aug. 14, 1991	Base-wide sampling of monitoring wells
Nov. 7 to Nov. 15, 1991	Sample ground-water test holes
Nov. 18 to Nov. 27, 1991	Install and develop monitoring wells and pumping wells: Site 1, 2, 6, 11, 13, 14, and 16
Dec. 2 to Dec. 13, 1991	Install piezometer; sample ground-water test holes, monitoring wells, and sediment; land survey: Sites 1, 2, 6, 13, 14, and 16
March 9 to March 13, 1992	Land survey
April 6 to April 15, 1992	Conduct aquifer tests, sample monitoring wells: Sites 1, 2, 6, 13, 14, and 16

Depth to ground water at the study sites varied from 6 to 8 ft below ground level (BGL). This enabled the employment of a small, truck-mounted auger rig to drill through the top of the water table and collect ground-water samples directly into a bailer. Water samples were then decanted into a 250-mL septum bottle, leaving sufficient headspace to insert a syringe. A sample of the headspace was then injected into a field GC. The volatile nature of the fuel and solvent constituents created a natural concentrating mechanism in the headspace of the septum bottles, allowing the GC to detect small quantities of volatile contaminants. The success of this method resulted in its use throughout the rest of the investigation.

2.1.2.2 Monitoring Well Drilling and Soil Sampling

Types, numbers, and locations of monitoring wells installed at NAS Fallon are discussed in sections devoted to the specific sites. Single and dual completion wells were installed in the upper aquifer to detect floating and sinking contaminants; three wells in the intermediate aquifer provided hydrologic and stratigraphic data as well as characteristics of the water.

Alluvial wells were drilled with hollow stem augers. Soil samples were collected at the capillary fringe using 6-in. brass sleeves placed inside a 2-ft split barrel sampler that was advanced ahead of the auger bit. After the sampler was removed from the borehole, the soil in the brass sleeves was monitored with a hand-held photoionization detector (PID). If volatile organic vapors were detected, the sleeve from the interval with the elevated reading was packaged for shipment to the analytical laboratory. Soil cores from the remaining sleeves were extruded and used for lithologic logging and headspace analysis with the field GC. Samples above and below the water table were obtained using a 5-ft continuous sampler. This sample was used strictly for lithologic analysis.

2.1.2.3 Monitoring Well Installation

Casing used in well construction was pre-cleaned 2.375-in. outside diameter (o.d.), schedule-40 PVC with flush-threaded joints. Screens were 2.375-in. -o.d., flush-threaded PVC with 0.010-in. machined slots, also pre-cleaned. Screened intervals were sand packed (size 8/12 well-rounded silica sand) to 24 in. above the screen. In some cases, sand that was drilled from the monitoring well collapsed around the screen and was used as a filter pack. In these instances, the sand was predominantly coarse-grained and similar in size to the silica sand used for well installation. After development of the well, no adverse effects were found on water quality. A 24-in. bentonite seal using ¼-in. bentonite pellets was placed above the sand. Casing intervals between screens in multiple completion wells were also sealed with bentonite. Water-table completions were screened to 2 ft above the top of the water table to allow for fluctuations in the water level. The casing interval above the water-table completion was grouted to within 1 ft below ground surface (BGS) using 6/1 neat cement (cement-bentonite grout). Where concrete or asphalt pavement was present, the PVC casings were cut to fit inside a ground-level, flush-mounted protective cover. All completed stickups have individual locks and all covers are water tight. All wells were installed with a concrete apron to provide mechanical stability and to prevent the penetration of surface drainage into the grouted hole. The concrete aprons slope away from the protective cover. Monitoring wells MW03 and MW08 were completed as multiple completion wells. All other wells were single completions.

2.1.2.4 Pumping Well Installation

Three single completion pumping wells were installed. These wells were constructed of 5-in. o.d. PVC. All other specifications are the same as those described for the 2-in. wells. One pumping well was installed at Site 2, one installed upgradient from Site 1, and the remaining well installed upgradient from Site 6.

2.1.2.5 Well Development

Well development proceeded by alternately pumping and surging the wells until the water was clear or it became apparent that further development would not significantly improve the clarity of the water. When recharge and height of the water column were sufficient, pumping was accomplished with an air-lift pump. The pump was fitted with a neoprene wiper to enhance its use as a surge block. Most of the upper completions did not yield sufficient water to accommodate the air lift pump and were instead developed by alternately pumping with a peristaltic pump and surging with a bailer.

2.1.2.6 Piezometer Installation

Piezometers were installed at various sites during field work for two reasons: to provide adequate spatial coverage to develop local potentiometric contour maps at individual sites or site groups, and to provide information on the areal extent and thickness of free-phase contamination. The piezometers that were installed to determine potentiometric surfaces were constructed using either an open-ended PVC pipe or 1-in. PVC pipe with a 1-ft slotted (0.010 in.) screen on the bottom. The screens are well below the water table and, therefore, are not recommended for water-quality measurements because of the location and length of the screened intervals. Piezometers that were screened across the water table were used for two purposes. The ones found adjacent to PW02 and PW03 were used during pumping tests to measure drawdown. The remaining piezometers were placed near areas where free-phase product had been identified during monitoring well installation.

In all cases, these piezometers were installed using the small, truck-mounted rig operated by ORNL personnel. They were installed using the native sand drilled from the borehole. No surface bentonite seal was used to prevent infiltration of surface water into the annular space. However, in most cases, a larger-diameter PVC outer casing or a flush-mounted well vault was cemented in place to provide protection and stabilization of the piezometer head. These piezometers could possibly be used to provide water-quality data,

but do not meet Nevada state specifications for this purpose because of the lack of an annular seal (bentonite). Furthermore, they were not developed to remove fines from the screened interval and casing. Piezometers are by definition small-diameter, non-pumping wells used for measuring the elevation of a water table or potentiometric surface.

2.1.2.7 Aquifer Testing

Aquifer characteristics were determined by pumping tests and bail tests performed by ORNL and a step drawdown test conducted in a previous investigation by ERM-West. Results are discussed in Appendix E and in the sections devoted to the specific sites.

The valley fill sediments contain four aquifers designated as the shallow alluvial aquifer, the intermediate aquifer, the deep alluvial aquifer, and the basalt aquifer. Wells penetrating the intermediate aquifer on the facility indicate a head difference of about 5 to 9 ft between the shallow (unconfined) and the intermediate (confined) aquifers. The head is higher in the intermediate aquifer, indicating artesian conditions that prevent downward migration of ground water at the facility. Thus, the investigation involved only the shallow aquifer. No tests were performed on the deep aquifers.

An *in situ* instrument, the colloidal borescope, was used at selected wells during the investigation to observe colloid-sized particles in ground water. The borescope, connected to fiber-optic cables fitted with water-tight connections, is lowered into the screened interval of a monitoring well. The movement of colloids is tracked on a VHS recorder. By knowing the optical magnification, the dimensions of the field of view, and the compass orientation of the instrument in the well, ground-water velocity and flow direction can be inferred (Kearl et al. 1992). Colloidal borescope measurements for NAS Fallon IR Program sites are presented in Appendix E.

Water-Table Elevation Mapping

A comprehensive program of measuring water levels in all wells and piezometers and at all drain staff gauges was initiated in July 1990. Water levels were measured monthly

and data stored in a computer data base. The data were used to characterize the ground water surfaces and to produce water-table elevation maps at all of the NAS Fallon RI sites. These maps are shown in the sections for individual sites. Additionally, head measurements in the three widely spaced wells completed in the intermediate aquifer were used to produce a water-table elevation map (potentiometric surface map) of the intermediate aquifer on the facility (Fig. 2.1, p. 2-9). These measurements confirmed a year-round artesian head in the intermediate aquifer. Generally, the ground-water-flow direction on maps is assumed to be perpendicular to the gradient contours if the aquifer is homogeneous and isotropic. However, heterogeneity and anisotropy in the shallow alluvial aquifer are likely to create considerable variations in the actual ground-water-flow direction, depending on potential preferential flow paths such as the former Carson River channels (see Appendix E). The general gradients in the shallow aquifer all appear to be east-southeast, which is consistent with a regional evaluation presented by Glancy (Glancy 1986).

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understanding

2.1.2.8 Geophysical Survey

During August 1989 and again in November 1990, electromagnetic (EM) geophysical surveys were performed at sites at NAS Fallon. These surveys mapped differences in the electrical conductivity of the shallow ground water and soil profile and helped guide the selection of monitoring well locations at Site 1, Site 2, Site 10, Site 19, and Site 23. Geophysical-survey methodology and results are presented in Appendix B.

2.1.2.9 Ground-Water Sampling

Each monitoring well was sampled at least twice during the course of the investigation unless it contained free-phase product. See figures in Sects. 3 to 10 for the locations of monitoring wells. Appendix J summarizes the ground-water-sampling program. An additional round of sampling was conducted in October 1993, following the conclusion of the RI. This work was performed under the direction of the NAS Fallon Environmental Division by Alpha Analytical, Inc. Appendix K presents the field sampling plan and analytical results of this activity.

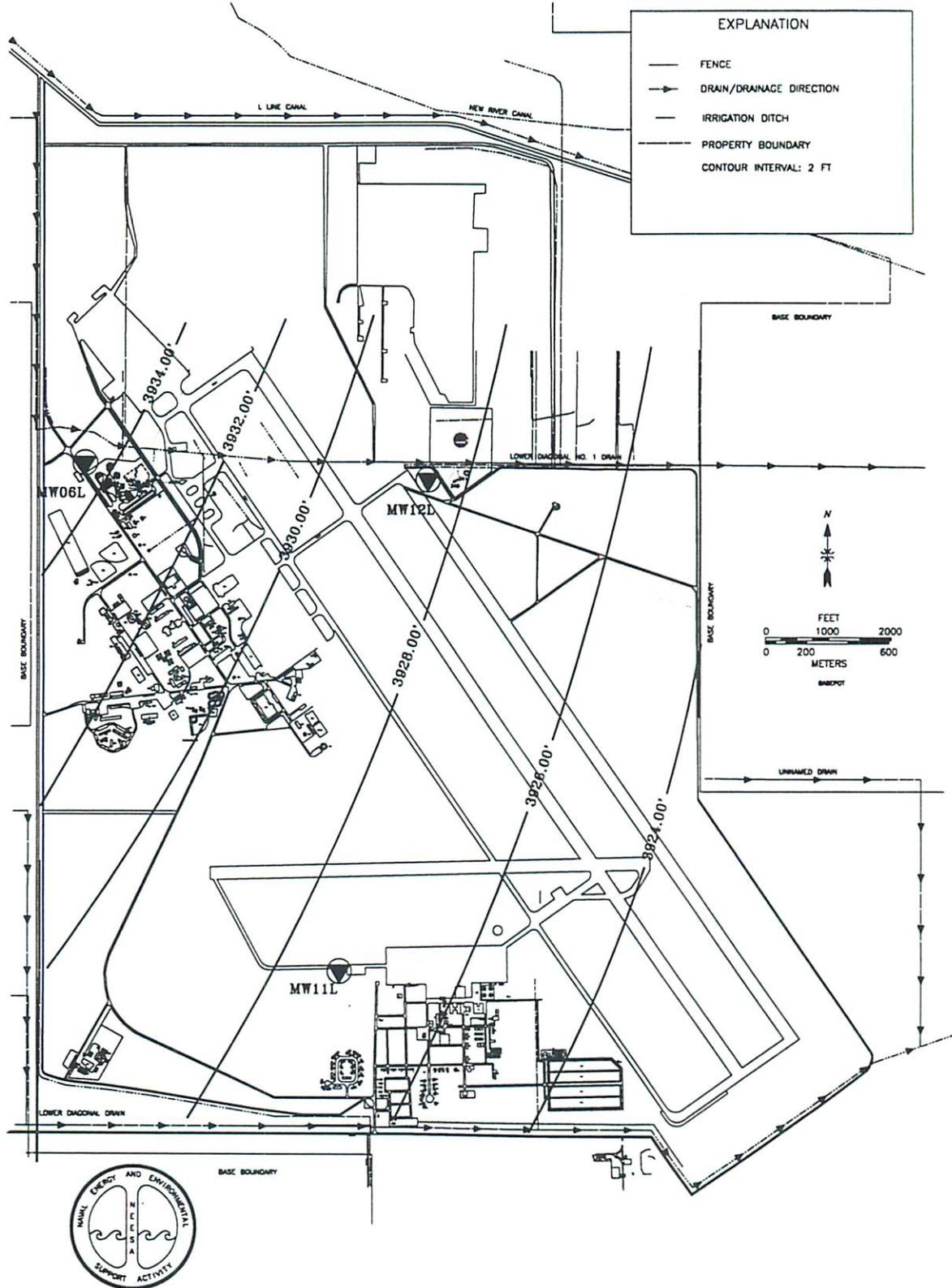


Fig. 2.1. Water-table elevation map of the intermediate aquifer (measurements taken June 1991).

Target compounds and analytes for samples collected during the RI included VOCs, high-boiling-point petroleum hydrocarbons (HBPHCs), low-boiling-point petroleum hydrocarbons (LBPHCs), semivolatile organic compounds (SVOCs), PCBs and pesticides (PCBs/pest), metals (including cations Na, Ca, Mg, K, Fe, Al, Mo, and Mn), and anions (Cl, F, NO₃, PO₄, and SO₄). HBPHCs and LBPHCs are sometimes combined as PHCs or TPHs. Both rounds of ground-water sampling included field measurements of ground-water pH, conductivity, temperature, and alkalinity as CaCO₃.

The work plan presents the sample container requirements, the preservation, and the holding times for each sample analysis. An exception was made for the VOCs and LBPHCs, which are ordinarily preserved with HCl and have a 14-day holding time. Because the upper aquifer contains high concentrations of dissolved carbonate, the addition of acid to a ground-water sample results in an acid-base reaction in which CO₂ is released. This "fizzing" had the potential of purging volatile species from the sample. Consequently, the VOCs and LBPHCs were shipped unpreserved and with a seven-day holding time.

2.1.2.10 Surface-Water and Sediment Sampling

Drains, seep faces, and sediments were sampled to establish background water quality and to assess the potential for surface-water contaminant transport. Results of the sampling are discussed in site-specific sections and in Section 11.

There are two main drains running through the facility and several small, unnamed lateral drains (Fig. 2.2, p. 2-11). The drain on the north side of the facility is the Lower Diagonal No. 1 (LD #1) Drain, and the one on the south side is the Lower Diagonal (LD) Drain. The LD Drain is about 25 ft wide and 12 ft deep with an average water depth of about 2 ft during low flow in the winter months. Measured discharge rates ranged from 26 to 82 cfs (cubic ft per second). LD #1 Drain is about 12 ft wide, 12 ft deep, and averages about 1 ft of water during the winter. The flow in LD #1 Drain is relatively slow, and discharge rarely exceeds 2 cfs. Both drains represent potential

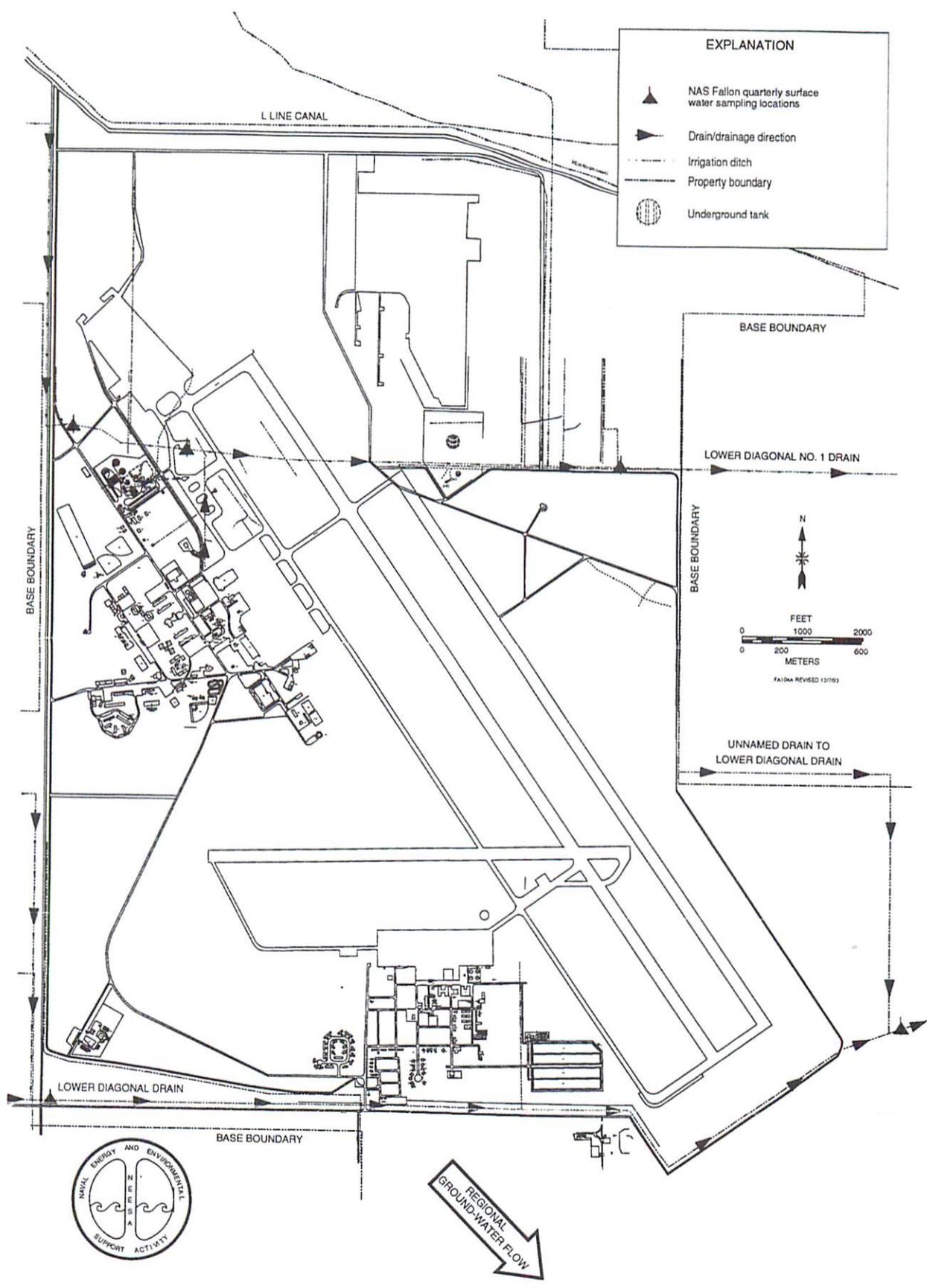


Fig. 2.2. NAS Fallon surface-water map.

Final

pathways for migration of contaminated ground water into the surface water. Thus, a series of water samples, SW-1 through SW-8, and installation of seven staff gauges allowed the characterization of the flow and contaminant transport for a 2-month period in the drains (August through October 1989). The staff gauges were also useful in relating the local ground-water potentiometric surface to the level of the water in the drains. A total of eight surface-water and sediment sample locations (four in each drain) were chosen based on proximity to the upstream and down-stream intersections of the drains with known or suspected contaminated ground water in the shallow aquifer. Two staff gauges, SW-1 and SW-8, were installed at gauging station locations, and staff gauges SW-9 through SW-13 were placed near suspected contaminant-plume discharge areas (Fig. 2.2, p. 2-11). Installation of the other staff gauges provided data for evaluating the interactions between ground-water and surface-water flow.

Water and sediment samples were collected from eight locations, four in each drain at locations SW-1 through SW-8 (Fig. 2.2, p. 2-11). Water samples were collected every two weeks for two months (four times). Sediment samples were collected once from the LD and LD #1 Drain locations and once from an unnamed lateral drain running north and south along the east side of the Group IV Sites. Sampling results are presented in the site-specific sections and in Sect. 11.

Surface-water samples were collected by wading out to the center of the drain, facing upstream, and allowing the open container to fill by gravity flow while submerging it in the drain. Samples for metals and anions were filtered through a 0.45- μm filter to remove suspended particles. Sediment samples were also collected near the center of flow at each location by scooping sediment off the drain bottom with the sample container. Other parameters measured at each sample location included water temperature, pH, and conductivity. Results of these measurements are presented in Sect. 11. Analytes of interest included VOCs, SVOCs, LBPHCs, HBPHCs, PCBs, pesticides, metals, major cations, and anions.

2.1.2.11 Field and Laboratory QA/QC

Field and laboratory quality assurance/quality control (QA/QC) procedures are described in the work plan and the field sampling plan. Analysis results of field and laboratory QA/QC samples are summarized in Appendix I.

2.1.2.12 Location and Elevation Survey

All monitoring wells and staff gauges were surveyed by ORNL from reference monuments tied to the state plane coordinate system. Appendix H contains a list of the northings and eastings and elevations.

2.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

2.2.1 Surface Features

The facility is situated in the Lahontan Valley, which serves as a sink for surface runoff from the surrounding mountains and the Carson River. The Carson Lake pasture, a series of ditches and small marshes, is approximately 3 miles south of the facility. The Stillwater Lakes, a chain of small lakes, ponds, and marshes, extend for 20 miles south of the Carson Sink in the northern half of the Carson Desert (Fig. 1.1, p. 1-5). These two wetland areas comprise an important stopover for migratory birds during the spring and fall. Recent drought years have caused the Stillwater Lakes wetlands to shrink from approximately 100,000 acres in 1983 to 4,000 in 1991.

The only discernable topographical relief at the facility is formed by the built-up areas of the runways, taxiways, and the aircraft parking aprons. Surface water at NAS Fallon flows to the Stillwater Lakes, while the shallow and intermediate aquifer generally flow toward Carson Lake. Much of the area around the facility is irrigated, and there are

several irrigation ditches to deliver water and two drains to remove excess water. The drains generally intersect the shallow aquifer and remove excess water from the farmland. Flow rates in the drains fluctuate with the irrigation season, although many drains flow all year and constitute wetland habitats for fish, water fowl, and other fauna. Locations of buildings and potential preferential flow paths are discussed in the sections devoted to the specific sites.

The major surface features of the activity were surveyed and mapped during the course of the RI.

2.2.2 Meteorology

The Fallon area experiences clear weather more than 300 days per year. The climate is the result of two main weather influences. The first influence is the Sierra Nevada range to the west acting as an effective barrier to airborne moisture originating in the Pacific Ocean. As the moisture-laden air rises over the mountains, much of the moisture is lost; consequently, only a small amount of precipitation reaches the Fallon area. Annual precipitation averages 4.3 to 7.5 in. The second dominant weather influence on the Fallon area is the flow of warm, moist air from the south. This moist air produces approximately 10 to 15 summer thunderstorms per year.

The evaporation rate of the area is high, averaging approximately 47 in. for the months of May through October. Humidity ranges from approximately 25% in the summer to approximately 65% in the winter. Daytime humidity is considerably lower than at night, particularly in the non-irrigated areas.

The normal maximum daily temperature during the hottest summer months (June and July) is approximately 90° F, while the minimum daily temperature during the coldest months (January and February) is approximately 16° F. Snow falls each year, but is generally very light and melts within a few days.

Wind speed in the area averages less than 7 mph, with the prevailing wind direction from the west. Strong surface winds, however, can occur from any direction (NAVFAC 1982).

2.2.3 Surface Water

2.2.3.1. Surface Water Description

The broad, flat alluvial plain on which the facility is located is part of the Basin and Range geological province. The Carson Desert is a hydrologically closed depression, with about 80% of its surface in the Carson River floodplain and the rest composed of playas and alluvial fans (Wilden and Speed 1974). The Carson River, augmented by the Truckee River via the Truckee Canal (part of the Newlands Irrigation Project), provides more than 95% of all surface runoff received by the Carson Desert.

The irrigation ditches in the vicinity of Fallon are generally less than 5 ft deep and do not intersect the shallow aquifer. The drains are typically 8 to 10 ft deep, intersecting the shallow aquifer to accept discharge of shallow ground water as well as surface water. The ditches and drains serve as recharge areas for the shallow aquifer during the irrigation season when flows are high. The drains carry water southeastward to Carson Lake and northeastward to Harmon and Stillwater Point Reservoirs. As noted in Sect. 2.1.2.9, there are two main drains running through the facility, LD #1 Drain and LD Drain, and several small, unnamed lateral drains (Fig. 2.2, p. 2-11).

2.2.3.2 Surface Water Quality

The results of VOC analysis by EPA method 624 on all water samples were negative: no analytes were present above the method detection limits of 5 to 10 $\mu\text{g/L}$.

Metals analyses were performed by EPA method 200.7, and several analytes exceeded baseline guidance as presented in federal (the CWA) and state criteria for aquatic habitat. The most notable elevated metals were arsenic, boron, barium, selenium, zinc, lithium, and sodium. Such elevated metals concentrations are a reflection of the entire region, not just the area encompassed by NAS Fallon. The water is also high in TDS, exceeding 1000 ppm

for most samples. These results are consistent with a recent report issued by the U.S. Geological Survey for the area in and near the Stillwater Wildlife Management Area (Table 2.2, p. 2-17). This report cites elevated levels of boron, lithium, arsenic, and molybdenum in surface water and suggests that these correlate to the relative toxicity of water to fish in the drains of the Carson Desert.

Anion analysis by EPA method 429 revealed that chloride ranged from 51 to 20,000 mg/L, with all samples at less than 200 mg/L except those from SW-6.

The water samples were analyzed for TPH by EPA method 418.1; several samples showed detectable, though not significant, concentrations. Furthermore, because the two upstream sampling locations, SW-1 and SW-5, showed some slightly elevated petroleum hydrocarbon concentrations, there is no evidence that the source of these compounds is located on the facility.

Sampling locations and summary results are contained in Sect. 11 of this document.

2.2.4 Geology of the Study Area

The geology of the study area is presented in two different formats. The history and regional description of the geologic formations are presented in the following sections. Geology information specific to the individual study sites is discussed in Sects. 3 to 10.

Depositional History

The area in and surrounding NAS Fallon is an intermontane valley. The mountains near NAS Fallon are composed primarily of a variety of consolidated igneous, sedimentary, and metamorphic rocks that range from Triassic to Quaternary in age. A more detailed description is presented by Wilden and Speed (1974).

The basin and range faulting that occurred during the Cenozoic age probably formed the bedrock surface below the valley fill sediments. This development of the intermontane valley was accompanied by deposition of sediments in and around the base to depths of several thousand feet. Detrital materials composing the valley fill were primarily derived

Table 2.2. Regional water-quality data for metals and anions

Constituent	Surface water concentration range, $\mu\text{g/L}$	Ground water concentration range, $\mu\text{g/L}$
Aluminum	<10 to 14,000	not available
Arsenic	<1 to 1400	37 to 730
Barium	34 to 400	not available
Beryllium	<10	<10 to 10
Boron	190 to 28,000	2200 to 120,000
Cadmium	<1 to 12	<1 to 1
Calcium	22,000 to 710,000	100,000 to 750,000
Chloride	8.6 to 26,000 mg/L	4300 to 27,000 mg/L
Chromium	<1 to 50	20 to 50
Cobalt	<1 to 7	<1 to 7
Copper	<10 to 80	2 to 9
Fluorine	not available	200 to 2700
Iron	190 to 16,000	90 to 330
Lead	<5 to 8	<5
Lithium	19 to 2800	400 to 8200
Manganese	130 to 1600	340 to 1800
Magnesium	6100 to 780,000	140,000 to 1,700,000
Mercury	<0.1 to 1.1	<1 to 1
Molybdenum	<1 to 1600	20 to 1500
Nitrogen	0.001 to 14 mg/L	0.01 to 34 mg/L
Nickel	<1 to 13	1 to 16
Phosphorus	<10 to 2500	90 to 770
Potassium	3100 to 450,000	110,000 to 490,000
Selenium	1.0 to 26	<1
Sodium	25 to 18,000 mg/L	2700 to 20,000 mg/L
Silver	<1 to 2	<1 to 1
Uranium	0.9 to 300	1.9 to 310
Vanadium	1 to 810	80 to 300
Zinc	<10 to 80	30 to 80
Total dissolved solids	560 to 41,000 mg/L	12,800 to 70,700 mg/L

Source: Hoffman et al. 1990

from three sources: 1) upstream valleys of the Carson River drainage, 2) upstream valleys of the Humbolt River basin, and 3) products of mechanical weathering of consolidated rocks in the Carson Desert itself. It appears that most of the fill in and around NAS Fallon was transported into the valley by the ancestral Carson River. A surface geologic map showing these ancestral Carson River channels, valley fill, and lake sediments (Fig. 2.3, p. 2-19) was developed by Morrison (1964).

The depositional character of the valley fill sediments at NAS Fallon was greatly influenced by the presence of the ancient Lake Lahontan, a Quaternary lake that was subject to numerous cycles of expansion and recession. Regional climatic changes caused dramatic oscillations of lake stages and shorelines throughout the Pleistocene Epoch. Subsurface stratigraphic evidence also suggests the existence of pre-Quaternary lakes in the valley. The pluvial influences on sediment deposition were extensive and probably varied during the greater part of Cenozoic time. The alternating influences of wave action, standing water, flowing water, and wind on the sediment transported into the valley by the Humbolt and Carson Rivers resulted in a complex sequence of interfingered and interbedded deposits of fluvial, deltaic, lacustrine, and eolian deposits. Morrison (1964) described these sediments and differentiated several stratigraphic units that are used in the description of the lithology at NAS Fallon. Morrison's work indicated that gravel, sand, silt, and clay are distributed in longitudinal, layered strata at NAS Fallon. These descriptions were confirmed during the installation of monitoring wells across the base. However, these highly transmissive, coarse-grained deposits were found to be both laterally and vertically discontinuous because of the nature of deposition. This complex, near-surface geology allows ground water to move along these restricted geometric limits of coarse-grained deposits, which are bordered by finer-grained silts, clays, and sands (associated with deltaic and near-shore lake deposits that were dissected by the coarser-grained deposits). Below the upper 20 ft of these interbedded coarse-grained and fine-grained deposits, there is a continuous layer of fine-grained silts and clays that form an aquitard, thus providing a natural barrier to the downward migration of ground water and contaminants.

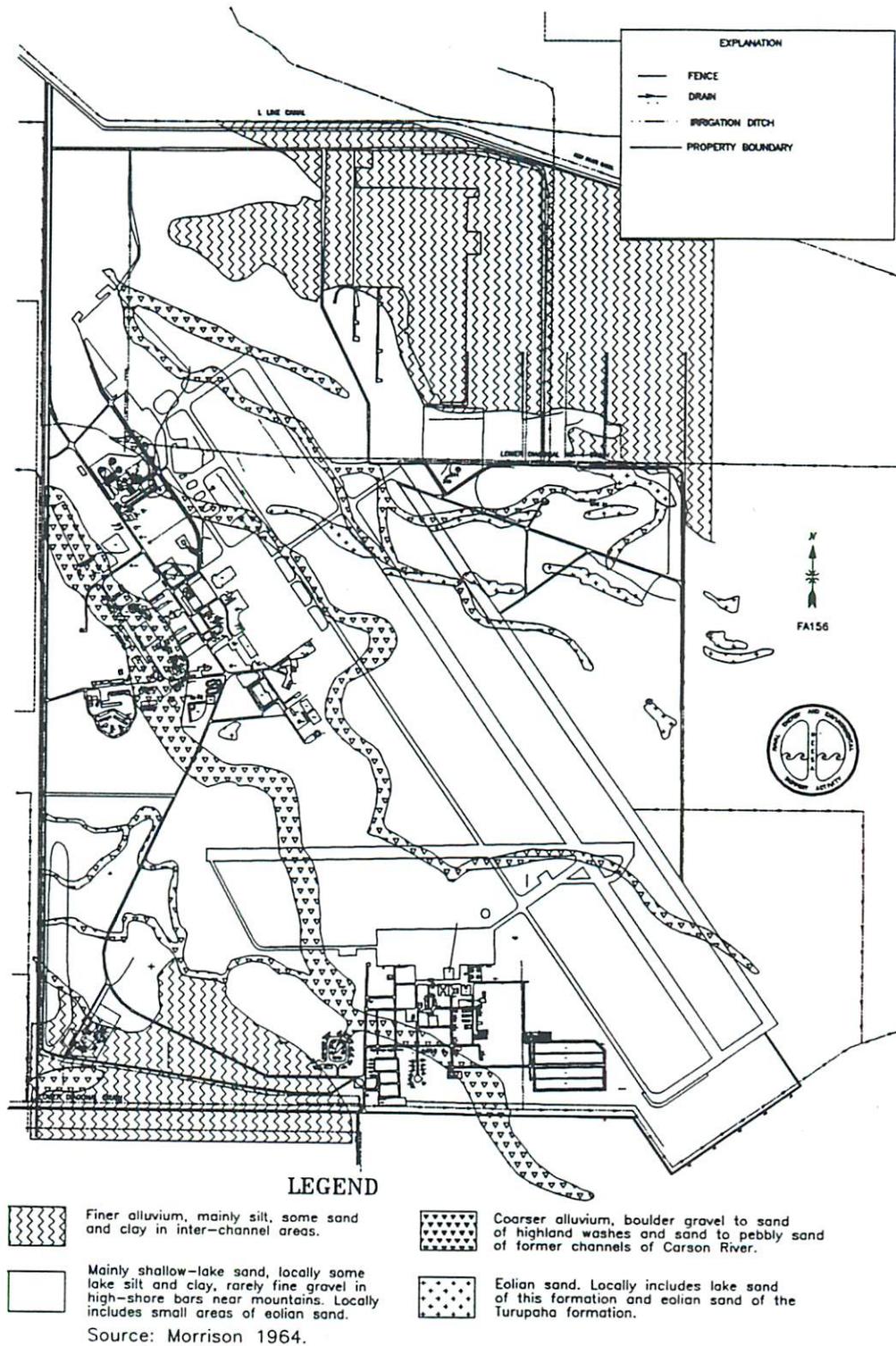


Fig. 2.3. NAS Fallon surface geologic map.

Morrison (1964) described the Quaternary sediments found in the Lahontan Valley as three rock-stratigraphic units, which are, from oldest to youngest, the Paiute Formation, Lahontan Valley Group, and the Fallon Formation. The Paiute Formation has alluvium and colluvium older than Lake Lahontan. The Lahontan Valley Group is a succession of intertonguing, deep-lake, subaerial, and shallow-lake sediments of Lake Lahontan and early post-Lake Lahontan age. The Fallon Formation contains younger subaerial sediments and the shallow-lake deposits with which they intertongue. A generalized geologic section depicting the stratigraphic occurrence at NAS Fallon is shown on Fig. 2.4, p. 2-21.

The general stratigraphy at NAS Fallon displays a trend progressively approaching the edge of the last recession of Lake Lahontan from northwest to southeast. A simplified fence diagram, constructed with data obtained during the drilling of deep monitoring wells installed at various sites across the base, illustrates the thinning of the Fallon Formation (Fig. 2.5, p. 2-22). The upper strata of the formation is composed of lake sand from Lake Lahontan and channel deposits of the ancient Carson River. The Group II Sites, on the other hand, approach the margins of the last advancement of Lake Lahontan that had an influence on the lithology of the study area (Fig. 2.4, p. 2-21). However, as previously described, the stratigraphy at NAS Fallon is quite variable and is characterized by intertonguing channel sands, near-shore sand, and silt deposits and clays characteristic of lake deposits.

2.2.5 Hydrology

The hydrology of the study area is presented in two different formats. The following sections contain general information on the regional and local hydrology. Hydrologic data specific to the individual study sites are discussed in Sects. 3 through 10.

2.2.5.1 Regional Hydrology

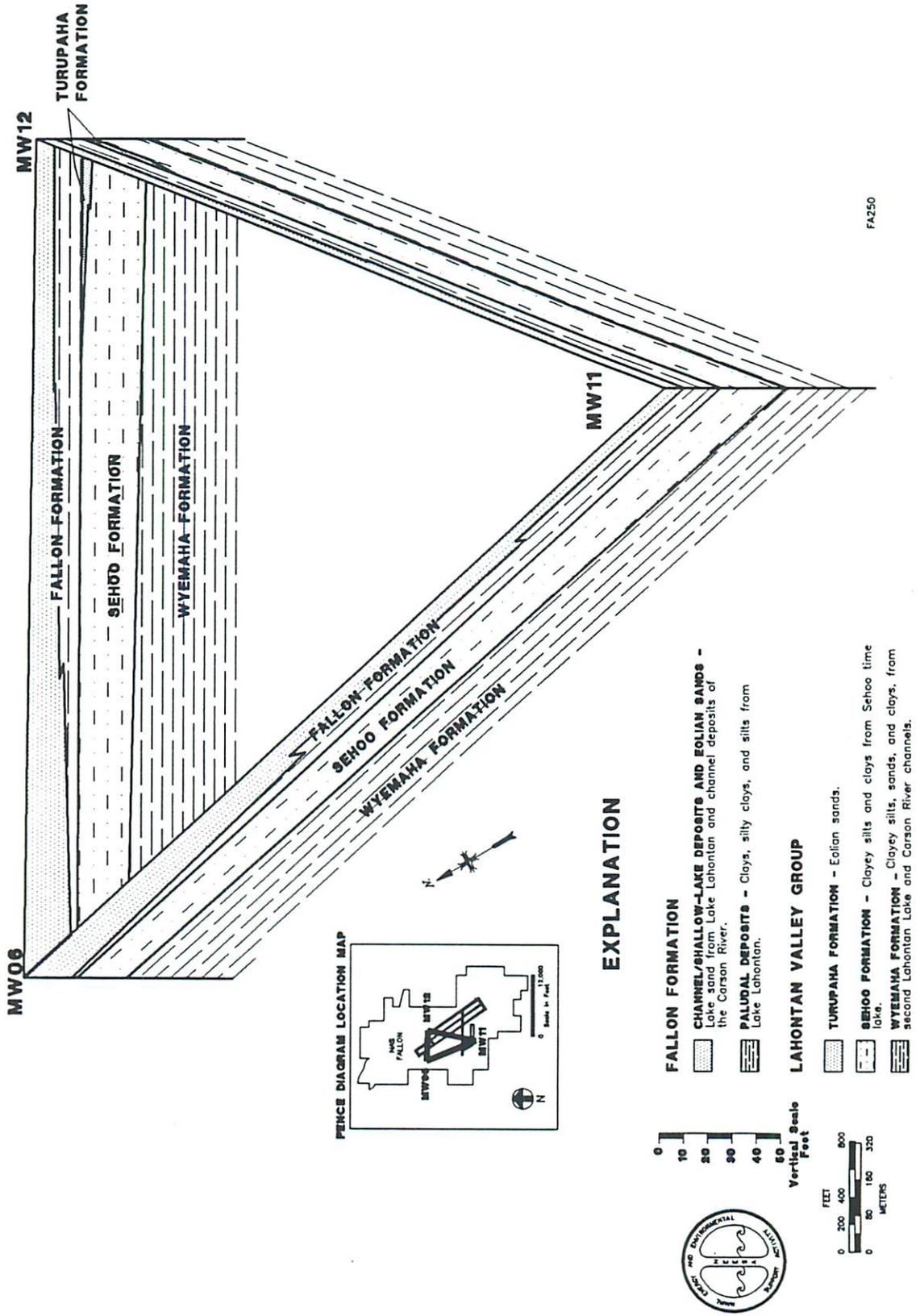
The west-central part of Nevada, including the Carson Desert, has a dry climate. The precipitation that does occur is usually caused by air masses moving generally eastward or northeastward from the Pacific Ocean or occasionally southeastward from the

Period	Epoch	Stratigraphic Unit	Generalized Lithology	Thickness in feet	Generalized Description	
Quaternary	Recent	Fallon Formation	[Stippled pattern]	4-20	Eolian sand	
			[Horizontal line pattern]		Near-shore deposits, fine-grained sand, silty sand. Channel sand and gravel from ancient Carson River	
	Pleistocene	Lahontan Valley Group	Turupaha Formation	[Stippled pattern]	0-2	Eolian sand
			Sehoo Formation	[Horizontal line pattern]	20-35	Deep-lake clay
Wyemaha Formation			[Stippled pattern]	>50	Shallow-lake sand	



LKSEC

Fig. 2.4. Generalized geologic section of stratigraphy at NAS Fallon.



FA250

Fig. 2.5. Simplified fence diagram of the intermediate aquifer wells.

Pacific northwest. These fast moving storms, usually occurring in the winter, produce precipitation on the Sierra Nevada mountains of eastern California and western Nevada. Although large amounts of precipitation fall in the higher elevations, the mountains create a rain shadow along the eastern slopes, which results in the aridity of the entire Great Basin.

The Sierra Nevada mountain snowfall is the major source of water replenishing the river systems flowing east into the basin. The runoff of the Carson, Walker, and Truckee Rivers flows into this basin where it either infiltrates the valley fill sediments or is dissipated by evaporation. The combination of high temperatures and brisk easterly winds result in a high rate of evaporation. The vast valley fill sediments found in the intermontane valleys, however, have ample storage space for the ground water received.

2.2.5.2 Hydrology of NAS Fallon

The Lahontan Valley lies within the rain shadow of the Sierra Nevada; thus, precipitation averages only 4.3 to 7.5 in. per year. The Newlands Irrigation Project provides more than 95% of all surface water received by the Carson Desert. Local precipitation and runoff contribute less than 1%, with some additional water supplied via drainage from the Lower Humboldt Drain. Water flowing into the NAS Fallon area exits principally through evaporation from the surface and evapotranspiration from crops and native plants. Surface water near NAS Fallon occurs primarily in irrigation ditches and drains, which deliver water to and drain water from the farmland surrounding the area.

There are two major drains at NAS Fallon: the LD Drain, which runs along the southwestern edge of the base and proceeds east along the southern boundary of the base proper; and the LD #1 Drain, which enters the base just north of Site 2, the New Fuel Farm, proceeds east from the west side of the base, and then drains to the south. The most important distinction between the irrigation ditches and the drains is that the drains are intended to accept discharge of shallow ground water as well as surface water and to conduct the water away from these areas whereas the irrigation ditches deliver water to the fields. Thus, minerals or salts leached from the farmland are removed by the drains.

The drains carry water southeastward to Carson Lake and northeastward to Harmon and Stillwater Point Reservoirs.

An abundant quantity of ground water is available in the valley fill sediments and the underlying volcanic strata of the Carson Desert due to the closed nature of the basin. However, due to the accumulation of salts in the basin, much of the ground water is of poor quality. The principal source of recharge to the shallow ground water is infiltration of irrigation water and leakage of unlined drains. Lahontan Reservoir is the source of the irrigation water. It is estimated that at least half of the annual release from Lahontan Reservoir, 380,000 acre-ft, infiltrates to the saturated zone before it reaches a surface discharge point into one of the lakes or marshes in the center of the basin. Compared with this amount, the possible contribution from runoff and precipitation in the basin and surrounding mountains is insignificant, totaling less than 1,300 acre-ft/year.

Ground water beneath the Lahontan Valley is present in four principal aquifer systems: 1) a shallow alluvial aquifer; 2) an intermediate alluvial aquifer; 3) a deep alluvial aquifer; and 4) a basalt aquifer. The shallow aquifer occupies the alluvium from the near surface to about 50 ft depth (see Appendix E). The seasonal high water table often occurs at depths ranging from 3 to 6 ft. The capillary fringe also fluctuates with the ground-water table. Definition of the exact thickness of the capillary fringe is difficult to ascertain in most instances. Generally, if the lithology of the sediments is fine-grained, the capillary fringe may be from 1 to 3 ft above the water table. Conversely, where the sediments are coarse-grained, the capillary fringe may be either nearly non-existent or from 1 to 2 in. in thickness.

The shallow aquifer is composed of interconnected zones of varying permeability ranging from highly transmissive channel sands to less transmissive clay flood-plain deposits. Regional ground-water flow is inferred to be southeastward toward Carson Lake, which lies about 3 miles from NAS Fallon. The regional shallow ground-water flow velocity is estimated to average 35 ft per year (Glancy 1986). Flow rates vary widely across NAS Fallon due to the heterogeneity of the local deposits, with the coarse-grained channel sands having higher flows than the fine-grained silts and clays. The lenticular nature of the deposits, however, has little overall effect on the movement of ground water and contaminants found in localized areas because of the low gradient across the entire facility.

The intermediate and deep alluvial aquifers are present beneath the shallow alluvial aquifer. On a regional basis, the boundary between the intermediate and shallow aquifer is chemical rather than physical (Glancy 1986). The water in the intermediate and deep aquifers is generally lower in dissolved salts than the shallow aquifer water. Head measurements of the intermediate aquifer have confirmed a year-round artesian head in the aquifer, which precludes downward migration from the shallow aquifer. The boundary between the shallow and the intermediate aquifer lies at about 25 to 50 ft BGS. At NAS Fallon, this boundary is described as a physical boundary created by an impermeable layer believed to be fine-grain lake sediments.

The head measurements in the three widely spaced wells completed in the intermediate aquifer have been utilized to produce a potentiometric map of the intermediate aquifer on the facility (Fig. 2.1, p. 2-9). Assuming isotropic conditions, ground-water flow in the intermediate aquifer is perpendicular to the gradient contours.

The boundary between the intermediate and deep aquifer lies at about 500 to 1,000 ft BGS regionally. The base of the deep alluvial aquifer lies at approximately 2,200 ft BGS. Water quality in both the intermediate and deep alluvial aquifers is better than that in the shallow alluvial aquifer. The basalt aquifer lies sandwiched in the alluvium at approximately 600 ft BGS. This aquifer is the major source of domestic water in the area and is probably recharged by the intermediate and deep alluvial aquifers. This aquifer is not present beneath NAS Fallon except possibly in the extreme northeast corner of the base; however, NAS Fallon derives all of its domestic water from this aquifer utilizing deep wells off base. For more information on the regional hydrology of the basalt and unconsolidated sedimentary aquifers in the Fallon area, see Glancy (1986).

2.2.6 Ground-Water Quality

Water in the portion of the upper alluvial aquifer underlying NAS Fallon is too saline to be considered potable. For example, specific conductance of ground water measured in the monitoring-well network varied from about 800 to more than 60,000 $\mu\text{mho/cm}$ (Appendix G).

Fresh water recharge to the upper aquifer occurs regionally during the irrigation season when irrigation ditches infiltrate to, and drains intersect, the water table. Specific conductance of the ground water generally increases both with depth and with distance downgradient from the recharge sources. In other words, the ground water becomes increasingly saline as it moves from recharge to discharge. Specific conductance measurements in the monitoring wells at the base demonstrate this stratification in the upper aquifer. The upper zone is 4 to 8 ft thick, beginning as fresh water and becoming brackish with increasing distance downgradient from the recharge source. The lower 10-ft zone of the aquifer may contain water that is brackish even near the recharge areas, becoming brine as it migrates across the facility. This pattern varies considerably, however, and the salinity in any particular area cannot be predicted with confidence. Evaporation and evapotranspiration occurring naturally throughout late prehistoric times resulted in a gradual accumulation of water-soluble salts in the upper soil horizons. Agricultural irrigation since the turn of the century has flushed these salts downgradient, causing a redistribution of salt concentrations both vertically and laterally in the aquifer (Glancy 1986).

Reports on regional water quality in the shallow alluvial aquifer and in irrigation return flows contain information on the range of concentrations of various metals and anions (Hoffman et al. 1990) (Glancy 1986). This information is summarized in Table 2.2, p. 2-17. Although there is a large variation in the concentrations of these constituents, there is a trend of increasing concentrations toward discharge areas at Stillwater Lakes and Carson Lake (Glancy 1986). Concentrations of many trace metals exceed various criteria for protection of aquatic life, crop protection, and fish reproduction. For example, background surface-water concentrations of boron often exceed 200 $\mu\text{g/L}$, which is believed high enough to effect fish production. In addition, concentrations of arsenic in ground water and surface water often exceed State of Nevada criteria for protection of aquatic life of 40 $\mu\text{g/L}$ and the U.S. EPA drinking water standard of 50 $\mu\text{g/L}$ (Hoffman et al. 1990). Average arsenic concentrations in the upper aquifer at the various NAS Fallon IR Program sites range from 426 $\mu\text{g/L}$ at Site 20 to 3300 $\mu\text{g/L}$ at the Group II Sites.

Minimum and maximum concentrations throughout the facility range from 13 $\mu\text{g/L}$ to 6400 $\mu\text{g/L}$. Hoffman reports regional arsenic concentrations ranging from <1 to 1400 $\mu\text{g/L}$. Although data from the NAS Fallon IR Program sites have a greater variability than reported by Hoffman's study (Hoffman et al. 1990), it is assumed that the arsenic in the ground water at NAS Fallon is naturally occurring. This assumption is based on the lack of historical evidence that any soluble arsenic compounds were disposed of on the base and the fact that upgradient monitoring wells do not have lower concentrations than those downgradient from the study areas.

2.2.7 Air Quality

Ambient air quality in the Fallon area is generally better than the National Ambient Air Quality Standards (NAAQS), with the exception of total suspended particulates (TSP). TSP concentrations have equalled or exceeded NAAQS during 8 out of the last 10 years. High TSP concentrations are probably caused by a combination of the heavy agricultural activity and the arid climate, which make the area highly susceptible to wind erosion (NAVFAC 1981).

2.2.8 Subsurface Migration Pathways

Due to the shallow water table, 3 to 10 ft BGS, contaminants released to the soils have a relatively high potential for migration to the ground water. However, an upward flow gradient exists between the deeper aquifers and the shallow aquifer. Thus, contaminants are prevented from reaching the basalt aquifer (the source of drinking water in the area) at depth. Also, there is a clay confining layer separating the shallow aquifer and the intermediate aquifer. Investigations conducted during the first iteration of RI field work verified the upward flow gradient from the intermediate aquifer and the existence of a 20-ft-thick, impermeable clay layer separating the two aquifers over the entire facility (Appendix E, Fig. E.1, p. E-3). These natural containment properties should prevent downward migration of contaminants.

Numerous studies have shown that dissolved organic species are not attenuated significantly as they migrate in ground water unless the aquifer contains significant organic matter (Josephson 1983; Pettyjohn and Hounslow 1983; Garbarini and Lion 1986). The total organic matter content of the soils at NAS Fallon is obviously low, based on visual observation and climatic factors. Because the organic content was not measured, it cannot be quantitatively related to contaminant attenuation. Moreover, natural biodegradation is likely to be a more significant removal mechanism for dissolved contaminants. Thus, even where the organic content is very low, it should not be assumed that dissolved contaminants will move with the ground water flow. Furthermore, the movement of the free-phase product may be slower than the ground-water flow by an order of magnitude or more (Ostendorf et al. 1989).

An important potential migration pathway is that of natural ground-water seepage to surface water through subsurface flow in the shallow alluvial aquifer to the drains. However, the irrigation ditches represent only a minor potential contaminant migration pathway when compared to the drains.

Contaminants in the shallow aquifer may ultimately discharge into the drains. All drains crossing the facility flow east toward Stillwater Point Reservoir. The regional ground-water flow direction is inferred to be east-southeastward toward Grimes Point. It is suspected that a ground-water divide splits the flow somewhere downgradient from the facility and that part of the ground-water flows toward Carson Lake Pasture, about 3 miles south of the facility, and the other portion flows toward Stillwater Point Reservoir, approximately 10 miles to the northeast (Appendix D, Fig. D.3, p. D-8).

Based on average determinations, contaminants in ground water could migrate approximately 35 ft/year (Glancy 1986). Variability in the shallow aquifer, however, indicates that some preferential ground-water flow paths may have much greater transmissivity. Pump tests conducted at various locations on the base indicated a wide range of linear flow velocities (Appendix E). Coarse-grained deposits found at various locations on the base exhibit greater flow velocities and may influence contaminant migration on a local scale. These coarse-grained deposits are lenticular in nature, are highly variable in

lithology, and may change within tens of feet both horizontally and vertically. This produces a complex flow regime. However, a low head gradient across the facility is likely to produce a flow rate that is relatively low (i.e., 35 ft/year or less).

If contaminated ground water is discharged into a drain, the migration could be several miles per day. However, hydrologic data indicates that ground-water movement towards the drains only occurs between irrigation seasons when the water levels in the drains are low. Thus, the water would be moving slowly or not flowing at all in some areas, and the rate of migration would be slow.

The drains that could be affected include the LD Drain, the LD #1 Drain, and their tributaries on facility (Appendix D and Fig. 2.2, p. 2-11). These drains discharge to the Stillwater Point Reservoir. Irrigation ditches on the facility are not located near the sites under investigation and do not intersect the shallow ground water; thus, it is unlikely that they represent contaminant migration pathways for any of the sites under investigation.

2.2.9 Demography and Land Use

In 1960, the total population of Churchill County was 8,452; by 1980, the population had increased to 13,917, thereby averaging an increase of approximately 550 new persons per year. The current population of Churchill County, therefore, is estimated at approximately 20,500 persons.

In 1980, the city of Fallon had a population of 4,262 within its corporate limits, representing 31% of the county population. Most county residents live in Fallon or the area of irrigated lands surrounding it. If the change in population percentage in the incorporated city limits compares with that of the total population of the county, the city of Fallon's population would be approximately 6,400 persons.

The most significant business activities in Churchill County, based on employment, are government and military activities associated with NAS Fallon. The next most important activities in the area are trade and agriculture.

Churchill County ranks tenth in size among Nevada's 16 counties, and incorporates almost 5,000 square miles, 91% of which is publicly owned. The largest private landowner in the area is the Southern Pacific Railroad. The remaining private land amounts to approximately 1.3% of the county area, most of which is irrigated farm land in the Fallon vicinity.

Most of the public land is undeveloped, flat desert or arid mountains. Approximately 43,500 acres of the county lies within the boundaries of the Walker River Indian Reservation. This portion of the county is primarily utilized for cattle grazing. Table 2.3, p. 2-31, details the primary land owners and land administration agencies controlling lands within Churchill County.

2.2.10 NAS Fallon Ecology

2.2.10.1 Vegetation

NAS Fallon was originally a greasewood community typical of alkali valley bottomlands, portions of which have since been irrigated and used as pasture. Typical plants for this area include saltbush, pickleweed, halogeton, greasewood, milkweed, poverty weed, alkali goldenbush, rabbitbrush, saltgrass, and sorghum.

The flat, alkali bottom lands comprising the southern portion of the Carson Sink currently receive sufficient irrigation return flow and Carson River water to be recognized as a wetlands area. Carson Lake is partly used as irrigated pasture, but is also valuable wetland habitat, especially for waterfowl. Vegetation typical of these areas includes bullbush, cattail, pondweed, widgeon grass, muskgrass, and coontail. Cottonwoods and willows occupy portions of the banks of various ponds, ditches, and drains.

2.2.10.2 Endangered and Threatened Plant Species

No endangered or threatened plant species designated by the state or federal government are known or likely occur in the region. However, several sensitive species in

Table 2.3. Land ownership and administration within Churchill County

Land Ownership	Acres	Percent
Bureau of Reclamation	420,624	13.4
Bureau of Land Management	2,235,425	70.9
State of Nevada	6,055	0.2
Truckee-Carson Irrigation District	31,813	1.0
Southern Pacific Land Company	243,462	7.7
Indian Lands		
Fallon Reservation	5,480	0.17
Fallon Colony	60	0.002
Walker River Reservation	43,496	1.4
Private Land	37,904	1.2
Other (bombing range, NAS Fallon, withdrawals)	113,960	4.0
Total	<u>3,138,280</u>	<u>100.0</u>
Total Private Lands	<u>281,366</u>	<u>9</u>
Total Public Lands	<u>2,856,914</u>	<u>91</u>

the area include *Camissonia nevadensis* (Nevada evening primrose) from the Forty-Mile Desert, immediately west of Carson Sink; *Penstemon aernarius* (Nevada dune beard-tongue) from Desert Peak; and *Eriogonum lemmonii* (Lemmon buckwheat) from the east side of Lahontan Reservoir. *Oryctes nevadensis* (Nevada oryctes); and *Eriogonum robustum* (altered andesite buckwheat) may also occur on NAS Fallon lands.

2.2.10.3 Wildlife

Terrestrial wildlife in the region consists of species adapted to desert or dependent on wetlands. About 67 species of mammals inhabit the area. Mountain ranges in the region, outside of the area of impact, support large mammals such as mountain lions and mule deer. Common mammals of the area include coyote, black-tailed hare, jackrabbit, deer mouse, antelope ground squirrel, and kangaroo rat.

More than 252 species of birds have been recorded regionally. Upland game birds of the desert are the ring-necked pheasant, sage grouse, the introduced chukar partridge, quail, and mourning dove. A variety of raptors and songbirds are also present.

The Stillwater National Wildlife Management Area, seven miles east of NAS Fallon, and Carson Lake, four miles south of the station, support the two largest concentrations of waterfowl and shorebirds in the state. Important game birds include canvasbacks, whistling swans, and Canada geese. Nongame species include the American avocet, black-necked stilt, white-faced ibis, and dowitchers.

2.2.10.4 Aquatic Life

The drains at the station may be inhabited by mosquitofish, bullhead, catfish, and sunfish.

2.2.10.5 Endangered Animal Species

Federally listed endangered and threatened animal species that may utilize the NAS Fallon and range areas include the peregrine falcon and the southern bald eagle. The above species are most likely to be found hunting the wetland portions of the area but may occasionally be seen elsewhere. The nearest breeding habitat is to the northwest of NAS Fallon.

3. SITE 1, CRASH CREW TRAINING AREA

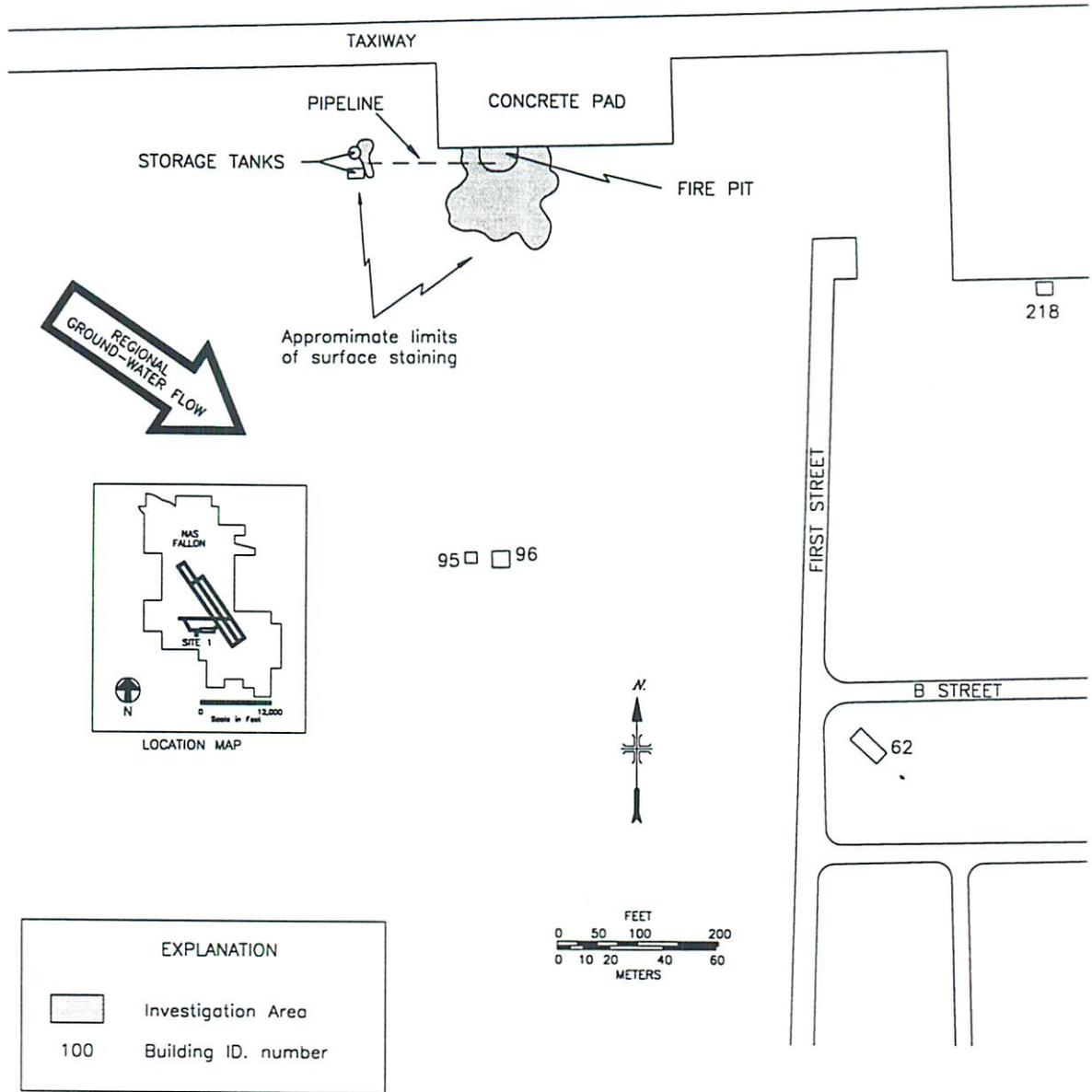
3.1 SITE BACKGROUND

3.1.1 Site Description

The Crash Crew Training Area is located in the southern part of NAS Fallon as shown on Fig. 1.2, p. 1-10, and Plate 1. The site consists of an unlined, earth-bermed pit and two aboveground storage tanks of approximately 1,000- and 5,000-gal capacity (Fig. 3.1, p. 3-2). The tanks are located about 180 ft west of the pit and feed the pit through underground piping. The pit is approximately 25 ft in diameter and about 3 ft deep (Dames and Moore 1988). The soil in the pit and around the tanks is stained. A recent inspection of the area by NAS Fallon environmental personnel revealed 15 to 20 ft of light staining beyond the confines of the pit.

3.1.2 Site History

From the mid-1950s until April 1988, the fire pit was used to conduct fire training activities for NAS Fallon personnel. The pit was reportedly used to burn an estimated total of 1.1 million gal of flammable liquids. The flammable liquids were obtained as waste products from the old and new fuel farms, the aircraft maintenance shop, and the vehicle maintenance shop. The wastes burned included off-specification fuel, napalm, oil, and solvents (Dames and Moore 1988). It is estimated that approximately 90% of the waste material was fuel, 9% oil, and 1% solvents. From 1982 to April 1988, only off-specification JP-5 fuel from the new fuel farm was burned in the pit.



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Surface staining based on Dames and Moore, 1988.

Fig. 3.1. Site 1, Crash Crew Training Area.

3.1.3 Previous Investigations

The only previous investigation performed at the Crash Crew Training Area was Phase I, PA/SI, of the IR Program. The study consisted of a visual inspection, records search, and on-site interviews. The PA/SI recommended that the site be included in the RI due to contaminated soils and probable contaminated ground water. The study recommended soil sampling and the installation of ground-water monitoring wells. Recommended test parameters were TPHs, VOCs, SVOCs, PCBs, and lead (Dames and Moore 1988).

3.1.4 Investigative Approach

Stained soil was viewed as verification that contamination existed at the site. In addition to planned activities, two soil borings were drilled during the first iteration sampling to assess the extent of soil contamination around the burn pit. The locations of down-gradient monitoring wells were modified based on ground-water-test-hole and geophysical-survey results. The work plan describes the approach and rationale for the investigation (ORNL 1989).

3.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

3.2.1 Surface-Water Hydrology

No permanent surface-water features are associated with Site 1. However, precipitation may cause ponding in the crash crew pit. Consequently, the water in this area would either evaporate or infiltrate into the subsurface. Also, the water-table elevation map for the site indicates potential ground-water discharge to the LD drain, approximately 2,500 ft to the south.

3.2.2 Ground-Water Hydrology

Monitoring wells MW14, MW15U&L, MW16, MW17, MW50U&L, MW51U&L, and PW02 were installed at Site 1 to characterize the shallow alluvial aquifer. The water-table elevation map for the aquifer is presented in Fig. 3.2, p. 3-5. Depth to ground water at the site varies seasonally and ranges from 5.5 to 9.0 ft BGS (see Appendix H, Table H.3). MW11L was installed in the intermediate aquifer to define the effect the intermediate aquifer has on contaminant transport. MW11L averaged a static head 2.5 ft above ground level, approximately 8.5 ft higher than the static water level in the adjacent well MW11U, which is completed in the shallow aquifer. Therefore, ground water movement in the intermediate aquifer has an upward flow component. Bail and slug tests were performed on all these wells except MW50U, which had free-phase product. These tests indicated hydraulic conductivities that ranged from 0.3 to 10.9 ft/d.

3.3 STUDY AREA INVESTIGATION

3.3.1 Surface-Water and Sediment Investigations

Due to the lack of surface water, no sediment or surface-water samples were taken at Site 1.

3.3.2 Geological Investigation

The lithology information for the Crash Crew Training Area was obtained using a 5-ft continuous sampler or using a 1.5-ft or 2-ft split spoon utilizing the California method during the installation of monitoring wells MW11U, MW11L, MW14, MW15U, MW15L, MW16U, MW16L, MW17, MW50U, MW50L, and PW02. The exceptions were MW15U, MW16U, MW50U, and MW51U, which were installed adjacent to existing lower completions.

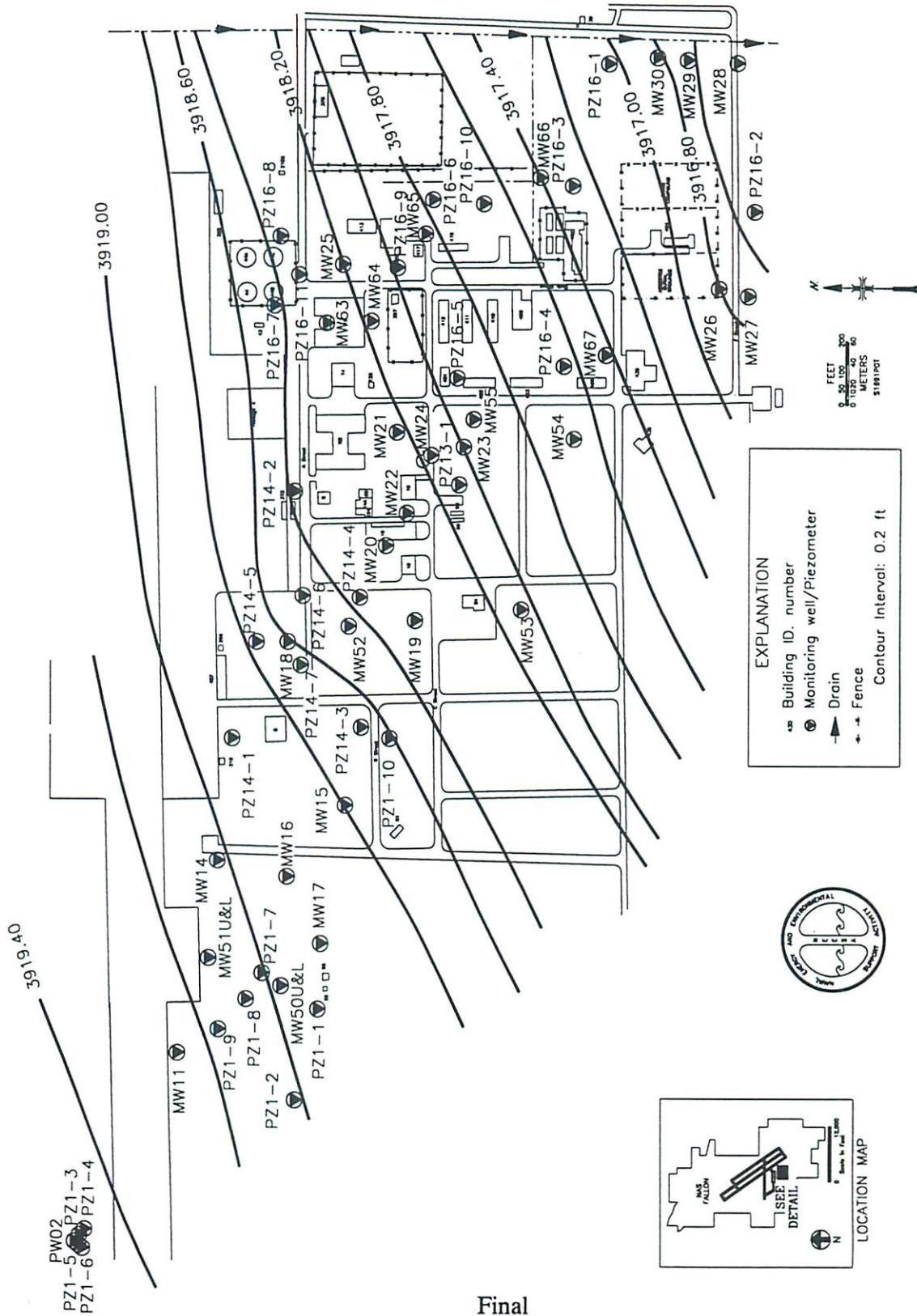


Fig. 3.2. Water-table elevation map for the shallow alluvial aquifer at Site 1 (measurements taken April 1992).

PW02 was installed upgradient from the site; monitoring wells MW14, MW15U, MW15L, MW16U, MW16L, and MW17 were installed downgradient. Monitoring wells MW50U, MW50L, MW51U, and MW51L were installed in the area of suspected contamination. Well summary forms with well construction and lithologic descriptions are found in Appendix F.

All monitoring wells penetrated the entire Fallon Formation and reached the Seho Formation, which is the aquitard for the shallow aquifer, at a total depth of approximately 20 to 24 ft BGL. The Fallon Formation at Site 1 is typical of the lithofacies found at other areas on the base. The depositional history based on this lithologic sequence appears to be deltaic in nature, subsequently dissected by ancient Carson River paleo-channel deposits. MW11L, MW15L, MW16L, and MW17L display well-developed channel sands typical of a paleo-channel. Where this appears, it is approximately 10 ft BGL and varies in thickness from 8 to 10 ft. The channel sands are predominantly medium- to coarse-grained, with occasional 3- to 5-mm pebbles that are angular to sub-rounded and loosely consolidated. MW16 appears to have scoured through the upper contact of the Seho Formation. This is supported by the grayish-brown silty clay with sand at 25 ft BGL. The simplified fence diagram shown on Fig. 3.3, p. 3-7, shows the stratigraphy based on drilling logs. MW50L and MW51L both showed alteration of the lithology from very dark gray to black due to staining from the spilled fuel.

3.3.3 Geophysical Investigation

An EM-31 geophysical survey was conducted at Site 1 to help guide the selection of monitoring well locations. Specifically, the survey was employed to map differences in the electrical conductivity of the shallow ground water and soil profile.

Results from the geophysical survey are shown on Fig. 3.4, p. 3-8. The data for this particular map have not been smoothed; thus, some noise is apparent. The abundant, dark, concentric rings represent surface metallic debris. The larger contours trending in a south-westerly direction across the site could represent high salinity, increased soil-moisture content, the influence of a former river channel, or a combination of the three. Appendix B describes the geophysical survey methodology.

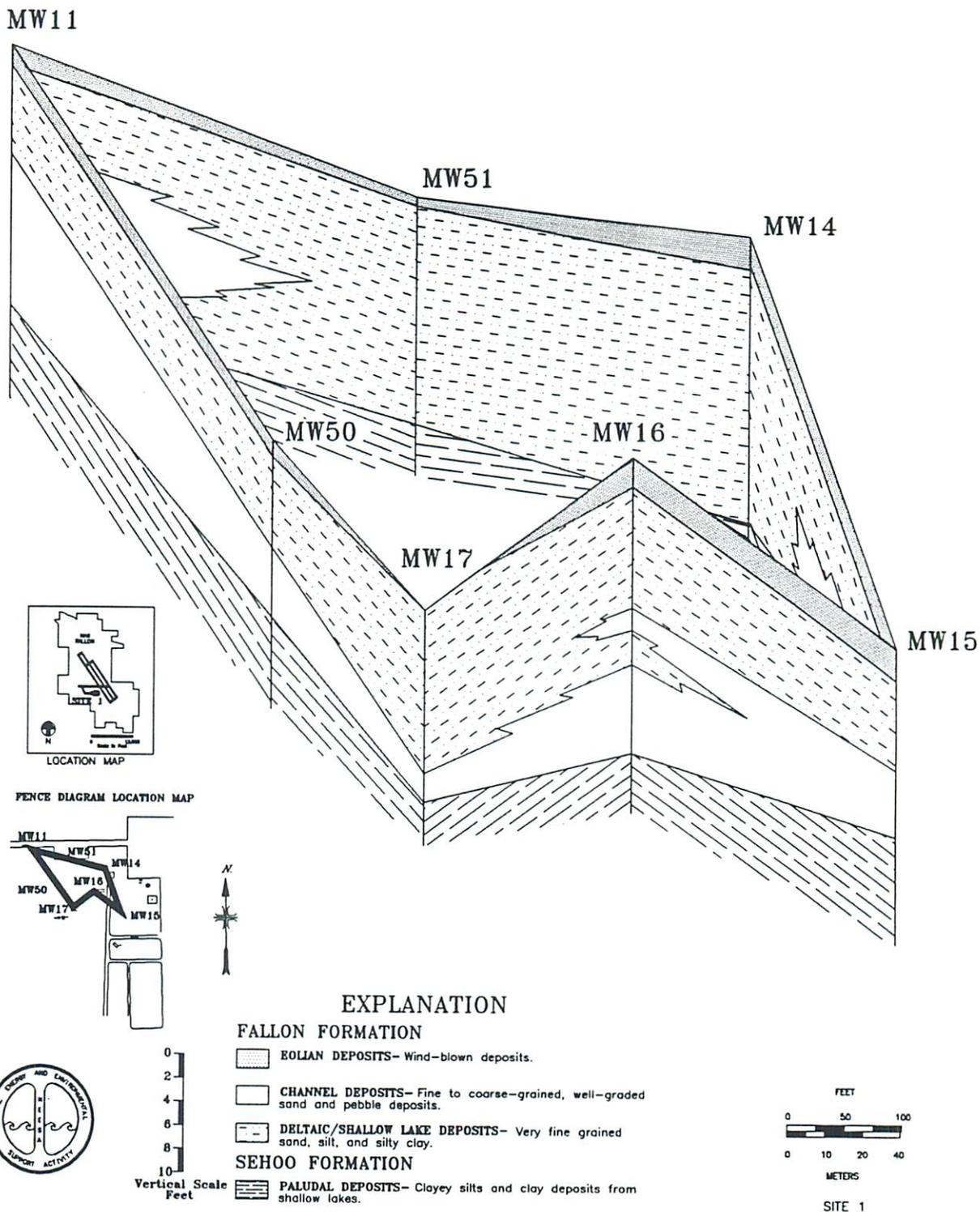


Fig. 3.3. Simplified fence diagram for monitoring wells installed at Site 1.

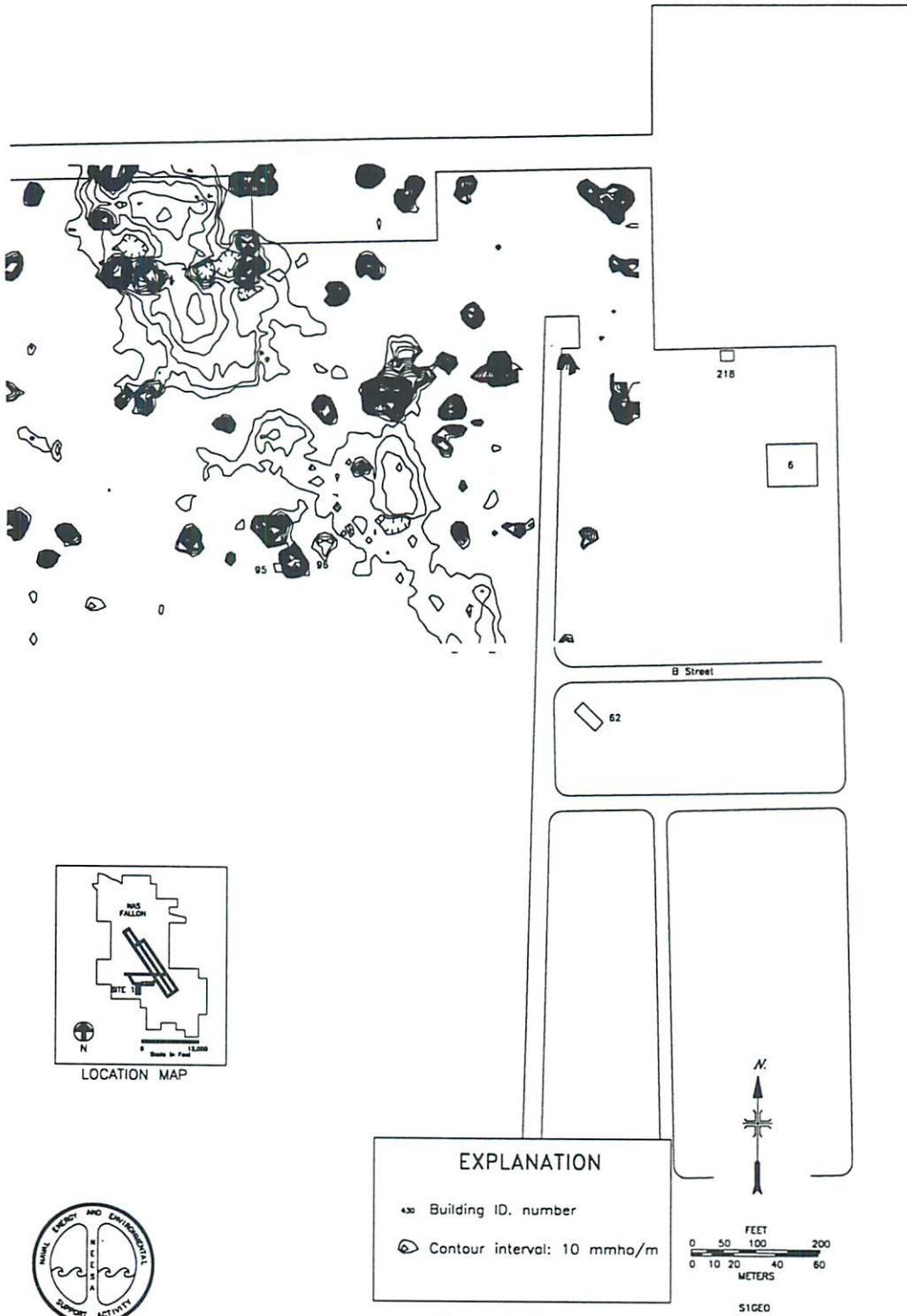


Fig. 3.4. Site 1, Crash Crew Training Area. Quadrature geophysical contour map.

3.3.4 Vadose Zone and Soil Investigation

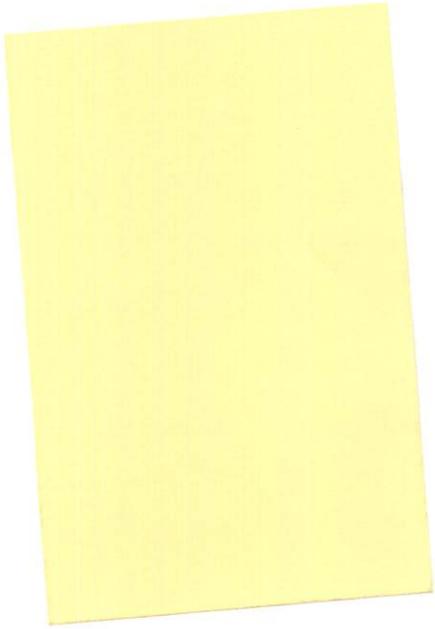
Eight soil borings were drilled during the first iteration of Phase II site characterization at Site 1. Sampling locations are shown on Fig. 3.5, p. 3-10. Borehole numbers and sampling intervals are shown below.

<u>Borehole number</u>	<u>Sample Intervals, ft</u>		
BH01	0.0 to 2.0	3.0 to 5.0	6.0 to 8.0
BH02	0.0 to 2.0	3.0 to 5.0	6.0 to 8.0
BH03	1.5 to 2.0	3.5 to 4.0	
BH03A	0.0 to 2.0	4.0 to 6.0	
BH04	1.5 to 2.0	3.5 to 4.0	
BH04A	0.0 to 2.0	4.0 to 6.0	
BH05	1.5 to 2.0	3.5 to 4.0	
BH06	1.5 to 2.0	3.5 to 4.0	

In addition to borehole samples, soil samples were collected during the installation of monitoring wells MW14, MW15, MW16, MW17 at the 7 to 9-ft depth only. All soil samples collected from Site 1 were analyzed for LBPHCs, HBPHCs, PCBs/pest, SVOCs, VOCs, and metals. No soil samples were collected at Site 1 during the second iteration of site characterization.

3.3.5 Ground-Water Investigation

The first iteration of the ground-water investigation at Site 1 involved the boring of 57 ground-water test holes, the installation of eight monitoring wells, and the location of



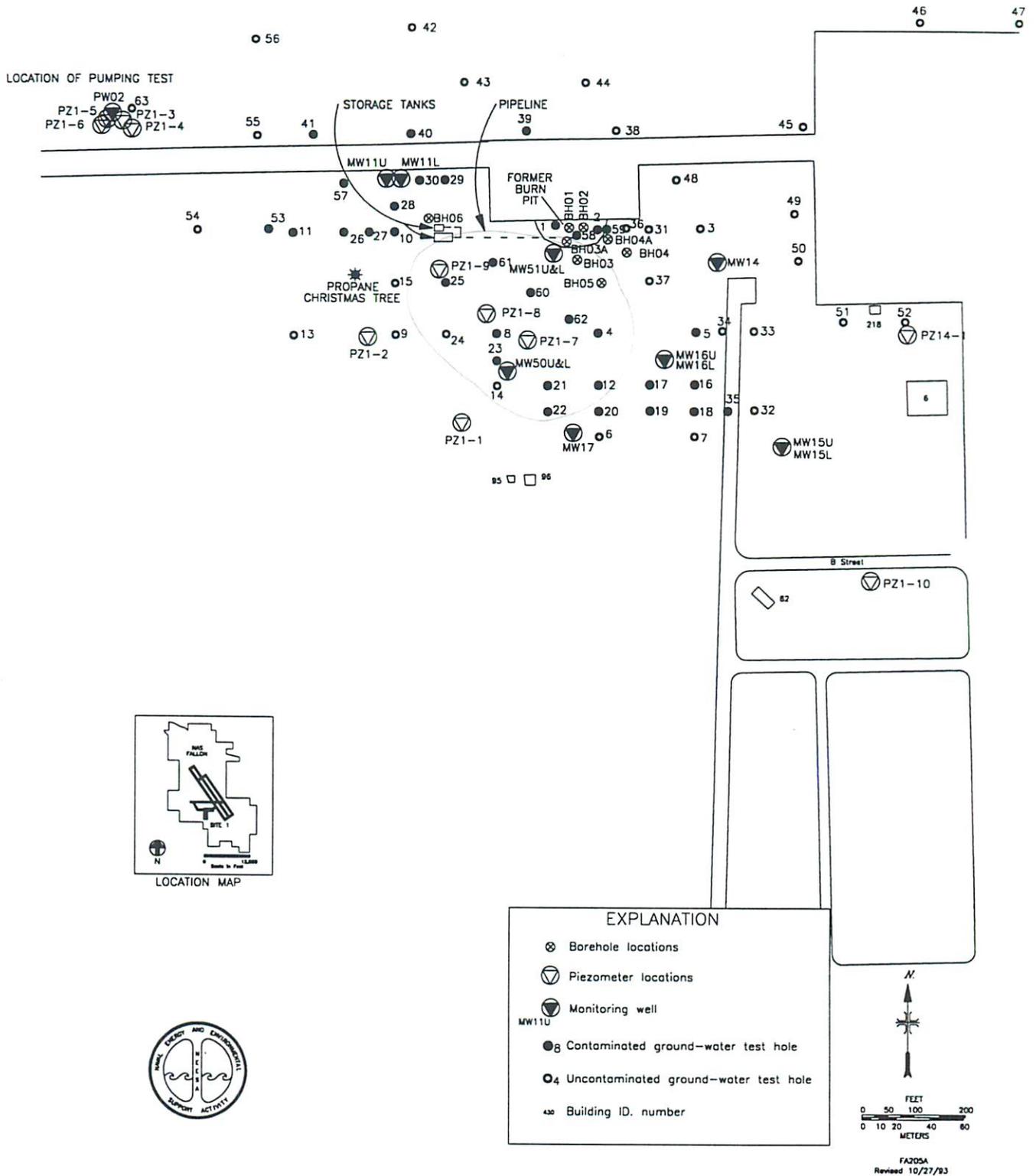


Fig. 3.5. Site 1, Crash Crew Training Area. Sample locations.

two piezometers. Recommendations for subsequent investigation at Site 1 were based on results from the first sampling iteration and recommendations made in the *Preliminary Site Characterization Summary* (PSCS) (ORNL 1992c). The second iteration of ground-water investigation at the site included the boring of eight additional ground water test holes, the installation of five monitoring wells, and the location of eight piezometers. Sample locations for Site 1 are shown on Fig. 3.5, p. 3-10.

The ground-water test holes were used to delineate a PHC plume on the ground water underlying the site and to determine suitable locations for monitoring wells. Water samples from the monitoring wells were sent to an off-site laboratory and analyzed for LBPHCs, HBPHCs, PCBs/pest, SVOCs, VOCs, and metals. Also, samples were analyzed in the field for temperature, pH, and conductivity. Results of water-quality field measurements for all sites are presented in Appendix G. The monitoring wells and piezometers were used to determine ground-water levels and to measure the thickness of free-phase hydrocarbon product on the ground water surface.

3.4 NATURE AND EXTENT OF CONTAMINATION

3.4.1 Vadose Zone and Soils

Soil samples were sent to a Navy-certified laboratory for analysis; results are presented in Table 3.1, p. 3-12. Soil contamination at the site consists of PHC-related compounds and solvents. Concentrations of PHCs in soil exceed the NDEP action level of 100 mg/kg in soils within the fire pit as shown by samples from BH01 and BH02 (Fig. 3.6, p. 3-16). Sample numbers 3549D and 3550D, taken from BH01, and sample numbers 3553D and 3554D, taken from BH02, were collected as duplicate samples and analyzed for VOCs only. However, the samples were not true duplicates in the sense that one sample was collected from a vertical section a few inches deeper than the other sample.

The major surface-soil contamination is confined to the fire pit, where soil is contaminated from the surface to the water table. Contamination dissipates rapidly within a few

Some soil contam. at
former ABTS AREA!

Final

Table 3.1. Soil sample results for Site 1

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	PCB/Pesticide, µg/kg (*3)	Semivolatiles µg/kg (*4)	Volatiles µg/kg (*5)
BH01 11/90	3549	0 - 2	2100.00	2200.00 E 5.40 T 2.40 X 23.00	NP	2-Meth 7500.0 4-Chlo 160.0 4-Metp 1500.0 Acen 270.0 Bis2 380.0a Di-N 190.0 Fluor 950.0 Naph 2700.0 Phena 310.0	1,2DCE 120.0 2-But 930.0 Acet 2300.0a B 160.0 E 2100.0 Methcl 40.0a Tetra 14000.0 T 1900.0 TCE 3200.0 X 19000.0
BH01 11/90	3549D	0 - 2	NP	NP	NP	NP	Acet 1000.0a E 1800.0 Tetra 12000.0 T 1700.0 TCE 1400.0 X 15000.0
BH01 11/90	3550	3 - 5	300.00	420.0 E 0.70 T 0.30 X 3.70	NP	2-Meth 1600.0 4-Metp 2200.0 Bis2 200.0a Fluor 130.0 Naph 410.0 Phena 76.0 Phen 270.0	1,2DCE 110.0 2-But 1400.0 Acet 2400.0a B 82.0 E 380.0 Methcl 45.0a Tetra 2200.0 T 480.0 TCE 700.0 X 2300.0
BH01 11/90	3550D	3 - 5	NP	NP	NP	NP	Acet 4700.0a E 310.0 Tetra 1700.0 T 350.0 TCE 380.0 X 4000.0
BH01 11/90	3551	6 - 8	200.00	X 140.0 0.70	NP	2-Meth 690.0 4-Metp 1300.0 Bis2 270.0a Naph 180.0 Phen 230.0	2-But 450.0 Acet 2000.0a E 210.0 Methcl 300.0a Tetra 2400.0 T 310.0 TCE 200.0 X 1600.0
BH02 11/90	3552	0 - 2	4300.00	1000.00 B 0.09 E 7.50 T 1.00 X 7.50	NP	4-Chlo 180.0 4-Metp 2300.0 Bis2 340.0a Di-N 2200.0 Fluor 470.0 Phena 240.0 Phen 250.0	2-But 660.0 E 1600.0 Tetra 2800.0 T 1800.0 TCE 1400.0 X 11000.0

Table 3.1. Soil sample results for Site 1 (cont.)

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	PCB/Pesticide, µg/kg (*3)	Semivolatiles µg/kg (*4)	Volatiles µg/kg (*5)
BH02 11/90	3553	3 - 5	310.00	19.00	U	2-Meth 290.0 4-Metp 150.0 Bis2 280.0a Di-N 37.0 Fluor 66.0 Phena 47.0	1,2DCE 3.0 2-But 62.0 Acet 500.0a E 64.0 Methcl 24.0a Tetra 600.0 T 38.0 TCE 31.0 X 520.0
BH02 11/90	3553D	3 - 5	NP	NP	NP	NP	2-But 85.0 Acet 950.0a E 47.0 Methcl 260.0a Tetra 300.0 T 22.0 TCE 14.0 X 350.0
BH02 11/90	3554	6 - 8	3100.00	760.00 B 0.06 E 1.10 T 0.60 X 5.50	NP	2-Meth 5400.0 4,6Din 93.0 4-Chlo 120.0 4-Metp 2600.0 Acen 230.0 Bis2 350.0a Di-N 460.0 Fluor 590.0 Naph 2300.0 Phena 300.0 Phen 340.0	E 1900.0 Tetra 94000.0 T 1900.0 TCE 1600.0 X 15000.0
BH02 11/90	3554D	6 - 8	NP	NP	NP	NP	E 2400.0 Tetra 67000.0 T 2300.0 TCE 1600.0 X 16000.0
BH03 03/91	3610	1.5 - 2	U	U	NP	Bis2 220.0*J	Methcl **
BH03 11/90	3611	3.5 - 4	U	U	NP	Bis2 1300.0a	Methcl ** Tetra 34.0
BH03A 11/90	3557	0 - 2	U	U	NP	Bis2 280.0a	Methcl 21.0a
BH03A 11/90	3558	4 - 6	U	13.00	NP	Bis2 380.0a	Acet 8.0a Methcl 8.0a
BH04 03/91	3612	1.5 - 2	U	U	NP	Bis2 **	Methcl **
BH04 03/91	3613	3.5 - 4	U	U	NP	Bis2 **	Methcl **

Table 3.1. Soil sample results for Site 1 (cont.)

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (1)	Total LBP PHC, mg/kg (2)	PCB/Pesticide, µg/kg (3)	Semivolatiles, µg/kg (4)	Volatiles, µg/kg (5)
BH04A	3559	0 - 2	U	6.00	NP	Bis2	Methyl 170.0a 6.0a
BH04A	3560	4 - 6	U	U	NP	Bis2	Methyl 380.0a Tetra 28.0a 2.0
BH05	3614	1.5 - 2	U	U	NP	Bis2	Methyl 550.0a ..
BH05	3615	3.5 - 4	U	U	NP	Bis2	Methyl 230.0*J ..
BH06	3616	1.5 - 2	U	U	NP	Bis2	Methyl 810.0a ..
BH06	3617	3.5 - 4	U	U	NP	Bis2	Methyl
MW14	3566	7 - 9	U	U	NP	Bis2	Methyl 68.0*J 3.0*J
MW15	3567	7 - 9	U	U	NP	U	Methyl 3.0*J
MW16	3568	7 - 9	U	U	NP	Bis2	Methyl 1.2DCE 11.0 TCE 4.0*J 9.0
MW17	3569	7 - 9	U	U	NP	Bis2	T 3.0*J TCE 1.0*J 62.0*J
PW02	3902	6.5 - 8	U	U	NP	U	Acet 32.0*J ..

- ** - unusable data due to method blank contamination
- a - suspected laboratory contaminant
- *1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
- *2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
- *3 - EPA method 3550/8080, quantitation limit: 8.3 µg/kg
- *4 - EPA method 3550/8270, quantitation limit: 350 µg/kg
- *5 - EPA method 8240, quantitation limit: 5 µg/kg
- J - concentration estimated
- 1,2DCE - 1,2-dichloroethene (total)
- 2-But - 2-butanone
- 2-Meth - 2-methylnaphthalene
- 4,6Din - 4,6-dinitro-2-methylphenol
- 4-Chlo - 4-chlorophenyl-phenylether
- 4-Metp - 4-methylphenol
- Acen - acenaphthene
- Acet - acetone
- B - benzene
- Bis2 - bis(2-ethylhexyl) phthalate
- DI-N - di-n-butylphthalate
- E - ethylbenzene
- Fluor - fluorene
- HBP - high boiling point
- LBP - low boiling point
- Methyl - methylene chloride
- Naph - naphthalene
- NP - analysis not performed
- PHC - petroleum hydrocarbons
- Phen - phenol
- Phena - phenanthrene
- T - toluene
- TCE - trichloroethene
- Tetra - tetrachloroethene
- U - no compounds detected
- X - xylenes (total)

Table 3.1. Soil sample results for Site 1 (cont.)

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg				
Compound	#	Average	Minimum	Maximum
Aluminum	1	2,830	2,830.00	2,830.00
Antimony	0 ND		ND	ND
Arsenic	1	8	7.70	7.70
Barium	1	21	21.10	21.10
Beryllium	0 ND		ND	ND
Boron	1	4	3.80	3.80
Cadmium	0 ND		ND	ND
Calcium	1	1,950	1,950.00	1,950.00
Chromium	1	6	5.60	5.60
Cobalt	1	5	4.60	4.60
Copper	1	37	36.50	36.50
Iron	1	9,080	9,080.00	9,080.00
Lead	1	3	2.80	2.80
Lithium	1	5	4.50	4.50
Magnesium	1	1,560	1,560.00	1,560.00
Manganese	1	77	77.00	77.00
Mercury	0 ND		ND	ND
Molybdenum	0 ND		ND	ND
Nickel	1	5	5.40	5.40
Potassium	1	480	480.00	480.00
Selenium	0 ND		ND	ND
Silver	0 ND		ND	ND
Sodium	1	1,090	1,090.00	1,090.00
Thallium	0 ND		ND	ND
Vanadium	1	28	27.50	27.50
Zinc	1	37	37.10	37.10

- number of samples with detectable quantities of analyte
 ND - analyte not detected

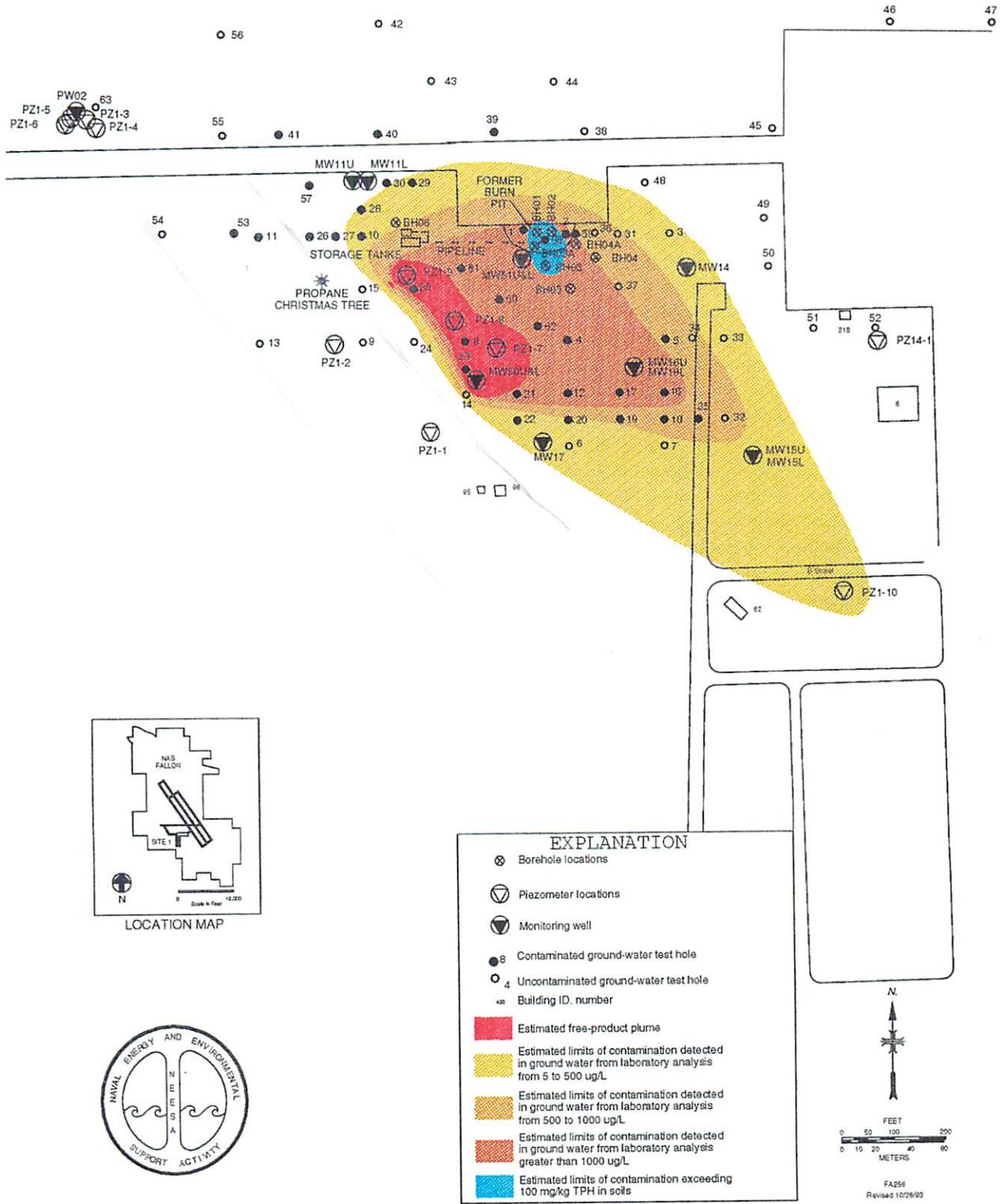


Fig. 3.6. Site 1, Crash Crew Training Area. Contaminant boundary map.

yards south of the pit as shown by the rapid decrease in contaminant types and concentrations between BH03A and BH04A, which are closer to the pit than BH03, BH04, and BH05. Soil borings BH03A and BH04A were drilled to further refine the definition of soil contamination and were, therefore, numbered out of sequence. No surface-soil contamination was detected associated with the aboveground tanks, shown by sample results from BH06. The only other soil contamination discovered outside the fire pit area is associated with the plume of contaminated ground water. Soil sample results for samples taken in the capillary fringe from MW16 and MW17 indicate that only solvent-related compounds have contaminated the soil at any considerable distance from the pit. In general, a rapid decrease in the number and concentration of contaminants is seen with increasing distance from the pit.

3.4.2 Ground Water

The first iteration of the Site 1 ground-water characterization was summarized in the PSCS (ORNL 1992c). Recommendations in the PSCS led to a second iteration of characterization activities beginning three months after (November 1991) the last of the first iteration samples were taken (August 1991). The following sections generally discuss these activities separately. However, in certain cases it is necessary to combine discussion of these tasks for proper interpretation. Analytical data tables for the two activities are combined.

Sample locations and contaminant boundaries are shown in Fig. 3.6, p. 3-16. The figure presents ground-water contaminant plume boundaries based on two different types of data: 1) data indicating the presence and thickness of free product when collecting water-level measurements; and 2) data obtained from laboratory analyses of ground-water samples. The plume boundary for each type of data is drawn around sample locations where detectable levels of contaminants were indicated by the measurement method.

3.4.2.1 First Iteration Activities

Ground-water samples collected from Site 1 are presented in Table 3.2, p. 3-19. Based on results from ground-water-test-hole screening, it was intended that monitoring wells MW14, MW15U, MW15L, and MW17 be placed just outside the dissolved-contaminant ground-water plume. Results from the first iteration of sampling (April 1991) indicated that all contaminant concentrations for MW14 and MW17 were below the NDEP action level for PHCs. MW15U and MW15L reportedly had concentrations of the solvent trichloroethene (TCE) of 5.0 and 23.0 $\mu\text{g/L}$, respectively. The second round of sampling (August 1991) detected no contaminants at MW14. Results from MW17 indicated a TCE concentration of 6.0 $\mu\text{g/L}$, and samples from MW15U and MW15L had no TCE contamination. Figure 3.6, p. 3-16, indicates the detection of contaminants from MW15U and MW15L that were not anticipated based on ground-water-test-hole screening.

MW16U and MW16L were intentionally completed within the plume boundary. MW16U was screened across the top of the water table, and MW16L was screened at the bottom of the shallow alluvial aquifer. The results of the first sampling iteration for MW16U indicated relatively high levels of dissolved PHCs and solvents, with TCE detected at levels up to 45.0 $\mu\text{g/L}$. The second round of sampling at MW16U confirmed the presence of hydrocarbons and also indicated that benzene and xylene were present at concentrations of 5.5 $\mu\text{g/L}$ and 7.0 $\mu\text{g/L}$ respectively. However, no solvents were detected. No contaminants were detected in MW16L, indicating that the contamination is essentially confined to the upper few feet of the aquifer and that the ground-water flow is essentially laminar and horizontal. In fact, results from the lower well completions, MW15L and MW16L, which show concentrations far below the solubility-limit concentration for TCE, indicate that there is probably not a dense non-aqueous-phase liquid (DNAPL) plume at the site.

MW11U was installed as an upgradient well based on one clean ground-water-test-hole drilled prior to the delineation of the plume boundaries. It was sampled twice as part of routine sampling, once in July 1990 (sample number 3467) and again in November 1990 (sample number 3778). Neither sample from MW11U contained detectable levels of contaminants.

Table 3.2. Water sample results for Site 1

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Total PHC mg/L (*3)	PCB/Pesticide, µg/L (*4)	Semivolatiles µg/L (*5)	Volatiles µg/L (*6)
MW11L 07/90	3468	NP	NP	U	U	U	U
MW11U 07/90	3467	NP	NP	U	U	U	U
MW11U 04/91	3778	U	U	NP	U	U	U
MW14 04/91	3733	Die 50.0	U	NP	U	U	U
MW14 08/91	3832	Die 50.0	U	NP	NP	U	U
MW15L 04/91	3727	Die 290.0	65.0	NP	U	U	1,2DCE 18.0 Tetra 1.0*J TCE 23.0
MW15L 08/91	3824	Die 300.0	U	NP	NP	U	NP
MW15L 08/91	3894	NP	NP	NP	NP	NP	U
MW15U 04/91	3730	U	U	NP	U	U	1,2DCE 1.0*J TCE 5.0
MW15U 08/91	3831	Die 70.0	U	NP	NP	U	Acet ** TCE 3.0*J
MW16L 04/91	3729	U	U	NP	U	U	1,2DCE 7.0 TCE 2.0*J
MW16L 08/91	3826	Die 60.0	U	NP	NP	U	NP
MW16L 08/91	3896	NP	NP	NP	NP	NP	U
MW16U 04/91	3728	Die 13000.0	95.0	NP	U	U	1,1DCE 5.0 1,2DCE 110.0 B 3.0*J TCE 45.0
MW16U 08/91	3825	Die 12000.0	B 5.5 X 7.0	NP	NP	Benzo 6.0*J	NP
MW16U 08/91	3825D	NP	B 7.0*J X 3.0*J	NP	NP	NP	NP
MW16U 08/91	3895	NP	NP	NP	NP	NP	U
MW17 04/91	3731	Die 140.0	U	NP	U	U	TCE 5.0*J
MW17 08/91	3828	Die 80.0	U	NP	NP	U	TCE 6.0

Table 3.2. Water sample results for Site 1 (cont.)

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Total PHC mg/L (*3)	PCB/Pesticide, µg/L (*4)	Semivolatiles µg/L (*5)	Volatiles µg/L (*6)
MW50L 12/91	3927	JP5 90.0	U	NP	NP	U	U
MW50L 04/92	3999	Die 70.0	U	NP	NP	U	U
MW50U 12/91	3925	Die 590.0	Ga 840.0 B 27.0 T 20.0 X 9.0	NP	NP	Bis2 26.0a	1,1DCE 28.0 TCE 69.0
MW51L 12/91	3930	JP5 160.0	Ga 120.0 T 1.0*J X 4.0*J	NP	NP	U	TCE 1.0*J
MW51L 12/91	3931	JP5 150.0	Ga 120.0 X 3.0*J	NP	NP	U	U
MW51L 04/92	3989	JP5 70.0	X 2.0	NP	NP	U	U
MW51U 12/91	3929	Die 32000.0	Ga 6100.0 B 800.0 E 100.0 T 490.0 X 560.0	NP	NP	2-Meth 22.0*J 4-Metp 480.0 Benzo 177.0 Naph 14.0*J Phen 44.0	2-But 1100.0 2-Hex 91.0 4-Methyl-2-P 2200.0 Acet 4400.0a TCE 690.0
MW51U 12/91	3929D	NP	B 160.0*J T 330.0 X 420.0	NP	NP	NP	2-But 450.0 4-Methyl-2-P 2000.0 Acet 4400.0a TCE 840.0
MW51U 04/92	3969	Die 72000.0	Ga 1400.0 B 19.0 E 7.0 T 18.0 X 38.0	NP	NP	2,4Dim 13.0 2-Meth 28.0 2-Metp 10.0 4-Metp 910.0 Bis2 7.0*J Naph 19.0 Phen 72.0	1,1DCE 1.0*J 4-Methyl-2-P 270.0 Acet 53.0*J Methcl ** TCE 45.0*J
MW51U 04/92	3969D	NP	B 22.0*J T 20.0*J X 49.0*J	NP	NP	2-Meth 22.0*J 4-Metp 890.0 Naph 20.0*J Phen 65.0*J	4-Methyl-2-P 200.0 Acet 80.0*J Methcl 37.0*J TCE 55.0*J
MW51U 04/92	3970	Die 41000.0	Ga 2300.0 B 92.0 E 30.0 T 160.0 X 240.0	NP	NP	2,4Dim 7.0*J 2-Meth 17.0 2-Metp 5.0*J 4-Metp 400.0 Bis2 9.0*J Naph 13.0 Phen 33.0	2-Hex 60.0*J 4-Methyl-2-P 1800.0 Acet 940.0*J Methcl ** TCE 330.0 Vinyl 3.0*J
MW51U 04/92	3970D	NP	B 85.0 E 41.0*J T 150.0 X 210.0	NP	NP	2,4Dim 7.0*J 2-Meth 17.0*J 2-Metp 5.0*J 4-Metp 410.0 Bis2 9.0*J Naph 13.0*J Phen 30.0	2-Hex 1300.0*J Acet 860.0*J Methcl 16.0*J TCE 290.0

Table 3.2. Water sample results for Site 1 (cont.)

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Total PHC mg/L (*3)	PCB/Pesticide, µg/L (*4)	Semivolatiles µg/L (*5)	Volatiles µg/L (*6)
PW02 12/91	3928	Die 70.0	U	NP	NP	Bis2 **	U
PZ1-10 12/91	3944	Die 60.0	U	NP	NP	Bis2 **	TCE 6.0
PZ1-10 04/92	3980	Die 70.0	U	NP	NP	U	Methcl 1.0*J TCE 1.0*J

**	- unusable data due to method blank contamination	Benzo	- benzoic acid
a	- suspected laboratory contaminant	Bis2	- bis(2-ethylhexyl) phthalate
*1	- EPA method 8015 Modified, quantitation limit: 50 µg/L	Die	- HBP PHC as compared to diesel fuel
*2	- EPA method 8015/8020, quantitation limit: 50 µg/L	E	- ethylbenzene
*3	- EPA method 418.1, quantitation limit: 1 mg/L	Gas	- LBP PHC as compared to gasoline
*4	- EPA method 608, quantitation limit: 0.05 µg/L	HBP	- high boiling point
*5	- EPA method 625, quantitation limit: 5 µg/L	JP5	- HBP PHC as compared to JP-5 jet fuel
*6	- EPA method 624, quantitation limit: 5 µg/L	LBP	- low boiling point
*J	- concentration estimated	Methcl	- methylene chloride
1,1DCE	- 1,1-dichloroethene	Naph	- naphthalene
1,2DCE	- 1,2-dichloroethene (total)	NP	- analysis not performed
2,4Dim	- 2,4-dimethylphenol	PHC	- petroleum hydrocarbons
2-But	- 2-butanone = MEK!	Phen	- phenol
2-Hex	- 2-hexanone	T	- toluene
2-Meth	- 2-methylnaphthalene	TCE	- trichloroethene
?-Metp	- 2-methylphenol	Tetra	- tetrachloroethene
-Metp	- 4-methylphenol	U	- no compounds detected
4-Methyl-2-P	- 4-methyl-2-pentanone	Vinyl	- vinyl chloride
Acet	- acetone	X	- xylenes (total)
B	- benzene		

Table 3.2. Water sample results for Site 1 (cont.)

Anions, mg/L EPA method 429 Quantitation limit: 0.5 mg/L				
Compound	#	Average	Minimum	Maximum
Chloride	9	15,108	71.00	35,000.00
Fluoride	1	5	5.00	5.00
Nitrate, as N	0 ND		ND	ND
Phosphate	0 ND		ND	ND
Sulfate	8	6,975	1,200.00	16,000.00

- number of samples with detectable quantities of analyte
ND - analyte not detected

Metals, µg/L EPA method 200.7 Quantitation limit: 1 µg/L				
Compound	#	Average	Minimum	Maximum
Aluminum	3	51	42.80	56.40
Antimony	0 ND		ND	ND
Arsenic	6	409	38.20	892.00
Barium	8	93	23.40	202.00
Beryllium	0 ND		ND	ND
Boron	8	31,466	4,660.00	60,400.00
Cadmium	0 ND		ND	ND
Calcium	6	99,217	19,700.00	343,000.00
Chromium	0 ND		ND	ND
Cobalt	1	72	72.00	72.00
Copper	5	103	22.40	333.00
Iron	6	35	24.80	59.10
Lead	0 ND		ND	ND
Lithium	8	299	68.90	593.00
Magnesium	6	132,700	14,600.00	289,000.00
Manganese	6	419	20.40	1,980.00
Mercury	1	0	0.24	0.24
Molybdenum	6	912	492.00	1,730.00
Nickel	1	178	178.00	178.00
Potassium	6	147,667	51,900.00	286,000.00
Selenium	0 ND		ND	ND
Silver	5	13	5.50	21.70
Sodium	6	7,561,667	2,450,000.00	14,900,000.00
Thallium	0 ND		ND	ND
Vanadium	6	152	22.90	351.00
Zinc	7	68	20.70	133.00

- number of samples with detectable quantities of analyte
D - analyte not detected

MW11L was installed adjacent to MW11U to assess the vertical head gradient between the intermediate and shallow aquifers. Head measurements in MW11L, completed in the intermediate aquifer, exceeded 2 ft above ground level whereas measurements in the shallow MW11U were approximately 7 ft BGL. These results verify the positive vertical head between the intermediate and upper aquifer and confirm that there is no pathway for downward migration of contaminants. This interpretation was confirmed by the lack of contamination in MW11L.

Evaluation of analytical data for metals and anions in the ground water reveals that the general water quality of the shallow aquifer on the facility is very poor, approaching brine conditions. The metals are considered to be naturally occurring because the concentrations do not differ significantly across the facility, and regional studies indicate that the general water quality is poor due to high concentrations of dissolved metals. Hoffman et al. (1990) reported dissolved solid concentrations ranging from 12,800 mg/L to 70,700 mg/L for six ground-water wells in the area. Exceptions are noticed locally near fresh water recharge zones associated with irrigation ditches and drains.

3.4.2.2 Second Iteration Activities

Preliminary evaluation of the laboratory data, field data, and discussions with HAZWRAP, Navy, and NDEP personnel led to the conclusion that some additional field work was needed at Site 1. Based on the results of the first iteration of IR Program field work, additional investigations were recommended to collect the data needed to complete the site characterization and risk assessment. The following observations from the first iteration of characterization activities led to the recommendations. First, solvent-related compounds form the distal portion of the ground-water plume, with most of the PHC compounds contained within the central part of the plume. Thus, further assessment of the concentration gradients of contaminants in soil and water within the plume was recommended. Second, the solvents [TCE and 1,2-dichloroethene (1,2-DCE)] detected at the site have the potential of forming a DNAPL plume. Therefore, a recommendation was made to further assess the presence of DNAPL by testing the ground water closer to the source of contamination.

For the second iteration of characterization at Site 1, an additional upgradient well was recommended. The well was designed as a 5-in.-diameter pumping well for aquifer testing, and four piezometers were to be installed around the well as observation points. The 5-in. well was designed to be fully penetrating and fully screened. Two additional monitoring well pairs were recommended for installation within the boundaries of the identified plume. One well pair was to be placed within the old fire pit to check for free-phase product on the ground water and sinking product at the bottom of the shallow alluvial aquifer. The other well pair was to be placed outside the fire pit, but inside the plume, in order to identify contaminant concentration gradients within the plume. Each well pair was to include one shallow well screened across the water table surface to assess floating contaminants, and one well to be completed at the bottom of the shallow aquifer to check for sinking contaminants.

If free-phase product was detected on the ground water under the old fire pit, three piezometers were to be installed around the area to assess the extent of the free-phase product plume. Ground-water test holes were to be drilled at all proposed well and piezometer locations prior to well installation to ensure optimum well placement. The proposed well locations were to be modified accordingly.

All work was to be performed in accordance with the work plan with respect to drilling, installing, and sampling wells. Two rounds of ground-water samples were to be collected from the proposed new wells. Wells with free product would require sampling only once. The first round of samples was to be collected shortly after completion of the wells, and the second round was collected about 3 months later, after receipt of the data from the first round.

For the second iteration of characterization at Site 1, six ground-water test holes were drilled in order to select the locations for monitoring wells. The results indicated that free product was present southwest of the fire pit.

The first well pair installed during the November 1991 drilling was MW50 U&L. Layne Western Environmental from California performed the drilling with a CME-75 hollow stem auger rig. Free product was encountered at the site and has since been measured at over 1 ft thick in MW50U (see Appendix H, Table H.3). This was the first confirmed, measurable product encountered at Site 1. Field screening of the soil samples from the capillary fringe indicated highly contaminated soil; however, no contamination

what does
this mean?

was indicated in the vadose zone or at the bottom of the aquifer. Because the contamination in the soil appeared to be related solely to the free-phase product on the ground water, no soil samples from these wells were submitted for laboratory analysis.

Water samples collected from MW50 U&L were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from the first round of sampling indicated that MW50L contained 90 $\mu\text{g/L}$ of HBPHCs as JP-5 and no SVOCs and VOCs. Results from the second round of sampling reported HBPHCs at a concentration of 70 $\mu\text{g/L}$. Results for SVOCs and VOCs were again reported as no compounds detected. The absence of detectable solvents in MW50L confirms the absence of a DNAPL plume at the site. MW50U reported 590 $\mu\text{g/L}$ HBPHCs as diesel fuel, 840 $\mu\text{g/L}$ LBPHCs as gasoline (benzene 27 $\mu\text{g/L}$, toluene 20 $\mu\text{g/L}$, and xylenes 9 $\mu\text{g/L}$), TCE at 69 $\mu\text{g/L}$, and 1,1-dichloroethene (1,1-DCE) at 28 $\mu\text{g/L}$. It should be noted that care was taken not to include free product in the water samples obtained from MW50U. This was accomplished by lowering a 3-ft bailer below the surface of the product and collecting a sample by using an adapter fitted to the bottom of the bailer.

The second well pair, MW51 U&L, was installed inside of the former fire pit. No free product was encountered; however, based on field screening, the soils were contaminated from the surface to the water table. The bulk of product encountered in MW50U and in the three subsequently installed piezometers, PZ1-7, PZ1-8, and PZ1-9, probably originated at the fire pit and migrated to the southwest as the result of a localized water-table gradient. Some product may also have originated from the fuel storage tank and pipelines. Because soil samples from a number of soil borings drilled in and around the fire pit had already been submitted for laboratory analysis, no additional samples were deemed necessary to characterize the soil contamination.

Water samples collected from MW51 U&L were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Water from the first round of sampling at MW51L contained 160 $\mu\text{g/L}$ of HBPHCs as JP-5 and 120 $\mu\text{g/L}$ of LBPHCs as gasoline. Results from the second round of sampling were reported as 70 $\mu\text{g/L}$ of HBPHCs as JP-5. No solvents were detected. Care was taken during sampling to obtain samples from near the bottom of the well to test for sinking contaminants. Results for MW51L indicate that no sinking product plume is present. First round results for MW51U reported 32 mg/L (32,000 $\mu\text{g/L}$) HBPHCs as diesel fuel, 6.1 mg/L (6,100 $\mu\text{g/L}$) LBPHCs as gasoline (including benzene

800 $\mu\text{g/L}$, toluene 490 $\mu\text{g/L}$, xylenes 560 $\mu\text{g/L}$, and ethylbenzene 100 $\mu\text{g/L}$, TCE at 690 $\mu\text{g/L}$, 2-butanone at 1100 $\mu\text{g/L}$, 2-hexanone at 91 $\mu\text{g/L}$, 4-methyl-2-pentanone at 2200 $\mu\text{g/L}$, acetone at 4400 $\mu\text{g/L}$, and numerous other PHC and solvent-related SVOCs. Two second round samples from MW51U reported results for HBPHCs of 72 mg/L (72,000 $\mu\text{g/L}$) and 41 mg/L (41,000 $\mu\text{g/L}$) respectively. Other second round results (from four samples) reported LBPHCs as gasoline from 1400 to 2300 $\mu\text{g/L}$ (including benzene 19 to 92 $\mu\text{g/L}$, ethylbenzene 7 to 41 $\mu\text{g/L}$, toluene 18 to 160 $\mu\text{g/L}$, and xylenes 38 to 240 $\mu\text{g/L}$). TCE was detected at levels ranging from 45 to 330 $\mu\text{g/L}$, along with other PHC and solvent-related VOCs and SVOCs.

The upgradient "clean" well, PW02, was installed on the northwest side of the Delta Taxiway in the area identified as having the most coarse-grained deposits found at the site. This was determined during lithologic observations from ground-water-test-hole screening. Four piezometers were installed around the well to use as observation wells for a pumping test. First round sample results from PW02 revealed HBPHCs as diesel at 70 $\mu\text{g/L}$. A pumping test was performed on April 14 and 15, 1992. The well produced only 2.5 to 3.0 gal/min at a sustainable rate. Drawdown in the pumping well was approximately 10 ft; however, very little drawdown was observed in the piezometers.

The severely reduced permeability at PW02 is probably due to the increased content of fine-grain material at this site. At Site 2 where 10 to 50 gpm pumping rates were obtained, the channel deposits were well sorted and coarser. Consequently, deposits surrounding well PW02 will not exert the same influence of ground-water migration as observed at Site 2.

Slug and bail tests were performed on the other wells at the site with the exception of MW50U, which had free-phase product. These results are included in Appendix E. Piezometer PZ1-10 was installed downgradient from MW15 to further assess the ground-water flow gradient at the site. It was installed as a fully screened piezometer suitable for ground-water sampling. A water sample was collected from near the bottom of the piezometer to check for TCE, which had been detected upgradient in MW15L at 23 $\mu\text{g/L}$. Results from the piezometer indicated TCE at 6 $\mu\text{g/L}$ and HBPHCs as diesel at 60 $\mu\text{g/L}$.

Sample results collected by Alpha Analytical, Inc. in October 1993, are presented in Appendix K.

3.4.3 Air

The atmospheric medium is not considered a concern because PHCs and solvents have not been disposed of at the site since April 1988. Thus, sufficient time has elapsed for mobile volatile contaminants at or near the surface to have dissipated, leaving concentrations below levels of concern. Ambient VOC measurements taken on site with a PID in the human breathing zone confirm no detectable airborne volatile contaminants.

3.5 CONTAMINANT FATE AND TRANSPORT

Phase II site-characterization activities indicate that the contaminants of concern at Site 1 are PHCs (primarily JP-5) and solvents. Results also indicate that the contaminated media of concern include the soils and shallow ground water underlying the site.

3.5.1 Contaminant Persistence

Chlorinated solvents such as TCE are persistent in an environment such as NAS Fallon. TCE does not undergo chemical degradation and is not significantly sorbed by the soil matrix.

Discussion of the fate and persistence of spilled jet fuel is not a simple matter because JP-5 is composed of many individual compounds with widely varying properties. Jet fuels are made by blending naphtha, gasoline, and kerosene, themselves mixtures of widely varying composition. For example, the distillation range of a similar jet fuel, JP-4, reportedly varies from 140 to 270° C, with component hydrocarbons ranging from C-4 to C-14 compounds. One typical analysis of JP-4 showed 61% alkanes, 29% cycloalkanes, 8% alkylbenzenes, 1% indans and tetralins, <1% naphthalenes, and up to 5% olefins. Another reference stated that JP-4's major components could be characterized as 63% alkanes, 16% cycloalkanes, 18% alkylbenzenes and benzene, and 3% naphthalene. This wide range in composition and classes of compounds means that the concentration of

individual compounds will also vary widely. For example, Roberts and Thomas (1986) have shown that the concentration of normal-decane varied from 0.81% to as much as 2.16% in different samples of jet fuel. Obviously, the environmental behavior of the individual compounds varies significantly.

3.5.1.1 Chemical Reactions of Fuel Hydrocarbons

Fuel hydrocarbons are composed of a host of individual compounds, most of which can be broadly classed as alkanes (e.g., *n*-octane) or aromatics (e.g., benzene). These compounds may undergo substantial biodegradation, but they are not subject to any chemical (non-biological) reactions of environmental significance.

3.5.1.2 Biodegradation

TCE can be biodegraded in the environment (Korte 1989). However, the conditions leading to biodegradation are apparently not present at NAS Fallon. Reducing conditions and soil organic matter are required. The lack of TCE biodegradation is also indicated by the fact that the common degradation products of TCE, which are 1,2-DCE and chloroethene, have not been reported in significant quantities.

In contrast to TCE, many of the components of JP-5 are easily biodegraded in an aerobic environment (API 1975; Atlas 1981). The actual amount of biodegradation is site specific because the microbes need both moisture and nutrients to thrive. Microbes are generally less active in ground water than in soil; however, biodegradation in aerobic ground water usually progresses indefinitely because there is a continuous supply of nutrients and moisture.

Recent work by numerous authors (e.g., Ward 1985) has demonstrated that there are indigenous microflora everywhere in the subsurface. Subsurface microorganisms have lower activities than do those in surface soils; however, subsurface microflora can effectively mineralize organic contaminants under aerobic conditions. Indeed, Wilson et al. (1985) have shown that biodegradation at the margin of the plume is often rapid.

Rifai et al. (1988) have modeled the biodegradation at an aviation fuel spill site. Their paper contains a thorough description of the factors governing the biodegradation of benzene, toluene, and xylene in the subsurface. In general, the mass loss due to biodegradation was most sensitive to the coefficient of reaeration from the water table, the coefficient of anaerobic decay within the contaminant plume, and the hydraulic conductivity. The *in situ* bioremediation field pilot study being conducted at Site 2, the New Fuel Farm, has demonstrated an apparent increase in biodegradation when air is supplied to the subsurface. However, the low hydraulic conductivity in the fine-grained zones at NAS Fallon limits the amount of intrinsic biodegradation. The possible rate at which biodegradation can occur is regulated by the transport of oxygen to the system.

The above explanation is supported by the work of Wilson et al. (1987). These authors studied an aviation fuel spill in Michigan and found that the heart of the plume contained high concentrations of methane and alkylbenzenes with no detectable oxygen. The heart of the plume was surrounded by an anaerobic zone of biological activity with greatly reduced concentrations of alkylbenzenes and no oxygen. This anaerobic zone was surrounded by an aerobic region with detectable oxygen and even greater reductions in alkylbenzene concentrations. A renovated or pristine zone surrounded the aerobic zone of treatment with high concentrations of oxygen and no detectable contaminants.

At the Crash Crew Training Area, biodegradation is inhibited by the presence of free-phase product. The free product is toxic to subsurface microbes and will not be biodegraded except at the fringe of the affected area; therefore, the JP-5 in the subsurface at this site will persist indefinitely without outside intervention.

3.5.2 Potential Routes of Migration

A synopsis of media-specific contaminant transport pathways, assimilation routes, exposure points, and affected biota for NAS Fallon is given in Appendix D. The following paragraphs expand on these evaluations in light of the characterization activities completed during Phase II of the IR Program at Site 1.

Direct exposure pathways for contaminated soils at Site 1 include dermal contact, ingestion, and inhalation of dust particles and volatile constituents. Potentially affected biota include indigenous plants and burrowing animals as well as any personnel associated with activities conducted at this location (fire training exercises are no longer conducted in this vicinity). No future construction or maintenance activities are anticipated with the exception of remediation activities. Plant and animal populations are controlled on NAS Fallon property; thus, exposures associated with these biota are minimized. The fact that most of the contamination is in the subsurface also prevents contaminated soils at Site 1 from constituting a primary exposure pathway.

Direct exposure pathways for ground water include use of contaminated ground water extracted from the shallow aquifer and intermediate aquifer. The shallow aquifer is not pumped on NAS Fallon property and, due to its high salinity, is used for human consumption in only two out of sixteen households in the area surrounding the base (Appendix D). Both of these wells are located east of the facility and are not downgradient from any contaminant plumes. Twelve wells tapping the shallow aquifer and ten wells tapping the intermediate aquifer are known to exist within a radius of two miles on the down-gradient (southeast) side of the base. The uses of these wells range from two that are used for drinking water to four which are not used at all due to naturally poor water quality.) site 6

Available site-characterization results indicate that, due to an upward flow gradient between the intermediate and shallow aquifers, contaminants are not migrating into the intermediate aquifer or into the deep basalt aquifer (Appendix E). Additionally, a confining clay layer approximately 20 ft thick is known to exist between the contaminated shallow aquifer and the intermediate aquifer. All monitoring well boreholes drilled during the RI of the 21 sites were drilled down to this clay layer, confirming its existence over the entire facility. The depth to the clay layer varied from 10 to 25 ft BGS across the facility. It is believed that these natural containment mechanisms prevent contaminants from reaching the intermediate aquifer.

Inspection of the drainage system (Fig. 2.2, p. 2-11) and the ground-water elevation map (Fig. 3.2, p. 3-5) associated with the site indicates that the plume from Site 1 would intersect the LD Drain long before approaching any downgradient wells. Ground water that flows under the drains could potentially, over a very long period of time, reach downgradient ground-water wells or Carson Lake Pasture several miles to the south; however, most of the contaminants seem to be in the top 3 to 5 ft of the aquifer and are expected to remain there due to essentially horizontal laminar flow in the shallow aquifer. Thus, the contaminants would discharge into the drain rather than pass beneath it. In addition, given the distance (approximately 2000 ft) from Site 1 to the LD Drain, it is unlikely that contaminants would discharge into the drain at levels of concern. The lack of use of shallow ground water in the immediate vicinity and the natural containment properties associated with the regional ground-water flow system inhibit the shallow ground water from serving as a direct exposure pathway.

Ground-water discharge to the drain would generally occur only during non-irrigation periods, when the drain water level is low. If discharge should occur, it could be transported to Stillwater Point Reservoir a few miles east of the facility. Therefore, the most sensitive and critical pathway is the ground-water-to-surface-water connection in the drains and exposures to various inhabitants and users of the surface water (Appendix D). Potential off-site transport mechanisms include: 1) eventual seepage discharge of contaminated ground water and free product to surface water, and 2) discharge of contaminated surface water (from rainfall and human activity) to surface-water drainage systems.

3.5.3 Contaminant Migration

Table 3.3, p. 3-32, compares the mobility of TCE and some components of jet fuel (a discussion of the varied composition of jet fuel is presented in Sect. 3.5.1). Because there are so many types of compounds, migration rates of dissolved compounds are not easily predicted. Some of the jet fuel components, for example, are very volatile and will rapidly disperse in the atmosphere. Others, such as xylene, are not so volatile and will rapidly

Table 3.3. Comparison of mobility of TCE and certain components of jet fuel

Compound	Solubility, mg/L ^a	Log K _{oc}	Mobility in ground water classification ^b	Boiling point, °C ^a
Benzene	1780	1.93	high mobility	80.1
Ethylbenzene	150	2.6	low mobility	136.2
Hexane	13		low mobility	68.7
Cyclohexane	55		low mobility	81.0
Methylcyclohexane	14		low mobility	101
Naphthalene	30		low mobility	217.9
Nonane	0.07		very low mobility	151
Octane	0.7		very low mobility	125.7
Toluene	500	2.28	medium mobility	110.8
Trichloroethene	1100	2.10	medium mobility	87.0
Xylenes	158	2.59	low mobility	138-144

^a Source: Verschueren, K. 1983. *Handbook of Environmental Data on Organic Chemicals*. Second ed. VanNostrand Reinhold Company, New York.

^b Source: Roy, W. R., and R. A. Griffin. 1985. Mobility of organic solvents in water-saturated soil materials. *Environmental Geology and Water Sciences*, 7(4):241-247.

K_{oc} = partition coefficient (K_p) + fractional mass of organic carbon

migrate through the soil to the water table. For example, Aurelius and Brown (1987) have shown that even if volatilization is significant, some spilled xylene will migrate rapidly to the water table. Moreover, if the soil is moist, a greater percentage of the spilled components will flow to the water table. The increased leaching with higher soil moisture is due to water filling the smaller soil pores and then repelling the spilled hydrocarbons. The repulsion effect and the hydrocarbons' lower kinematic viscosity results in rapid flow in the larger pores. It has been reported that these phenomena result in migration to the water table 10 to 1000 times faster than water.

Once fuel hydrocarbons come in contact with the water table, most will remain in the capillary fringe because they are either lighter than water or immiscible. These compounds are considered to be highly mobile in the environment, but because they are so easily biodegraded and volatilized, their cumulative effect is generally quite small. Xylenes and other aromatics are most likely to dissolve in the ground water and be conducted from the spill area.

3.6 BASELINE RISK ASSESSMENT (BRA)

The risk assessment for Site 1 is presented in the BRA (Volume III of the RI Report).

It is important to note that the BRA is simply a screening tool. By using the highest contaminant concentration as the exposure level, the risk assessments are worst-case scenario. Therefore, on the basis of a conservative risk calculation, the BRA shows those sites that may require further consideration. If a site exhibits potential risk, the Navy will take mitigating action to ensure the site is environmentally safe. A risk assessment summary is presented in Sect. 3.7.

3.7 SUMMARY AND CONCLUSIONS

Soil - TPH contamination greater than the NDEP action level of 100 mg/kg, along with other petroleum-related compounds and solvents were found in the former burn pit. However, contamination rapidly dissipates outside of the pit. The only other soil contaminants at the site were low levels of VOCs found in the capillary fringe that were associated with a dissolved contaminant ground water plume. Thus, it is concluded that the preponderance of soil contamination at Site 1 is confined to the former burn pit.

The risk assessment for human health indicated that cancer risks for both current and future exposure scenarios were below the point of concern. The hazard index (HI) for non-carcinogenic effects for both current and future scenarios was also well below the point of concern. The HIs for ecological risk were above the point of concern for phytotoxicity, the mouse, and the peregrine falcon.

Ground Water - A dissolved contaminant plume containing petroleum constituents and solvents was identified. Also, free petroleum product was measured in wells at levels that exceed the NDEP action level for removal actions. The presence of a solvent-related DNAPL plume was investigated, but no evidence of one was found.

The risk assessment indicated no current exposure, thus no current risk, from the ground water. The future off-base scenario included the use of ground water for non-consumptive purposes only. Cancer risks for the scenario were above the point of concern. The inhalation of volatile compounds during household activities (e.g., dishwashing) contributes 97% of the risk. The HI for non-carcinogenic effects for the future use scenario was also above the point of concern. The HI for ecological risk was above the point of concern for phytotoxicity.

3.8 RECOMMENDATIONS

Soil - A removal action is recommended for the former burn pit area only. This recommendation is based on the following factors: 1) the NDEP action level for TPH in soils is exceeded, and 2) the HIs for some ecological risks are above the point of concern.

Ground Water - A removal action is required for free-product recovery because the NDEP action level is exceeded. Upon removal of free product, residual product in soils at and above the capillary fringe should be assessed.

4. SITE 3, HANGAR 300 AREA

4.1 SITE BACKGROUND

4.1.1. Site Description

The Hangar 300 Area, located in the west-central portion of NAS Fallon as shown on Fig. 1.2, p. 1-10, and Plate 1, consists of several separate areas: the north and south disposal areas, bowser disposal area, O/WS area, ground-support equipment (GSE) area, and the wells air start building area. Because of their relatively close proximity to each other, the areas are grouped together as a single site (Fig. 4.1, p. 4-2). In general, suspected contamination at each site is a result of the disposal of aircraft and vehicle maintenance wastes to unpaved ground surfaces adjacent to or near paved areas (Dames and Moore 1988).

The north and south disposal areas consist of unpaved, relatively level areas. The bowser area, located north of the apron and east of the drainage ditch, is a graveled, relatively level area. The O/WS area and adjacent drainage ditch are located just west of the bowser area. The ditch drains northeast and connects with a series of ditches intersecting the LD #1 Drain on the eastern boundary of the base. The wells air start building area is located between buildings 374 and 432. The partially unpaved GSE storage area is located just west of building 374.

4.1.2 Site History

The north and south disposal areas were used intermittently, between 1960 and 1981, for the disposal of waste aircraft fluids. The fluids were reportedly carried to the pavement edges or beyond and dumped on the ground surface. Approximately 4000 gal of fluids were disposed of at each site. The bowser area was used for disposal of waste aircraft fluids between 1960 and 1984. It is estimated that approximately 12,500 gal of

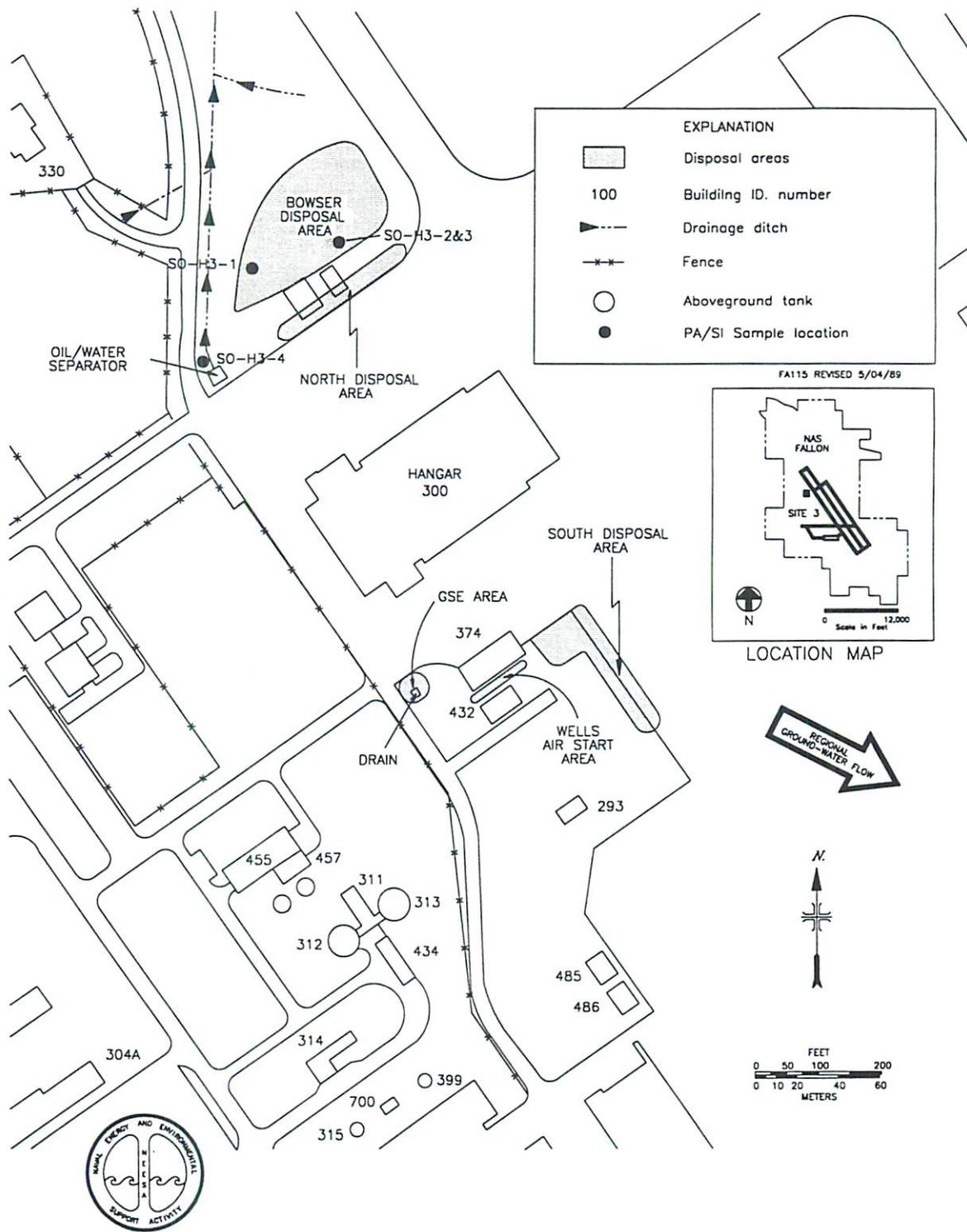


Fig. 4.1. Site 3, Hangar 300 Area.

Final

waste were disposed of in this area. Contaminants at these areas consisted of JP-5, hydraulic fluids, lube oil, and solvents including carbon tetrachloride, TCE, and PD-680 (stoddard solvent) (Dames and Moore 1988).

The O/WS received aircraft maintenance wastes as described above and aircraft cleaning solvents (Turco). It is estimated that as much as 3,000 gal of wastes may have gone to the separator. These wastes originated from the Hangar 300 floor drain and were discharged to the separator from 1960 to 1986. The equipment periodically malfunctioned, allowing wastes to bypass the separator and flow directly into the ditch.

The wells air start building area received compressor blowdown from the adjacent wells air start building area from 1978 to 1987. This blowdown, containing lube oil, was directed outside the building where it probably ponded or drained slightly to the west. It is estimated that approximately 750 gal of lube oil may have reached the unpaved area (Dames and Moore 1988).

The GSE area received waste fluids from spills and leaks from an adjacent storage area between 1960 and 1987. It is estimated that approximately 1,350 gal of fluids, similar to those disposed of in the north and south disposal areas, were released to the site.

4.1.3 Previous Investigations

During Phase I, PA/SI, of the IR Program, limited soil sampling was conducted in order to evaluate the potential for contamination at Site 3 (Dames and Moore 1988). Surface and shallow subsurface samples were collected from the bowser disposal area and in the drainage ditch near the O/WS (Fig. 4.1, p. 4-2). Samples were analyzed for TPHs by EPA method 418.1 and VOCs by EPA method 8240. The three samples from the bowser disposal area were collected from depths of 6 to 12 in. Two of the samples had TPH concentrations of less than 100 mg/kg (the NDEP action level) and undetectable levels of VOCs. The other sample (SO-H3-1) contained 15,000 mg/kg TPH and 710 $\mu\text{g}/\text{kg}$ total xylenes, the only VOCs detected.

One surface-soil sample (SO-H3-4) was collected in the drainage ditch immediately downstream of the O/WS. Concentrations of TPHs were 3100 mg/kg; however, no VOCs were detected.

The PA/SI recommended areas at Site 3 to be included in Phase II of the IR Program for the following reasons: probable soil contamination and possible ground-water contamination as a result of past disposal practices in the north and south disposal areas; confirmed local soil contamination in the bowser disposal area from analysis of samples; confirmed local soil contamination at the O/WS and drainage ditch from analysis of sample; visible soil contamination as a result of past disposal practices in the wells air start building area; visible soil contamination and possible ground-water contamination as a result of past disposal practices in the GSE storage area.

The PA/SI recommended additional soil sampling and the installation of ground-water monitoring wells at Site 3 areas. Recommended test parameters were TPHs, VOCs, and lead.

4.1.4 Investigative Approach

Samples of stained soils containing TPHs exceeding 100 mg/kg were viewed as verification that contamination existed at the site (Dames and Moore 1988). Some modifications to the work plan were made during the course of the investigation. These included the use of the ground-water-test-hole method, the modification of downgradient monitoring well locations, and the elimination of the proposed geophysical survey. Also, soil borings were drilled with a small, truck-mounted drilling rig instead of the hand auger specified in the work plan.

4.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

4.2.1 Surface-Water Hydrology

No permanent surface-water features are associated with Site 3. However, the drainage ditch associated with the O/WS drains northeast and connects with the LD #1 Drain. Also, the water-table elevation map for the site indicates potential ground-water discharge to the LD Drain, approximately 8,000 ft to the south.

4.2.2 Hydrogeology

The water-table elevation map of the monitoring wells used to complete the evaluation of the shallow alluvial aquifer is shown in Fig. 4.2, p. 4-6. Bail tests of the monitoring wells indicated hydraulic conductivities ranging from 0.24 ft/d to 15 ft/d. The ground-water gradient trends southeast across the site and is in agreement with the regional flow system. Depth to ground water at the site varies seasonally and ranges from 5.5 to 7.5 ft BGS (see Appendix H, Table H.3).

4.3 STUDY AREA INVESTIGATION

4.3.1 Surface-Water and Sediment Investigations

Three sediment samples were collected during Phase II from the ditch associated with the O/WS. The samples were taken from the top 6 in. of ditch sediment and sent to an off-site laboratory for analysis. Analysis parameters included HBPHCs, LBPHCs, SVOCs, VOCs, and metals.

4.3.2 Geological Investigation

The installation of monitoring wells MW38, MW39L, MW40, MW41L, MW42L, MW43L and MW44L facilitated obtaining the lithologic information for Site 3. Lithologic samples were obtained from these borings either by using a 5-ft continuous sampler or a 2-ft split-spoon sampler utilizing the California method. No lithologic descriptions were obtained from MW39U, MW41U, MW42U, and MW43U because they were installed within 3 ft of their respective lower completions. MW38, MW39, and MW40 were installed up-gradient from the site, while MW42 and MW43 were installed downgradient. Monitoring wells MW41 and MW44 were installed in areas under investigation for contamination. Well summary forms with well construction and lithologic descriptions can be found in Appendix F.

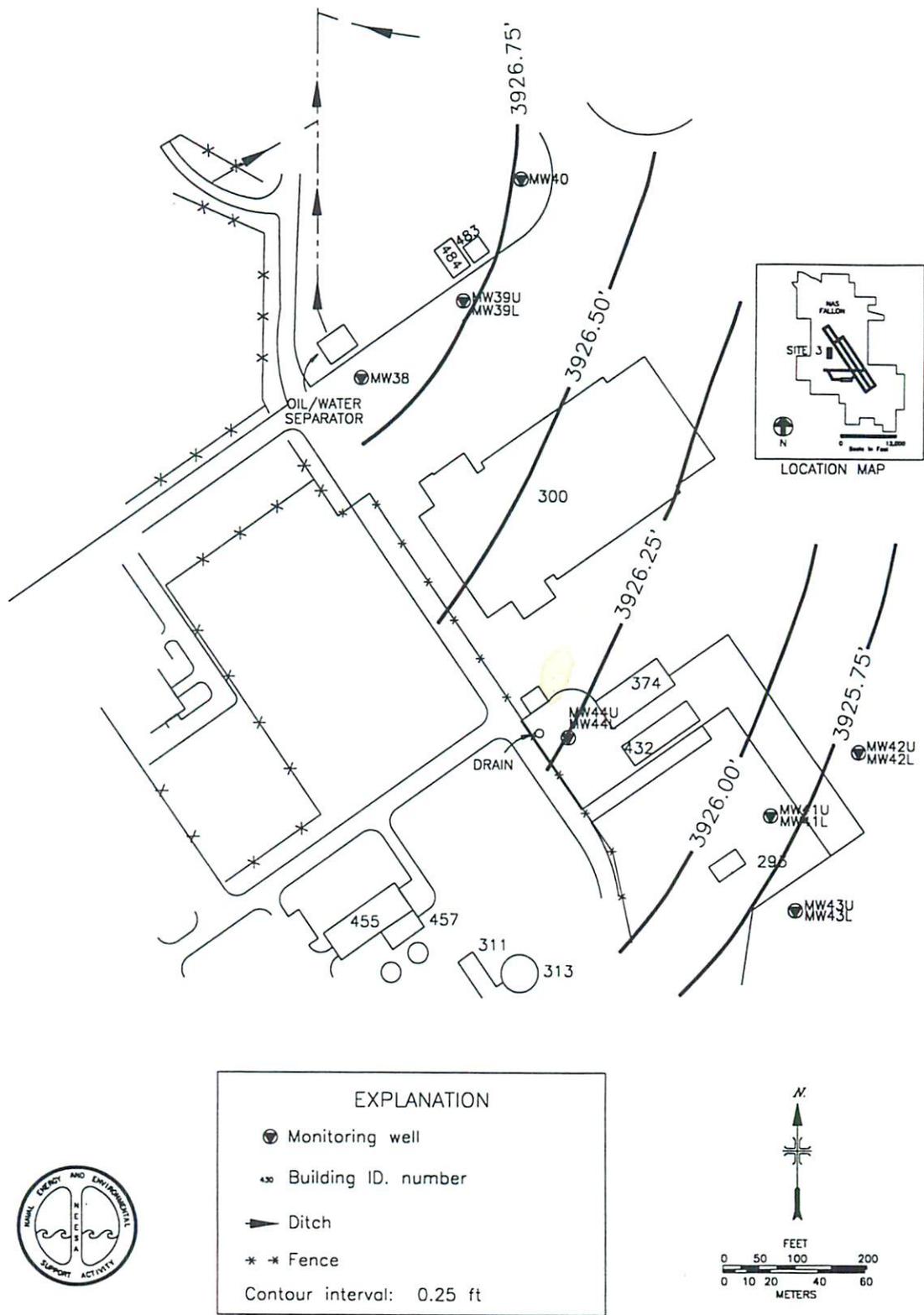


Fig. 4.2. Water-table elevation map for the shallow alluvial aquifer at Site 3 (measurements taken June 1991).

All wells installed at Site 3 penetrated the entire Fallon Formation, which had a thickness of 14 to 20 ft. All monitoring wells that were logged for lithology also penetrated the top of the Seho Formation (the Seho forms the aquitard between the upper and intermediate aquifers here as it does throughout the base). Figure 4.3, p. 4-8, graphically displays the simplified fence diagram constructed from the wells that were logged. The depositional environment is one of intermingled, near-shore deposits and shallow-lake deposits from the last expansion of Lake Lahontan, which affected this area during the Recent Epoch and subsequent channel development. The upper 20 ft of these wells have predominantly very fine grained sands interbedded with sandy silt and silty sands, all of which are very poorly graded. Monitoring wells MW38, MW44, and MW42, however, exhibit deposit characteristics of channel sediments, which had dissected the other sediments after deposition. The development of these channel deposits are very poor; channel thickness is 3 to 4 ft with widths less than 15 ft. The sediments are not coarse and are only moderately sorted. This most likely represents deposits created by dissection of beach sands by a low velocity stream such as those typically found near the mouth of a delta. Similar to other channel-type deposits found at NAS Fallon, this small anomaly trends northwest to southeast.

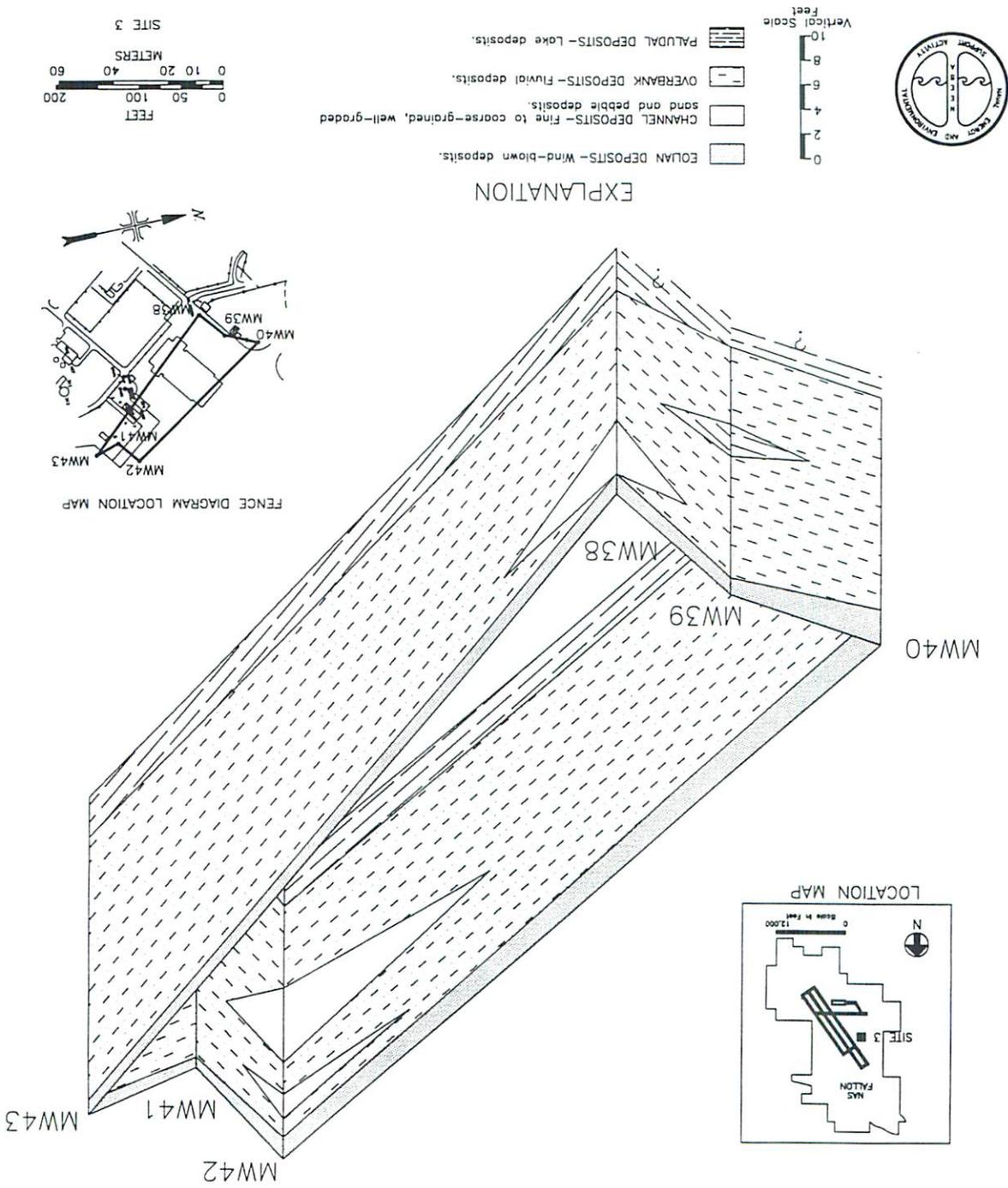
4.3.3 Vadose Zone and Soil Investigation

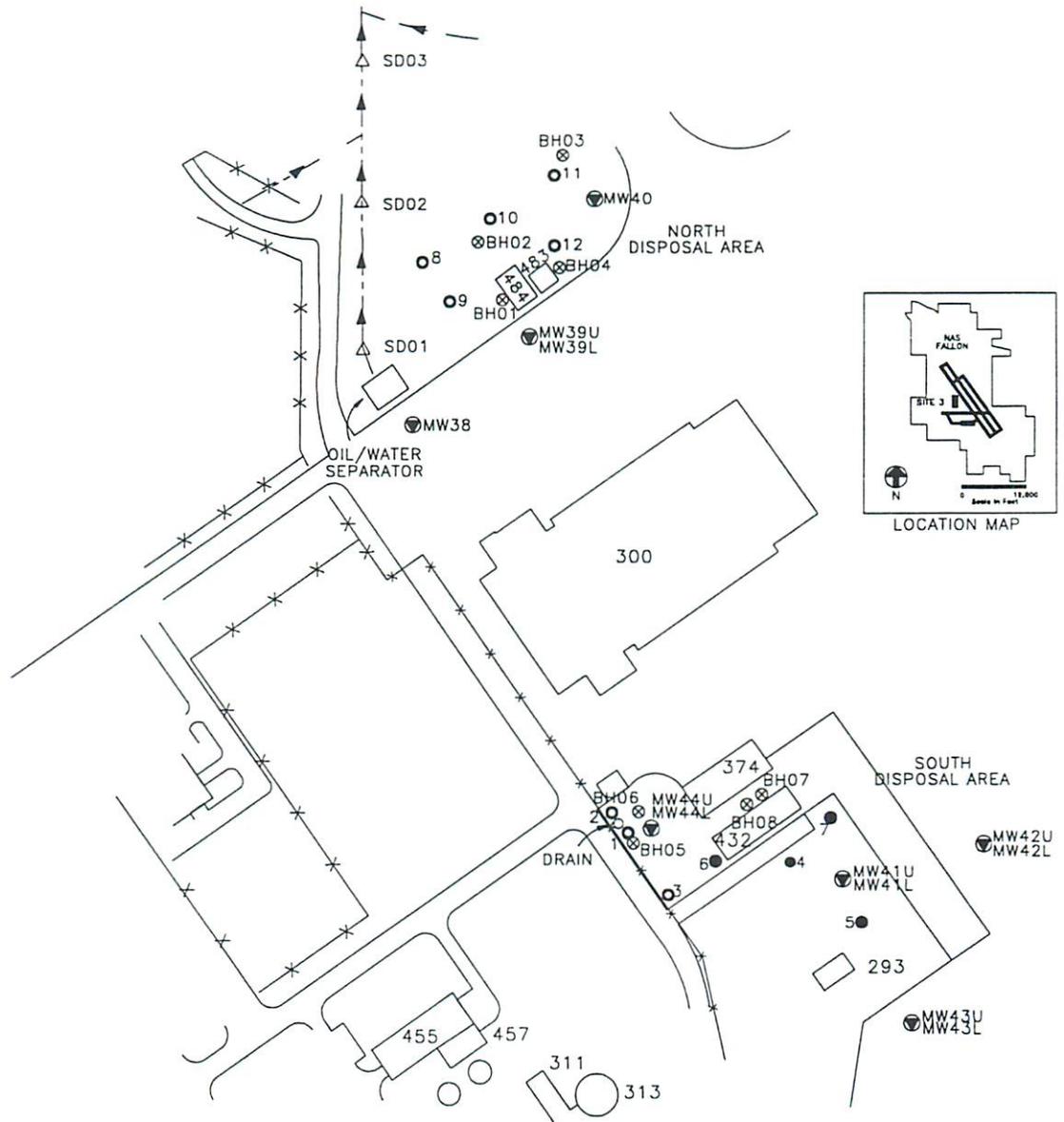
Eight soil borings were drilled at Site 3 during the first iteration of Phase II site characterization. Sampling locations are shown on Fig. 4.4, p. 4-9. Borehole numbers and sampling intervals are shown below.

<u>Borehole number</u>	<u>Sample Intervals, ft</u>	
BH01	0.0 to 2.0	5.0 to 7.0
BH02	0.0 to 2.0	5.0 to 7.0
BH03	0.0 to 2.0	5.0 to 7.0
BH04	0.0 to 2.0	5.0 to 7.0
BH05	0.0 to 2.0	2.0 to 4.0
BH06	0.0 to 2.0	2.0 to 4.0
BH07	0.0 to 2.0	2.0 to 4.0
BH08	0.0 to 2.0	2.0 to 4.0

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Fig. 4.3. Simplified fence diagram for monitoring wells installed at Site 3.



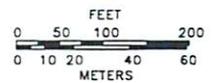


EXPLANATION

- MW43L ● Monitoring well
- ⊗ Soil boring locations
- Contaminated ground-water test hole
- Uncontaminated ground-water test hole
- △ Soil sediment sample location
- 430 Building ID. number
- Ditch
- * * Fence



N



FA207

Fig. 4.4. Site 3, Hangar 300 Area. Sample locations.

In addition to the borehole samples, soil samples were collected during the installation of monitoring wells MW38, MW39, MW40, MW41, MW42, MW43, and MW44. Samples from these wells were collected at 5 to 7 ft or 7 to 9 ft. All soil samples were analyzed for LBPHCs, HBPHCs, SVOCs, VOCs, and metals. No soil samples were collected at Site 3 during the second iteration of Phase II site characterization.

4.3.4 Ground-Water Investigation

The ground-water investigation at Site 3 involved boring twelve ground-water test holes and installing twelve monitoring wells. These activities were conducted during the first iteration of Phase II characterization. No second iteration ground-water investigations were necessary at Site 3. However, ground water was collected from monitoring wells during two separate rounds of sampling. Sample locations for Site 3 are shown on Fig. 4.4, p. 4-9.

The ground-water test holes were used to delineate a PHC and solvent plume on the ground water in the south area and to determine suitable locations for monitoring wells. Water samples from the monitoring wells were sent to an off-site laboratory and analyzed for LBPHCs, HBPHCs, SVOCs, VOCs, and metals. Also, samples were analyzed in the field for temperature, pH, and conductivity. Results of water-quality field measurements for all sites are presented in Appendix G.

4.4 NATURE AND EXTENT OF CONTAMINATION

4.4.1 Surface Water and Sediments

Three sediment samples were collected in the ditch associated with the O/WS (Fig. 4.4, p. 4-9). Only one sample had contaminant concentrations above regulatory levels. This sample, number SD02, contained 200 mg/kg TPHs (70 mg/kg HBPHCs, 130 mg/kg LBPHCs), thus exceeding the NDEP action level of 100 mg/kg TPHs (Appendix A). These results indicate that contamination is sporadic and of relatively low concentration.

4.4.2 Vadose Zone and Soils

Soil sample results are presented in Table 4.1, p. 4-12. Soil contamination at the site consists of PHC-related compounds and solvents. Several samples showed minor contamination by PHCs and other organic compounds, but none of the soil samples contained levels of contaminants exceeding the NDEP action level of 100 mg/kg TPHs in soils. Thus, it is concluded that soil contamination at the Site 3 areas (the north and south disposal areas, bowser disposal area, O/WS area, GSE area, and wells air start building area) is confined to small areas of relatively low concentrations.

4.4.3 Ground Water

Ground-water sample locations are shown on Fig. 4.5, p. 4-15. The figure also presents ground-water contaminant plume boundaries based on data obtained from laboratory analyses of ground-water samples.

The four wells drilled to assess ground-water contamination at the north area included one well completed at the base of the shallow aquifer, MW39L, and three wells screened across the top of the water table, MW38, MW39U, and MW40. Two rounds of sampling were conducted, one in April 1991 and one in August 1991. Some PHCs and related compounds were detected at relatively low levels in MW38 and MW39U; however, MW39L and MW40 were essentially clean with respect to all analytical parameters (Table 4.2, p. 4-16).

Eight wells were drilled to assess ground-water contamination at the south area. Because ground-water-test-hole screening had indicated TCE contamination (a compound that may sink in ground water if concentrations are sufficient), all wells were installed as pairs, with one well completed at the bottom of the shallow alluvial aquifer and one well completed at the top of the water table. Three of the well pairs, MW42U and L, MW43U and L, and MW44U and L, were specifically located to be on the outside of the limits of contamination detected by the test-hole method. The other well pair, MW41U and L, was purposely placed inside the plume to assess the concentration of contaminants within the plume. Two rounds of sampling were conducted, one in April 1991 and the other in

Table 4.1. Soil sample results for Site 3

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)	Volatiles, µg/kg (*4)
BH01 03/91	3658	0 - 2	20.00*J	U	Bis2 **	Methcl **
BH01 03/91	3659	5 - 7	U	U	Bis2 **	Methcl **
BH02 03/91	3660	0 - 2	U	U	Bis2 **	Methcl **
BH02 03/91	3661	5 - 7	U	U	Bis2 340.0*J	Methcl X ** 1.0*J
BH03 03/91	3662	0 - 2	U	U	Bis2 **	Acet Methcl 6.0*J **
BH03 03/91	3663	5 - 7	U	81.00	Bis2 Phena ** 89.0*J	Acet E Methcl X ** 32.0a 29.0 15.0
BH04 03/91	3664	0 - 2	U	U	Bis2 **	Methcl **
BH04 03/91	3665	5 - 7	U	U	Bis2 **	Acet Methcl 8.0*J **
BH05 03/91	3667	0 - 2	U	U	Bis2 **	Methcl **
BH05 03/91	3668	2 - 4	U	U	Bis2 **	Methcl **
BH06 03/91	3669	0 - 2	U	U	Bis2 **	Methcl **
BH06 03/91	3670	2 - 4	U	U	Bis2 **	Methcl **
BH07 03/91	3697	0 - 2	U	U	Bis2 140.0*J	Methcl **
BH07 03/91	3698	2 - 4	U	U	Bis2 360.0*J	Methcl **
BH08 03/91	3699	0 - 2	U	U	Bis2 140.0*J	Methcl **
BH08 03/91	3700	2 - 4	14.00	U	U	Methcl **
MW38 03/91	3596	5 - 7	U	U	Bis2 **	Methcl 30.0a
MW39 03/91	3597	7 - 9	U	U	Bis2 **	Methcl 29.0a

Table 4.1. Soil sample results for Site 3 (cont.)

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)		Volatiles, µg/kg (*4)	
MW40 03/91	3598	7 - 9	U	U	Bis2	**	Methcl	**
MW41 03/91	3599	7 - 9	U	U	Bis2	**	Methcl TCE	** 3.0*J
MW42 03/91	3601	7 - 9	U	U	Bis2	100.0*J	Methcl	**
MW43 03/91	3602	5 - 7	U	U	Bis2	83.0*J	Methcl	**
MW44 03/91	3603	5 - 7	U	U	Bis2	72.0*J	Methcl	**
SD01 03/91	3701	0-6 inches	U	U	Bis2	630.0*J	Acet Methcl	44.0a **
SD02 03/91	3702	0-6 inches	70.00	X 130.00 0.43	2-Meth Bis2 Naph	5000.0 1500.0*J 310.0*J	Acet Methcl T	20.0a ** 2.0*J
SD03 03/91	3703	0-6 inches	U	U	Bis2	190.0*J	Methcl	**

** - unusable data due to method blank contamination
a - suspected laboratory contaminant
*1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
*2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
*3 - EPA method 3550/8270, quantitation limit: 350 µg/kg
*4 - EPA method 8240, quantitation limit: 5 µg/kg
*J - concentration estimated
2-Meth - 2-methylnaphthalene
Acet - acetone
Bis2 - bis(2-ethylhexyl) phthalate
E - ethylbenzene

HBP - high boiling point
LBP - low boiling point
Methcl - methylene chloride
Naph - naphthalene
PHC - petroleum hydrocarbons
Phena - phenanthrene
T - toluene
TCE - trichloroethene
U - no compounds detected
X - xylenes (total)

Table 4.1. Soil sample results for Site 3 (cont.)

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg				
Compound	#	Average	Minimum	Maximum
Aluminum	19	7,434	2,280.00	18,600.00
Antimony	0	ND	ND	ND
Arsenic	19	7	1.20	25.50
Barium	19	71	29.60	154.00
Beryllium	18	0	0.15	0.61
Boron	18	16	1.40	67.10
Cadmium	3	1	0.79	1.20
Calcium	19	7,604	2,130.00	15,500.00
Chromium	19	7	2.60	12.90
Cobalt	17	6	3.10	12.90
Copper	19	31	7.60	97.60
Iron	19	12,865	5,210.00	26,100.00
Lead	19	8	1.70	38.70
Lithium	19	11	3.50	26.30
Magnesium	19	3,586	1,210.00	8,190.00
Manganese	19	262	113.00	889.00
Mercury	4	0	0.03	0.06
Molybdenum	2	5	2.50	7.50
Nickel	19	7	3.50	14.00
Potassium	19	1,761	393.00	3,920.00
Selenium	0	ND	ND	ND
Silver	7	1	0.69	2.50
Sodium	19	1,932	293.00	8,570.00
Thallium	0	ND	ND	ND
Vanadium	19	28	12.90	50.50
Zinc	19	50	24.70	106.00

- number of samples with detectable quantities of analyte
 ND - analyte not detected

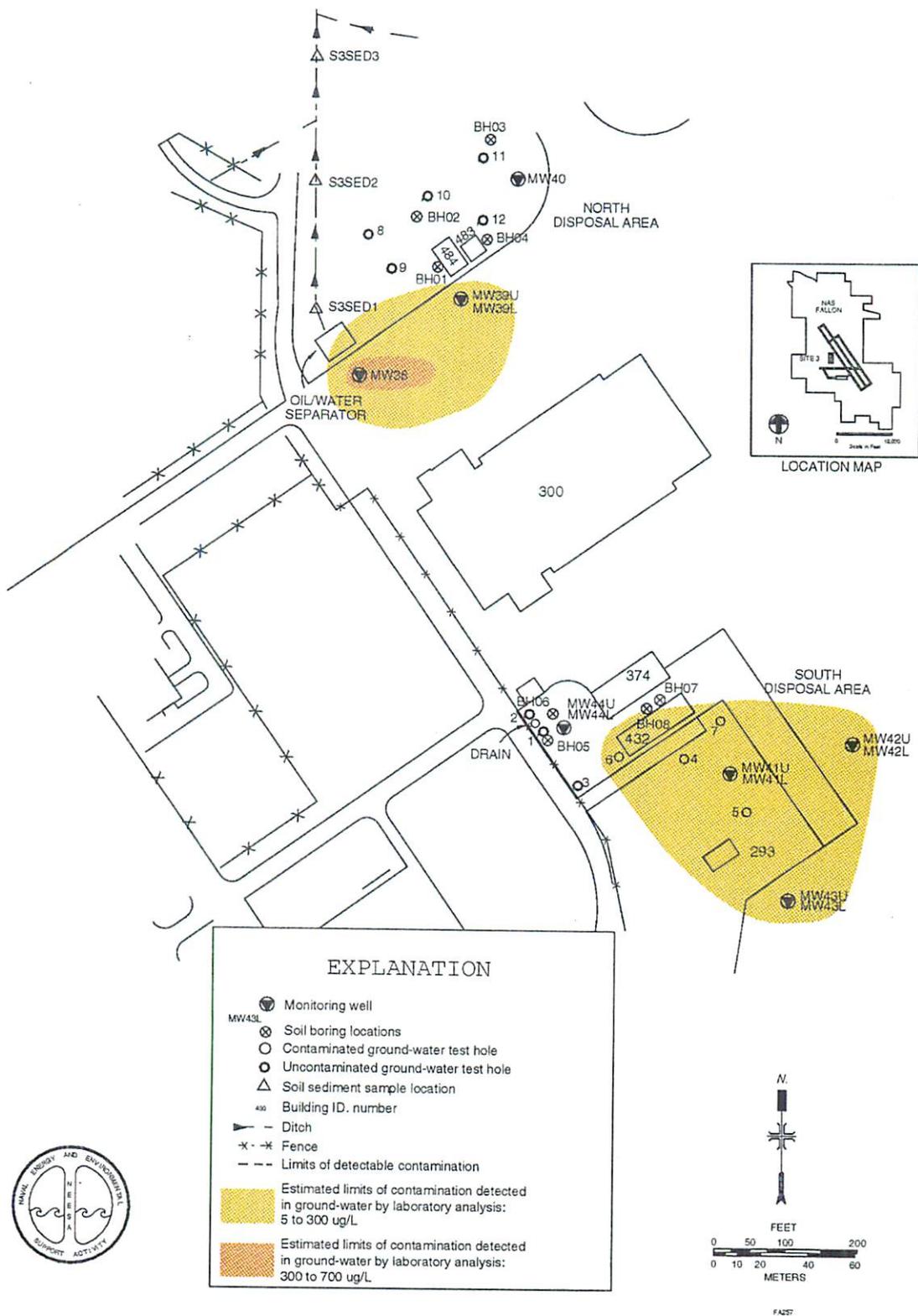


Fig. 4.5. Site 3, Hangar 300 Area. Contaminant boundary map.

Table 4.2. Water sample results for Site 3

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	PCB/Pesticide, µg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
MW38 04/91	3806	Die 310.0	Gas 200.0	NP	U	E 5.0
MW38 08/91	3871	Die 470.0	Gas X 340.0 1.0*J	NP	U	U
MW39L 04/91	3807	U	U	NP	U	U
MW39L 08/91	3868	U	U	NP	Bis2 **	U
MW39U 04/91	3808	Die 60.0	U	NP	U	U
MW39U 08/91	3869	Die 60.0	U	NP	U	U
MW40 04/91	3810	U	U	NP	U	U
MW40 08/91	3872	U	U	NP	U	U
MW41L 04/91	3797	U	U	NP	U	Methcl ** TCE 3.0*J
MW41L 04/91	3798	U	U	NP	U	Methcl ** TCE 3.0*J
MW41L 08/91	3866	U	U	NP	U	U
MW41U 04/91	3799	Die 90.0	Gas 160.0	NP	U	1,1DCE 2.0*J 1,2DCE 33.0 Methcl ** TCE 160.0
MW41U 08/91	3863	U	U	NP	U	1,1DCE 1.0*J TCE 120.0
MW41U 08/91	3864	U	Gas 250.0	NP	U	TCE 9.0
MW42L 04/91	3796	U	U	NP	U	Methcl **
MW42L 08/91	3862	U	U	NP	U	U
MW42U 04/91	3792	U	U	U	U	U
MW42U 08/91	3861	Die 60.0	U	NP	U	TCE 1.0*J

Table 4.2. Water sample results for Site 3 (cont.)

Location	Sample Number	Total HBP PHC, $\mu\text{g/L}$ (*1)	Total LBP PHC, $\mu\text{g/L}$ (*2)	PCB/Pesticide, $\mu\text{g/L}$ (*3)	Semivolatiles, $\mu\text{g/L}$ (*4)	Volatiles, $\mu\text{g/L}$ (*5)
MW43L 04/91	3793	U	U	NP	U	U
MW43L 08/91	3860	U	U	NP	U	Methcl **
MW43U 04/91	3794	Die 340.0	U	NP	U	Methcl **
MW43U 08/91	3859	Die 410.0	U	NP	U	U
MW44L 04/91	3805	U	U	NP	U	Methcl **
MW44L 08/91	3873	U	U	NP	U	U
MW44U 04/91	3800	U	U	NP	U	Methcl **
MW44U 08/91	3874	U	U	NP	U	U

** - unusable data due to method blank contamination

*1 - EPA method 8015 Modified, quantitation limit: 50 $\mu\text{g/L}$

*2 - EPA method 8015/8020, quantitation limit: 50 $\mu\text{g/L}$

*3 - EPA method 608, quantitation limit: 0.05 $\mu\text{g/L}$

*4 - EPA method 625, quantitation limit: 10 $\mu\text{g/L}$

*5 - EPA method 624, quantitation limit: 5 $\mu\text{g/L}$

*J - concentration estimated

1,1DCE - 1,1-dichloroethene

1,2DCE - 1,2-dichloroethene (total)

Bis2 - bis(2-ethylhexyl) phthalate

Die - HBP PHC as compared to diesel fuel

E - ethylbenzene

Gas - LBP PHC as compared to gasoline

HBP - high boiling point

LBP - low boiling point

Methcl - methylene chloride

NP - analysis not performed

PHC - petroleum hydrocarbons

TCE - trichloroethene

U - no compounds detected

X - xylenes (total)

Table 4.2. Water sample results for Site 3 (cont.)

Metals, µg/L EPA method 200.7 Quantitation limit: 1 µg/L				
Compound	#	Average	Minimum	Maximum
Aluminum	12	64	47.90	82.80
Antimony	7	40	32.20	46.90
Arsenic	13	1,306	80.10	4,430.00
Barium	13	23	13.30	85.30
Beryllium	0	ND	ND	ND
Boron	13	94,231	56,800.00	126,000.00
Cadmium	0	ND	ND	ND
Calcium	13	68,562	5,700.00	287,000.00
Chromium	0	ND	ND	ND
Cobalt	0	ND	ND	ND
Copper	13	48	27.80	84.80
Iron	13	28	17.40	37.60
Lead	0	ND	ND	ND
Lithium	13	378	113.00	638.00
Magnesium	13	156,777	16,800.00	359,000.00
Manganese	13	61	4.50	155.00
Mercury	2	0	0.20	0.36
Molybdenum	13	2,326	1,110.00	3,440.00
Nickel	0	ND	ND	ND
Potassium	13	203,985	81,800.00	337,000.00
Selenium	1	42	42.20	42.20
Silver	13	15	5.00	20.30
Sodium	13	11,880,769	6,870,000.00	17,200,000.00
Thallium	0	ND	ND	ND
Vanadium	13	196	39.00	581.00
Zinc	11	28	8.60	81.40

- number of samples with detectable quantities of analyte
 ND - analyte not detected

August 1991. Sample results for MW41U included TCE concentrations of 160 $\mu\text{g/L}$ and 120 $\mu\text{g/L}$ for the April and August samplings. MW41U also contained PHC contamination below regulatory levels and other solvent-related compounds; however, no free-phase or sinking product was measured. MW41L contained only some minor amounts of solvent-related organic compounds, thus indicating that no DNAPL plume is present. Sample results for MW42L, MW43L, and MW44U and L indicated no contamination during the two rounds of sampling. However, relatively low concentrations of HBPHCs (60 to 410 $\mu\text{g/L}$) were detected in MW42U during the second round of sampling and in MW43U during both rounds of sampling.

Sample results collected by Alpha Analytical, Inc., in October 1993, are presented in Appendix K.

4.4.4 Air

The atmospheric medium is not considered a concern at Site 3 areas because PHCs and solvents have not been disposed of since 1987. Thus, sufficient time has elapsed for mobile volatile contaminants at or near the surface to have dissipated, leaving concentrations below levels of concern. Ambient VOC measurements taken on site with a PID in the human breathing zone confirmed no detectable airborne volatile contaminants.

4.5 CONTAMINANT FATE AND TRANSPORT

Site-characterization activities indicate that the primary contaminants of concern at Site 3 are TPH-related wastes and solvents in the surface soils and shallow ground water.

4.5.1 Contaminant Persistence

See Sect. 3.5.1 for a discussion of the persistence of solvents and jet fuel.

4.5.1.1 Chemical Reactions of Fuel Hydrocarbons

See Sect. 3.5.1.1 for a discussion of the reactions of fuel hydrocarbons, including alkanes and aromatics.

4.5.1.2 Biodegradation

See Sect. 3.5.1.2 for a discussion of the biodegradation of solvents and jet fuel. There is no free-phase product at the Hangar 300 area to inhibit biodegradation. Consequently, it may be assumed that microbial activity is consuming the jet-fuel-derived hydrocarbons at the site. Because concentrations are low and contaminant locations sporadic, biodegradation rates may also be slow.

4.5.2 Potential Routes of Migration

A synopsis of media-specific contaminant transport pathways, assimilation routes, exposure points, and affected biota for NAS Fallon is given in Appendix D. The following paragraphs expand on these evaluations in light of the characterization activities completed at Site 3.

Potential exposure pathways for contaminated soils at Site 3 include dermal contact, ingestion, and inhalation of dust particles and volatile constituents. Affected biota include indigenous plants and burrowing animals as well as personnel associated with site excavation activities. Plant and animal populations are controlled on NAS Fallon property; thus, exposures associated with these biota are minimized. Restricted access and lack of surface-soil contamination further prevent contaminated soils at Site 3 from constituting a primary exposure pathway.

Direct exposure pathways for ground water include use of contaminated ground water extracted from the shallow aquifer and the underlying intermediate aquifer. The shallow aquifer is not pumped on NAS Fallon property and, due to its high salinity, is used for human consumption in only two out of sixteen households in the downgradient area

surrounding the base (Appendix D). Both of these wells are located east of the facility and are not downgradient from any contaminant plumes. Twelve wells tapping the shallow aquifer and ten wells tapping the intermediate aquifer are known to exist within a radius of two miles on the downgradient (southeast) side of the base. The uses of these wells range from two that are used for drinking water to four that are not used at all due to naturally poor water quality. The drinking-water wells are not downgradient from any IR Program sites.

Available site-characterization results indicate that, due to an upward flow gradient between the intermediate and shallow aquifers, contaminants are not migrating into the intermediate aquifer (Appendix D). Additionally, a confining clay layer is known to exist between the contaminated shallow aquifer and the intermediate aquifer. All monitoring well boreholes drilled during the RI were drilled down to this clay layer, confirming its existence over the entire facility. Depth to the clay layer varied from 10 to 25 ft BGS. The clay layer was approximately 20 ft thick at the three locations where it was completely penetrated (MW06L, MW11L, and MW12L). It is believed that these natural containment mechanisms prevent contaminants from reaching the intermediate aquifer.

The plume is not traveling toward the nearest ditch, the unnamed ditch at the north disposal area. Inspection of the drain system (Appendix D) and the ground-water elevation map (Fig. 4.2, p. 4-6) associated with the site, indicate that the plume from Site 3 is traveling toward the LD Drain 8,000 ft to the south and would intersect the drain long before reaching any downgradient wells. Ground water that flows under the drains could potentially, over a very long period of time, reach downgradient ground-water wells or Carson Lake pasture several miles to the south. However, most of the contaminants seem to be in the top 3 to 5 ft of the aquifer and are expected to remain there due to essentially horizontal laminar flow in the shallow aquifer. Thus, the contaminants would be more likely to discharge into the drain than to pass beneath it. Furthermore, the shallow ground-water plume would disperse and degrade naturally over the distance of 8,000 ft to the drain, removing any potential threat. It is, therefore, unlikely that the plume will ever discharge into the drain system or remain so concentrated as to pose a threat during the time it would take to travel in ground water to downgradient wells over two miles away.

The lack of use of shallow ground water in the immediate vicinity and the natural containment properties associated with the regional ground-water-flow system inhibit the shallow ground water from serving as a direct exposure pathway. Thus, without evidence of other pathways or exposure points, it was not necessary to collect additional subsurface data at the site.

Surface-water transport of surface-soil contamination from the site is possible via the unnamed ditch that joins the LD #1 Drain. Considering the scattered point-source nature of surface-soil contamination at the site and the infrequent occurrence of surface runoff, this transport mechanism did not warrant further investigation. The original O/WS at the site is out of service and is no longer connected to the hangar's floor drains. A new O/WS has been installed that discharges water to the sanitary sewer and is not associated with the unnamed drainage ditch.

4.5.3 Contaminant Migration

See Sect. 3.5.3 for a discussion of contaminant migration.

4.6 BASELINE RISK ASSESSMENT (BRA)

The risk assessment for Site 3 is presented in the BRA (Volume III of the RI Report). A risk assessment summary is presented in Sect. 4.7.

4.7 SUMMARY AND CONCLUSIONS

Soil - Several samples showed minor contamination by PHCs and other organic compounds, but none of the soil samples contained levels of contaminants exceeding the NDEP action level of 100 mg/kg TPHs in soils. Thus, it is concluded that soil contamination at Site 3 is confined to small areas of relatively low concentrations.

The risk assessment determined that cancer risks for both current and future uses are well below the point of concern. The human health HIs for both current and future uses are also well below the point of concern, as are the HIs for ecological risk.

Ground water - Two dissolved contaminant plumes were identified at Site 3, one in the north area and one in the south area. The north area plume was comprised of relatively low levels of PHCs and related compounds. Moderate levels of TCE and other solvents, as well as petroleum products, were identified in the south area plume. The risk assessment indicated no current exposure, thus no current risk, from the ground water. No future exposures are anticipated due to the fact that ground water will not be pumped on base. Also, natural attenuation of the contaminants over a 2-mile distance precludes future off-base exposures. Thus, it is concluded that there is no exposure from contaminants at Site 3.

4.8 RECOMMENDATIONS

Soil - No action is recommended based on the following factors; 1) contaminant concentrations do not exceed NDEP action levels, and (2) all risks are below the point of concern.

Ground water - No action is recommended due to the lack of current exposures and the improbability of future exposures from contaminated ground water at Site 3.

5. SITE 20, CHECKERBOARD LANDFILL

5.1 SITE BACKGROUND

5.1.1 Site Description

The Checkerboard Landfill is located in the southwestern corner of NAS Fallon near the boundary as shown on the general base map (Fig. 1.2, p. 1-10, and Plate 1). The site is on a nearly level area of open ground near the Checkerboard Building (Fig. 5.1, p. 5-2).

5.1.2 Site History

Waste-disposal activities at the Checkerboard Landfill consisted of the burial of an estimated 85,000 tons of wet garbage, trash, and rubble between 1951 and 1965. The site was the depository of the majority of solid wastes generated during this period. Sludge scraped from the wastewater treatment plant is also known to have been buried there. In addition, the disposal of approximately 1,400 gal of waste liquids, probably from the old vehicle maintenance shop and aircraft maintenance shop, may have occurred at the site. Burning of these liquids, primarily PHCs, may also have occurred (Dames and Moore 1988).

Landfilling at the site was conducted with bulldozers that constructed trenches across the site in an east-west direction. The depth of excavation is unknown. The trenches were subsequently filled with waste and then backfilled with soil. It is possible that excavations may have been of sufficient depth to deposit wastes below the water table.

5.1.3 Previous Investigations

The only previous investigation performed at the Checkerboard Landfill was Phase I, PA/SI, of the IR Program. The PA/SI consisted of a visual inspection and a records search for potential contaminants at the site. The Phase I study concluded that because

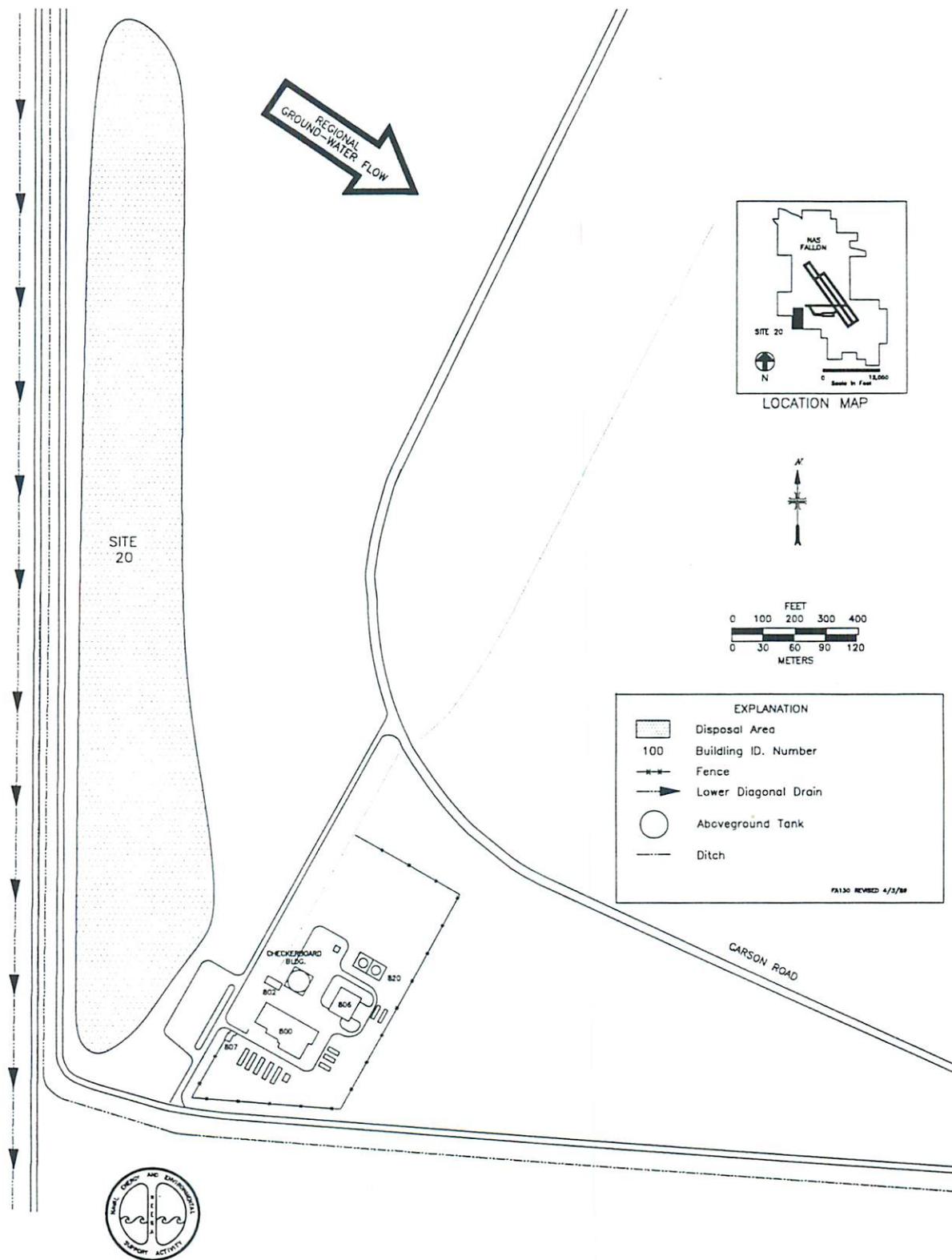
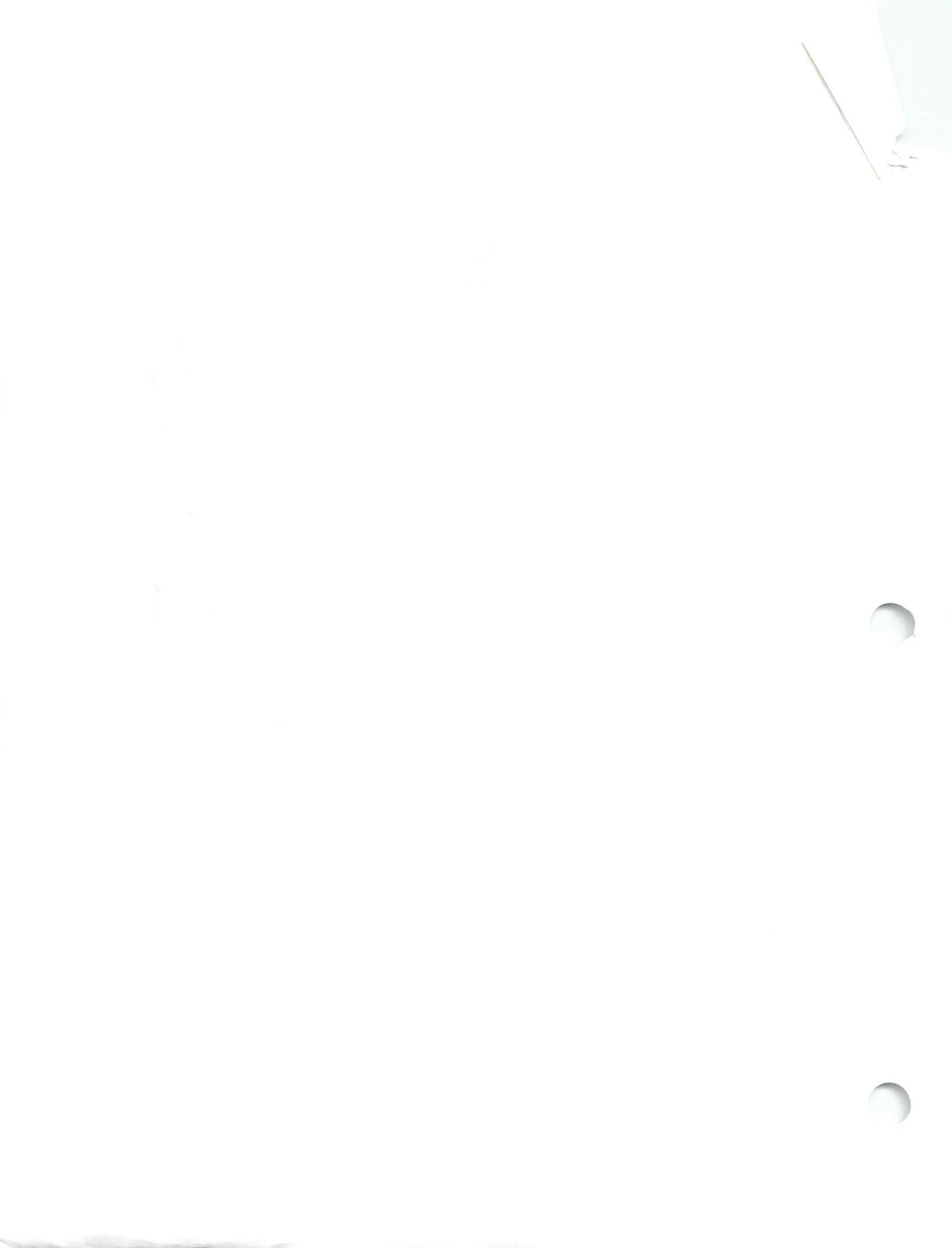


Fig. 5.1. Site 20, Checkerboard Landfill.



disposal of liquid hydrocarbons and other hazardous materials (paint wastes and metals) was suspected, soil and ground-water contamination in the area was likely (Dames and Moore 1988).

The PA/SI recommended soil sampling and the installation of ground-water monitoring wells at Site 20. Five wells were recommended; one upgradient, two in the disposal area, and two downgradient. Recommended test parameters were TPHs, VOCs, SVOCs, and metals.

5.1.4 Investigative Approach

Records indicating types and amounts of wastes disposed of at the site were regarded as verification that contamination existed. For this investigation, it was assumed that some soil contamination existed within the landfill area. However, characterizing the contents of a landfill is an impractical undertaking, and the important issue was whether or not contaminants were migrating from the site. Modifications to the work plan included use of the ground-water-test-hole method and slight changes in the locations of downgradient monitoring wells.

5.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

5.2.1 Surface-Water Hydrology

No surface-water features are associated with Site 20. However, the water-table elevation map (Fig. 5.2, p. 5-4) for the site indicates potential ground-water discharge to the LD Drain, approximately 500 ft to the south.

5.2.2 Hydrogeology

Characteristics of the shallow alluvial aquifer were evaluated using monitoring wells MW33U and L, MW34, MW35, MW36, and MW37. The water-level elevation map

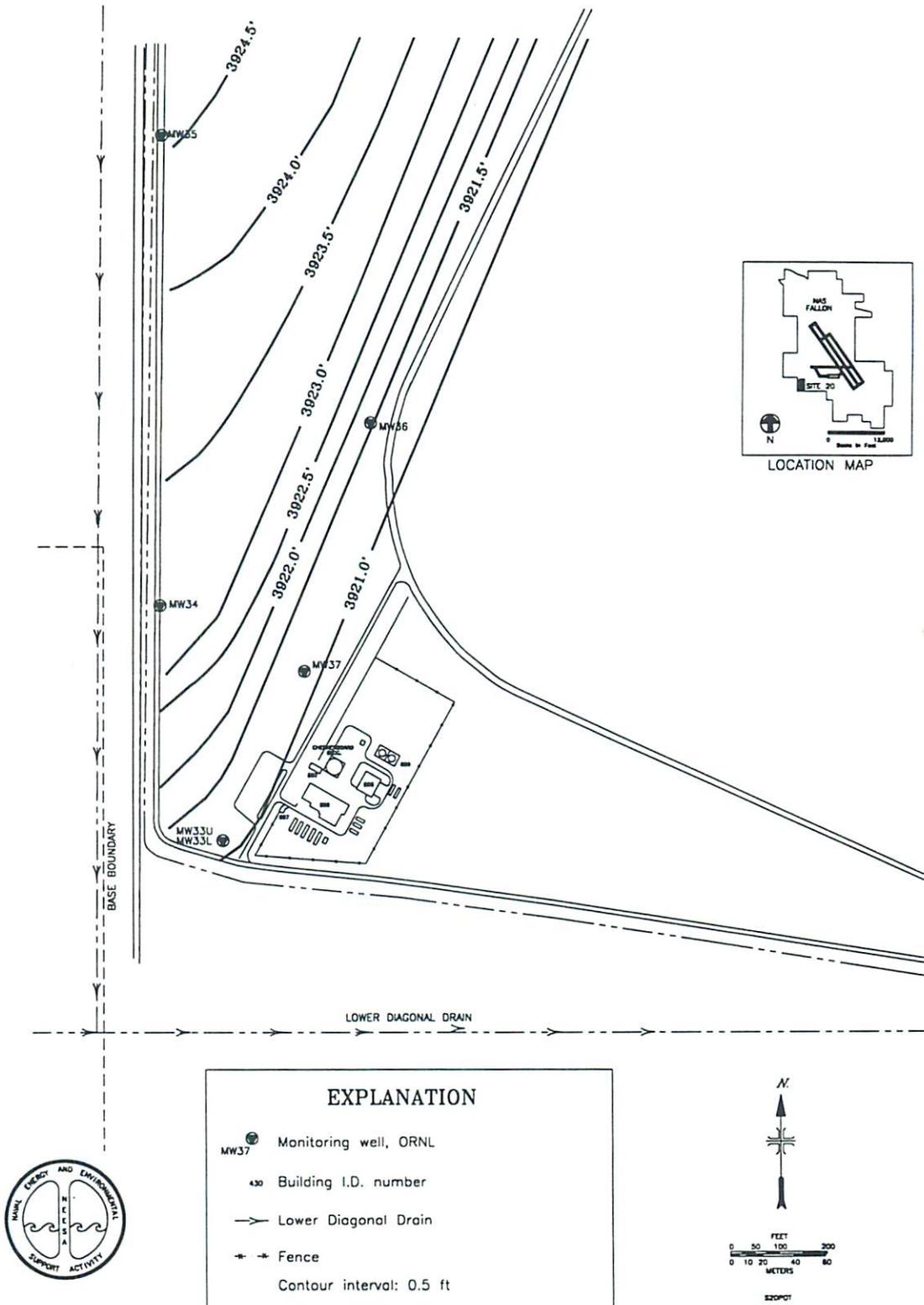


Fig. 5.2. Water-table elevation map for the shallow alluvial aquifer at Site 20 (measurements taken September 1991).

shown in Fig. 5.2, p. 5-4, displays a southeastern trending surface, which is consistent with the regional flow pattern. Hydraulic conductivities for these wells ranged from 0.3 to 3.9 ft/d. These ranges coincide with the lithology found in the monitoring wells. Water levels varied considerably across this site at different periods of the year. Depths to ground water varied from 3.0 to 7.5 ft (see Appendix H, Table H.3). During the irrigation season, the supply ditch west of the site raised water levels 2 to 2.5 ft in wells MW34 and MW35. Only small influences were observed in the monitoring wells on the downgradient side of the site.

$$v = \frac{K dh}{n dl}$$

$$h/L = \frac{0.0075}{10^{-1}} \left(\frac{50 \text{ ft}}{5 \text{ m}} \right)$$

$$v = \frac{0.08 \text{ ft}}{1 \text{ yr}}$$

5.3 STUDY AREA INVESTIGATION

5.3.1 Surface-Water and Sediment Investigations

Due to the absence of surface water, no sediment or surface-water samples were taken at Site 20.

5.3.2 Geological Investigation

The installation of monitoring wells MW33L, MW34, MW35, MW36, and MW37 facilitated the acquisition of lithologic information for this site. MW33U was not logged because it was installed 4 ft east of MW33L. Lithologic samples were obtained using a 5-ft continuous sampler advanced in front of the bit in a hollow-stem auger or by using a 2-ft split-spoon sampler utilizing the California method. Monitoring wells MW33, MW36, and MW37 were installed downgradient from the site; MW34 and MW35 were installed upgradient. Well summary forms with well construction and lithologic descriptions can be found in Appendix F. A simplified fence diagram constructed from lithology logs of the wells installed at Site 20 is shown on Fig. 5.3, p. 5-6. All wells were installed in the Fallon

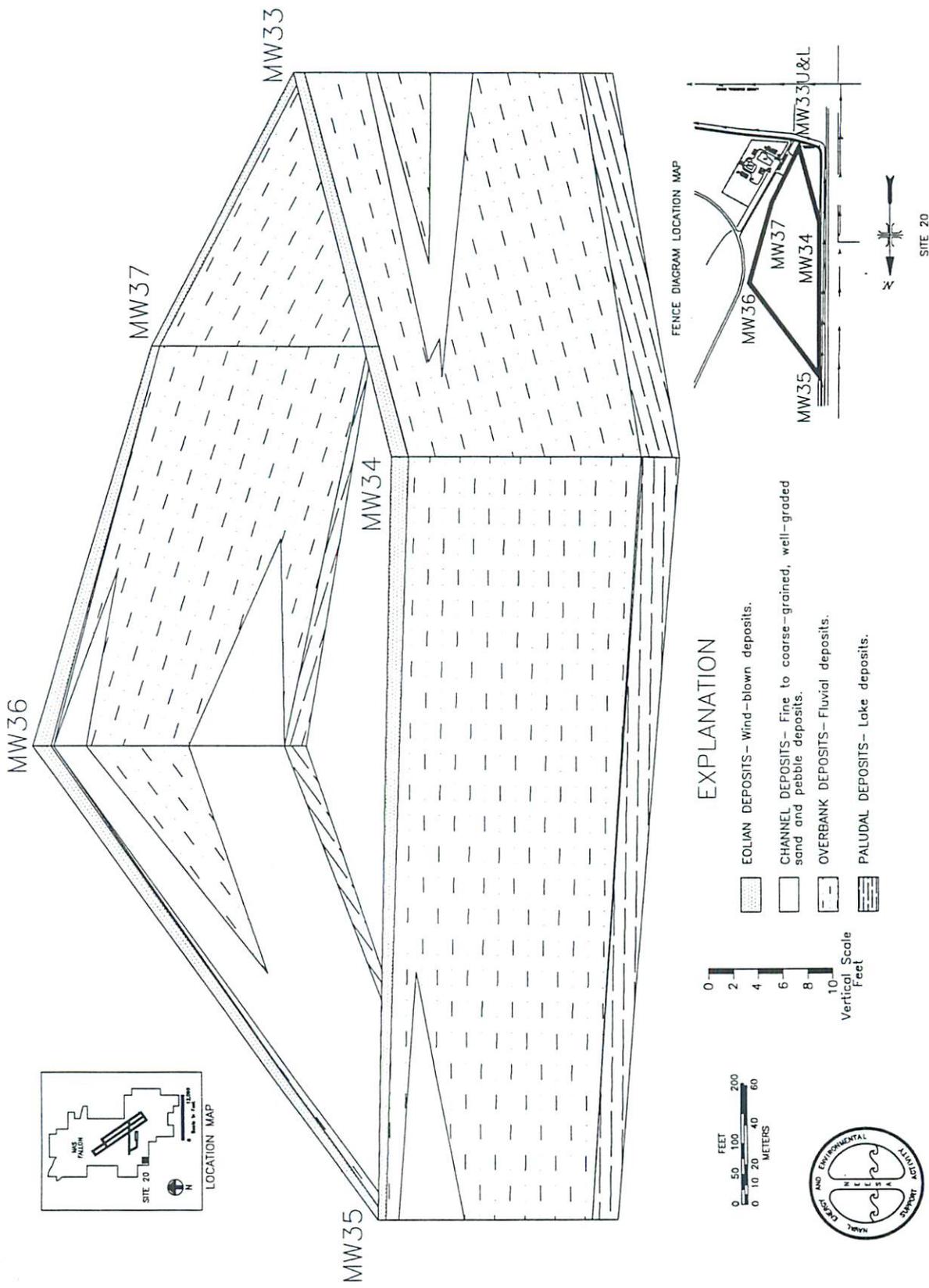


Fig. 5.3. Simplified fence diagram for monitoring wells installed at Site 20.

Formation. The sediments of the Fallon Formation are approximately 30 ft thick in this area. The Fallon Formation appears as interbedded fine-grained sands and sandy silts, indicating a beach and near-shore depositional environment.

5.3.3 Vadose Zone and Soil Investigation

No soil borings were drilled at Site 20; however, soils were screened during the drilling of ground-water test holes. Sample locations are shown on Fig. 5.4, p. 5-8. Also, soil samples were collected at the 5- to 7-ft interval during the installation of MW34 and MW35 and at the 7- to 9-ft interval during the installation of MW33 and MW36. Samples were sent to an off-site laboratory and analyzed for LBPHCs, HBPHCs, SVOCs, VOCs, and metals. Soil samples were collected from Site 20 during the first iteration of Phase II characterization activities only.

5.3.4 Ground-Water Investigation

The ground-water investigation at Site 20 involved boring 36 ground-water test holes and installing six monitoring wells (five shallow completions screened across the top of the water table and one deep completion screened at the bottom of the shallow aquifer). These activities were conducted during the first iteration of Phase II characterization. No second iteration ground-water investigations were necessary at Site 20. Ground-water-test-hole and monitoring well locations are shown on Fig. 5.4, p. 5-8.

The ground-water test holes were used to determine suitable locations for monitoring wells. Water samples from the monitoring wells were sent to an off-site laboratory and analyzed for LBPHCs, HBPHCs, PCB/pest, SVOCs, VOCs, anions, and metals. Also, samples were analyzed in the field for temperature, pH, and conductivity. Results of water-quality field measurements for all sites are presented in Appendix G.

5-8

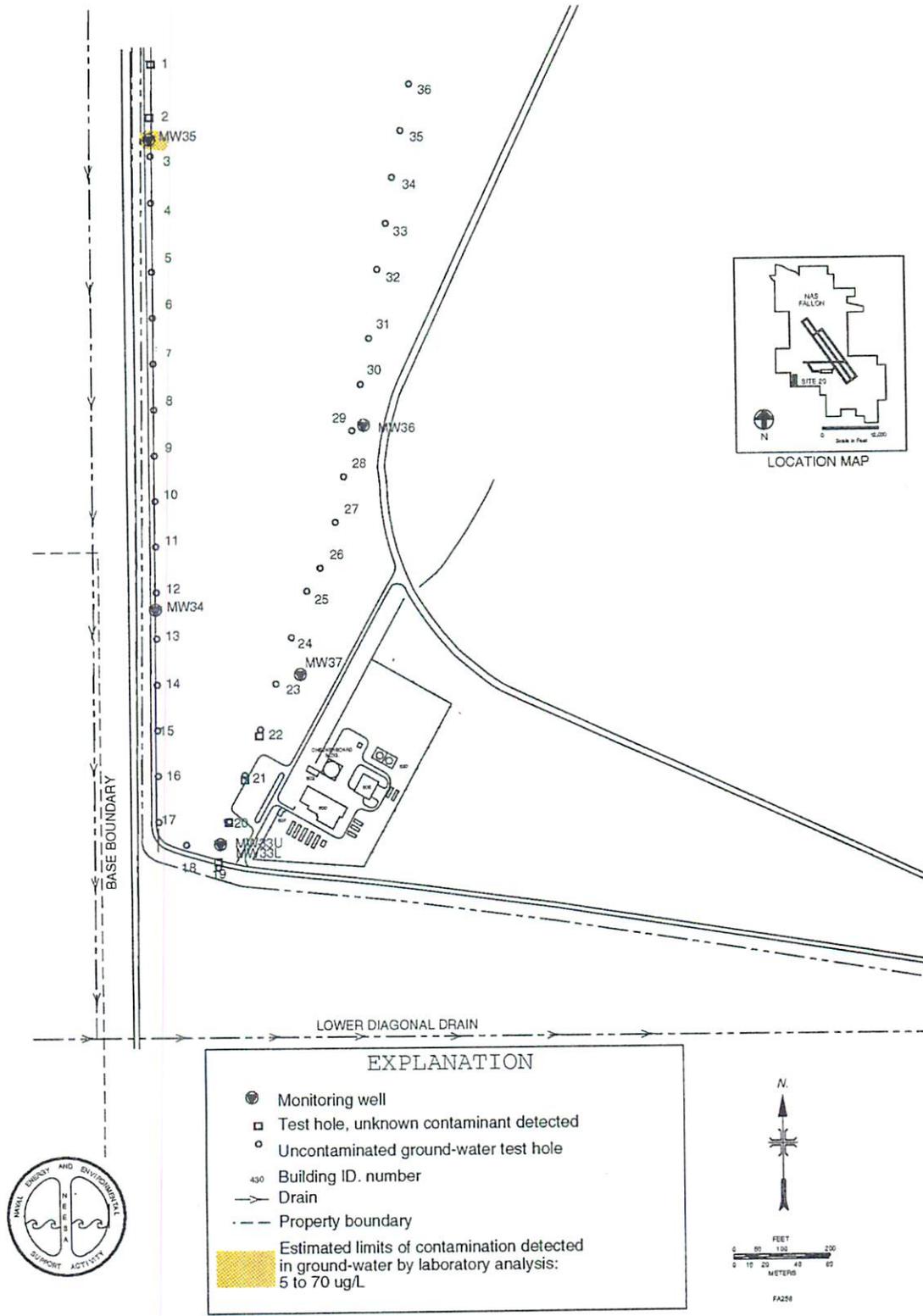


Fig. 5.4. Site 20, Checkerboard Landfill. Contaminant boundary map.

Final

5.4 NATURE AND EXTENT OF CONTAMINATION

5.4.1 Vadose Zone and Soils

Soil sample results are presented in Table 5.1, p. 5-10. No contaminants were reported in the samples. Thus, it appears that no contamination is present in the soils outside the landfill boundary.

5.4.2 Ground Water

did not screen for chlorinated HC

Ground-water sampling locations and contaminant boundaries are shown on Fig. 5.4, p. 5-8. No contamination was detected during screening of the ground-water test holes (Appendix C). However, PID analysis of six ground-water test holes did reveal contamination of an unknown type. It is surmised that the detected contaminants must have a very short retention time in the GC column and were thus not detected during screening. Another possibility is that the contaminants may have been present only in the vadose zone and were not detected by the ground-water testing. The characteristics of the detected contaminants are consistent with those of methane gas, which is commonly produced during the biodegradation of buried organic matter in land-fills; however, methane is not normally detected with a PID. A water sample was collected from one of the anomalous test holes and submitted for a complete GC/mass spectrometer laboratory analysis. The only compound detected was toluene at 2 ppb (parts per billion).

Two rounds of ground-water sampling were conducted, one in April 1991 and one in August 1991. No PHC contamination was detected in any of the water samples during the first round of sampling. However, one upgradient well (MW35) contained a detectable quantity of HBPHCs (72.0 $\mu\text{g/L}$ as diesel) during the second round of sampling. It is believed that the landfill is not the source of this contamination because the well is located just upgradient from the landfill boundary. No further investigation was conducted due to the fact that the contaminant was detected in only one round of sampling and was of relatively low concentration.

Table 5.1. Soil sample results for Site 20

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)	Volatiles, µg/kg (*4)
MW33 03/91	3590	7 - 9	U	U	Bis2 93.0*J	Methcl **
MW34 03/91	3592	5 - 7	U	U	Bis2 **	Methcl **
MW35 03/91	3593	5 - 7	U	U	Bis2 **	Methcl **
MW36 03/91	3594	7 - 9	U	U	Bis2 **	Methcl **

- ** - unusable data due to method blank contamination
 *1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
 *2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
 *3 - EPA method 3550/8270, quantitation limit: 350 µg/kg
 *4 - EPA method 8240, quantitation limit: 5 µg/kg
 *J - concentration estimated

- Bis2 - bis(2-ethylhexyl) phthalate
 HBP - high boiling point
 LBP - low boiling point
 Methcl - methylene chloride
 PHC - petroleum hydrocarbons
 U - no compounds detected

Voll TT
 Lab reports

5.4.3 Air

The atmosphere is not considered to be a contaminated medium of concern at Site 20 because burial of the wastes effectively contains contaminants in the subsurface environment. Ambient VOC measurements taken on site with a PID in the human breathing zone confirmed no detectable airborne volatile contaminants.

5.5 CONTAMINANT FATE AND TRANSPORT

Site-characterization activities indicate very little environmental contamination outside the landfill perimeter at Site 20. Although not detected during site-characterization activities, contaminants from PHC-related wastes, metals, and paints may be present but are not migrating. Contaminated media may include the soils within the landfill and possibly the shallow ground water underlying the facility, although sufficient time has elapsed since the waste disposal for most mobile or degradable compounds to have either disappeared or degraded.

5.5.1 Contaminant Persistence

There is little information regarding the contents of the Checkerboard Landfill. Furthermore, the site characterization conducted as part of this study demonstrated that contaminants are not migrating from the site. Consequently, a detailed discussion of contaminant persistence is unwarranted. Previous discussions regarding the persistence of solvents and fuels (see Sect. 3.5.1) are applicable to this site.

It should be noted, however, that because a landfill is heterogeneous, pockets of contamination could exist that are encapsulated (e.g., in original containers) or whose migration or biodegradation is otherwise inhibited by the surrounding waste. Contaminants in these circumstances would persist indefinitely. On the other hand, where fuels, solvents and paints are buried in low quantities, the heterogeneous nature of the landfill

could provide an ample carbon source and oxygen exchange for biodegradation. Indeed, some biodegradation is apparently occurring as suggested by field evidence for methane production from the landfill. Although some could be trapped in pockets within the landfill, the methane produced will migrate readily through the subsurface.

The landfill is also certain to contain concrete, rebar, wood, and various metallic objects. Much of this material will not degrade significantly and will persist in its present form indefinitely.

5.5.2 Potential Routes of Migration

A synopsis of media-specific contaminant transport pathways, assimilation routes, exposure points, and affected biota for NAS Fallon is given in Appendix D. The following paragraphs expand on these evaluations in light of the characterization activities completed at Site 20.

Direct exposure to contaminated soils at Site 20 would first require removal of the overlying backfill. If contaminants are exposed through excavation, exposure pathways for contaminated soils include dermal contact, ingestion, and inhalation of dust particles and volatile constituents. Affected biota include indigenous plants (with root systems deep enough to penetrate the overlying backfill) and burrowing animals, as well as personnel associated with site excavation activities. Because NAS Fallon is a restricted area, plant and animal populations at the site are controlled, and exposures associated with these biota are minimized. Direct exposure to the human populace is restricted to naval personnel, their families, and subcontractors. Health and safety measures requiring effective environmental monitoring, and environmentally safe construction practices further mitigate exposure to contaminated soils during on-site activities. Limited access and lack of surface-soil contamination thus prevent contaminated soils at Site 20 from constituting a primary exposure pathway.

Direct exposure pathways for ground water include use of potentially contaminated ground water extracted from the shallow aquifer and the intermediate aquifer. The shallow aquifer is not pumped on NAS Fallon property and, due to its high salinity, is used sparingly for human consumption in the surrounding area (Appendix D). Thus, direct exposures to contaminants through extraction of the shallow ground water in the area are believed to be minimal. Available site-characterization results indicate that contaminants are not migrating into the intermediate aquifer (Appendix D). The semiarid climate of the region also minimizes the potential for percolation of residual soil contaminants into the underlying saturated zone. Indeed, the numerous alkali flats in the surrounding area indicate a negative water balance for the region, which renders downward percolation unlikely.

As with the soils and potentially contaminated ground water associated with Site 20, surface water does not constitute a substantial direct exposure pathway. Due to the infrequency of surface runoff resulting from excessive precipitation and the fact that contaminants are contained in a buried state, little, if any, contaminant-transport potential exists.

Potentially contaminated ground water may, however, act as a source for contaminating surface water that could constitute an exposure pathway to downstream receptors. Furthermore, wastes deposited below the water table offer the potential of contributing dissolved contaminants to the surrounding ground water. Contaminants associated with the shallow ground water may then migrate downgradient for eventual seepage discharge into the surrounding drains.

Restricted access and institutional controls again minimize any surface-water exposures on NAS Fallon property. Contaminated surface water does, however, have the potential to transport contaminants off site to exposure points. As explained in Appendix D, off-site exposure points associated with surface water include recreational exposure, direct exposure to biota that inhabit contaminated surface-water channels and wetlands, secondary exposure to humans who consume contaminated biota, and exposures associated with the final deposition of contaminated waters into reservoirs and wetlands.

Seepage discharge of ground-water contaminants to off-site surface-water receptors is, thus, the primary exposure pathway for contaminants of concern at Site 20. The principal exposure pathway of concern is the regional surface-water system extending from the down-gradient (southeastern) edge of the facility to Stillwater Point Reservoir and the Stillwater National Wildlife Refuge. Inspection of the ground-water elevation map (Fig. 5.2, p. 5-4) and the surface-water drainage map shows that the shallow ground water is probably discharging into the LD Drain. However, lack of contaminants in the downgradient wells indicates that there is little reason for concern about surface-water contamination from this site. Based on the results of the investigation, there is no substantial ground-water contaminant plume at the site.

5.5.3 Contaminant Migration

No contaminants have been shown to migrate from the Checkerboard Landfill.

5.6 BASELINE RISK ASSESSMENT (BRA)

Quantitative risk assessments for soil and ground water were not conducted due to the absence of contamination.

5.7 SUMMARY AND CONCLUSIONS

Soil - No contamination was detected in soil samples collected from the perimeter of the landfill boundary. No quantitative risk assessment was conducted due to the absence of contamination.

Ground water - No contamination was detected in ground-water samples collected from downgradient wells at the landfill boundary. Thus, it is concluded that no contaminants are currently migrating from the site. Also, because no new material has been introduced to the site for nearly 30 years, it is unlikely that future migration of contaminants will occur. No quantitative risk assessment was conducted due to the absence of contamination.

5.8 RECOMMENDATIONS

Soil - Due to the absence of contamination outside the landfill boundary, no action is recommended.

Ground water - Based on the current lack of contaminant migration beyond the landfill boundary and the improbability of future migration, no action is recommended.

6. SITE 24, ROAD OILING AREA

6.1 SITE BACKGROUND

6.1.1 Site Description

The Road Oiling Area is located along the north, east and southeast boundaries of NAS Fallon as shown on the general site map (Fig. 1.2, p. 1-10, and Plate 1). Site 24 consists of perimeter roads that were oiled with waste oils, fuels, and solvents for dust control (Fig. 6.1, p. 6-2). The roads were formerly unpaved; however, portions are presently paved.

6.1.2 Site History

The unpaved perimeter roads were oiled during 1943 to 1946 and 1951 to 1981. Wastes disposed of included waste oils, hydraulic fluids, antifreeze, leaded gasoline, carbon tetrachloride, motor vehicle gasoline (mogas), JP-4, JP-5, TCE, and TCA. Waste liquids were transported from the shop area by bowsers, some of which were equipped with spray bars. The bowsers were then pulled around the perimeter roads and allowed to empty. An estimated 37,000 gal of waste were disposed of in this manner. Since termination of road oiling in 1981, portions of the disposal area along the north perimeter road have been paved (Dames and Moore 1988).

6.1.3 Previous Investigations

The only previous investigation performed at Site 24 was Phase I, PA/SI, of the IR Program. The PA/SI consisted of a visual inspection and a records search of the potential contaminants at the site. Based on the amount and type of liquid wastes disposed of at the site, the Phase I study concluded that soils and ground-water contamination was likely. The PA/SI recommended shallow soil sampling on the unpaved portion of the site.

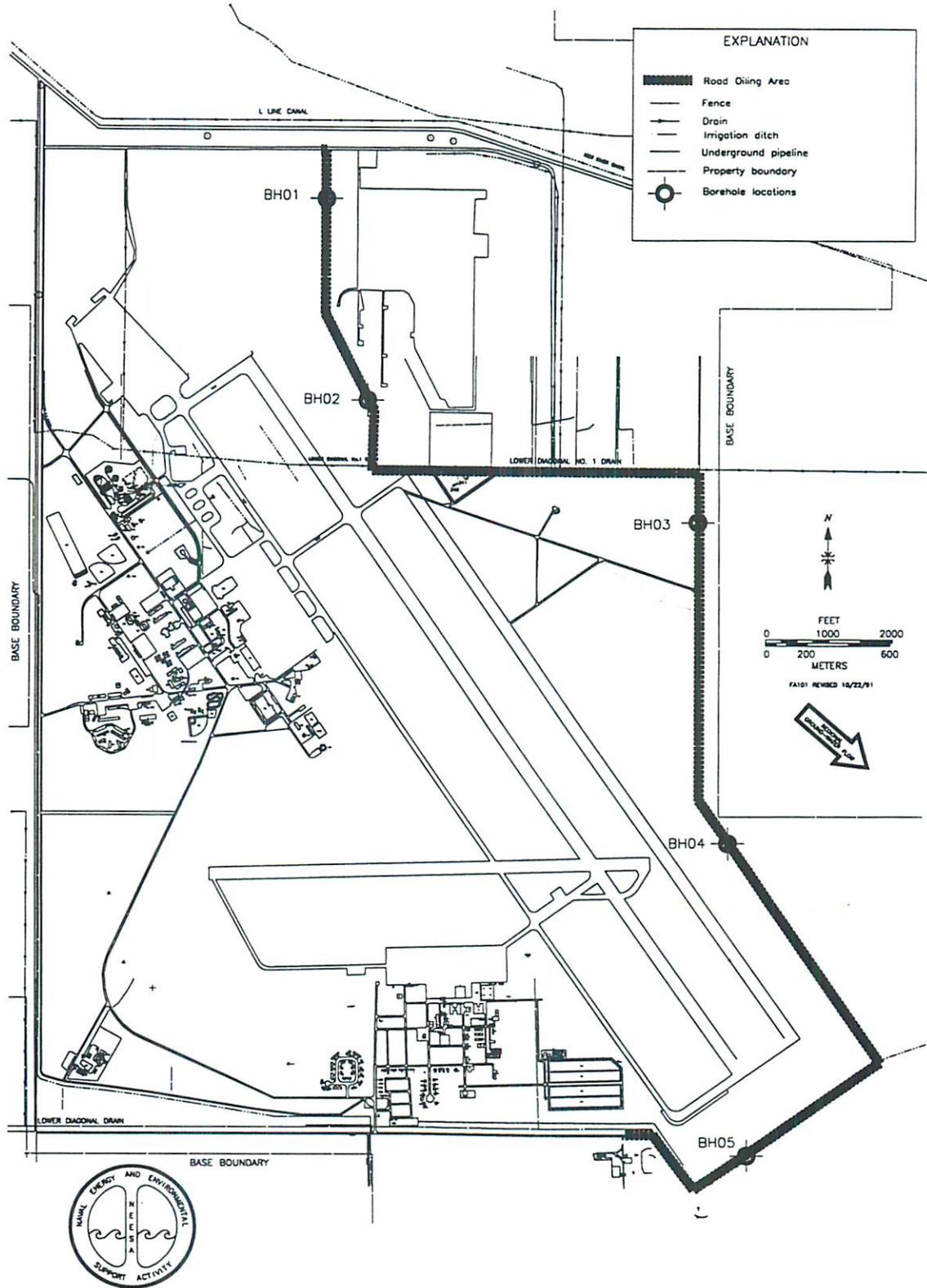


Fig. 6.1. Site 24, Road Oiling Area, showing sample locations.

Recommended test parameters were TPHs, VOCs, PCBs, SVOCs, and metals (Dames and Moore 1988).

6.1.4 Investigative Approach

The proposed investigation included drilling and sampling five soil borings along the length of unpaved road. The locations of soil borings were changed slightly from those shown in the work plan.

6.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

6.2.1 Surface-Water Hydrology

No surface-water features are associated with Site 24. However, surface-water runoff resulting from occasional precipitation could transport contaminated surface sediments or dissolved constituents to the LD #1 Drain.

6.2.2 Hydrogeology

A description of the regional and local hydrogeology is presented in Sect. 2.2.6.

6.3 STUDY AREA INVESTIGATION

6.3.1 Surface-Water and Sediment Investigations

Due to the lack of surface water, no sediment or surface-water samples were taken at Site 24.

6.3.2 Vadose Zone and Soil Investigation

Five soil borings were drilled at Site 24 (Fig. 6.1, p. 6-2). Borehole numbers and sampling intervals are shown below.

<u>Borehole number</u>	<u>Sample Intervals, ft</u>	
BH01	0.0 to 2.0	8.0 to 10.0
BH02	0.0 to 2.0	8.0 to 10.0
BH03	0.0 to 2.0	5.0 to 7.0
BH04	0.0 to 2.0	5.0 to 7.0
BH05	0.0 to 2.0	5.0 to 7.0

The five soil borings were drilled down to the water table. Samples were sent to an off-site laboratory and analyzed for LBPHCs, HBPHCs, SVOCs, VOCs, and metals. Soil samples were collected from Site 24 during the first iteration of Phase II characterization activities only.

6.3.3 Ground-Water Investigation

No ground-water investigation was conducted at Site 24. However, the ground-water-test-hole survey for the Group II Sites included several locations along the affected roads (see Sect. 8.3.4).

6.4 NATURE AND EXTENT OF CONTAMINATION

6.4.1 Vadose Zone and Soils

Soil sample results are shown in Table 6.1, p. 6-5. No HBPHCs, LBPHCs, or organic compounds were detected. The concentrations of metals may appear to be elevated, but when compared to other soil sample results for other sites on the facility, the concentrations are consistent with the regional range of values.

Table 6.1. Soil sample results for Site 24

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)	Volatiles, µg/kg (*4)
BH01 04/91	3715	0 - 2	U	U	U	Acet Methcl 22.0a **
BH01 04/91	3716	8 - 10	U	U	Bis2 **	Acet Methcl 24.0a **
BH02 04/91	3717	0 - 2	U	U	Bis2 **	Acet Methcl 8.0*J **
BH02 04/91	3718	8 - 10	U	U	U	Methcl **
BH03 04/91	3719	0 - 2	U	U	Bis2 800.0*J	Methcl **
BH03 04/91	3720	5 - 7	U	U	Bis2 **	Methcl **
BH04 04/91	3721	0 - 2	U	U	Bis2 **	Methcl **
BH04 04/91	3722	0 - 2	U	U	Bis2 **	Methcl **
BH04 04/91	3723	5 - 7	U	U	Bis2 **	Methcl **
BH05 04/91	3724	0 - 2	U	U	Bis2 **	Methcl **
BH05 04/91	3725	5 - 7	U	U	Bis2 **	Methcl **

** - unusable data due to method blank contamination
a - suspected laboratory contaminant
*1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
*2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
*3 - EPA method 3550/8270, quantitation limit: 350 µg/kg
*4 - EPA method 8240, quantitation limit: 5 µg/kg
*J - concentration estimated

Acet - acetone
Bis2 - bis(2-ethylhexyl) phthalate
HBP - high boiling point
LBP - low boiling point
Methcl - methylene chloride
PHC - petroleum hydrocarbons
U - no compounds detected

Table 6.1. Soil sample results for Site 24 (cont.)

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg				
Compound	#	Average	Minimum	Maximum
Aluminum	11	6,339	2,020.00	11,800.00
Antimony	0 ND		ND	ND
Arsenic	11	5	3.00	12.30
Barium	11	87	29.90	213.00
Beryllium	9	0	0.11	0.49
Boron	10	30	7.70	105.00
Cadmium	0 ND		ND	ND
Calcium	11	11,455	1,530.00	40,600.00
Chromium	11	6	2.70	9.30
Cobalt	11	5	2.70	8.40
Copper	11	70	9.40	316.00
Iron	11	11,145	5,060.00	19,200.00
Lead	11	4	0.82	7.80
Lithium	11	15	2.80	39.00
Magnesium	11	3,887	903.00	8,030.00
Manganese	11	246	57.30	777.00
Mercury	5	0	0.03	1.00
Molybdenum	0 ND		ND	ND
Nickel	11	5	2.50	9.70
Potassium	11	1,904	487.00	3,800.00
Selenium	0 ND		ND	ND
Silver	6	1	0.56	1.50
Sodium	11	2,831	271.00	6,940.00
Thallium	1	0	0.30	0.30
Vanadium	11	23	9.70	30.90
Zinc	11	72	25.00	308.00

- number of samples with detectable quantities of analyte
 ND - analyte not detected

6.4.2 Ground Water

As mentioned in Sect. 6.3.3, no ground-water investigation was conducted at Site 24. However, ground-water test holes were drilled along the affected road and showed no detectable contamination in the ground water (see Sect. 8.4.2).

6.4.3 Air

The atmosphere is not considered to be a medium of concern at Site 24 because surface application of the wastes is conducive to rapid dispersal of any volatile constituents. Additionally, sufficient time has elapsed (waste disposal activities were terminated in 1981) for volatilization and biodegradation of shallow, gas-phase contaminants to be complete.

6.5 CONTAMINANT FATE AND TRANSPORT

Site-characterization activities indicate little, if any, environmental contamination at Site 24. It is believed that a combination of biodegradation, photodegradation, and wind erosion removed any contaminants that were present. Consequently, discussion of contaminant fate and transport is unnecessary.

6.6 BASELINE RISK ASSESSMENT (BRA)

Quantitative risk assessments for soil and ground water were not conducted due to the absence of contamination.

6.7 SUMMARY AND CONCLUSIONS

Soil - There is no evidence of fuel-related soil contamination associated with waste disposal activities at the site. No quantitative risk assessment was conducted due to the absence of contamination.

Ground water - No ground-water investigation was conducted at Site 24. However, ground-water test holes drilled along the affected road showed no detectable contamination. No quantitative risk assessment was conducted due to the absence of contamination.

6.8 RECOMMENDATIONS

Soil - No action is recommended due to the absence of soil contamination.

Ground water - No action is recommended due to the absence of ground-water contamination.

7. GROUP I SITES: SITE 2, NEW FUEL FARM; SITE 4, TRANSPORTATION YARD

7.1 SITE BACKGROUND

The Group I Sites contain two adjacent areas of interest: Site 2, the New Fuel Farm, and Site 4, the Transportation Yard.

7.1.1 Site Description

The Group I Sites are located in the northwestern portion of NAS Fallon in the northern area of the facility (Fig. 1.2, p. 1-10, and Plate 1). The New Fuel Farm, Site 2, currently stores fuels at the site, including JP-8, diesel, and mogas. (Note: NAS Fallon changed from JP-5 to JP-8 in October 1993.) Approximately 3,300,500 gal of JP-8 reside in three underground and three aboveground storage tanks (Fig. 7.1, p. 7-2). Eight thousand gallons of diesel fuel and 12,000 gal of mogas are routinely stored at the fuel farm. Also, two underground AV 100/130 gas tanks having a total storage capacity of 100,000 gal were located at the site until June 1992. These tanks, designated 204-6 and 204-7, were removed under the UST removal program (PRC 1992). The fuel farm's main operations consist of fueling and defueling aircraft and periodic testing of the various fuels stored at the facility. Additional areas of concern near the New Fuel Farm include the tank bottom disposal area and the weed control area. Due to the relatively close proximity of these areas to each other, they are considered a single site.

The Transportation Yard, Site 4, is located directly south of Site 2 (Fig. 7.1, p. 7-2). The site consists of two buildings, 371 and 378, that are used for vehicle maintenance and painting (Dames and Moore 1988).

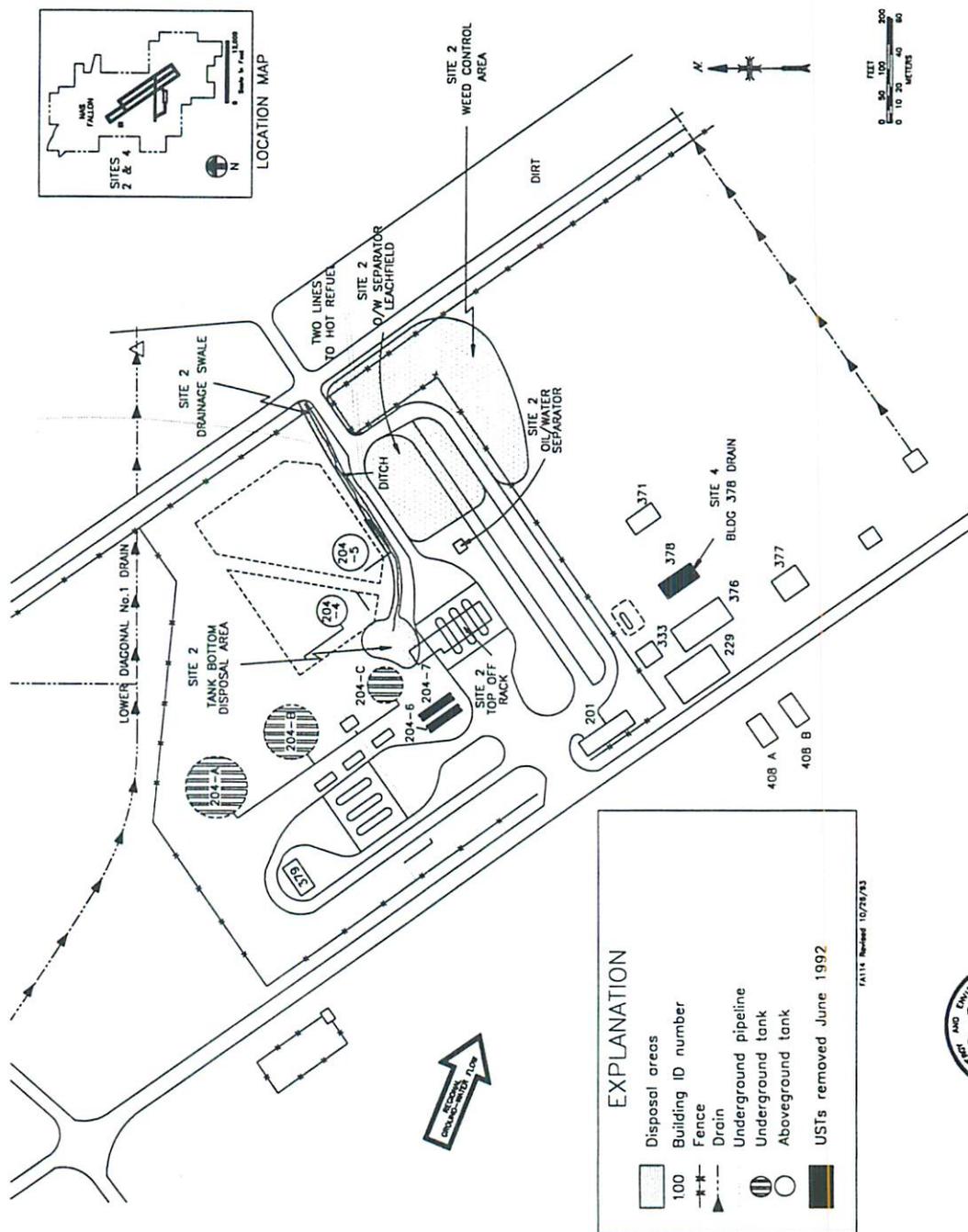


Fig. 7.1. Group I Sites: Site 2, New Fuel Farm; Site 4, Transportation Yard.

7.1.2 Site History

7.1.2.1 Site 2, New Fuel Farm

Site 2, the New Fuel Farm, was reportedly constructed in 1957 to provide fuel delivery services for NAS Fallon. The New Fuel Farm was used in conjunction with the Old Fuel Farm (Site 16) until 1963 at which time the Old Fuel Farm was taken out of service. The New Fuel Farm's main operations consist of storing and dispensing petroleum fuels routinely used on the facility. Stored fuels include jet-fuel, avgas, diesel, and mogas. Jet fuel is supplied to the fuel farm via an underground pipeline from Sparks, Nevada. Other stored fuels are delivered to the site by truck. In addition to the storage tanks and associated piping, other areas of interest at Site 2 include the O/WS leachfield, the tank bottom disposal area, and the weed control area (Fig. 7.1, p. 7-2).

The O/WS collects surface runoff and spills from the tank and loading rack area. The separator was installed in 1981 and is connected to a leachfield located 150 ft northeast. A JP-5 fuel spill of about 2,000 gal occurred in the area in 1985. Also, daily draining of fuel trucks in the loading rack area may have resulted in as much as 18,000 gal of fuel spillage in the area between 1957 and 1981 (Dames and Moore 1988).

The tank bottom disposal area is an unpaved swale into which tank bottom liquids, consisting of approximately 90% water and 10% fuel, were disposed. Disposal took place in the area from 1957 to 1981, during which up to 60,000 gal of fuel may have been discarded. In addition, up to 5,000 gal of JP-4 or JP-5 may have been released to the area from a leaking fuel tank during the early 1960s. Small amounts of waste fuel were periodically applied to unpaved ground in the weed control area from 1957 to 1981. It is estimated that about 500 gal of fuel may have been applied during this period (Dames and Moore 1988).

The history of environmental concerns associated with Site 2 can be found in Sect. 1.1.3.1, Site 2 Investigations, p. 1-6.

Presently, Phase II efforts, combined with other environmental investigations (ERM-West 1988; NDEP 1990), indicate free-phase petroleum hydrocarbon (primarily JP-5 jet fuel) on the shallow water table underlying the site. Subsurface soil and dissolved ground-water contaminants are also present in varying concentrations.

Investigations at Site 2 were expedited due to regulatory concern over petroleum contamination at the site. The results of these investigations are included in the *Preliminary Site Characterization Summary and Engineering Evaluation/Cost Analysis for Site 2, New Fuel Farm; Naval Air Station Fallon, Nevada* (ORNL 1991). This document makes recommendations for free-product-recovery systems at the site. At the time of the writing of this RI report, the Navy has procured the services of Groundwater Technology Government Services, Inc., (GSI) to conduct free-product-recovery operations at the site. GSI is in the process of modifying the free-product-recovery plan for the site based on additional field studies. The field studies involved the construction of additional wells for pumping tests, vapor extraction tests, and interim free-product recovery. Following field testing and ground-water modeling, the most effective removal technology will be chosen for the site.

7.1.2.2 Site 4, Transportation Yard

Site 4, the Transportation Yard, is believed to have been constructed in 1971. The area serves to store and maintain vehicles used by the Public Works Department.

Building 378 was used from 1976 to 1981 for painting and light overhaul operations. The building has a cement floor and associated floor drain that reportedly was used to flush wastes into the subsoils beneath the building. It is not known if the drain system includes a grease trap. Inspection indicates that no leachfield exists. Wastes disposed of through the building 378 drain included radiator coolants, vehicle fluids, and paint wastes.

7.1.3. Previous Investigations

Three previous environmental investigations have been conducted at the Group I Sites prior to Phase II of the IR Program, including a site investigation performed by ERM-West (ERM-West 1988), Phase I, PA/SI, of the IR Program (Dames and Moore 1988), and NDEP's investigation of an alleged fuel release in January/February 1988 (NDEP 1990).

7.1.3.1 ERM-West

A soil-gas survey was conducted during the ERM-West investigation of the facility. Soil-gas samples were taken at a depth of approximately 2.75 ft from 85 sample locations. Soil-gas samples were analyzed with an organic vapor analyzer (OVA). Three areas exhibited high OVA readings as shown in Fig. 7.2, p. 7-6. The three areas include: 1) the O/WS leachfield area, 2) the area north of the truck refueling pumps, and 3) the area east of building 201. Although intended to estimate the concentration gradient resulting from underlying contaminants, soil-gas results were sporadic and produced high and low concentration readings between consecutive sample locations. Soil-gas analysis in the top 2.75 ft of surface soil could not accurately determine the underlying plume boundaries due to geological heterogeneities.

During the week of April 25, 1988, ERM-West completed seven soil borings and installed eight 2-in. monitoring wells on and around Site 2 (Fig. 7.3, p. 7-7). Boreholes 23 and 14 were drilled to a depth of 40 ft to assess the underlying soils. The remaining five soil borings and eight monitoring wells were advanced to shallower depths to assess contamination in the uppermost permeable zone and to avoid penetration of the underlying clay layer.

Thirteen soil samples from soil borings and monitoring well boreholes were submitted for laboratory analysis of TPH and VOCs (ERM-West 1988). Soil samples were obtained using a California-modified sampler fitted with brass sleeves and pushed ahead of the hollow stem augers during drilling. Samples were collected at 1.5 to 2.0-ft intervals in the upper 5 ft of the boring and at 5-ft intervals thereafter.

Water samples from the eight monitoring wells were also submitted for analysis. Wells were developed by pumping approximately 60 gal of water from each well until a clear discharge was established. Five well volumes of water were then removed and temperature, conductivity, and pH checked for stabilization before samples were collected. Sample pumping rates were controlled to minimize degassing of volatiles during sample collection (ERM-West 1988).

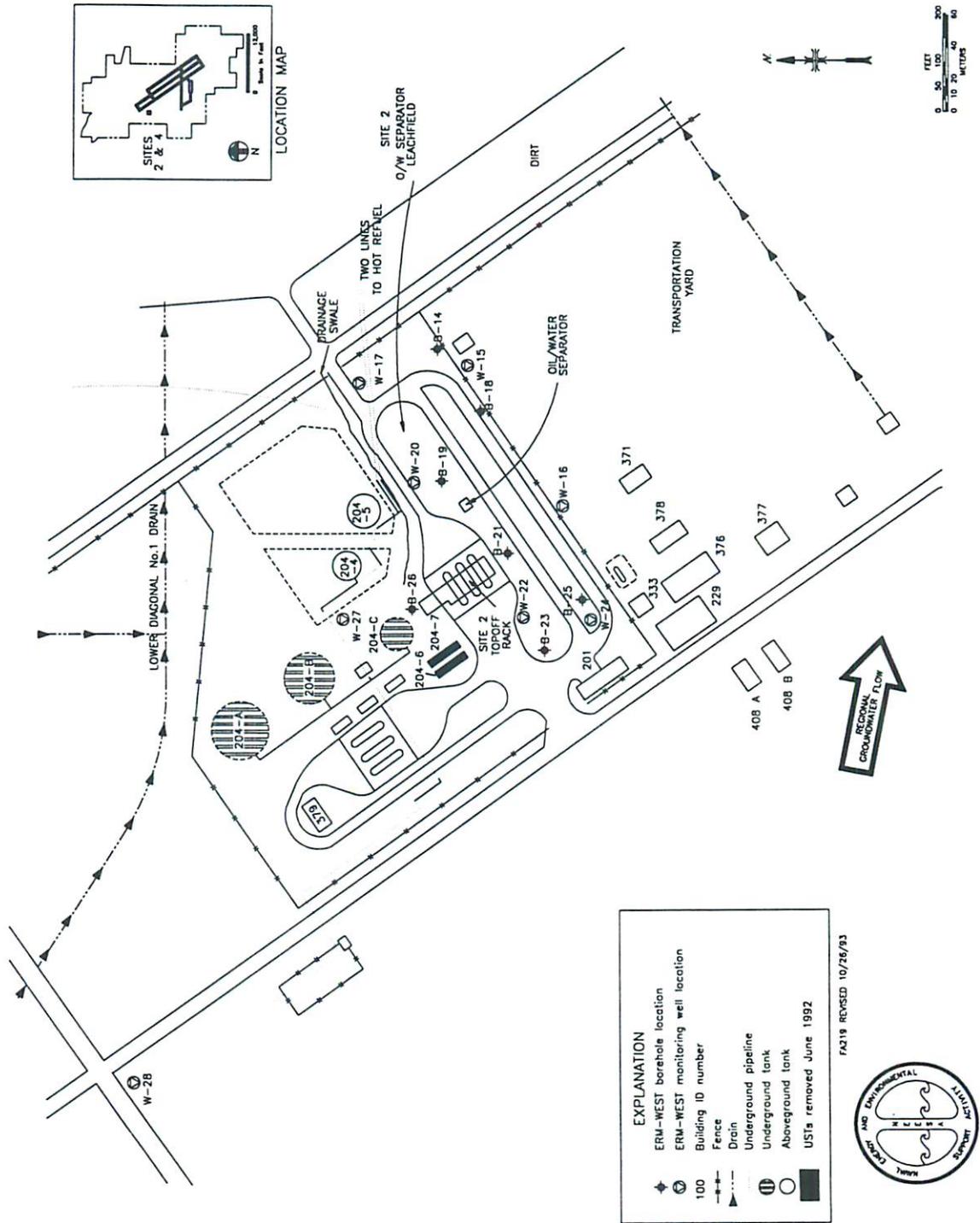


Fig. 7.2. Group I Sites. Potentially contaminated areas identified during ERM-West soil-gas survey.

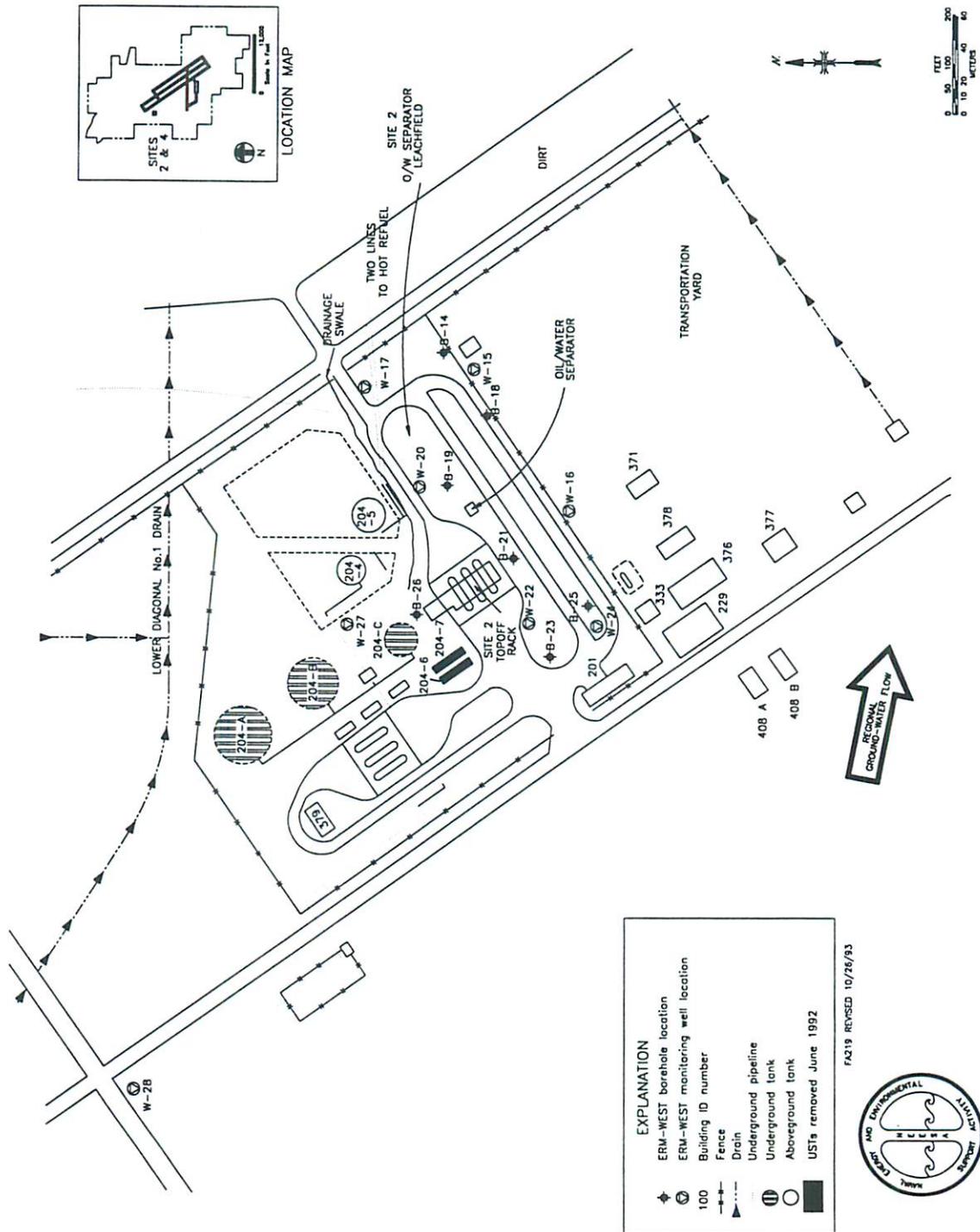


Fig. 7.3.. Group I Sites. Soil borings and monitoring wells installed during ERM-West investigation.

Ground-water sampling results appear in Table 7.1, p. 7-9, and indicate benzene contamination in wells W-15 and W-20 of 0.028 and 0.29 mg/L respectively. In addition, monitoring well W-20 contained 4.61 ft of free-phase product. While initial sampling of W-27 showed TPH contamination at 520 mg/L, results from subsequent sampling efforts indicated no contamination was present. Results from soil sampling (Table 7.2, p. 7-10) indicated elevated PHC concentrations at sample locations W-17, W-20, B-21, B-19, and B-26.

7.1.3.2 Phase I, IR Program

The Phase I investigation, PA/SI, at the Group I Sites consisted of a visual inspection, records search, on-site interviews, and limited soil sampling. Based on results from NDEP's original investigation (1986), the PA/SI recommended Site 2 for inclusion in the RI due to confirmed ground-water contamination in the southeastern portion of the New Fuel Farm, including areas of the leachfield and the O/WS. The weed control area at Site 2 and the building 378 drain at Site 4 were also recommended for inclusion in the RI due to possible soil and ground-water contamination from past disposal activities (Dames and Moore 1988).

Limited soil sampling was conducted at the tank bottom disposal area at Site 2. Two shallow soil samples were collected from 6 in. BGS and analyzed for TPHs by EPA method 418.1. Results for the samples were 260 mg/kg and 4200 mg/kg respectively. Because these results exceeded the NDEP action level of 100 mg/kg, the tank bottom disposal area was recommended for inclusion in the RI.

The PA/SI recommended additional soil sampling and the installation of ground-water monitoring wells for the RI at Site 2. A total of five wells were suggested, three within the area of suspected contamination, one upgradient and one downgradient. Recommended test parameters were TPH, VOCs, SVOCs, and lead.

Table 7.1. Ground-water analysis, ERM-West investigation

Ground-water analysis, mg/L					
Well number	Analysis				
	Total petroleum hydrocarbons EPA method 418.1 (detection limit 0.002)	Volatile organic compounds EPA method 601/602 (detection limit 0.002)			
		Benzene	Ethylbenzene	Toluene	Xylene
W-15	4	0.028	0.011	0.0065	0.16
W-28	<3	0.0013	0.0024	0.0038	0.0049
W-17	<3	0.0007	0.0017	0.0042	0.014
W-16	<3	0.0008	0.0043	0.01	0.03
W-24	<3	0.0018	0.0032	0.008	0.02
W-20	24,000	0.29	0.15	0.008	0.83
W-22	<3	0.0011	0.0014	0.0029	0.0088
W-27	520	0.0012	0.0026	0.0055	0.018

Source: ERM-West 1988. Results based on analysis of one round of sampling.

Table 7.2. Soil analysis, ERM-West investigation

Soil analysis, mg/kg									
Sample location	Sample depth, m	Analysis							
		Total Petroleum Hydrocarbons			Volatile Organic Compounds EPA method 8010/8020, detection limit 0.01				
		EPA method 418.1, detection limit 30.0	EPA method 625/8270, select ion, detection limit 1.0	EPA method 625/8270, full scan, detection limit 1.0	Benzene	Ethylbenzene	Tetrachloroethy	Toluene	Xylene
W-16	3.6 to 3.8	ND	NA	NA	NA	NA	NA	NA	NA
W-16	3.8 to 4.0	ND	NA	NA	NA	NA	NA	NA	NA
W-17	(Comp.)	1,200	ND	ND	NA	NA	NA	NA	NA
B-18	2.9 to 3.1	ND	NA	NA	NA	NA	NA	NA	NA
B-19	2.1 to 2.3	ND	NA	2,900	0.15	NA	0.02	0.05	0.90
W-20	3.0 to 3.2	440	NA	NA	NA	NA	NA	NA	NA
B-21	2.1 to 2.3	NA	1,100	NA	0.04	0.28	0.01	0.45	1.90
W-22	(Comp.)	ND	NA	NA	0.01	0.01	0.01	0.01	0.01
W-24	(Comp.)	ND	NA	NA	NA	NA	NA	NA	NA
B-26	2.1 to 2.3	NA	2,300	NA	ND	0.07	ND	0.06	0.44
B-25	(Comp.)	ND	NA	NA	NA	NA	NA	NA	NA
W-27	(Comp.)	ND	NA	NA	NA	NA	NA	NA	NA
W-28	(Comp.)	ND	NA	NA	NA	NA	NA	NA	NA

Source: ERM-West 1988. Results based on analysis of one round of sampling.

NA = not analyzed.

ND = not detected.

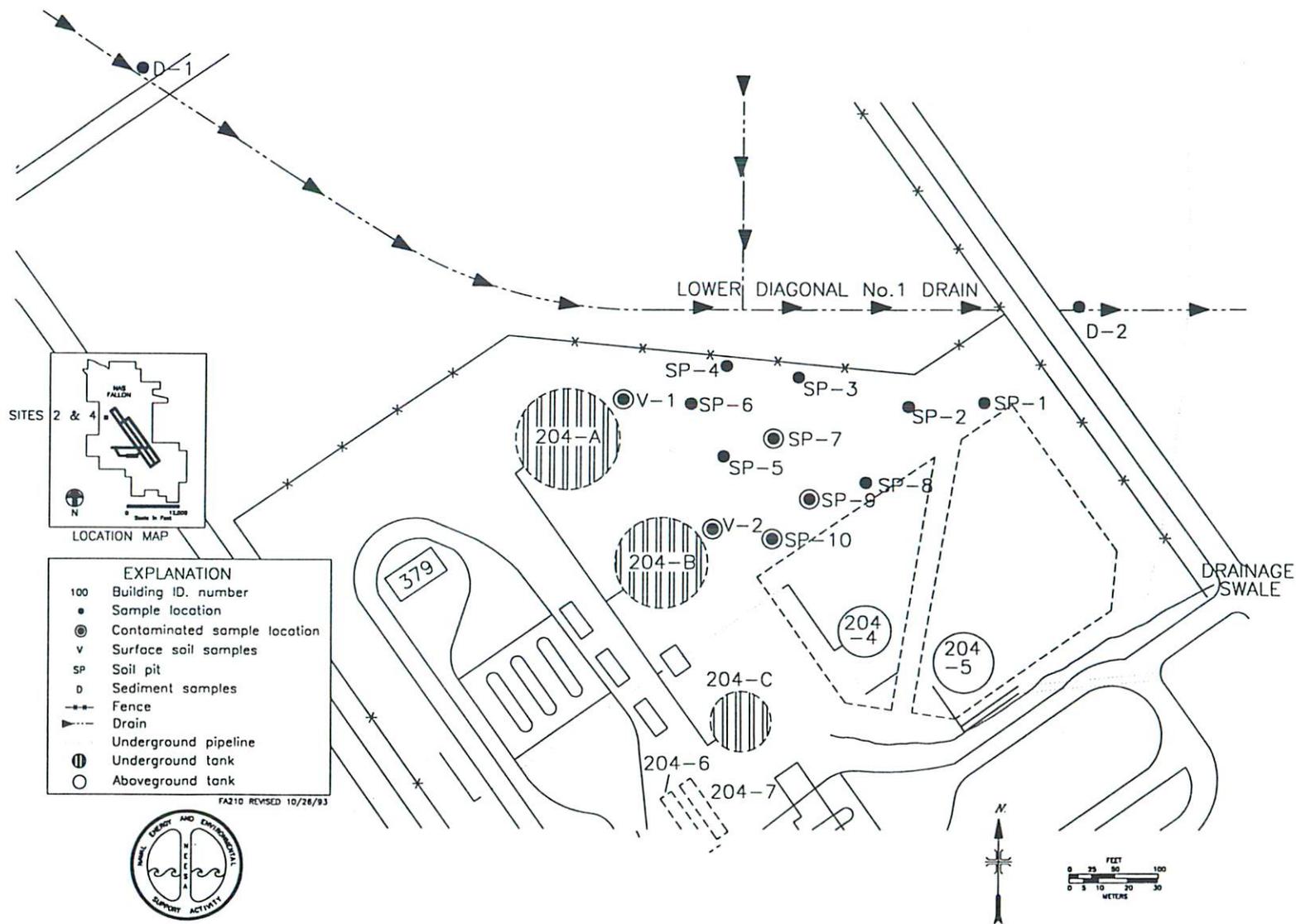
(Comp.) = composite.

7.1.3.3 NDEP Investigation

The NDEP conducted an investigation of an alleged fuel release in January/February 1988 (NDEP 1990). Soil samples were obtained from ten soil pits and two surface sample locations (Fig. 7.4, p. 7-12). The soil pits were excavated with a backhoe to a depth of approximately 2.4 m or to ground water, whichever was reached first. Soil samples were logged at 0.6-m intervals, after being screened with a Photovac PID equipped with a 10.6-eV lamp. Samples exhibiting elevated PID readings or suspected of containing contamination were submitted for laboratory analysis within 24 h of collection. Soil samples for laboratory analysis were placed in clean, one-quart jars with a wooden sampling tool and fitted with aluminum lid sleeves. Surface soil samples collected near the vent systems for underground tanks 204-A and 204-B and sediment samples collected from the LD #1 Drain were also submitted for analysis. Two sediment samples were obtained from the drain, one just before it entered the facility and one immediately downgradient from Site 2.

Ground-water samples were also submitted to the laboratory. The ground-water samples included: 1) one sample taken from soil pit number 1, and 2) two ground-water samples from domestic drinking water wells allegedly impacted by activities at NAS Fallon. The drinking water samples were obtained from two shallow (30 to 50-ft) residential wells located at 2360 Wildes Road and 4225 South Harmon Road. Water samples were collected in clean, 1-gal amber bottles and sealed with Teflon septum caps.

Laboratory results for the NDEP investigation appear in Table 7.3, p. 7-13. The soil samples indicated contamination in three of the soil pits and the two surface samples. TPH contamination levels of 310, 928, and 12,900 mg/kg were detected in soil pits 7, 9, and 10 respectively. None of the remaining soil pits showed contamination above the method detection limit (EPA method 8015) of 10 mg/kg. Surface soil samples taken near the tank vents indicated hydrocarbon contamination levels of 7,690 mg/kg near tank 204-A and 2,350 mg/kg near tank 204-B. These results indicate either discharge from the underground tanks through the vent system or vapor-phase product condensation around the vents. The hydrocarbons encountered in all samples were consistent with JP-5/diesel



7-12

Fig. 7.4. Group I Sites. Soil samples collected during NDEP investigation of Site 2.

Table 7.3. Soil and ground-water analyses, NDEP investigation

Soil and ground-water analyses mg/kg for soil, mg/L for ground water			
Sample locations	Sample medium	Total Petroleum Hydrocarbons	
		Soil EPA method 8015, detection limit 10	Ground water EPA method 8015, detection limit 0.5
SP-1	Subsoil ^b	ND	NA
SP-2	Subsoil	ND	NA
SP-3	Subsoil	ND	NA
SP-4	Subsoil	ND	NA
SP-5	Subsoil	ND	NA
SP-6	Subsoil	ND	NA
SP-7	Subsoil	310	NA
SP-8	Subsoil	ND	NA
SP-9	Subsoil	928	NA
SP-10	Subsoil	12,900	NA
V-1 (tank 204-A) ^a	Surface soil ^c	7,690	NA
V-2 (tank 204-B)	Surface soil	2,350	NA
D-1	Sediment	ND	NA
D-2	Sediment	ND	NA
SP-1	Ground water	NA	ND
Wildes Road	Residential well	NA	ND
South Harmon Road	Residential well	NA	ND

Source: NDEP 1990. Results based on analysis of one round of sampling.

ND = not detected
NA = not applicable

^a These tanks, labeled 204-1 and 204-2 when these samples were taken, have since been changed to 204-A and 204-B. These designations are used here for consistency with the rest of the RI report.

^b Subsoil samples taken from various unspecified depths between 2 ft and 8 ft BGS.

^c Surface samples taken at approximately 1 ft BGS.

product. As shown in Table 7.3, p. 7-13, none of the ground-water, domestic-well, or sediment samples showed any PHC contamination in excess of the detection limit of the laboratory analysis method. The investigation concluded that a release of JP-5 jet fuel did occur on February 22, 1988 (NDEP 1990).

7.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

7.2.1 Surface-Water Hydrology

The LD #1 Drain borders the Group I Sites to the north of Site 2 (Fig. 7.1, p. 7-2).

7.2.2 Ground-Water Hydrology

Monitoring wells MW01 through MW10, MW13, and PW01 were used at the Group I Sites to evaluate the upper alluvial aquifer (see Fig. 7.5, p. 7-15, for well locations). Hydraulic conductivity values from either slug or pumping tests run on these wells ranged from 2 ft/d in MW08 to 220 ft/d in PW01. This wide range is indicative of the extremely variable nature of the subsurface at the site. Based on aquifer tests alone, contaminant plumes should have spread several hundred feet. Thus, other mechanisms such as biodegradation and the complex subsurface geology are affecting plume migration at the Group I Sites. The water-table elevation map for this site is found on Fig. 7.6, p. 7-16. The flow direction at the sites is consistent with the regional flow. Depth to ground water at the Group I Sites varies seasonally and ranges from 5.5 to 9 ft BGS (see Appendix H, Table H.3).

7.3 STUDY AREA INVESTIGATION

7.3.1 Surface-Water and Sediment Investigations

No surface-water or sediment samples were taken at the Group I Sites. However, screening activities along the LD #1 Drain were conducted as a separate activity.

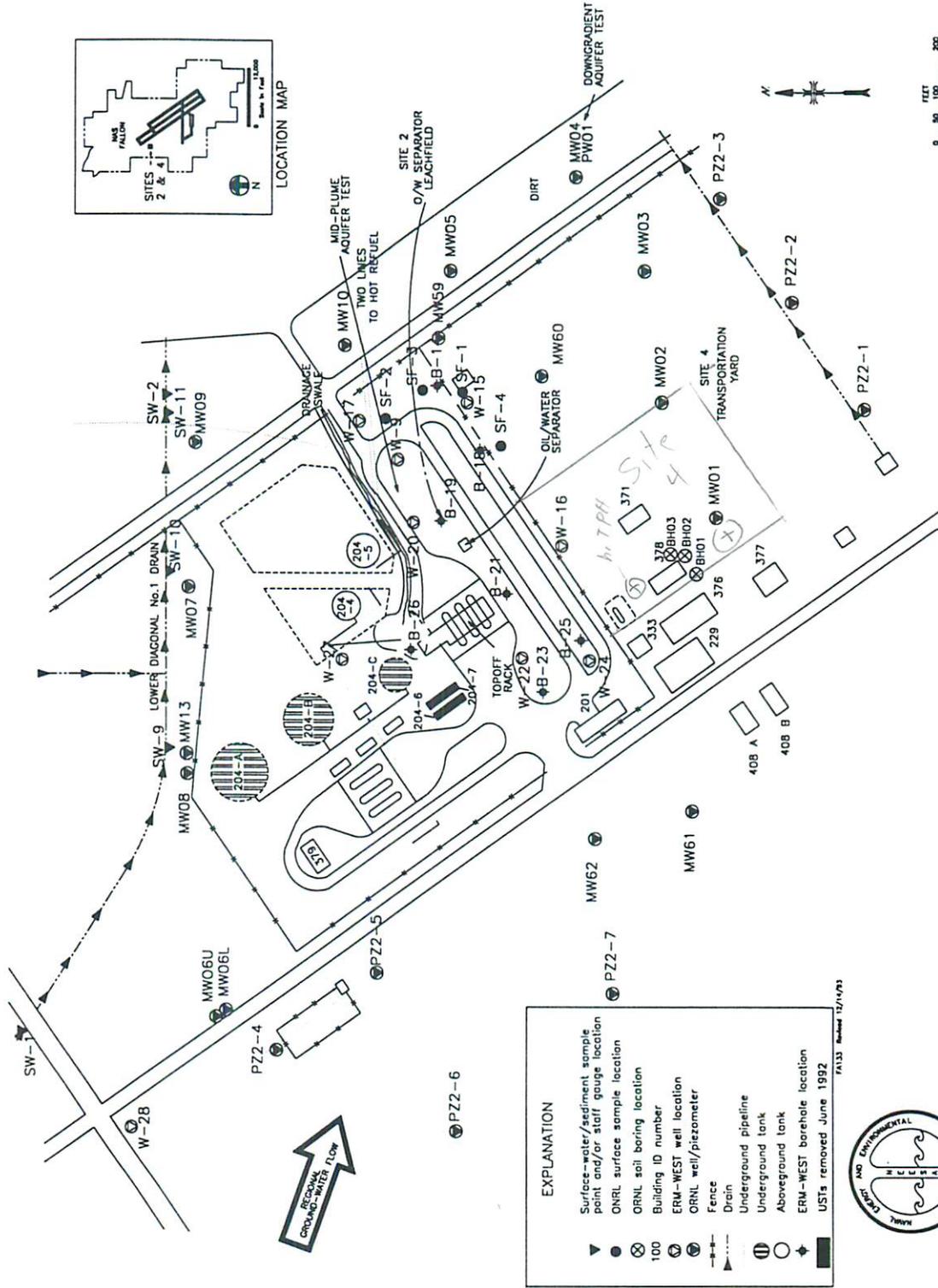


Fig. 7.5. Group I Sites. IR Program sample locations.



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EXPLANATION	
100	Building ID, number
⊙	Monitoring well/ Piezometer
▲	Sediment/surface-water sampling point
—▲—	and/or staff gauge location
—+—	Fence
— —	Drain
— —	Underground pipeline
⊖	Underground tank
⊕	Aboveground tank
■	USTs removed June 1992
Contour Interval: 0.2'	

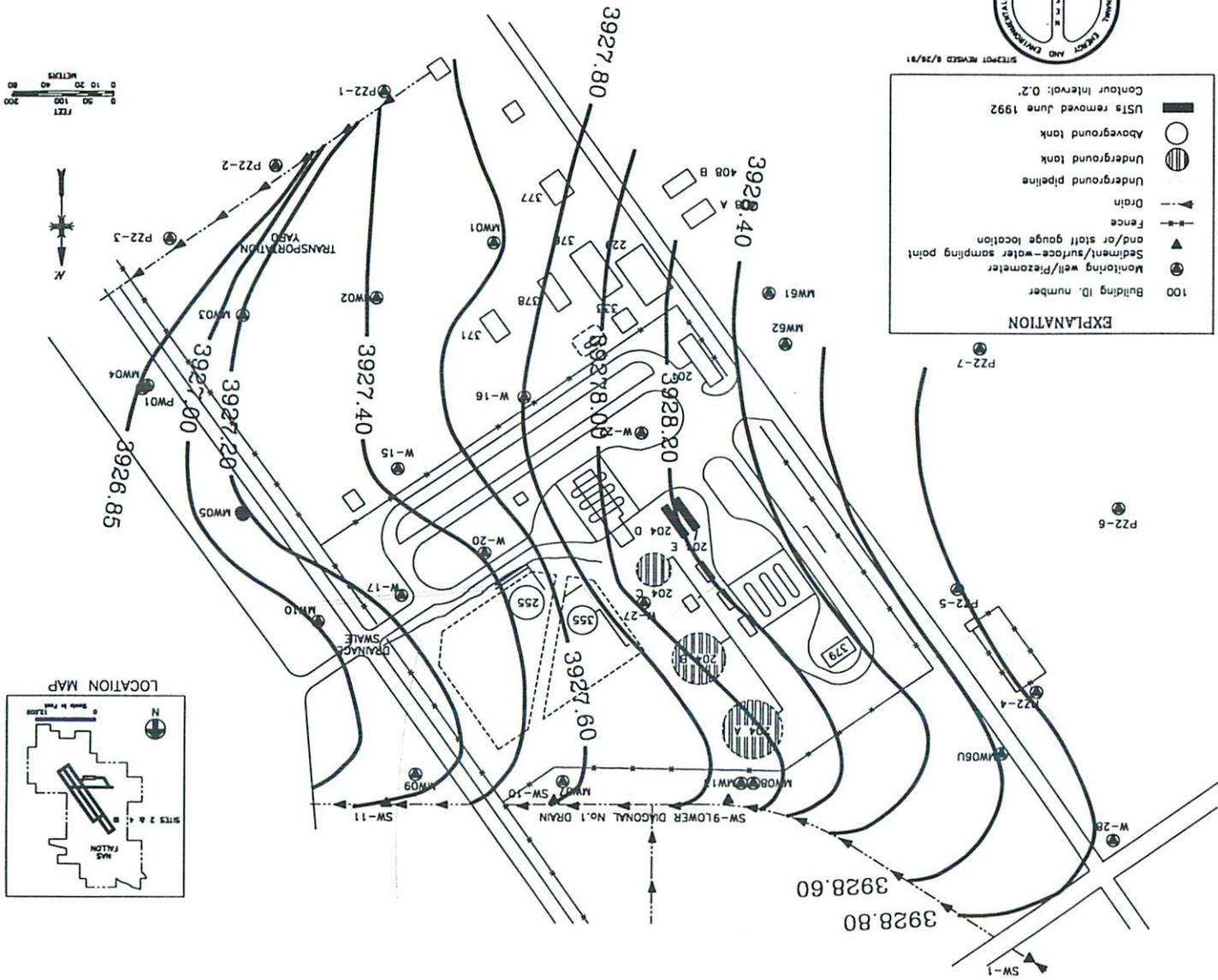


Fig. 7.6. Group I Sites. Water-table elevation map for the shallow alluvial aquifer (measurements taken January 1992).

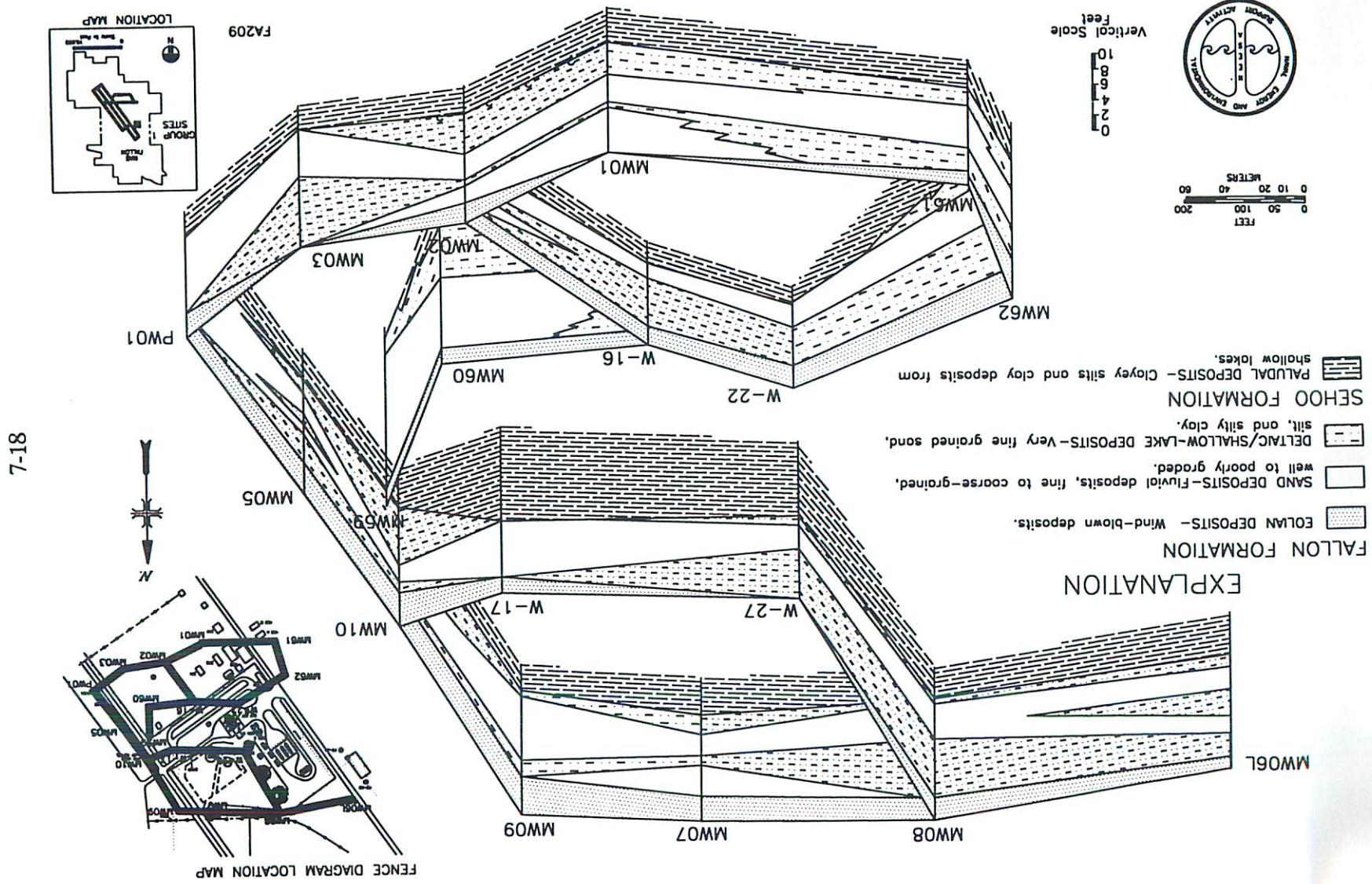
Section 11 discusses the results of that investigation. Due to the close proximity of the drain to Site 2, results from the characterization are relevant to the Group I Sites.

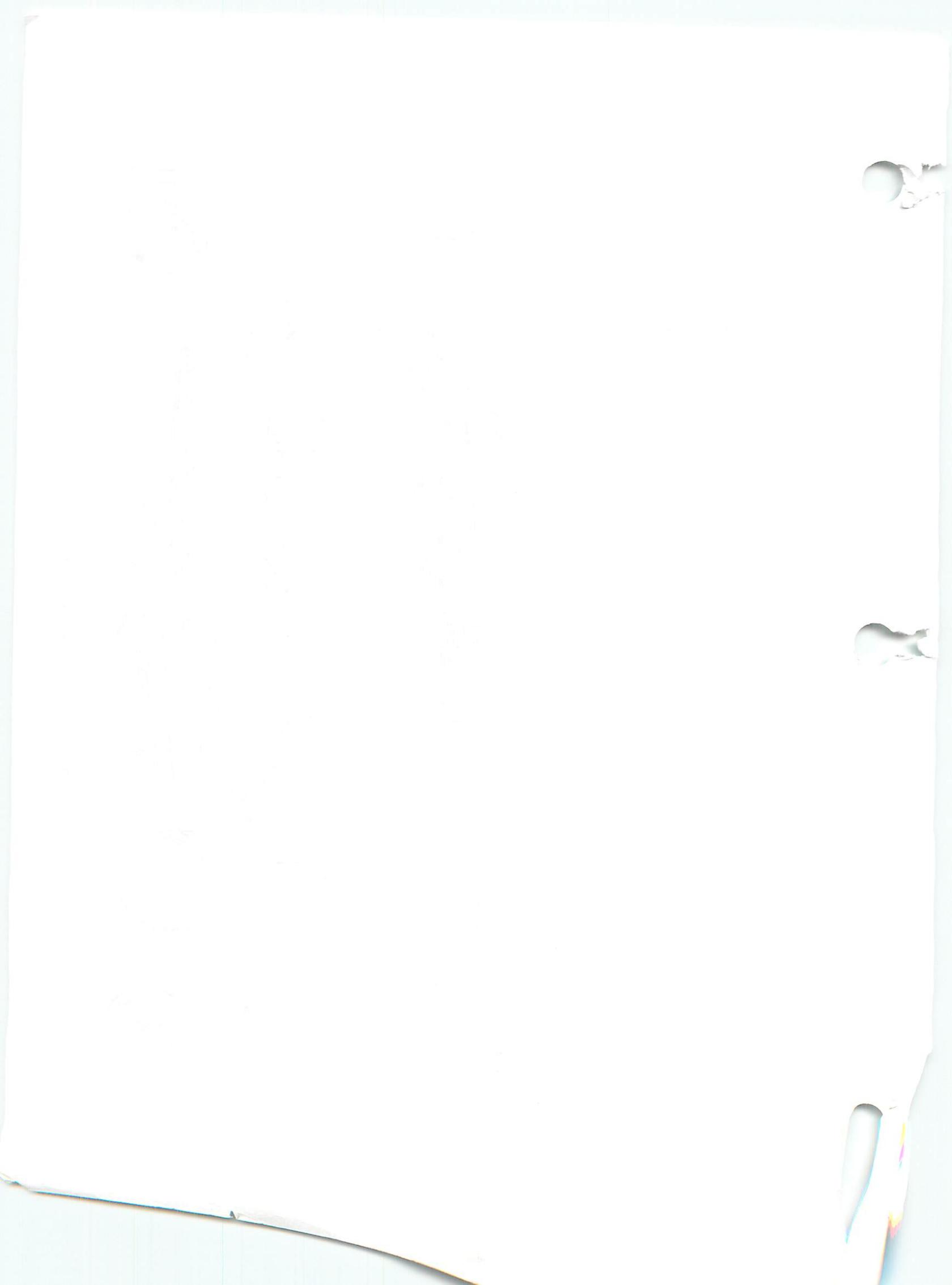
7.3.2 Geological Investigation

Lithology information was obtained using a 5-ft continuous sampler or a 1.5- or 2.0-ft split spoon utilizing the California method during the installation of monitoring wells PW01, MW01, MW02, MW03U&L, MW04, MW05L, MW06L, MW07, MW08L, MW09, MW10, MW59, MW60, MW61, and MW62. No lithologic descriptions were obtained from MW05U, MW06U, and MW08U since these wells were installed within 3 to 4 ft horizontally from their respective lower completions. Well summary forms and lithologic descriptions are found in Appendix F.

With the exception of MW01 and MW62, all monitoring wells installed by ORNL penetrated the entire Fallon Formation, which is from 17 to 20 ft thick, and the upper 1 to 3 ft of the Seho Formation. The lithology of this group is typical of the deltaic depositional environment seen in the Fallon formations. The deltaic sediments have been dissected by an ancient former Carson River channel. The upper 10 to 12 ft of the monitoring wells display predominantly poorly graded sands, pale brown to brown, fine- to medium-grained, with some silt and limonite staining. Interbedded with these sands are stringers of clayey silt. Occasional clay stringers are found that are grayish-brown to dark grayish-brown, with some scattered fine-grained sand. The lower 10 to 12 ft of the Fallon Formation is sand. These sand layers vary in lithology from fine- to medium-grained, poorly graded sand to fine- to coarse-grained, well-graded sand with abundant 3 to 4-mm pebbles. The aforementioned sands represent beach and deltaic deposits and are generally found in monitoring wells west of MW05, MW10, and PW01. The well-graded sands represent a paleo-river channel deposited by the ancient Carson River. Figure 7.7, p. 7-18, shows the simplified fence diagram of the selected wells covering this area. The sands are relatively thick and are medium- to coarse-grained, with occasional pebbles, very well graded, and are predominantly rounded to well-rounded. The well log of MW04, which is approximately 10 ft west of PW01, shows scouring from the paleo-channel terminating approximately 20 ft BGL and having a thickness of 13 ft. PW01 was located in the

Fig. 7.7. Simplified fence diagram for monitoring wells installed at the Group I Sites.





best channel sands found within the area of investigation and represents the most transmissive unit in the area.

7.3.3 Geophysical Investigation

A geophysical survey employing a Geonics EM-31 electromagnetometer coupled with an USRADS was conducted at Site 2. The EM survey mapped differences in electrical conductivity believed to be associated with free-phase jet fuel and fresh water recharge. Potential sources of fresh water recharge and/or contamination were identified as the O/WS leachfield, a leaky water hydrant near the fuel truck tophoff rack, and ponding runoff from rainfall (Fig. 7.8, p. 7-20). Appendix B describes the geophysical survey methodology.

7.3.4 Vadose Zone and Soil Investigation

The first iteration of Phase II site-characterization activities at the Group I Sites included a soil-gas survey and seven soil borings. In addition to the borehole samples, soil samples were also collected during the installation of monitoring wells MW02, MW04, MW05, MW06, MW08, and MW09. Second iteration activities included collecting soil samples during the installation of monitoring wells MW59 and MW60. Sampling locations are shown on Fig. 7.5, p. 7-15. Borehole numbers and sample intervals are shown below.

<u>Borehole number</u>	<u>Sample Intervals, ft</u>	
BH01	0.0 to 2.0	5.5 to 7.5
BH02	0.0 to 2.0	5.5 to 7.5
BH03	0.0 to 2.0	5.5 to 7.5
SF01	0.0 to 2.0	2.0 to 4.0
SF02	0.0 to 2.0	2.0 to 4.0
SF03	0.0 to 2.0	2.0 to 4.0
SF04	0.0 to 2.0	2.0 to 4.0
MW02	6.5 to 7.0	
MW04	8.5 to 9.0	
MW05	6.5 to 7.0	8.5 to 9.0
MW06	6.5 to 7.0	
MW08	6.5 to 7.0	
MW09	6.5 to 7.0	
MW59	5.0 to 6.5	
MW60	5.0 to 6.5	

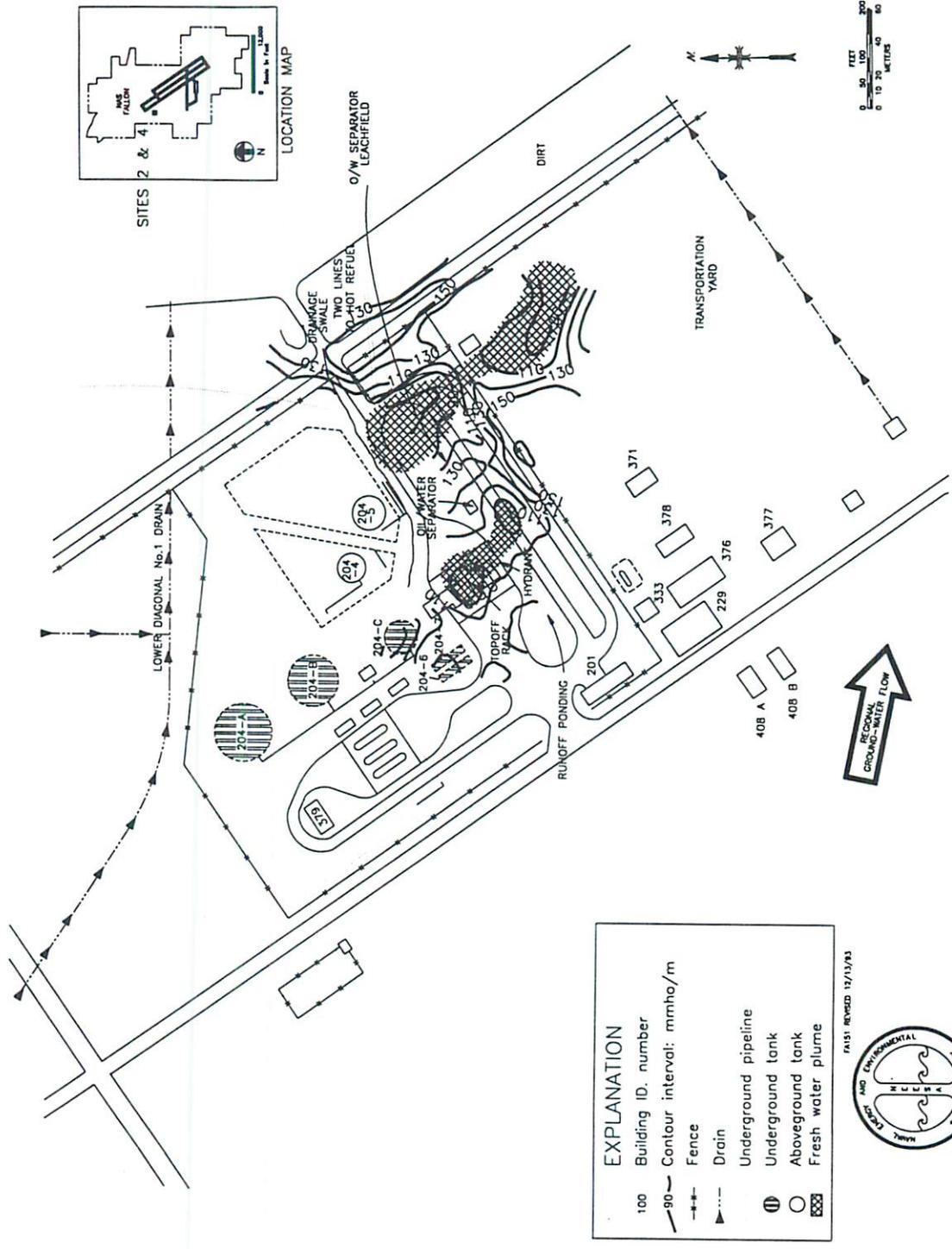


Fig. 7.8. Group I Sites. Geophysical survey map.

All soil samples collected from the Group I Sites were analyzed for LBPHCs, HBPHCs, SVOCs, VOCs, and metals. Samples collected from the weed control area (sample locations designated SF01, etc.) were also analyzed for PCBs/pest.

7.3.5 Ground-Water Investigation

The first iteration of the ground-water investigation at the Group I Sites involved boring 94 ground-water test holes and installing fifteen monitoring wells, one pumping well, and seven piezometers (Fig. 7.9, p. 7-22). Existing wells installed during the ERM-West investigation were also sampled. Recommendations for subsequent investigation were based on results from the first sampling iteration and recommendations made in the PSCS (ORNL 1992c). The second iteration of ground-water investigation at the Group I Sites included boring eleven additional ground-water test holes and installing four monitoring wells. Results of the ground-water-test-hole screening are given in Appendix C.

The ground-water test holes were used to delineate a PHC plume on the ground water underlying the facility and to determine suitable locations for monitoring wells. Water samples from the monitoring wells were sent to an off-site laboratory and analyzed for LBPHCs, HBPHCs, SVOCs, VOCs, anions, and metals. Also, samples were analyzed in the field for temperature, pH, and conductivity. Results of water-quality field measurements for all sites are presented in Appendix G.

7.4 NATURE AND EXTENT OF CONTAMINATION

7.4.1 Vadose Zone and Soils

Phase-II-investigation soil sample results for the Group I Sites are presented in Table 7.4, p. 7-23, and contaminant boundaries are shown on Fig. 7.10, p. 7-27. *Bis*(2-ethyl-hexyl) phthalate, methylene chloride, and acetone were reported as laboratory contaminants



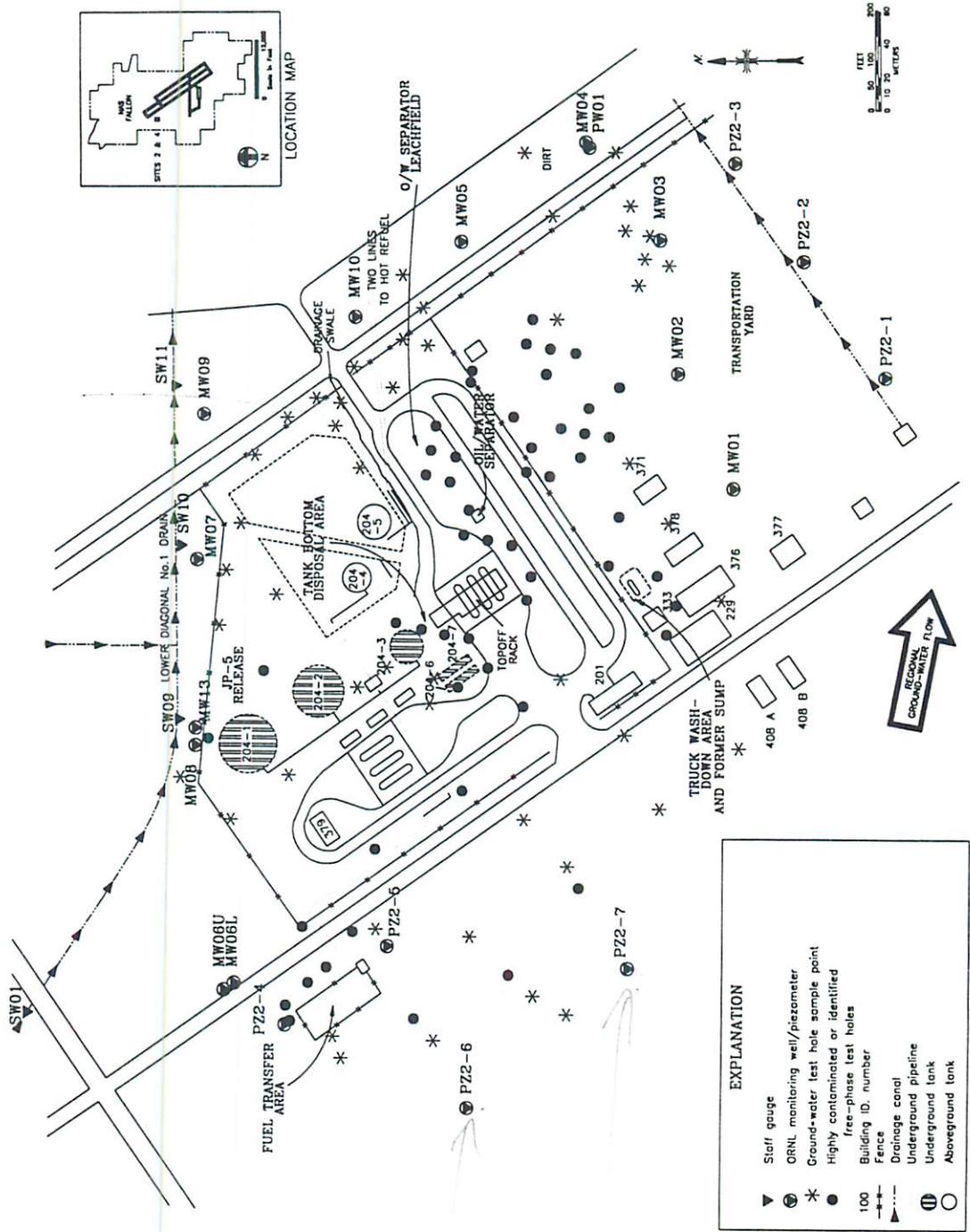


Fig. 7.9. Group I Sites. Location of ground-water test holes.

Table 7.4. Soil sample results for Group I Sites

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Total PHC, mg/kg (*3)	PCB/Pesticide, µg/kg (*4)	Semivolatiles, µg/kg (*5)	Volatiles, µg/kg (*6)
BH01 03/91	3688	0 - 2	U	U	NP	NP	Bis2 330.0*J	Methcl **
BH01 03/91	3689	5.5 - 7.5	U	U	NP	NP	Bis2 **	Methcl 10.0a
BH01 03/91	3690	5.5 - 7.5	U	U	NP	NP	U	Methcl **
BH01 03/91	3690R	5.5 - 7.5	NP	NP	NP	NP	Bis2 **	NP
BH01 12/91	3959	0 - 2	Die 6.00	U	NP	NP	Bis2 370.0*J	Methcl 3.0*J
BH01 12/91	3960	2 - 4	U	U	NP	NP	Bis2 4100.0a	Methcl 3.0*J
BH01 12/91	3961	2 - 4	U	U	NP	NP	Bis2 84.0*J	Methcl 3.0*J
BH01 12/91	3962	4 - 6	U	U	NP	NP	Bis2 610.0*J	Methcl 3.0*J
BH02 03/91	3691	0 - 2	U	U	NP	NP	Bis2 **	Methcl **
BH02 03/91	3692	5.5 - 7.5	U	U	NP	NP	Bis2 **	Methcl 13.0a
BH02 12/91	3963	0 - 2	U	U	NP	NP	Bis2 350.0*J	Acet Methc 7.0*J 2.0*J
BH02 12/91	3964	2 - 4	U	U	NP	NP	Bis2 210.0*J	Methcl 3.0*J
BH02 12/91	3965	4 - 6	U	U	NP	NP	Bis2 3100.0a	Methcl 7.0a
BH03 03/91	3693	0 - 2	U	U	NP	NP	Bis2 **	Methcl 12.0a
BH03 03/91	3694	5.5 - 7.5	U	U	NP	NP	Bis2 **	Methcl **
MW02 06/90	3436	6.5 - 7	NP	NP	U	NP	Bis2 430.0a	Acet Methcl 8.0a **
MW04 06/90	3439	8.5 - 9	NP	NP	U	NP	Bis2 1600.0a	Acet Methcl 6.0a T ** 1.0
MW05 06/90	3443	6.5 - 7	NP	NP	U	NP	Bis2 3900.0a	Acet Methcl 8.0a T ** 4.0

site 4

Table 7.4. Soil sample results for Group 1 Sites (cont.)

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Total PHC, mg/kg (*3)	PCB/Pesticide, µg/kg (*4)	Semivolatiles, µg/kg (*5)	Volatiles, µg/kg (*6)
MW05 06/90	3444	8.5 - 9	NP	NP	U	NP	Bis2 800.0a	Methcl T ** 3.0
MW06 06/90	3447	6.5 - 7	NP	NP	13	NP	Bis2 **	Methcl 15.0a
MW08 06/90	3450	6.5 - 7	NP	NP	16	NP	Bis2 2100.0a	Acet Methcl ** 32.0a
MW09 06/90	3451	6.5 - 7	NP	NP	U	NP	Bis2 **	Acet Methcl ** 19.0a
MW59 11/91	3908	5 - 6.5	U	U	NP	NP	Bis2 770.0a	Methcl 3.0*J
MW59 11/91	3909	5 - 6.5	U	U	NP	NP	Bis2 3900.0a	Methcl 3.0*J
MW60 11/91	3910	5 - 6.5	U	U	NP	NP	Bis2 4700.0a	Methcl 3.0*J
SD01 08/89	3154	0 - 1	NP	NP	7	U	Bis2 1200.0a	Acet Methcl ** 31.0a
SD02 08/89	3158	0 - 1	NP	NP	11	U	Bis2 2800.0a	Acet Methcl ** 57.0a
SF01 09/89	3175	0 - 2	NP	NP	40	4,4DDE 24.0 4,4DDT 10.0	Bis2 **	NP
SF01 09/89	3176	2 - 4	NP	NP	15	U	Bis2 **	NP
SF02 09/89	3177	0 - 2	NP	NP	140	4,4DDD 31.0 4,4DDE 22.0 4,4DDT 170.0	Bis2 **	NP
SF02 09/89	3177D	0 - 2	NP	NP	NP	4,4DDD 34.0 4,4DDE 23.0 4,4DDT 160.0	NP	NP
SF02 09/89	3178	2 - 4	NP	NP	2	U	Bis2 **	NP
SF03 09/89	3179	0 - 2	NP	NP	43	4,4DDD 7.8 4,4DDE 29.0 4,4DDT 37.0	Bis2 **	NP
SF03 09/89	3180	2 - 4	NP	NP	U	U	Bis2 **	NP

Table 7.4. Soil sample results for Group 1 Sites (cont.)

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Total PHC, mg/kg (*3)	PCB/Pesticide, µg/kg (*4)	Semivolatiles, µg/kg (*5)	Volatiles, µg/kg (*6)
SF04 09/89	3181	0 - 2	NP	NP	4	U	Bis2 **	NP
SF04 09/89	3182	2 - 4	NP	NP	U	U	Bis2 **	NP
SF04 09/89	3183	2 - 4	NP	NP	U	U	Bis2 **	NP

- ** - unusable data due to method blank contamination
a - suspected laboratory contaminant
*1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
*2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
*3 - EPA Method 418.1, quantitation limit: 1 mg/kg
*4 - EPA method 3550/8080, quantitation limit: 8.3 µg/kg
*5 - EPA method 3550/8270, quantitation limit: 350 µg/kg
*6 - EPA method 8240, quantitation limit: 5 µg/kg
*J - concentration estimated
4,4DDD - 1,1'(2,2dichloroethylidene) bis(4-chlorobenzene)
4,4DDE - 1,1'(dichloroethenylidene) bis(4-chlorobenzene)
4,4DDT - 1,1(2,2,2trichloroethylidene) bis(4-chlorobenzene)

- Acet - acetone
Bis2 - bis(2-ethylhexyl) phthalate
Die - HBP PHC as compared to diesel fuel
HBP - high boiling point
LBP - low boiling point
Methcl - methylene chloride
NP - analysis not performed
PHC - petroleum hydrocarbons
T - toluene
U - no compounds detected

Table 7.4. Soil sample results for Group I Sites (cont.)

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg			
Compound	#	Average	Minimum
Aluminum	7	10,617	3,960.00
Antimony	0	ND	ND
Arsenic	7	16	4.70
Barium	7	111	55.50
Beryllium	7	0	0.22
Boron	7	34	9.40
Cadmium	0	ND	ND
Calcium	7	8,877	3,200.00
Chromium	7	9	3.90
Cobalt	7	7	2.40
Copper	7	114	30.80
Iron	7	16,710	7,020.00
Lead	7	11	5.20
Lithium	7	17	8.10
Magnesium	7	5,286	2,510.00
Manganese	7	462	149.00
Mercury	5	0	0.03
Holybdenum	1	3	3.00
Nickel	7	8	3.30
Potassium	7	2,664	1,080.00
Selenium	0	ND	ND
Silver	0	ND	ND
Sodium	7	5,456	1,020.00
Thallium	1	0	0.30
Vanadium	7	35	15.10
Zinc	7	184	46.20
Aluminum	7	10,617	3,960.00
Antimony	0	ND	ND
Arsenic	7	16	4.70
Barium	7	111	55.50
Beryllium	7	0	0.22
Boron	7	34	9.40
Cadmium	0	ND	ND
Calcium	7	8,877	3,200.00
Chromium	7	9	3.90
Cobalt	7	7	2.40
Copper	7	114	30.80
Iron	7	16,710	7,020.00
Lead	7	11	5.20
Lithium	7	17	8.10
Magnesium	7	5,286	2,510.00
Manganese	7	462	149.00
Mercury	5	0	0.03
Holybdenum	1	3	3.00
Nickel	7	8	3.30
Potassium	7	2,664	1,080.00
Selenium	0	ND	ND
Silver	0	ND	ND
Sodium	7	5,456	1,020.00
Thallium	1	0	0.30
Vanadium	7	35	15.10
Zinc	7	184	46.20
Aluminum	7	10,617	3,960.00
Antimony	0	ND	ND
Arsenic	7	16	4.70
Barium	7	111	55.50
Beryllium	7	0	0.22
Boron	7	34	9.40
Cadmium	0	ND	ND
Calcium	7	8,877	3,200.00
Chromium	7	9	3.90
Cobalt	7	7	2.40
Copper	7	114	30.80
Iron	7	16,710	7,020.00
Lead	7	11	5.20
Lithium	7	17	8.10
Magnesium	7	5,286	2,510.00
Manganese	7	462	149.00
Mercury	5	0	0.03
Holybdenum	1	3	3.00
Nickel	7	8	3.30
Potassium	7	2,664	1,080.00
Selenium	0	ND	ND
Silver	0	ND	ND
Sodium	7	5,456	1,020.00
Thallium	1	0	0.30
Vanadium	7	35	15.10
Zinc	7	184	46.20

- number of samples with detectable quantities of analyte
 ND - analyte not detected

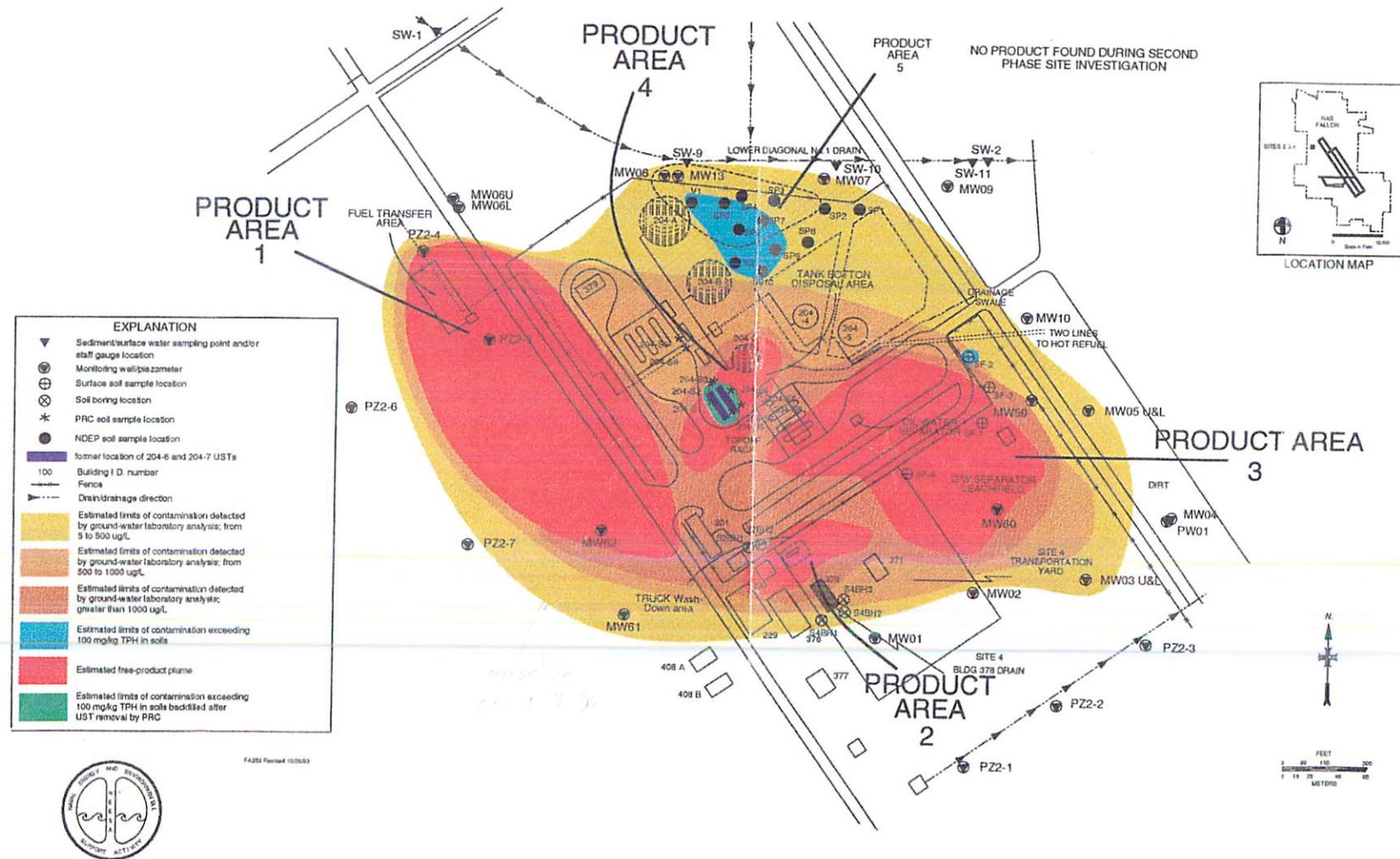


Table 7.4. Soil sample results for Group I Sites (cont.)

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg				
Compound	#	Average	Minimum	Maximum
Aluminum	7	10,617	3,960.00	19,400.00
Antimony	0 ND		ND	ND
Arsenic	7	16	4.70	40.00
Barium	7	111	55.50	226.00
Beryllium	7	0	0.22	0.82
Boron	7	34	9.40	62.40
Cadmium	0 ND		ND	ND
Calcium	7	8,877	3,200.00	13,700.00
Chromium	7	9	3.90	13.80
Cobalt	7	7	2.40	13.60
Copper	7	114	30.80	285.00
Iron	7	16,710	7,020.00	27,700.00
Lead	7	11	5.20	23.10
Lithium	7	17	8.10	29.00
Magnesium	7	5,286	2,510.00	8,840.00
Manganese	7	462	149.00	1,560.00
Mercury	5	0	0.03	0.07
Molybdenum	1	3	3.00	3.00
Nickel	7	8	3.30	14.50
Potassium	7	2,664	1,080.00	4,270.00
Selenium	0 ND		ND	ND
Silver	0 ND		ND	ND
Sodium	7	5,456	1,020.00	11,100.00
Thallium	1	0	0.30	0.30
Vanadium	7	35	15.10	55.10
Zinc	7	184	46.20	382.00

- number of samples with detectable quantities of analyte
 ND - analyte not detected

7-28

...les. **Very little PHC** contamination was identified. Indeed, only one
... control area, had TPH concentrations exceeding the
... (PH03) collected from various depths



7-28

many of the samples. Very little PHC contamination was identified. Indeed, only one
the weed control area, had TPH concentrations exceeding the
(BH01 to BH03) collected from various depths

in many of the samples. Very little PHC contamination was identified. Indeed, only one sample, No. 3177 from the weed control area, had TPH concentrations exceeding the NDEP action level of 100 mg/kg. Samples (BH01 to BH03) collected from various depths near the building 378 floor drain were uncontaminated.

Analytical data for all soil samples collected from borings in the weed control area, SF01, SF02, and SF03, indicated low concentrations of the pesticide (dichlorodiphenyl-trichloroethane (DDT) and its derivatives. This compound was used extensively by the military during the 1940s, 1950s, and 1960s and, due to an extremely long environmental half-life, is common in some areas. No record of its use at this location is presented in the PA/SI. However, it is not present at high concentrations and has low environmental mobility; thus, it is not considered a significant environmental threat. Additional discussion of pesticide mobility may be found in Sect. 10.5.3.

Results of the soil-gas survey are presented on Fig. 7.11, p. 7-29. These results were determined to be inconclusive because the depth of penetration of the probe was not close enough to the capillary fringe, resulting in sporadic rather than contiguous detection of contamination (ORNL 1991). Thus, the ground-water-test-hole technique was developed as an alternative screening method.

In addition to the contamination identified during the Phase II investigation, other soil contamination is known to exist at Site 2. An area of contaminated soil identified during the NDEP investigation (Sect. 7.1.3.3) is shown on Fig. 7.10, p. 7-27, as is contamination discovered when USTs 204-6 and 204-7 were removed. The following section summarizes the UST removal activities. Detailed information can be found in the draft UST removal report (PRC 1992).

UST Removal Activities

PRC Environmental Management, Inc., initiated removal activities of USTs 204-6 and 204-7 in April 1992. Prior to this, the tanks were sampled, pumped, and cleaned. The tanks most recently stored off-specification jet fuel. During excavation of UST-associated piping, two areas of widespread soil contamination were observed at a depth of approxi-

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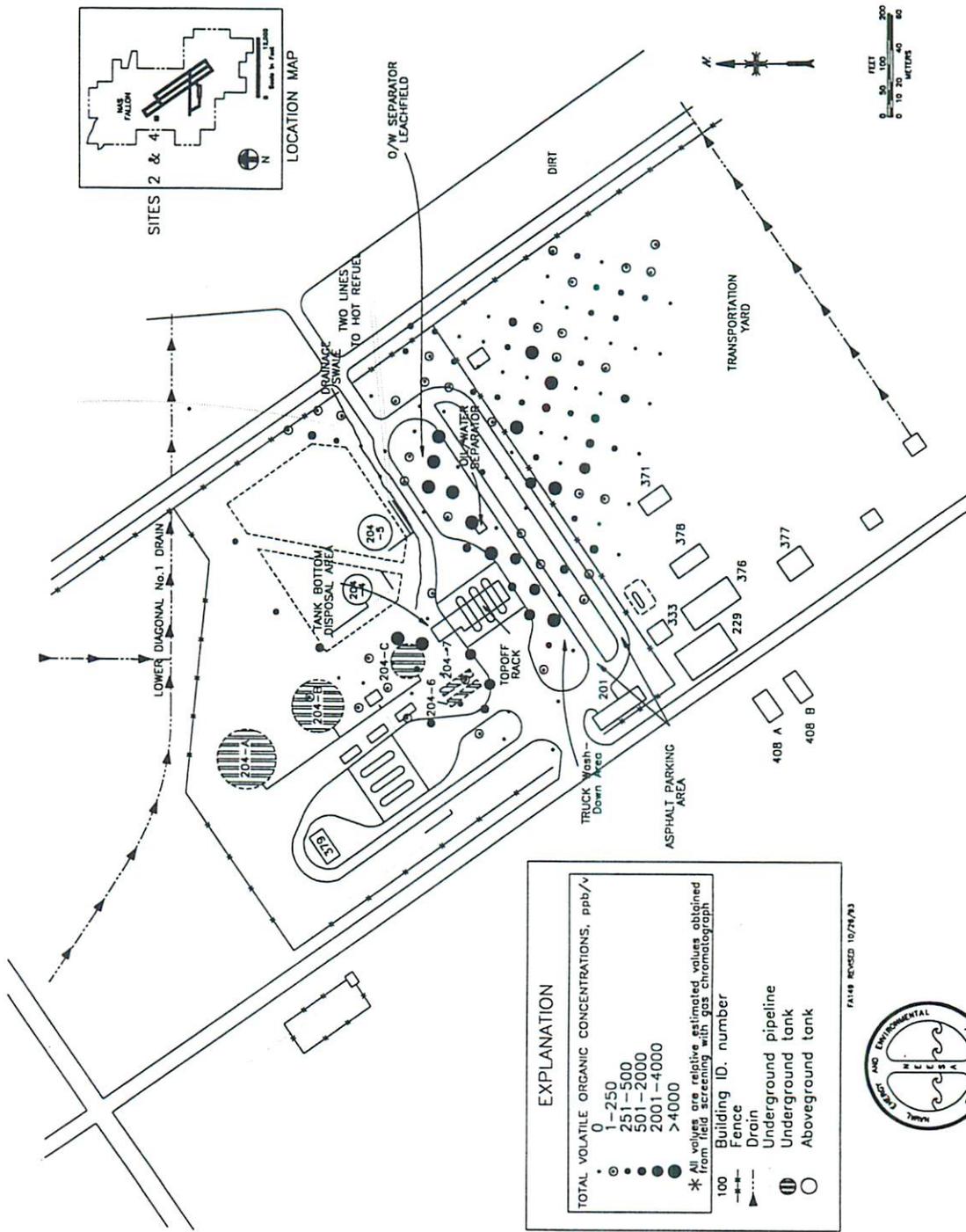


Fig. 7.11. Soil-gas survey sample points from ORNL investigation.

Actual tank removals took place during June 1992. Both soil and ground-water samples were collected from various depths in the excavation pits. There was no visible contamination or detectable odor to a depth of 6.5 ft BGS. However, soil samples collected in the saturated zone and taken at depths of 7 to 12 ft BGS had TPH concentrations ranging from 2400 to 152,000 mg/kg. The total depth of the excavation varied from 15 to 17 ft BGS. A ground-water sample collected from the area between the tanks before they were removed contained 2780 mg/L TPHs but nondetectable levels of BTEX compounds. Approximately 1 in. of free product was observed floating on the surface of the ground water that accumulated in the excavation pit.

Following tank removals, a product-recovery sump was constructed in the excavation pit, and a monitoring/recovery well was installed. The recovery sump was constructed by backfilling the excavation to a depth of approximately 8 ft BGS with clean, 2-in. crushed rock. A geotextile liner was laid over the gravel, and the TPH-contaminated soil was backfilled. A plastic sheet was then laid over the contaminated soil, and clean, excavated soil was backfilled to a depth of approximately 3 ft BGS. Clean road base was used to backfill to the ground surface. Additional road base and plastic sheets were added at the surface to create a crowned cap to promote drainage away from the site. During September 1992, a 4-in.-diameter monitoring/recovery well was installed in the sump (PRC 1992).

7.4.2 Ground Water

The first iteration of the Group I Sites ground-water characterization was summarized in the PSCS (ORNL 1992c). Recommendations in the PSCS led to a second iteration of characterization activities. The following sections generally discuss these activities separately. However, in certain cases, it is necessary to combine discussion of these tasks for proper interpretation. Analytical data for the two activities are combined in Table 7.5, p. 7-31. Existing wells installed during the ERM-West investigation are designated EW16, etc., in this table.

Table 7.5. Water sample results for Group I Sites

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Total PHC, mg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
EW16 07/90	3473	NP	NP	U	Bis2 120.0a	U
EW16 10/90	3516	U	U	NP	NP	Methcl 1.0a
EW17 07/90	3471	NP	NP	U	U	Acet 2.0a
EW17 10/90	3517	U	U	NP	NP	U
EW22 07/90	3474	NP	NP	U	Bis2 36.0a	Methcl **
EW22 07/90	3475	NP	NP	U	Bis2 **	Methcl **
EW22 10/90	3515	U	U	NP	NP	Carbdi 1.0
EW27 07/90	3476	NP	NP	U	Bis2 39.0a	Acet Methcl 1.0a **
EW27 07/90	3477	NP	NP	U	Bis2 **	Methcl **
EW27 11/90	3533	U	U	NP	NP	U
EW27 02/91	8453	U	U	NP	NP	NP
FB00 06/90	3440	NP	NP	U	U	Bro Dibro Methcl 21.0 4.0 **
MW01 07/90	3463	NP	NP	U	U	Acet 2.0a
MW01 11/90	3532	U	U	NP	NP	U
MW02 07/90	3464	NP	NP	U	U	Acet 4.0a
MW02 11/90	3526	U	U	NP	NP	Methcl 1.0a
MW03L 07/90	3466	NP	NP	U	U	U
MW03L 11/90	3530	U	140.0	NP	NP	U
MW03U 07/90	3470	NP	NP	U	U	U

Table 7.5. Water sample results for Group I Sites (cont.)

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Total PHC, mg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
MW03U 11/90	3531	U	U	NP	NP	U
MW03U 11/90	3564	U	U	NP	NP	U
MW03U 02/91	8450	JP5 50.0	U	NP	NP	NP
MW04 07/90	3454	NP	NP	U	U	U
MW04 11/90	3538	U	U	NP	NP	U
MW04 11/90	3565	U	U	NP	NP	U
MW04 02/91	8452	U	U	NP	NP	NP
MW05L 07/90	3456	NP	NP	U	U	Acet 1.0a
MW05L 11/90	3536	U	T X 84.0 1.0 6.0	NP	NP	U
MW05U 07/90	3459	NP	NP	U	Bis2 **	U
MW05U 11/90	3537	U	U	NP	NP	Methcl 3.0a
MW06L 07/90	3461	NP	NP	U	Bis2 **	U
MW06L 11/90	3544	U	U	NP	NP	Methcl 4.0a
MW06U 07/90	3465	NP	NP	U	U	U
MW06U 11/90	3542	U	U	NP	NP	Methcl 2.0a
MW06U 11/90	3543	U	U	NP	NP	Methcl 4.0a
MW06U 02/91	8451	U	U	NP	NP	NP
MW07 07/90	3478	NP	NP	U	Bis2 70.0a	U
MW07 07/90	3507	NP	NP	3	NP	NP

Table 7.5. Water sample results for Group I Sites (cont.)

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Total PHC, mg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
MW07 11/90	3523	U	U	NP	NP	U
MW07 11/90	3524	U	U	NP	NP	U
MW08L 07/90	3480	NP	NP	U	U	U
MW08L 11/90	3521	U	U	NP	NP	U
MW09 07/90	3460	NP	NP	U	U	Acet 4.0a
MW09 11/90	3535	U	U	NP	NP	U
MW10 07/90	3457	NP	NP	2	Bis2 **	U
MW10 11/90	3541	U	U	NP	NP	Methcl 2.0a
MW13 07/90	3508	NP	NP	U	U	U
MW13 11/90	3522	U	B 110.0 0.9	NP	NP	E 3.0 X 2.0
MW59 12/91	3940	Die 60.0	X 1.0*J	NP	U	U
MW59 04/92	3983	Die 60.0	U	NP	U	U
MW60 12/91	3945	JP5 140.0	U	NP	Bis2 **	U
MW60 12/91	3946	Die 90.0	U	NP	U	U
MW60 04/92	3984	Die 80.0	U	NP	U	U
MW61 12/91	3938	Die 230.0	U	NP	Bis2 **	U
MW61 04/92	3982	U	U	NP	U	Carbdi **
MW62 12/91	3939	JP5 110.0	Gas X 1300.0 43.0	NP	U	U

Table 7.5. Water sample results for Group I Sites (cont.)

**	- unusable data due to method blank contamination	Dibro	- dibromochloromethane
a	- suspected laboratory contaminant	Die	- HBP PHC as compared to diesel fuel
*1	- EPA method 8015 Modified, quantitation limit: 50 µg/L	E	- ethylbenzene
*2	- EPA method 8015/8020, quantitation limit: 50 µg/L	Gas	- LBP PHC as compared to gasoline
*3	- EPA method 418.1, quantitation limit: 1 mg/L	HBP	- high boiling point
*4	- EPA method 625, quantitation limit: 10 µg/L	JP5	- HBP PHC as compared to JP-5 jet fuel
*5	- EPA method 624, quantitation limit: 5 µg/L	LBP	- low boiling point
*J	- concentration estimated	Methcl	- methylene chloride
Acet	- acetone	NP	- analysis not performed
B	- benzene	PHC	- petroleum hydrocarbons
Bis2	- bis(2-ethylhexyl) phthalate	T	- toluene
Bro	- bromoform	U	- no compounds detected
Carbdi	- carbon disulfide	X	- xylenes (total)

Table 7.5. Water sample results for Group I Sites (cont.)

Anions, mg/L EPA Method 429 Quantitation limit: 0.5 mg/L				
Compound	#	Average	Minimum	Maximum
Chloride	20	916	7.20	2,400.00
Fluoride	4	2	0.61	3.60
Nitrate, as N	5	11	4.60	18.00
Phosphate	0 ND		ND	ND
Sulfate	20	1,514	2.60	3,900.00

- number of samples with detectable quantities of analyte
ND - analyte not detected

Metals, µg/L EPA method 200.7 Quantitation limit: 1 µg/L				
Compound	#	Average	Minimum	Maximum
Aluminum	13	181	41.70	1,460.00
Antimony	1	38	38.20	38.20
*Arsenic	37	1,290	15.30	4,660.00
Barium	37	58	13.60	139.00
*Beryllium	2	1	1.20	1.40
Boron	43	30,322	1,050.00	91,700.00
Cadmium	0 ND		ND	ND
Calcium	22	43,147	1,880.00	205,000.00
Chromium	0 ND		ND	ND
Cobalt	0 ND		ND	ND
*Copper	18	31	10.60	77.20
Iron	20	142	26.00	1,420.00
Lead	9	3	2.00	5.50
Lithium	43	81	27.90	153.00
Magnesium	22	17,254	971.00	59,300.00
Manganese	20	374	2.20	2,050.00
Mercury	1	0	0.21	0.21
Molybdenum	19	430	30.10	1,310.00
Nickel	0 ND		ND	ND
Potassium	22	37,317	5,630.00	130,000.00
Selenium	3	26	21.50	30.70
Silver	5	7	5.00	9.00
Sodium	25	2,552,800	131,000.00	8,790,000.00
Thallium	0 ND		ND	ND
Vanadium	30	277	16.70	1,230.00
*Zinc	28	57	7.30	338.00

- number of samples with detectable quantities of analyte
* - some or all results contain unusable data
ND - analyte not detected

Sample locations and contaminant boundaries are shown in Fig. 7.10, p. 7-27. The figure presents ground-water contaminant plume boundaries based on two different types of data: 1) data indicating the presence and thickness of free product when collecting water-level measurements; and 2) data obtained from laboratory analyses of ground-water samples. The plume boundary for each type of data is drawn around sample locations where detectable levels of contaminants were indicated by the measurement method.

7.4.2.1 First Iteration Activities

After initial screening using ground-water test holes, site-characterization activities included the installation of fifteen monitoring wells, one pumping well, and seven piezometers in and around the Group I Sites. Most of the wells were installed to confirm the limits of the dissolved product plume indicated by the ground-water test holes. Monitoring wells MW06U & L were installed as dual completion, "clean," upgradient wells. Wells MW07 (single completion), MW08U & L (dual completion), and MW09 (single completion) were installed between the fuel farm and the LD #1 Drain. MW08U failed to recharge after purging and was replaced with MW13. The remaining six wells were installed downgradient along the southern and eastern site boundaries. MW03U & L and MW05U & L are dual completions, and the other four wells are single completions. The pumping well, PW01, was installed as an offset to MW04. The well was used to determine hydrological parameters for the underlying aquifer (see Appendix E). The pumping test was performed at this location because it was identified as the most transmissive area found at the Group I Sites. This was based on the coarse-grained lithology extending throughout the entire thickness of the upper alluvial aquifer. Based on those parameters, the linear velocity of 560 ft/year is most likely the highest velocity found on the facility. Thus, it is presented as a worse-case scenario. Bail tests demonstrated that the permeability of subsoils in this area varied as much as an order of magnitude (see Sect. 7.2.2).

As shown in Fig. 7.10, p. 7-27, five areas of free-phase product contamination were delineated during first iteration activities: 1) the area between the pumping station and the fuel farm, 2) the area near a former sump used for collecting fuel from leaking tanker

trucks at the fuel farm, 3) the O/WS and associated leachfield area, 4) the area just north of the toff rack, and 5) the area east of underground tank 204-A [product was not detected at area 5 during second iteration sampling (see Sect. 7.4.2.2)] (see Appendix H, Table H.3, for product thickness measurements). It was undetermined if areas 2, 4, and 5 were actually connected to one another since testing was blocked by cultural features such as underground piping, utilities, tanks, and paved areas.

First round sample results (July 1990) from monitoring wells indicated no dissolved PHC contaminants in the ground water. Second round sample results (November 1990) were similar; however, small concentrations of LBPHCs were reported from monitoring wells MW03L, MW05L, and MW13. Results of VOC and SVOC analyses from both rounds of first iteration sampling indicated the presence of the common laboratory contaminants *bis*(2-ethylhexyl) phthalate, methylene chloride, and acetone in several samples. Carbon disulfide was detected in one sample; however, the result was below the method quantitation limit.

The ground-water metals and anion analyses indicate that naturally high TDS occur in the upper aquifer of the region. These dissolved solids have rendered the ground water in parts of the Carson Desert unfit for domestic use (Appendix D). This problem was not addressed by the RI because activities conducted at Site 2 have no potential to introduce these contaminants into the soil or ground water.

The first iteration characterization activities, combined with results from previous investigations, provided a data base for characterization of contaminants underlying the New Fuel Farm; however, contaminant concentration gradients in the portion of the dissolved plume between the leachfield and the southern plume boundary and the western plume boundary were not well characterized .

7.4.2.2 Second Iteration Activities

Preliminary evaluation of the laboratory data, field data, and discussions with HAZ-WRAP, Navy, and NDEP personnel led to the conclusion that some additional field work was needed at the Group I Sites. Based on the results of the first iteration of IR Program field work, additional investigations were recommended to collect the data required to

characterize the extent and degree of contamination and to complete the risk assessment and removal action design. The following observations from the first iteration of characterization led to the recommendations. First, the contaminant concentration gradient between the product plume and the distal dissolved-plume boundary needed to be assessed. Also, test borings were needed to assist in the removal action design. No additional field investigations were proposed for Site 4.

Specific actions for the second iteration of characterization at Site 2 were outlined. Two additional shallow, single completion wells were to be installed within the plume. The purpose of these wells was to define the contaminant concentration gradient between the product plume and the distal plume boundary and to determine the influence on the plume of paleo-river deposits. Two other wells were to be installed near the distal end of the plume emanating from the vicinity of the pumping station west of the main road. One of these wells was to be installed within the product plume and the other one outside of the plume boundaries.

Ground-water test holes were to be drilled at all proposed well locations prior to well installation to ensure optimum placement. Test borings were also planned to assist in the removal action design. Two additional soil borings were requested by NDEP to determine if soil contamination was present in the vicinity of a tentatively identified contaminant source (a former sump reportedly used for catching fuel leaking from refueling trucks).

The following outlines the results from the second iteration characterization at Site 2. Eleven ground-water test holes were drilled in order to select monitoring well locations. The results indicated that free product extended south of ERM-West well W-15 into the transportation yard and south of the pumping station located west of the fuel farm.

The first well installed was MW59. It was placed east of W-15 within the limits of detectable contamination based on the ground-water-test-hole screening method (Fig. 7.10, p. 7-27). Field screening of the soil samples collected during drilling indicated slight contamination of soils at the water table; however, subsequent laboratory analysis of the soil sample detected only minor amounts of some laboratory-related volatile and semivolatile compounds. The ground-water sample from MW59 contained HBPHCs as diesel at 60 $\mu\text{g/L}$ and xylene at below quantitation limits (BQL) (1 $\mu\text{g/L}$). Thus, this well appears to be relatively clean.

The second well installed, MW60, was located between two ground-water test holes, one that was only slightly contaminated and another that contained several inches of free-phase product. Field screening of the soil samples from the capillary fringe of MW60 indicated only very slightly contaminated soil, and subsequent laboratory analysis of the sample detected only minor amounts of laboratory-related volatile and semivolatile compounds. Water samples collected from MW60 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from the first round of sampling (December 1991) indicate that MW60 contained 140 $\mu\text{g/L}$ of HBPHCs as JP-5. Second round sampling results (April 1992) reported HBPHCs as diesel at a concentration of 80 $\mu\text{g/L}$.

The third well installed, MW61, was located inside of the plume boundary on the west side of the fuel farm plume (Fig. 7.10, p. 7-27). It was located just southeast of GW95, a ground-water test hole that appeared to be near the plume boundary. Field screening of soil samples from the capillary fringe of MW61 indicated no soil contamination; therefore, no sample was submitted for laboratory analysis. Water samples collected from MW61 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from the first round of sampling indicate that MW61 contained 230 $\mu\text{g/L}$ of HBPHCs as diesel. Second round results indicated no contamination in the well.

MW62 was located inside of the product portion of the plume boundary west of the fuel farm entrance (Fig. 7.10, p. 7-27). It was located just southeast of GW96, a ground-water test hole that encountered free-phase product. Field screening of soil samples from MW62 indicated contaminated soil at the capillary fringe but no other soil contamination. Because soil contamination appeared to be related only to the free product on the ground water, no soil samples were submitted for laboratory analysis. Water samples collected from MW62 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from sampling indicate that MW62 contained 110 $\mu\text{g/L}$ of HBPHCs as JP-5 and LBPHCs at 1300 $\mu\text{g/L}$ as gasoline (xylenes at 43 $\mu\text{g/L}$). Note that care was taken not to include free product in the water sample obtained from MW62 so that the results reflect only dissolved constituents in the ground water. Slug and bail tests were performed on all new wells at the site with the exception of MW62, which contained free-phase product.

A total of 14 test borings were drilled to assist in the engineering design of the free-product-recovery system. Ten of the 14 test borings revealed product on the ground water. The four test borings that did not show product were all located in what was identified as product area 5 during first iteration activities. Subsequently, four more ground water test holes were drilled in the same area, and no free-phase product was found.

Two additional soil borings were drilled as requested by NDEP to determine if soil contamination was present in the vicinity of a tentatively identified contaminant source (a former sump reportedly used for catching fuel leaking from refueling trucks). Soil samples were collected for laboratory analysis from every 2-ft interval from the surface to below the water table (3 intervals per borehole). Soil samples collected from BH01 and BH02 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results indicated that all samples were without contaminants except the sample from the first 0 to 2-ft interval in BH01, which contained 6 $\mu\text{g/L}$ of HBPHCs as diesel. Thus, the conclusion is that no surface-soil contamination remains at the former sump area.

?
need
logs

7.4.3 Air

The atmosphere is not considered to be a contaminated medium of concern because volatile constituents introduced into the shallow subsurface will rapidly volatilize, and PID measurements taken at the site indicated no detectable VOCs. The air quality of the surrounding region is good, and prevailing air currents will rapidly disperse any volatile contaminants that may be released.

7.5 CONTAMINANT FATE AND TRANSPORT

Phase II site-characterization activities indicate that the contaminants of concern are PHCs. Results also indicate that the contaminated media of concern include the soils and shallow ground water underlying the site.

7.5.1 Contaminant Persistence

See Sect. 3.5.1 for a discussion of the persistence of jet fuels.

7.5.1.1 Chemical Reactions of Fuel Hydrocarbons

See Sect. 3.5.1.1 for a discussion of the reactions of fuel hydrocarbons, including alkanes and aromatics.

7.5.1.2 Biodegradation

See Sect. 3.5.1.2 for a discussion of the biodegradation of jet fuel. At the Group I Sites, biodegradation is inhibited by the presence of free-phase product. The product is toxic to subsurface microbes and will biodegrade only at the fringe of the affected area. Because of the large quantities present, the JP-5 in the subsurface at this site will, therefore, persist indefinitely.

7.5.2 Potential Routes of Migration

A synopsis of media-specific contaminant transport pathways, assimilation routes, exposure points, and affected biota for NAS Fallon is given in Appendix D. The following paragraphs expand on these evaluations in light of the characterization activities completed at the Group I Sites.

The contaminated media of concern at the Group I Sites include the soils and shallow ground water underlying the area. Direct exposure pathways for contaminated soils at Group I Sites include dermal contact, ingestion, and inhalation of dust particles and volatile constituents. Potentially affected biota include indigenous plants and burrowing animals as well as personnel associated with site excavation activities. Plant and animal populations are controlled on NAS Fallon property, thus minimizing exposures associated

with these biota. Because NAS Fallon is a restricted area, direct exposure to the human populace is restricted to naval personnel and subcontractors. Restricted access and lack of surface-soil contamination thus prevent contaminated soils at the Group I Sites from constituting a primary exposure pathway.

Direct exposure pathways for ground water include use of contaminated ground water extracted from the shallow aquifer and the intermediate aquifer. The shallow aquifer is not pumped on NAS Fallon property and, due to its high salinity, is used sparingly for human consumption in the surrounding area (Appendix D). Thus, the potential for direct exposures to contaminants through extraction of the shallow ground water in the area is believed to be minimal.

Available site-characterization results indicate that contaminants are not migrating into the intermediate aquifer. The PA/SI report postulates the existence of an upward flow gradient in the surrounding area (Dames and Moore 1988). This is confirmed by Phase II characterization data (Appendix E). Additionally, a confining clay layer is known to exist between the contaminated shallow aquifer and the intermediate aquifer over the entire facility as demonstrated by installation of IR Program wells at several other sites. It is believed that these natural containment mechanisms prevent contaminants from reaching the intermediate aquifer.

The preferred flow path appears to be consistent with the regional flow direction, which tends to be toward the LD Drain more than two miles south of the site. It is also more than two miles to the nearest off-site, downgradient domestic well (Appendix D). (Note: None of the wells south of the facility are used for drinking water.) Seasonal fluctuations in the water levels in LD #1 Drain, however, may cause local development of a flow gradient toward LD #1 Drain and allow discharge of contaminated ground water into this drain. Currently, surface-water samples are analyzed quarterly by an NDEP-certified laboratory for the presence of PHCs.

Contaminants presently associated with the shallow ground water could migrate down-gradient for eventual seepage discharge into the LD Drain; however, considering the time and distance involved, it is not likely that contaminants would escape degradation in order to migrate to the south drain. Restricted access and institutional controls again minimize surface-water exposures on NAS Fallon property. However, contaminated surface water

could potentially transport contaminants off site to exposure points (see Appendix D).

As with ground water, contaminated soils associated with Group I Sites do not constitute a substantial direct exposure pathway. Soils may, however, serve as a source term for atmospheric transport of contaminated particulates, and both contaminated soils and ground water may act as a source for contaminating surface water. Contaminated surface water may then serve as an exposure pathway to receptors. The nearest surface water is the LD #1 Drain, which occasionally receives surface runoff from the area.

Exposures to wind-blown transport of contaminated soils are minimal due to restricted access in the immediate vicinity, the natural cohesive properties of native surface soils, and dust-control measures employed during construction activities. In addition, the air quality of the region is good, and airborne particulate matter is quickly dispersed. Hence, atmospheric transport is not considered a threat to the environment.

Except in areas where ponding of precipitation occurs, downward transport of residual soil contamination to the underlying aquifer via surface-water percolation is not considered significant because of the semiarid climate. Indeed, the alkali flats in the surrounding area indicate a negative regional water balance.

Ground- and surface-water transport to off-site receptors is thus the primary exposure pathway for contaminants of concern at the Group I Sites. Potential off-site transport mechanisms include: 1) eventual seepage discharge of ground-water contaminants to surface water migrating off site, and 2) discharge of contaminated surface water (from rainfall and human activity) to surface-water drainage systems. The principal exposure pathway of concern is thus the regional surface-water system, including the LD #1 Drain, which borders Site 2 on the north, and the LD Drain, which runs along the southeastern edge of the facility.

While the existence of soil and ground-water contaminants in excess of action limits does not in itself mandate active remediation, according to NDEP regulations the existence of free-phase product on the ground water in excess of 0.5 in. does require the implementation of an active removal action. Design of a free-product removal system for the Group I Sites has been initiated in conjunction with Phase II activities (ORNL 1991).

7.5.3 Contaminant Migration

See Sect. 3.5.3 for a discussion of contaminant migration.

7.6 BASELINE RISK ASSESSMENT (BRA)

The risk assessment for the Group I Sites is presented in the BRA (Volume III of the RI report). A risk assessment summary is presented in Sect. 7.7.

7.7 SUMMARY AND CONCLUSIONS

Soil - Analysis results from samples collected during Phase II of the IR Program indicated very little PHC contamination in soil at the Group I Sites. However, the focus of characterization activities at the sites was the free product at the water table and the associated dissolved-contaminant ground-water plume.

No contamination exceeding the NDEP action level was detected at Site 4, Transportation Yard (including the building 378 floor drain). Only one surface sample, from the weed control area, exceeded the action level at Site 2. Other samples from the weed control area contained the pesticide DDT and its derivatives (10 to 170 $\mu\text{g}/\text{kg}$).

Soil sampling data collected from investigative activities outside of the IR Program indicate additional contaminated areas at Site 2. An investigation by NDEP into an alleged fuel spill identified areas east of USTs 204-A and 204-B with surface and sub-surface contamination exceeding the action level (NDEP 1990). These areas were not targeted for soil sampling during Phase II of the IR Program because they were discovered after Phase II activities had begun. Other soil contamination was identified in June 1992 during the removal of USTs 204-6 and 204-7 (PRC 1992).

Sampling activities during tank removal indicated contamination near the tanks and piping that exceeded the NDEP action level. Following tank removal, the soils were placed back in the excavation pit. The Phase II ground-water investigation delineated a free-product plume in this area.

Data suitable for quantitative risk assessment were available only for pesticides at the weed control area. The risk assessment determined that cancer risks for both current and future uses were well below the point of concern. The HIs for both current and future uses were also well below the point of concern. Quantitative risk assessments were not performed at other Site 2 areas.

It is concluded that the weed control area does not warrant further attention based on the following: 1) current and future risks for human health are well below the point of concern for both cancer risks and the non-carcinogenic HI, 2) the contamination is limited to a small area of surface soil, 3) ground water has not been affected, 4) the quality of underlying ground water is not suitable for human consumption, and 5) the negative water balance in the area is not conducive to contaminant migration.

Ground water - Four areas of free petroleum product exceeding the NDEP action level for removal action were identified at the Group I Sites (Fig. 7.10, p. 7-27). Due to their source areas, the plumes are all considered a part of Site 2. A dissolved-contaminant plume associated with the free-product areas was also delineated. Dissolved-contaminant concentrations were relatively low with only one sample exceeding 1000 $\mu\text{g/L}$ TPHs. Dissolved contaminant concentrations should be assessed following the removal actions.

There is no current exposure, thus no current risk, from the ground water. No future exposures are anticipated due to the fact that ground water will not be pumped on base. Also, natural attenuation of the contaminants over a more than 2-mile distance makes future off-base exposures unlikely.

7.8 RECOMMENDATIONS

Soil: Site 2, New Fuel Farm - A removal action is recommended for those areas where the NDEP action level for TPHs is exceeded, excluding the weed control area.

Site 4, Transportation Yard - Due to the lack of contamination, a recommendation of no action is made.

Ground water: Site 2, New Fuel Farm - A removal action is required for areas where free-product thickness exceeds the NDEP action level (removal actions are in process). The ground-water recommendation is deferred until results of the free-product removal are assessed.

Site 4, Transportation Yard - No ground-water contamination was identified; thus, a recommendation of no action is made.

**8. GROUP II SITES: SITE 6, DEFUEL DISPOSAL AREA; SITE 7,
NAPALM BURN PIT; SITE 21, RECEIVER SITE LANDFILL;
SITE 22, NORTHEAST RUNWAY LANDFILL**

8.1 SITE BACKGROUND

8.1.1 Site Description and History

The Group II Sites consist of four sites that are grouped together due to their close proximity to each other and potential for overlapping areas of contamination: Site 6, Defuel Disposal Area; Site 7, Napalm Burn Pit; Site 21, Receiver Site Landfill; and Site 22, Northeast Runway Landfill. As shown in Fig. 1.2, p. 1-10, and Plate 1, the Group II Sites are located in the northeastern portion of NAS Fallon.

8.1.1.1 Site 6, Defuel Disposal Area

The Defuel Disposal Area consists of two regions of relatively level, unpaved surface soils. As shown in Fig. 8.1, p. 8-2, one of the suspected disposal areas lies within Site 21, the Receiver Site Landfill. The exact size of the disposal areas is not known but is estimated to have been approximately 500 by 500 ft each (Dames and Moore 1988).

Activities at Site 6 consisted of disposal of off-specification JP-5 and JP-4 removed from aircraft fuel tanks by trucks. This fuel was contaminated with water or sediment and is commonly referred to as defuel. The trucks were driven to the defuel areas where the fuel was dumped on the ground surface. It is estimated that a total of 70,000 gal of defuel were disposed of at the two areas between 1966 and 1972 (Dames and Moore 1988).

8.1.1.2 Site 7, Napalm Burn Pit

The Napalm Burn Pit is also reportedly located within Site 21, the Receiver Site Landfill (Fig. 8.1, p. 8-2). However, the pit could not be located by the PA/SI team

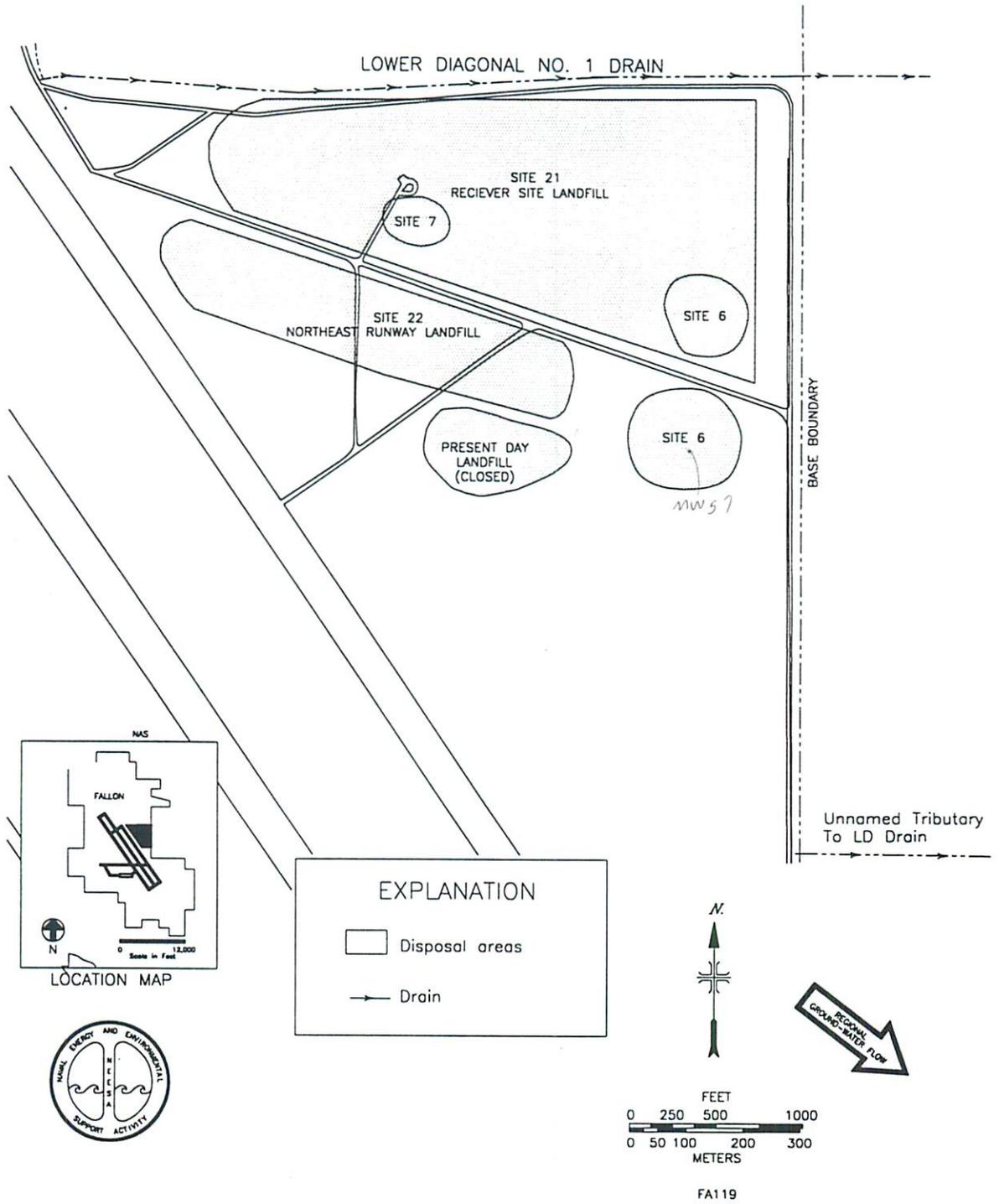


Fig. 8.1. Group II Sites: Site 6, Defuel Disposal Area; Site 7, Napalm Burn Pit; Site 21, Receiver Site Landfill; Site 22, Northeast Runway Landfill.

during the Phase I study nor was it identified on air photos of the area. Disposal of excess napalm by burning was reportedly practiced at Site 7 from the early 1960s to 1983. Burning was accomplished by placing napalm canisters in a pit where they were axed open, saturated with diesel fuel, and ignited. It is estimated that as many as 240,000 gal may have been disposed of in this manner (Dames and Moore 1988).

Testimony by the former NAS Fallon Fire Chief at a public meeting held September 4, 1991, in Fallon refuted the existence of this site. He stated that napalm was burned at Site 1, the Crash Crew Training Area.

8.1.1.3 Site 21, Receiver Site Landfill

Site 21, the Receiver Site Landfill, is the largest of the Group II Sites (Fig. 8.1, p. 8-2). Within it lie two other sites in the group, the alleged napalm burn pit and one of the defuel disposal areas. The site consists of nearly level, unpaved ground.

The Receiver Site Landfill received waste generated at NAS Fallon between the years of 1965 and 1980 when land disposal activities consisted of burying waste in trenches. Solid waste included wet garbage, trash, and rubble. It is believed that approximately 1,000 gal of liquid waste, including JP-5, gasoline, diesel fuel, waste oils, and hydraulic fluids generated from aircraft maintenance and Public Works Transportation, were also disposed of at the site. Burning of liquid wastes on site is reported to have occurred. Disposal of hydrocarbon waste at the site was prohibited in 1975, and after 1979, only dry trash and rubble were allowed in the landfill. Disposal activities on the site were discontinued in 1980 to 1981 when landfill operations were moved to the adjacent Northeast Runway Landfill (Dames and Moore 1988).

8.1.1.4 Site 22, Northeast Runway Landfill

The Northeast Runway Landfill is located south of the Receiver Site Landfill (Fig. 8.1, p. 8-2). The site consists of nearly level, unpaved ground. Landfill disposal activities were transferred from the Receiver Site Landfill to the Northeast Runway

Landfill in 1980 through 1981, where operations continued until 1987. During this period, an estimated 60,000 tons of refuse were disposed of at the site. Disposal consisted of burying wastes in north-south excavated trenches. Wastes were similar to those disposed of at the Receiver Site Landfill except that waste disposal was more restrictive and fewer hazardous materials were included (Dames and Moore 1988).

8.1.2 Previous Investigations

The only previous investigation performed at the Group II Sites was Phase I, PA/SI, of the IR Program. The PA/SI consisted of on-site interviews, a visual inspection, and a records search of each site. The study recommended the inclusion of all four sites in the RI due to potential soil and ground-water contamination. Conclusions drawn from the Phase I study are summarized below (Dames and Moore 1988):

Site 6, Defuel Disposal Area: due to the amount of liquid-hydrocarbon waste applied to the site, soil and ground-water contamination is probable.

Site 7, Napalm Burn Pit: landfill operations in the vicinity of the site prevent location of the napalm burn pit. Contamination of soils may have resulted from incomplete incineration of napalm and diesel fuel; however, the high viscosity of napalm and small quantities of unburned waste should limit this possibility.

Site 21, Receiver Site Landfill: because liquid-hydrocarbon wastes were disposed of at the site, soil and possibly ground-water contamination may be present. In addition, it is suspected that other hazardous substances such as paint wastes and metals may have been discarded at the site.

Site 22, Northeast Runway Landfill: although monitored to minimize hazardous wastes, the landfill may have received minor amounts of paint wastes and metals. These hazardous substances may have resulted in soil and ground-water contamination.

The PA/SI recommended soil sampling and installing eight ground-water monitoring wells at the Group II Sites. Recommended well locations were: one upgradient from the sites; one between the LD #1 Drain and the Receiver Site Landfill; four in the disposal areas; and two downgradient. Recommended test parameters were TPHs, VOCs, SVOCs, and metals.

8.1.3 Investigative Approach

Records indicating the type and amount of wastes disposed of at the sites were taken as verification that contamination existed. For this investigation, it was assumed that some soil contamination existed within the landfill area. However, characterizing the contents of a landfill is an impractical undertaking, and the important issue was whether or not contaminants were migrating from the sites. Modifications to the work plan included use of the ground-water-test-hole method and slight changes in the location of down-gradient monitoring wells.

8.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

8.2.1 Surface-Water Hydrology

The LD #1 Drain borders the Group II Sites north of Site 21, the Receiver Site Landfill. An unnamed tributary to the LD Drain is located approximately one-half mile southeast of Site 6, the Defuel Disposal Area. (Fig. 8.1, p. 8-2).

8.2.2 Ground-Water Hydrology

Monitoring wells MW12U, MW45, MW46, MW47, MW48, MW49, and PW03 were used to evaluate the shallow alluvial aquifer (Fig. 8.2, p. 8-6). MW12L was installed in the intermediate alluvial aquifer to find what effect hydraulic parameters had on contaminant transport. The static head of MW12L is approximately 7 ft higher than that of adjacent

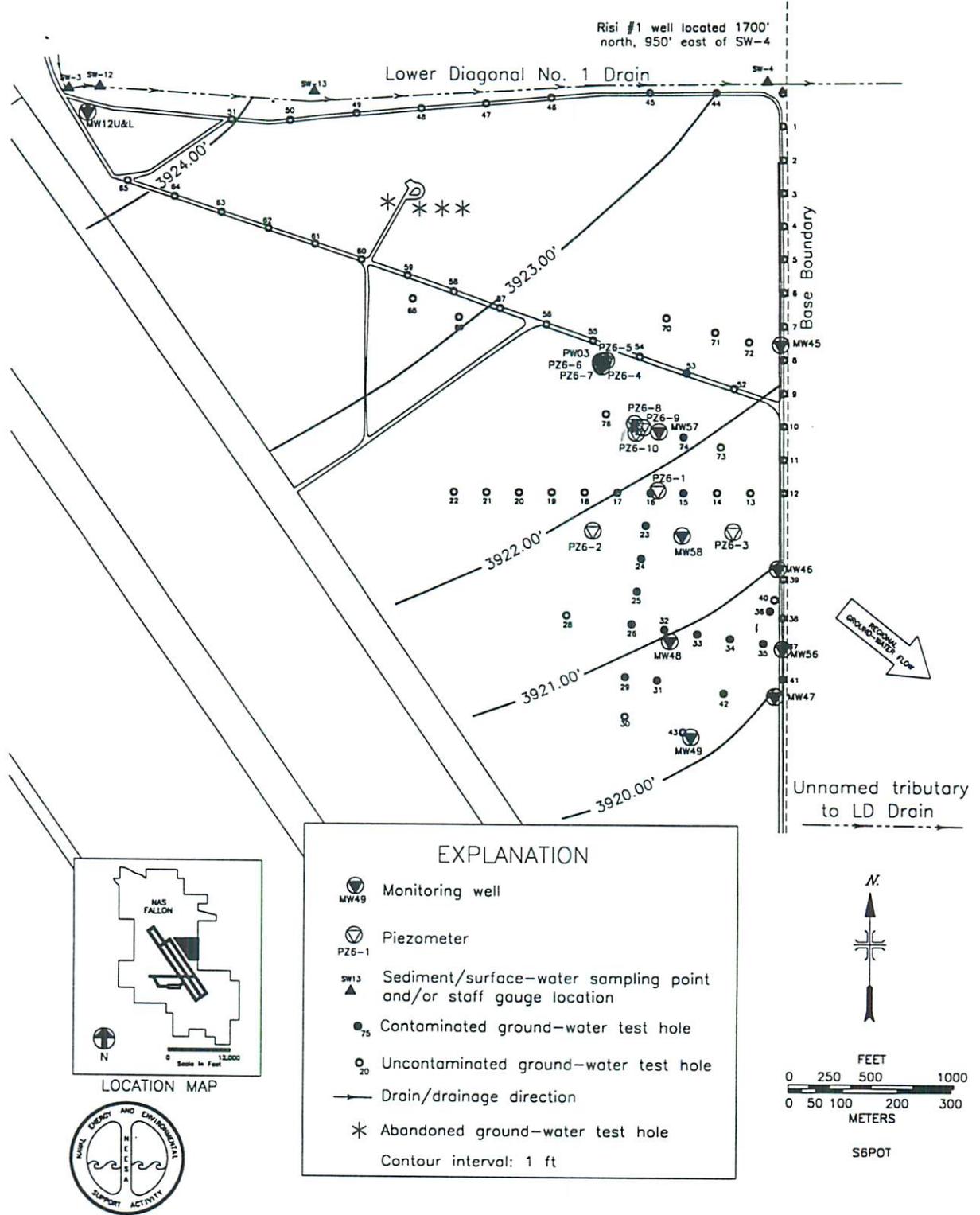


Fig. 8.2. Group II Sites. Water-table elevation map for the shallow alluvial aquifer (measurements taken June 1991).

V = 101-114/y

well MW12U, which is completed in the shallow aquifer; this precludes any downward migration of contaminants. Hydraulic conductivities based on bail-slug tests ranged from 0.3 ft/d in MW47 to 6.8 ft/d in MW48. A pumping test at PW03 provided a linear ground-water velocity of 4.5 ft/year, which is consistent with the type of sediments found across the site (Appendix E). This area is homogeneous with respect to the sediments, grading from silty clay at the surface to clay with depth. The water-table elevations indicate a gradient consistent with the regional flow direction, which is to the southeast and was confirmed by evaluation of data from the colloidal borescope (Appendix E). Depth to ground water at the Group II Sites varies seasonally and ranges from 3.5 to 11 ft BGS (see Appendix H, Table H.3).

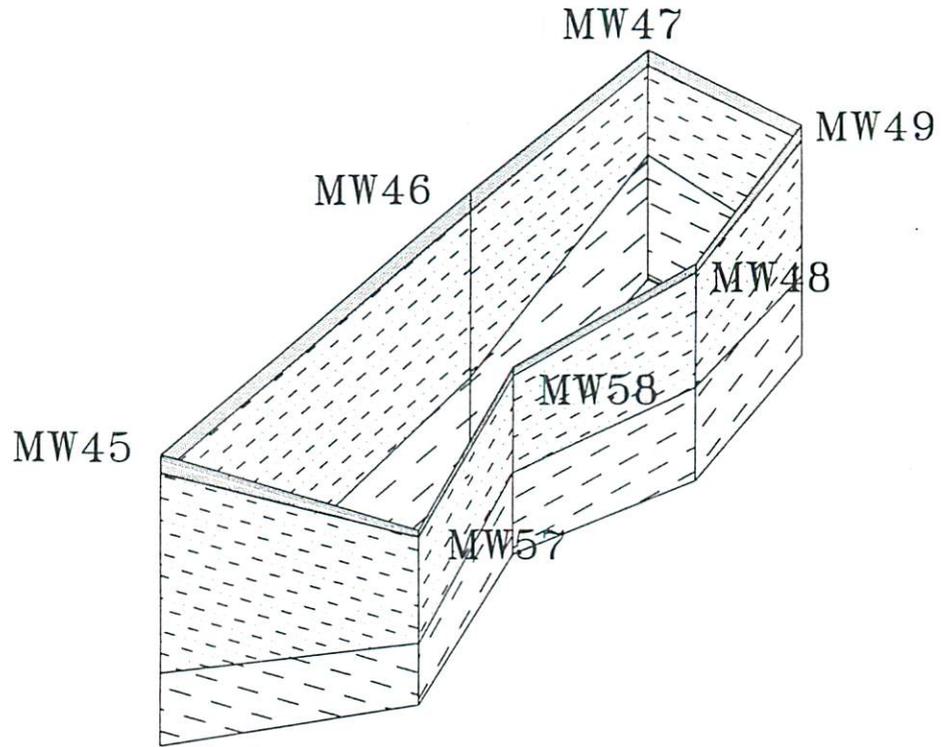
8.3 STUDY AREA INVESTIGATION

8.3.1 Surface-Water and Sediment Investigations

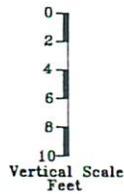
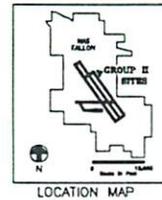
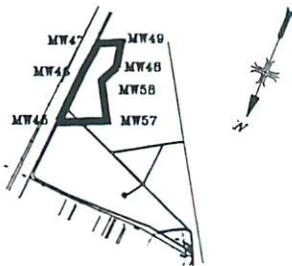
No surface-water or sediment samples were taken at the Group II Sites. However, screening along the LD #1 Drain was conducted as a separate activity. Due to the close proximity of the drain to Site 21, results from the drain characterization are relevant to the Group II Sites (see Sect. 11).

8.3.2 Geological Investigation

The lithology information for the Group II Sites was obtained during the installation of monitoring wells MW12L, MW45, MW46, MW47, MW48, MW49, MW57, and MW58 and PW03. The lithology was obtained by two methods: 1) the use of a 5-ft continuous sampler advanced in front of the hollow-stem auger or 2) driving a 1.5 or 2.0-ft sampler utilizing the California method. The only exception to this was MW12U, which was installed approximately 8 ft south of the lower completion. No lithology information was obtained from this well. Fig. 8.3, p. 8-8, shows the simplified fence diagram and the relationship of the wells installed in this area. Monitoring wells MW12U and MW12L



FENCE DIAGRAM LOCATION MAP



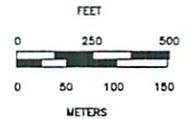
EXPLANATION

FALLON FORMATION

- EOLIAN DEPOSITS - Wind-blown deposits.
- DELTA/SHALLOW LAKE DEPOSITS - Very fine grained sand, silt, and silty clay.

SEHOO FORMATION

- PALUDAL DEPOSITS - Clayey silts and clay lake deposits.



SITE 6

Fig. 8.3. Simplified fence diagram for monitoring wells installed at the Group II Sites.

were installed as upgradient wells for these sites while monitoring wells MW45, MW46, MW47, and MW49 were installed downgradient. Monitoring wells MW48, MW57, and MW58 were installed in areas where ground-water test holes indicated contamination. All monitoring wells penetrated the entire Fallon Formation and from 3 to 8 ft of the Seho Formation, with the exception of the MW12L. This well fully penetrated the Seho and reached total depth in the Wymaha Formation. The upper 20 ft of the sediments represent near-shore deposition of silts and silty clays interbedded with silty clays and clays of ancient Lake Lahontan. The contact between Fallon Formation, represented as the near-shore deposits, and the deeper lake deposits of the Seho Formation is much higher in the section at this study area.

8.3.3 Vadose Zone and Soil Investigation

Four soil samples were collected at the Group II Sites when drilling boreholes for monitoring wells during the first iteration of Phase II site characterization. Two additional samples were collected when drilling wells during the second iteration of characterization. Sample locations are shown on Fig. 8.2, p. 8-6, and Fig. 8.4, p. 8-10. Associated well numbers and sampling intervals are shown below.

<u>Well Number</u>	<u>Soil Sample Interval, ft</u>
MW45	9.0 to 11.0
MW46	7.0 to 9.0
MW47	7.0 to 9.0
MW48	7.0 to 9.0
MW56	5.0 to 6.5
PW03	5.0 to 6.5

All soil samples collected from the Group II Sites were analyzed for HBPHCs, LBPHCs, SVOCs, and VOCs.

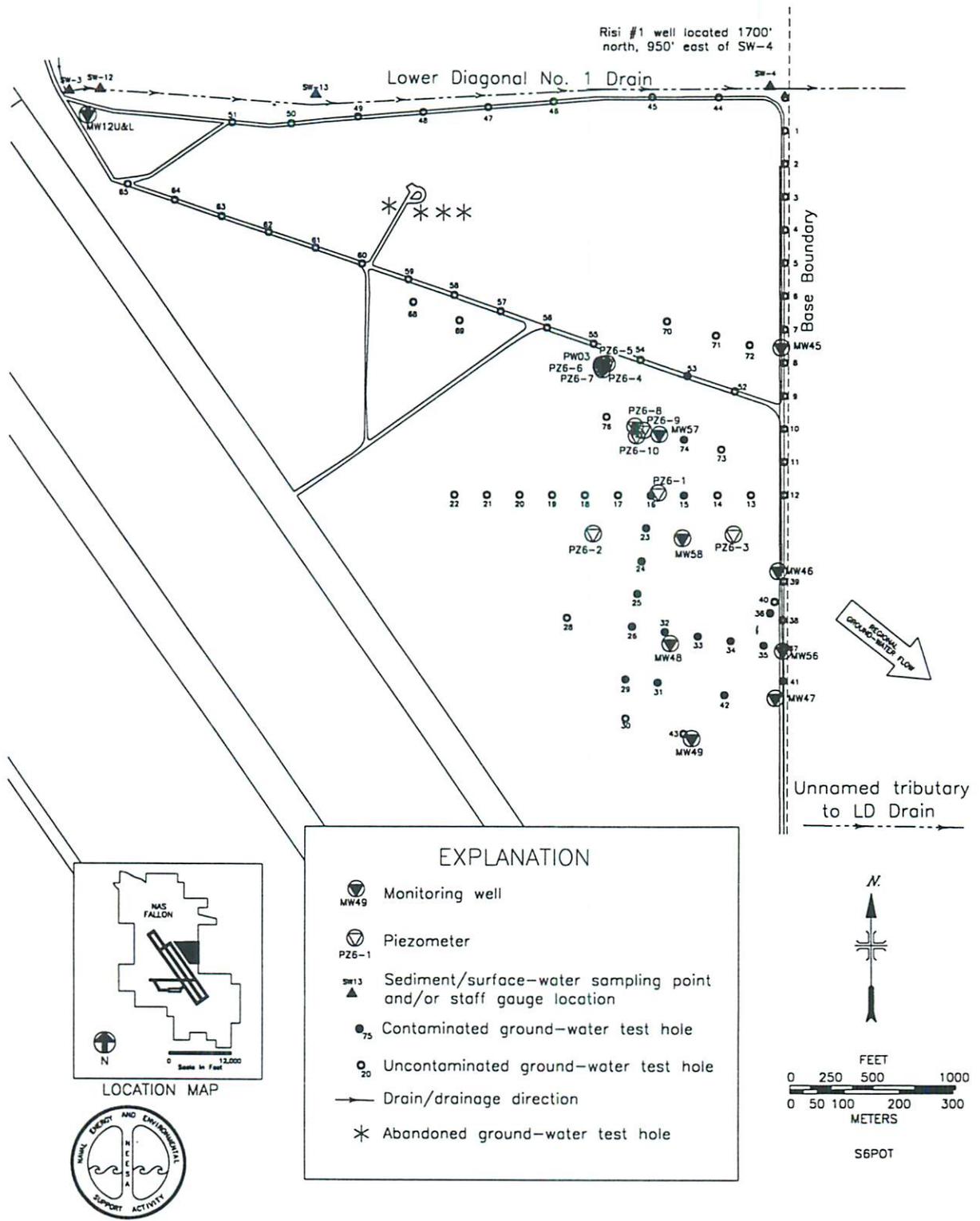


Fig. 8.4. Group II Sites. Sample locations.

8.3.4 Ground-Water Investigation

The first iteration of the ground-water investigation at the Group II Sites involved boring 79 ground-water test holes and installing seven monitoring wells and eight piezometers. Recommendations for subsequent investigation were based on results from the first sampling iteration and recommendations made in the PSCS (ORNL 1992c). The second iteration of ground-water investigation at the Group II Sites included boring nine additional ground-water test holes and installing four monitoring wells and seven additional piezometers. Sample locations for the Group II Sites are shown on Fig. 8.2, p. 8-6, and Fig. 8.4, p. 8-10. Results of ground-water-test-hole screening are given in Appendix C.

Ground-water test holes were used to delineate a PHC plume on the ground water underlying the facility and to determine suitable locations for monitoring wells. Water samples from the monitoring wells were sent to an off-site laboratory and analyzed for LBPHCs, HBPHCs, PCB/pest, SVOCs, VOCs, anions, and metals. Also, samples were analyzed in the field for temperature, pH, and conductivity. Results of water-quality field measurements for all sites are presented in Appendix G. The monitoring wells and piezometers were used to determine ground-water levels and to measure the presence and thickness of free-phase hydrocarbon product on the ground-water surface.

8.4 NATURE AND EXTENT OF CONTAMINATION

8.4.1 Vadose Zone and Soils

Soil sample results are presented in Table 8.1, p. 8-12. Analysis results for HBPHCs and LBPHCs indicate no compounds detected for all samples. *Bis*(2-ethylhexyl) phthalate and methylene chloride were reported as laboratory contaminants for all samples during the first iteration sampling. However, they were reported as detectable quantities during the second iteration of sampling (in MW56 and PW03). Detected levels are not considered significant, and the corresponding water samples from the same wells reported the compounds as laboratory contaminants only.

Table 8.1. Soil sample results for Group II Sites

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)	Volatiles, µg/kg (*4)
MW45 03/91	3605	9 - 11	U	U	Bis2 **	Methcl **
MW46 03/91	3606	7 - 9	U	U	Bis2 **	Methcl **
MW47 03/91	3607	7 - 9	U	U	Bis2 **	Methcl **
MW48 03/91	3609	7 - 9	U	U	Bis2 **	Methcl **
MW56 11/91	3907	5 - 6.5	U	U	Bis2 6300.0a	Methcl 9.0a
PW03 11/91	3906	5 - 6.5	U	U	Bis2 1300.0a	Methcl 3.0*J

- ** - unusable data due to method blank contamination
 a - suspected laboratory contaminant
 *1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
 *2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
 *3 - EPA method 3550/8270, quantitation limit: 350 µg/kg
 *4 - EPA method 8240, quantitation limit: 5 µg/kg
 *J - concentration estimated
- Bis2 - bis(2-ethylhexyl) phthalate
 HBP - high boiling point
 LBP - low boiling point
 Methcl - methylene chloride
 PHC - petroleum hydrocarbons
 U - no compounds detected

The soil sample for MW48 showed no petroleum contamination; however, the corresponding monitoring well samples contained both HBPHCs and LBPHCs. This was due to the fact that the soil sample was taken from the 7- to 9-ft depth interval, and the water level in the well was only about 5 ft BGS when sampled. Thus, the soil sample was taken deeper than the water sample and would not have included contaminants contained near the top of the water table.

8.4.2 Ground Water

The first iteration of the Group II ground-water characterization was summarized in the PSCS (ORNL 1992c). Recommendations in the PSCS led to a second iteration of characterization activities. The following sections, in general, discuss these activities separately. However, in certain cases it is necessary to combine these tasks for proper interpretation. Analytical data tables for the two activities are combined.

Sample locations are shown in Fig. 8.4, p. 8-10, a contaminant boundary map for Site 6 is shown in Fig. 8.5, p. 8-14. The figure presents ground-water contaminant plume boundaries based on two different types of data: 1) data indicating the presence and thickness of free product when collecting water-level measurements and 2) data obtained from laboratory analyses of ground-water samples. The plume boundary for each type of data is drawn around sample locations where detectable levels of contaminants were indicated by the measurement method.

8.4.2.1 First Iteration Activities

After initial screening using ground-water test holes, site-characterization activities included installing seven monitoring wells, eight piezometers, and two staff gauges (Fig. 8.2. p. 8-6). One upgradient well (MW12L) was completed in the intermediate aquifer; the remaining wells were completed across the top of the water table in the shallow alluvial aquifer. Five piezometers were installed north of the study area in conjunction with the LD #1 Drain investigation. Three additional piezometers were installed in and around Site 6.

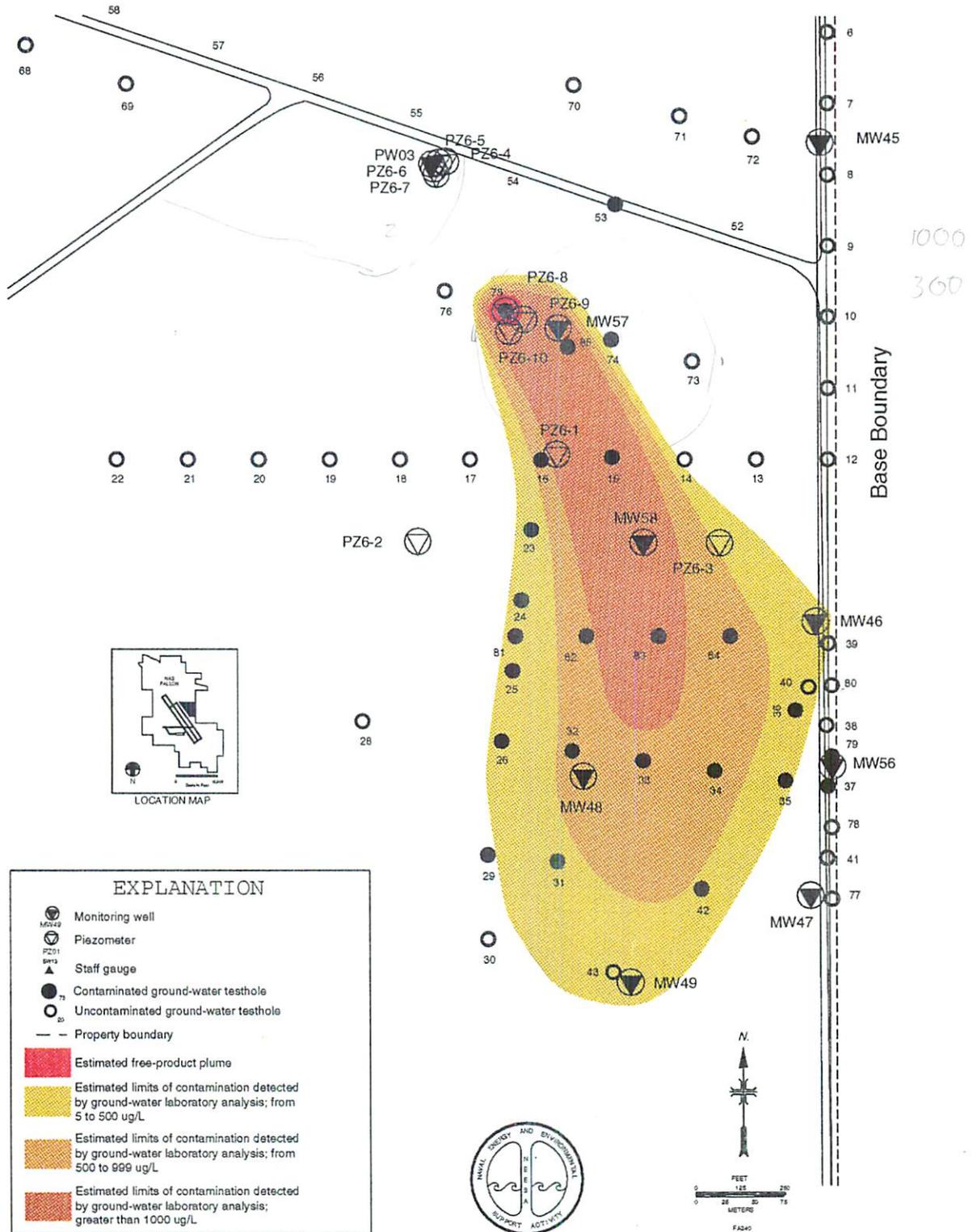


Fig. 8.5. Group II Sites. Contaminant boundary map for Site 6, Defuel Disposal Area.

Monitoring wells MW45, MW46, MW47, and MW49 were installed near areas shown as uncontaminated by the limits of detections of the ground-water-test-hole method. First round sample results (April 1991) for these wells indicated that all test parameters for all samples were below detection limits. Second round sample results (August 1992) for the same wells were similar, excluding PHCs in MW46 and MW49. These wells contained 86 $\mu\text{g/L}$ LBPHCs as gasoline and 1000 $\mu\text{g/L}$ HBPHCs as diesel respectively (Table 8.2, p. 8-16).

Ground-water screening revealed the location of a PHC plume emanating from the southernmost disposal area of Site 6 (Fig. 8.5, p. 8-14). Sample results from MW48, which was intentionally placed within the plume, had HBPHC concentrations ranging from 480 to 1100 $\mu\text{g/L}$ during the two rounds of sampling. Contaminants were not detected in any of the other test holes; it appears that there was only one disposal area for Site 6. An attempt to locate the napalm burn pit by drilling ground-water test holes was unsuccessful because buried trash and rubble fouled the drilling augers. } site
>

The upgradient wells, MW12U and MW12L, were clean with respect to suspected contaminants, although concentrations of some metals and anions indicate poor water quality in the shallow alluvial aquifer. The head differences in the two wells confirmed the upward flow gradient between the intermediate and shallow aquifers (Appendix D).

8.4.2.2 Second Iteration Activities

Preliminary evaluation of the laboratory data, field data, and discussions with HAZWRAP, the Navy, and NDEP personnel led to the conclusion that some additional field work was needed at the Group II Sites. Based on the results of the first iteration of IR Program field work, additional investigations were recommended to collect the data required to characterize the extent and degree of contamination. The following observations from the first iteration of characterization led to the recommendations. MW48 was intentionally installed within the plume boundaries and showed significant levels of PHCs although no free product was present. However, ground-water test holes near the source of the plume indicated that free-phase product may be on the shallow ground-water surface. Also, ground-water-test-hole screening indicated a dissolved contaminant plume

Sites 6, 7, 21, 22

8-16

Table &2. Water sample results for Group II Sites

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Total PHC, mg/L (*3)	PCB/Pesticide, µg/L (*4)	Semivolatiles, µg/L (*5)	Volatiles, µg/L (*6)
MW12L 07/90	3503	NP	NP	U	U	U	Acet 1.0a
MW12U 07/90	3502	NP	NP	U	U	U	U
MW12U 04/91	3815	U	U	NP	U	U	U
MW45 04/91	3813	U	U	NP	U	U	U
MW45 08/91	3891	U	U	NP	NP	U	U
MW46 04/91	3812	U	U	NP	U	U	U
MW46 08/91	3889	U	Gas 86.0	NP	NP	U	U
MW47 04/91	3817	U	U	NP	U	U	U
MW47 08/91	3886	U	U	NP	NP	U	U
MW48 04/91	3819	Die 1100.0	Gas 350.0	NP	U	U	U
MW48 04/91	3820	Die 820.0	Gas 350.0	NP	U	U	Clform 1.0*J Tetra 17.0
MW48 08/91	3883	Die 480.0	U	NP	NP	U	U
MW48 08/91	3884	U	U	NP	NP	U	U
MW49 04/91	3814	U	U	NP	U	U	U
MW49 08/91	3892	Die 1000.0	U	NP	NP	U	U
MW56 12/91	3933	U	U	NP	NP	Bis2 **	U
MW56 04/92	3988	U	U	NP	NP	U	U
MW57 12/91	3936	Die 3400.0	Gas 340.0 T 2.0 X 6.0	NP	NP	Bis2 **	U

Final

Table 8.2. Water sample results for Group II Sites (cont.)

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Total PHC mg/L (*3)	PCB/Pesticide, µg/L (*4)	Semivolatiles, µg/L (*5)	Volatiles, µg/L (*6)
MW57 04/92	3986	Die 3700.0	Gas 680.0 E 1.0 X 9.0	NP	NP	2-Meth 3.0*J Bis2 48.0a	U
MW58 12/91	3935	Die 220.0	Gas 180.0	NP	NP	U	U
MW58 04/92	3987	JP5 190.0	X 2.0	NP	NP	Bis2 4.0*J	U
PW03 12/91	3934	U	X 2.0*J	NP	NP	Bis2 **	U

** - unusable data due to method blank contamination

a - suspected laboratory contaminant

*1 - EPA method 8015 Modified, quantitation limit: 50 µg/L

*2 - EPA method 8015/8020, quantitation limit: 50 µg/L

*3 - EPA method 418.1, quantitation limit: 1 mg/L

*4 - EPA method 608, quantitation limit: 0.05 µg/L

*5 - EPA method 625, quantitation limit: 10 µg/L

*6 - EPA method 624, quantitation limit: 5 µg/L

*J - concentration estimated

2-Meth - 2-methylnaphthalene

Acet - acetone

Bis2 - bis(2-ethylhexyl) phthalate

Clform - chloroform

Die - HBP PHC as compared to diesel fuel

E - ethylbenzene

Gas - LBP PHC as compared to gasoline

HBP - high boiling point

JP5 - HBP PHC as compared to JP-5 jet fuel

LBP - low boiling point

NP - analysis not performed

PHC - petroleum hydrocarbons

T - toluene

Tetra - tetrachloroethene

U - no compounds detected

X - xylenes (total)

Table 8.2. Water sample results for Group II Sites (cont.)

Anions, mg/L EPA method 429 Quantitation limit: 0.5 mg/L				
Compound	#	Average	Minimum	Maximum
Chloride	9	8,019	37.00	30,000.00
Fluoride	2	5	5.10	5.80
Nitrate, as N	0 ND		ND	ND
Phosphate	2	23	22.00	24.00
Sulfate	9	3,846	9.70	13,000.00

- number of samples with detectable quantities of analyte
ND - analyte not detected

Metals, µg/L EPA method 200.7 Quantitation limit: 1 µg/L				
Compound	#	Average	Minimum	Maximum
Aluminum	7	97	41.70	290.00
Antimony	4	35	32.70	37.70
Arsenic	8	3,337	15.00	6,360.00
Barium	7	32	19.30	71.10
Beryllium	0 ND		ND	ND
Boron	9	74,882	3,070.00	133,000.00
Cadmium	1	6	6.10	6.10
Calcium	8	20,361	1,310.00	104,000.00
Chromium	0 ND		ND	ND
Cobalt	0 ND		ND	ND
Copper	7	41	10.20	56.80
Iron	7	37	23.10	47.50
Lead	0 ND		ND	ND
Lithium	9	125	41.40	185.00
Magnesium	7	7,541	3,630.00	24,300.00
Manganese	7	63	4.80	382.00
Mercury	1	2	2.00	2.00
Molybdenum	7	913	23.30	1,440.00
Nickel	0 ND		ND	ND
Potassium	7	195,571	13,200.00	295,000.00
Selenium	0 ND		ND	ND
Silver	6	9	5.90	10.90
Sodium	9	10,307,556	128,000.00	19,300,000.00
Thallium	0 ND		ND	ND
Vanadium	8	691	11.00	1,090.00
Zinc	7	75	26.00	221.00

- number of samples with detectable quantities of analyte
ND - analyte not detected

near the base boundary; however, laboratory samples taken from monitoring wells at the boundary indicated no contamination.

The discussion of results and potential receptors indicated the need for additional investigations at Site 6. More information on the concentration of contaminants within the identified plume and a more concise plume definition near the facility boundary were needed. Additional aquifer parameter data was also necessary in order to assess the flow and transport of the plume.

Because no contaminants were detected downgradient from Site 7, the Napalm Burn Pit, no additional field investigations were proposed. Similarly, because no contaminants were detected in the ground water downgradient from Site 21, the Receiver Site Landfill, and Site 22, the Northeast Runway Landfill, no additional field investigations were proposed for these sites. } site
7

The following are specific actions for the second iteration of characterization at Site 6. One upgradient well was recommended. The well was designed as a 5-in.-diameter pumping well for aquifer testing, and four piezometers were to be installed around the well for observation points. The 5-in. well was to be fully penetrating and fully screened. Two additional wells were planned within the boundaries of the identified plume to assess free-product extent and contaminant concentration gradients. If free-phase product was found within the plume, three piezometers were to be installed to assess the extent and thickness of the product lens. One additional well was proposed at the distal end of the plume to confirm the plume limit definition and to monitor for potential off-site contaminant migration. Ground-water test holes were proposed at all well and piezometer locations prior to well installation to ensure optimum placement.

The following are results from the second iteration characterization at Site 6. A total of 9 ground-water test holes were drilled at Site 6 prior to the installation of the 4 new wells (Fig. 8.5, p. 8-14). The test holes were numbered GW77 to GW85. Only GW85 encountered contaminant levels indicative of free-phase product. Test holes GW77, GW78, and GW80 were drilled in apparently uncontaminated areas. GW79 showed a very slight degree of contamination; however, when nearby well MW56 was sampled (December 1991 and April 1992), no contamination was detected in either the

soil or the ground water. Test holes GW81 to GW84 were drilled across the middle of the ground-water plume. GW81 and GW82 were relatively uncontaminated, while GW83 and GW84 were relatively contaminated.

The other wells installed during second iteration drilling were MW57, MW58, and PW03. Even though free-phase product was indicated by GW85, the well installed nearby, MW57, has not shown any measurable product. Consequently, the three piezometers proposed for the area were installed west of MW57 instead of around MW57 as planned. Of the three piezometers, only the upgradient one, PZ6-8, had confirmed measurable product, approximately 0.30 ft thick (see Appendix H, Table H.3). Thus, a removal action under NDEP regulations is required. Field screening of the soil samples from the capillary fringe of MW57 indicated contaminated soil; however, no contamination was indicated in the vadose zone or at the bottom of the aquifer. Because contamination in the soil appeared to be related solely to the ground water, no soil samples from MW57 were submitted for laboratory analysis.

Water samples collected from MW57 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from the first round of sampling indicated that MW57 contained 3400 $\mu\text{g/L}$ of HBPHCs as diesel and 340 $\mu\text{g/L}$ of LBPHCs as gasoline with toluene 2 $\mu\text{g/L}$ and xylenes 6 $\mu\text{g/L}$. The second round of sampling yielded similar results.

The second well installed inside the plume was MW58. This well was installed in the intermediate portion of the plume to evaluate contaminant gradients. No free product was encountered; however, the soils were contaminated at the water table based on field screening. Since no soil contamination was detected that was not related to the ground-water plume, no soil samples were submitted for laboratory analysis from MW58.

Water samples collected from MW58 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from the first round of sampling indicated that MW58 contained 220 $\mu\text{g/L}$ of HBPHCs as diesel and 180 $\mu\text{g/L}$ of LBPHCs as gasoline. Results from the second round of sampling indicated MW58 contained 190 $\mu\text{g/L}$ of HBPHCs as JP-5 and 2 $\mu\text{g/L}$ of xylenes.

The upgradient uncontaminated well, PW03, was installed northwest of the Site 6 plume in an attempt to investigate the effect of coarse-grain deposits. Four piezometers were installed around the well to use as observation wells for a pumping test. No soil

contamination was detected by field screening, and a soil sample submitted for laboratory analysis indicated no contamination. First round water sample results from PW03 indicated the presence of xylenes at 2 $\mu\text{g/L}$.

A pumping test was performed on April 14 and 15, 1991. The well produced only 0.3 gal/min at a sustainable rate. Drawdown in the pumping well was approximately 6 ft; no drawdown was observed in the piezometers. Considering the fine-grain material encountered and the low permeability measured by the pumping tests, ground-water flow rates are anticipated to be quite low in this area, thus inhibiting contaminant migration. Slug and bail tests were performed on the other wells at the site.

Sample results collected by Alpha Analytical, Inc., in October 1993, are presented in Appendix K.

8.4.3 Air

The atmosphere is not considered to be a medium of concern because volatile constituents introduced into the shallow subsurface rapidly evaporate. PID measurements taken around the area during field work detected no VOCs in the ambient air. The air quality of the surrounding region is good, and prevailing air currents will rapidly disperse any volatile contaminants that may be released.

8.5 CONTAMINANT FATE AND TRANSPORT

Phase II site-characterization activities indicate that the contaminants of concern at the Group II Sites are PHCs. Results also indicate that the contaminated medium of concern is the shallow ground water underlying the site.

8.5.1 Contaminant Persistence

There is little information regarding the contents of the Receiver Site and Northeast Runway Landfills. Furthermore, the site characterization conducted as part of this study

demonstrated that contaminants are not migrating from these sites. Consequently, a detailed discussion of contaminant persistence is unwarranted.

It should be noted, however, that because landfills are heterogeneous, pockets of contamination could exist that are encapsulated (e.g., in original containers) or whose migration or biodegradation is otherwise inhibited by the surrounding waste. Contaminants in these circumstances would persist indefinitely. On the other hand, where fuels, solvents, and paints are buried in low quantities, the heterogeneous nature of the landfill could provide an ample carbon source and oxygen exchange for biodegradation.

The landfills may also contain concrete, rebar, wood, and various metallic objects. Much of this material will not degrade significantly and will persist in its present form indefinitely.

See Sect. 3.5.1 for a discussion of the persistence of jet fuel.

8.5.1.1 Chemical Reactions of Fuel Hydrocarbons

See Sect. 3.5.1.1 for a discussion of the reactions of fuel hydrocarbons, including alkanes and aromatics.

8.5.1.2 Biodegradation

See Sect. 3.5.1.2 for a discussion of the biodegradation of jet fuels.

There is a thin layer of free-phase product in a limited area at Site 6. The pure fuel is toxic to subsurface microbes and may persist for a long time. On the other hand, the limited extent of contamination suggests that normal biodegradation may be sufficient to contain the spilled fuel for as long as is necessary.

8.5.2 Potential Routes of Migration

A synopsis of media-specific contaminant transport pathways, assimilation routes, exposure points, and affected biota for NAS Fallon is given in Appendix D. The following

paragraphs expand on these evaluations in light of the characterization activities completed at the Group II Sites.

Exposure to potentially contaminated soils at the Group II Sites could occur only if excavation activity is conducted in the landfills. Direct exposure pathways for potentially contaminated soils at the Group II Sites include dermal contact, ingestion, and inhalation of dust particles and volatile constituents. Potentially affected biota include indigenous plants and burrowing animals as well as personnel associated with site excavation activities. Plant and animal populations are controlled on NAS Fallon property, and exposures associated with these biota are thus minimized. Because NAS Fallon is a restricted area, direct exposure to the human populace is restricted to naval personnel, their families, and sub-contractors. Limited access and site activities geared towards environmental safety thus prevent potentially contaminated soils at the Group II Sites from constituting a primary exposure pathway.

Potential exposure pathways for ground water include use of contaminated ground water extracted from the shallow aquifer and the intermediate aquifer. However, the shallow aquifer is not pumped on NAS Fallon property and, due to its high salinity, is used sparingly in the surrounding area (Appendix D). There is one well tapping the shallow aquifer approximately one-quarter mile northeast of the plume; however, examination of the ground-water-elevation map (Fig. 8.2, p. 8-6) indicates that the plume is migrating away from the well. The well is used only for domestic water, not as drinking water. Other wells in the vicinity are farther away and even less likely to become contaminated based on ground-water flow patterns. Direct exposures to contaminants through extraction of the shallow ground water in the area are thus believed to be minimal.

Available site-characterization results indicate that contaminants are not migrating into the intermediate aquifer. The PA/SI report postulates the existence of an upward flow gradient in the surrounding area (Dames and Moore 1988). Investigative results confirm this theory. Additionally, a confining clay layer is known to exist between the contaminated shallow aquifer and the intermediate aquifer over the entire facility (Appendix D). It is believed that these natural containment mechanisms prevent contaminants from reaching the intermediate aquifer.

As with ground water, potentially contaminated soils associated with Group II Sites do not constitute a substantial direct exposure pathway. Soils may, however, contaminate ground water, which could eventually come in contact with surface water. Contaminated surface water may then serve as an exposure pathway.

Downward transport of potential soils contamination to the underlying aquifer via surface-water percolation is not considered significant because of the semiarid climate. The alkali flats in the surrounding area indicate a negative regional water balance. The downward transport necessary to produce existing ground-water contamination resulted from gradients introduced from excessive spills or disposal and not from the natural percolation process.

Ground- and surface-water transport to off-site receptors are the primary exposure pathways for contaminants of concern at the Group II Sites. The principal potential off-site transport mechanism is eventual seepage discharge of ground-water contaminants to surface-water migrating off site. Thus, the principal exposure pathway of concern is the regional surface-water system extending from the downgradient (southeastern) edge of the facility to Stillwater Point Reservoir and the Stillwater National Wildlife Refuge. An unnamed tributary to the LD Drain located about one-half mile southeast of the Site 6 plume is the nearest potential surface-water pathway. This considerable distance minimizes the possibility of ground-water contaminants discharging into surface water at levels of concern. An irrigation ditch, located approximately 50 ft east of the base boundary, is shallow and is not used south of the Heal ranch. Thus, it does not pose a potential pathway. Wells at the distal portion of the plume will serve to monitor the movement of the plume and provide warning of any potential discharge to the drain tributary.

8.5.3 Contaminant Migration

See Sect. 3.5.3 for a discussion of contaminant migration.

8.6 BASELINE RISK ASSESSMENT (BRA)

The risk assessment for the Group II Sites is presented in the BRA (Volume III of the RI Report). A risk assessment summary is presented in Sect. 8.7.

8.7 SUMMARY AND CONCLUSIONS

Soil - No contamination was reported in soil samples collected from the Group II Sites. Also, no soil contamination was indicated when installing ground-water test holes around the perimeters of the two landfills. Thus, any contamination present is confined within the landfill boundaries. Phase II investigations failed to confirm the presence of the Napalm Burn Pit, and testimony by a former NAS Fallon Fire Chief refuted the existence of the site. The lack of contamination made a quantitative risk assessment at the sites unnecessary.

Ground water - A small area of free product whose thickness exceeds the NDEP action level (0.5 in.) for removal actions was located at the southernmost disposal area of Site 6. An associated dissolved contaminant plume was also identified. The dissolved plume is near the base boundary but currently does not go off site. Dissolved PHC levels within the plume exceed the NDEP policy for discharge of affected ground waters to surface waters. However, the dissolved plume would have to migrate approximately one-half mile after crossing the base boundary before discharging to the LD Drain tributary, subjecting the contaminants to biodegradation and natural attenuation. No other ground-water contamination was found at the Group II Sites (e.g., the landfills). Thus, it is concluded that potential contaminants are not currently migrating from the landfills. Also, because hydrocarbon wastes were prohibited at the sites beginning in 1975, it is unlikely that future migration of contaminants will occur. No quantitative risk assessment was conducted at the landfills due to the lack of contamination.

There is no current exposure, thus no current risk, from the ground water at Site 6. The risk assessment postulated potential future off-base exposure from use of the ground water and discharge to surface water. However, the risk was not quantified because the compounds necessary for the assessment (e.g., individual constituents of fuel) were not detected within the plume.

8.8 RECOMMENDATIONS

Soil

Site 6, Defuel Disposal Area - No action is recommended due to the absence of soil contamination.

Site 7, Napalm Burn Pit - Because no evidence exists to support the presence of this site, no action is recommended.

Site 21, Receiver Site Landfill - No action is recommended due to the absence of soil contamination outside the landfill boundary.

Site 22, Northeast Runway Landfill - No action is recommended due to the absence of soil contamination outside the landfill boundary.

Ground Water

Site 6, Defuel Disposal Area - A removal action is required for free-product recovery because the NDEP action level is exceeded.

Site 7, Napalm Burn Pit - Because no evidence exists to support the presence of this site, no action is recommended.

Site 21, Receiver Site Landfill - Based on the current lack of contaminant migration from the landfill boundary and the improbable occurrence of future migration, no action is recommended.

Site 22, Northeast Runway Landfill - Based on the current lack of contaminant migration from the landfill boundary and the improbable occurrence of future migration, no action is recommended.

9. GROUP III SITES: SITE 9, WASTEWATER TREATMENT PLANT; SITE 18, SOUTHEAST RUNWAY LANDFILL

9.1 SITE BACKGROUND

The Group III Sites consist of Site 9, the Wastewater Treatment Plant, and Site 18, the Southeast Runway Landfill. Because of their close proximity to each other, these sites are grouped together.

9.1.1 Site Description

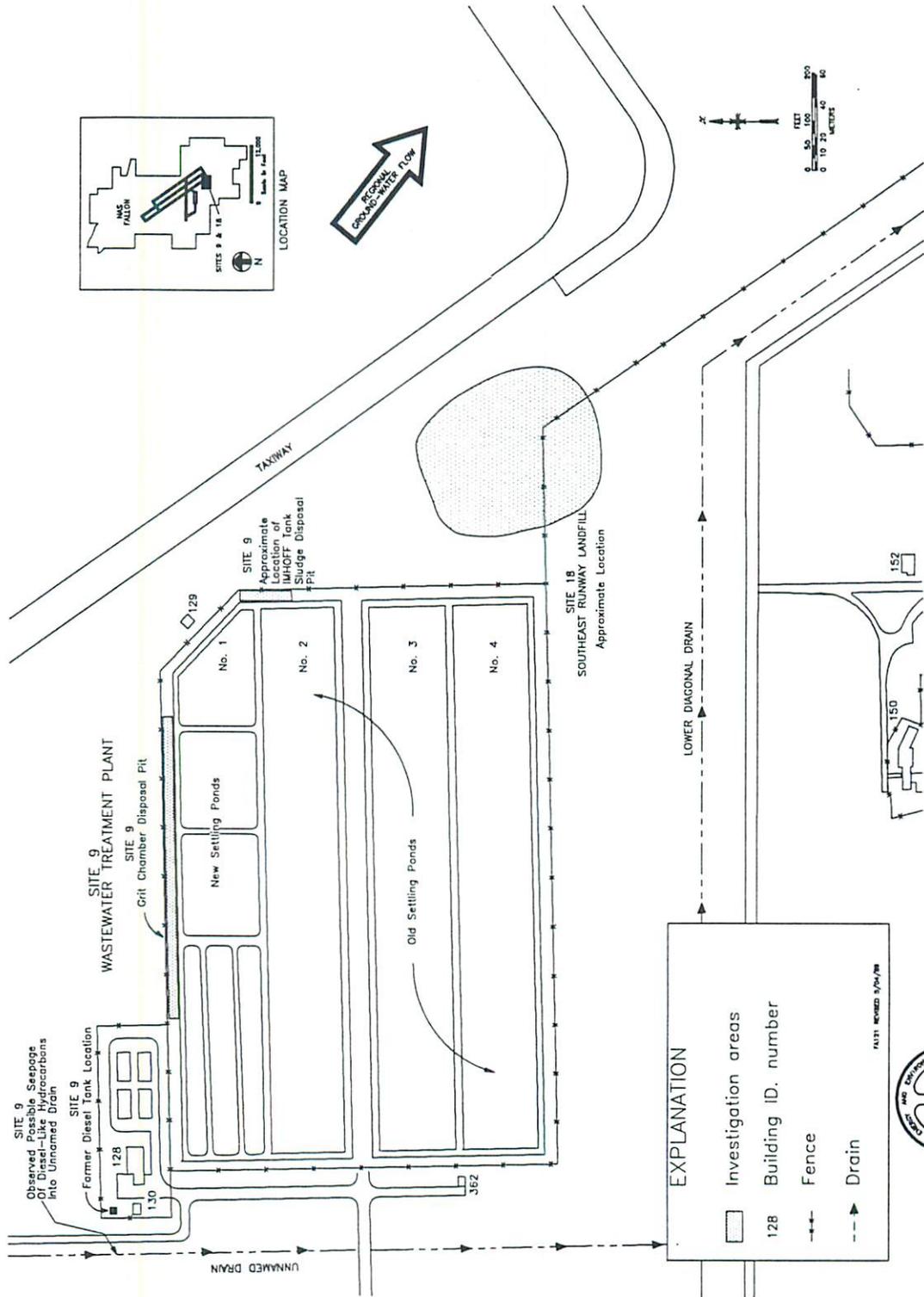
The Group III Sites are located in the southern portion of NAS Fallon (Fig. 1.2, p. 1-10, and Plate 1). The Wastewater Treatment Plant is the central treatment facility at the base and receives wastes via the sanitary sewer from basewide operations. The plant consists of treatment basins, settling ponds, and sludge and grit disposal areas (Fig. 9.1, p. 9-2). Formerly, a 500-gal underground diesel tank was located just north of the wastewater treatment building (Bldg. 130). The tank was removed in 1985 (Dames and Moore 1988).

The Southeast Runway Landfill is located southeast of the Wastewater Treatment Plant. However, the details of operation and the exact location of the site are unknown (Dames and Moore 1988).

9.1.2 Site History

9.1.2.1 Site 9, Wastewater Treatment Plant

Wastewater treatment operations have occurred at the same site at NAS Fallon from 1943 to the present. However, progressively modern treatment processes have necessitated three different types of treatment during this period. The initial system consisted of two redwood settling tanks that received sanitary waste and small amounts of industrial



EXPLANATION

- Investigation areas
- 128 Building ID. number
- Fence
- - - Drain

MULTI-MEDIA SYSTEMS



Fig. 9.1. Group III Sites: Site 9, Wastewater Treatment Plant; Site 18, Southeast Runway Landfill.

waste. Solids were settled out in the tanks and effluent was discharged into two settling ponds. Later, two additional tanks and ponds were added to the system. In 1961, an Imhoff tank system was installed to replace the redwood tank system. This system was used for the settling of sanitary and minor industrial wastes. System effluent was sent to the four ponds where additional settling, oxidation, and chlorination occurred. Finished effluent was discharged to the nearby unnamed drain. The Imhoff tank system was replaced in 1985 by an aerated lagoon treatment system. This present system pretreats the sanitary and minor industrial wastes in a grit chamber. The waste stream is then discharged to two of the former settling ponds for aeration (Dames and Moore 1988). The stream is subsequently chlorinated and discharged to the LD Drain.

The potential areas of contamination at the Wastewater Treatment Plant, include: 1) the grit chamber disposal pit and Imhoff tank sludge disposal pit, 2) the settling ponds used for the percolation and evaporation of treated sanitary sewer effluent, and 3) the soils and ground water underlying a diesel UST that was reportedly leaking upon removal in 1985. These potentially contaminated areas are shown in Fig. 9.1, p. 9-2.

Waste disposal activities at the grit chamber disposal pit consisted of burying sludge produced in the grit chamber from the Imhoff tank. In addition, sludge from the Imhoff tank was buried in a pit to the east of the settling ponds.

Contaminants may have entered soils and ground water underlying the settling ponds through percolation of treated effluent. Additional contamination may have resulted from the leaking diesel storage tank located north of the wastewater treatment building. Leaching of the sludge may have contaminated soil and ground water at the burial pits.

Contaminants of concern at Site 9 include diesel fuel, hazardous materials removed from the sanitary sewer discharge as grit, tank sludges, and contaminants contained in treated effluent. Suspected hazardous materials include metals, oils, paint wastes, and photographic chemicals (including silver, gold, and mercury) that may have been discharged to the sanitary sewer.

9.1.2.2 Site 18, Southeast Runway Landfill

The Southeast Runway Landfill is located near the southeast corner of the wastewater treatment facility. It is reported that basewide municipal refuse and industrial trash were buried at the site during World War II (1943 to 1946). Although no details of the exact landfill location or disposal activities are available, it is thought that material was buried in bulldozed trenches no deeper than the area water table. It is estimated that as many as 18,000 tons material were landfilled in this area. Suspected contaminants include paints, metals, and PHCs (Dames and Moore 1988).

9.1.3 Previous Investigations

The only previous investigation performed at the Wastewater Treatment Plant and the Southeast Runway Landfill was Phase I, PA/SI, of the IR Program. The PA/SI consisted of a visual inspection, on-site interviews, and a records search of the potential contaminants at the sites. The Phase I study recommended that the Wastewater Treatment Plant be included in the RI due to potentially contaminated soils or ground water at the burial pits, settling ponds, and former UST area. Visual inspection of the unnamed drain west of the plant located a diesel-fuel-like product emanating from the subsurface. Presumably, the product resulted from the leaking UST removed in 1985. The Southeast Runway Landfill was recommended for inclusion in the RI because hazardous materials were likely disposed of in the area, potentially contaminating soils and ground water (Dames and Moore 1988).

The PA/SI recommended soil sampling and the installation of ground-water monitoring wells at Sites 9 and 18. Four wells were recommended: one at the former tank pit, one upgradient and one downgradient from the treatment plant (Site 9), and one at the landfill (Site 18). Recommended test parameters were TPHs, VOCs, SVOCs, and metals.

9.1.4 Investigative Approach

Records indicating the type and amount of wastes disposed of at the sites were taken as verification that contamination existed. For this investigation it was assumed that some soil contamination existed within the landfill area and the settling ponds. However, characterizing the contents of a landfill or drilling in active settling ponds is an impractical undertaking, and the important issue was whether or not contaminants were migrating from the sites. The locations of downgradient monitoring wells were changed from those given in the work plan because ground-water-test-hole screening detected no organic compounds (see Appendix C).

9.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

9.2.1 Surface-Water Hydrology

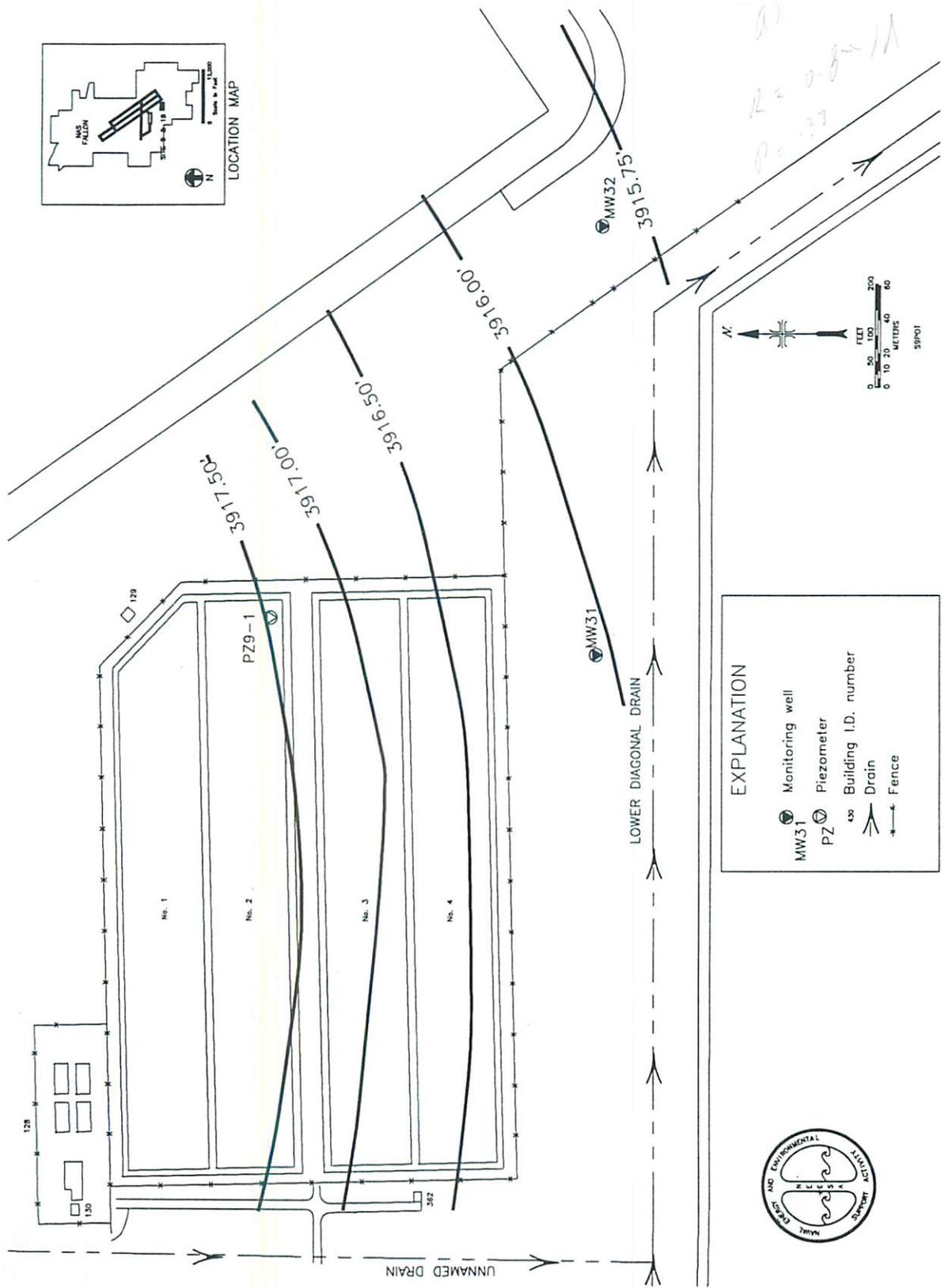
Effluents from the Wastewater Treatment Plant are discharged to the LD Drain approximately 1,000 ft to the south. The present wastewater treatment system has the potential of treating up to 375,000 gal of water per day (Dames and Moore 1988).

Also, surface-water runoff resulting from occasional precipitation could transport contaminated surface sediments or dissolved constituents to the drainage system.

9.2.2 Hydrogeology

Monitoring wells MW31 and MW32 as well as PZ9-1 were used to evaluate the upper alluvial aquifer for hydrologic parameters. Hydraulic conductivities determined by bail-slug tests for MW31 and MW32 were 0.25 and 0.55 ft/d respectively. The ground-water-elevation map (Fig. 9.2, p. 9-6), developed from water levels at this site, shows a

$V = 0.5 \text{ ft/yr}$
 $AS = 100$
 $R = 0.8 - 1.1$
 $P = .33$



EXPLANATION

- MW31 Monitoring well
- PZ Piezometer
- No. 1 Building I.D. number
- Drain
- Fence



Fig. 9.2. Group III Sites. Water-table elevation map for the shallow alluvial aquifer (measurements taken June 1991).

flow direction that is consistent with the regional flow direction to the southeast and is confirmed by data obtained by the colloidal borescope. Depth to ground water at the sites range from 6.5 to 8.5 ft BGS (see Appendix H, Table H.3). Based on the geologic interpretation and hydraulic data of these two sites, the upper alluvial aquifer appears to be relatively homogeneous.

9.3 STUDY AREA INVESTIGATION

9.3.1 Surface-Water and Sediment Investigations

No surface-water or sediment samples were collected from the Group III Sites.

9.3.2 Geological Investigation

The lithology of the Group III Sites was determined during the installation of monitoring wells MW31 and MW32. The lithology was obtained by the use of a 5-ft continuous sampler and a 2-ft split spoon utilizing the California method. Well summary forms with well logs and lithologic descriptions can be found in Appendix F. Both wells were installed for downgradient observation of Sites 9 and 18. The Fallon Formation, completely penetrated by these wells, has a thickness of approximately 17 ft at this location on the base. The lithologies of these monitoring wells indicate beach and near-shore deposition. The majority of the sediments are poorly graded sands that range in size from fine to coarse grained in a generally fining downward sequence. Interbedded with these sands are minor silty sands, and, in the case of MW32, two moderately sorted sands at 4 ft and 13 ft that are 1 ft thick (these sands are predominantly yellowish brown to pale brown, micaceous with minor accessory minerals, and calcareous). The wells also penetrated the top of the Seho Formation, which serves as an aquitard between the upper and intermediate aquifers.

9.3.3 Vadose Zone and Soil Investigation

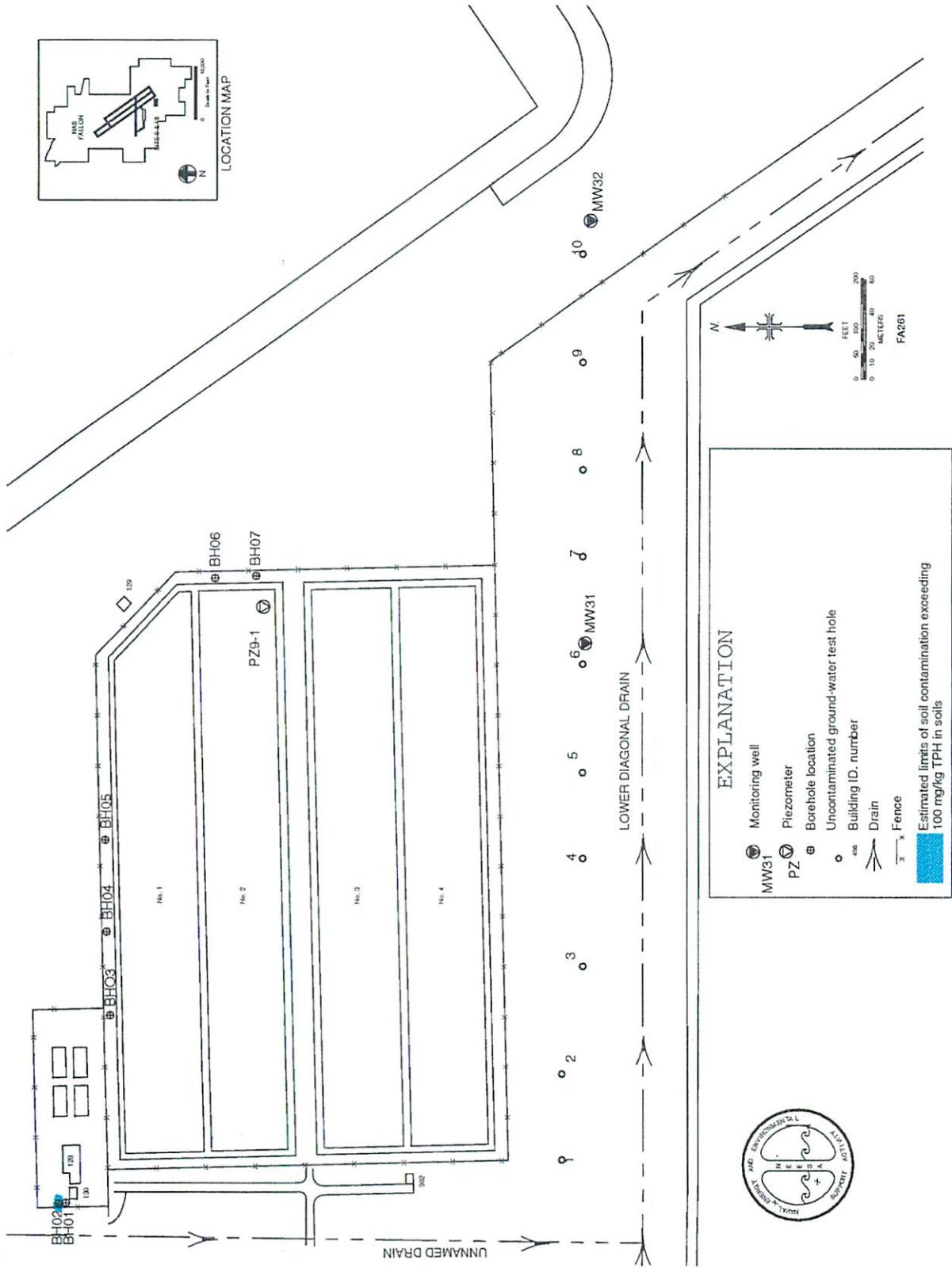
Eight soil borings were drilled at the Group III Sites (Fig. 9.3, p. 9-9). Borehole numbers and sampling intervals are shown below.

<u>Borehole number</u>	<u>Sample Intervals, ft</u>		
BH01	0.0 to 2.0	3.0 to 5.0	5.0 to 7.0
BH02	0.0 to 2.0	3.0 to 5.0	5.0 to 7.0
BH03	0.0 to 2.0	2.0 to 4.0	
BH04	0.0 to 2.0	2.0 to 4.0	
BH05	0.0 to 2.0	2.0 to 4.0	
BH06	0.0 to 2.0	2.0 to 4.0	
BH07	0.0 to 2.0	2.0 to 4.0	

In addition to the borehole samples, soil samples were collected during the installation of monitoring wells MW31 and MW32. Samples from these wells were collected at depths of 7 to 9 ft and 5 to 7 ft respectively. All soil samples collected from the Group III Sites were analyzed for LBPHCs, HBPHCs, SVOCs, VOCs, and metals. Also, samples from BH03 through BH07 were analyzed for PCB/pest. No soil samples were collected from the Group III Sites during the second iteration of Phase II site characterization.

9.3.4 Ground-Water Investigation

The ground-water investigation at the Group III Sites involved boring ten ground-water test holes and installing two monitoring wells and one piezometer. These activities were conducted during the first iteration of the Phase II characterization. No second iteration ground-water investigations were necessary at the Group III Sites. One round of water samples was collected from the monitoring wells and sent to an off-site laboratory for analysis. Samples were analyzed for LBPHCs, HBPHCs, PCB/pest, SVOCs, VOCs, anions, and metals. Sample locations are shown on Fig. 9.3, p. 9-9.



Final

Fig. 9.3. Group III Sites. Sample Locations.

9.4 NATURE AND EXTENT OF CONTAMINATION

9.4.1 Vadose Zone and Soils

Soil sample results are presented in Table 9.1, p. 9-11. Two of the soil borings (BH01 and BH02) were drilled near the former location of the diesel fuel UST (Fig. 9.3, p. 9-9). Soil samples for these two borings were taken continuously from the surface to the water table. BH02 contained 260 mg/kg of TPH and some associated volatile (ethylbenzene, xylenes) and SVOCs in the sample taken from 5 to 7 ft deep. The remaining soil borings were drilled to a depth of 4 ft in the grit chamber disposal pit and the Imhoff tank sludge disposal pit. No organic contaminants were detected in the samples except *bis*(2-ethylhexyl) phthalate, acetone, and methylene chloride, which were reported in many of the analyses as laboratory contaminants. None of the soil borings associated with the two grit disposal pits contained concentrations of metals higher than levels noted at other sites. No contaminants other than laboratory-related contamination were detected in the soil samples taken from the two downgradient monitoring well borings, MW31 and MW32.

9.4.2 Ground Water

Analyses of ground-water samples taken from the two monitoring wells at the Group III Sites indicated no significant contamination (Table 9.2, p. 9-13). Levels for all analyses from MW31 were reported as "no compounds detected". Toluene was reported at a concentration of 2 ppb in MW32. Thus, there does not appear to be any substantial ground-water contamination associated with the Group III Sites.

9.4.3 Air

The atmosphere is not considered to be a medium of concern because sludge and grit waste are contained in a buried state, and volatile constituents associated with treated effluents will rapidly evaporate during treatment. The air quality of the surrounding region is

Table 9.1. Soil sample results for Group III Sites

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	PCB/Pesticide, µg/kg (*3)	Semivolatiles, µg/kg (*4)	Volatiles, µg/kg (*5)
BH01 03/91	3646	0 - 2	U	U	NP	Bis2 290.0*J	Acet 9.0*J Methcl 210.0a
BH01 03/91	3647	3 - 5	U	U	NP	Bis2 **	Acet 10.0*J Methcl 40.0a
BH01 03/91	3648	5 - 7	U	U	NP	Bis2 410.0a	Methcl 21.0a
BH02 03/91	3655	0 - 2	U	U	NP	Bis2 **	Methcl **
BH02 03/91	3656	3 - 5	U	U	NP	Bis2 **	Methcl **
BH02 03/91	3657	5 - 7	U	X 260.00 1.20	NP	2-Meth 8400.0 Fluor 1200.0*J Naph 3900.0*J Phena 3500.0*J	1,2DCP 2.0*J Acet 27.0a E 10.0 Methcl ** X 150.0
BH03 04/91	3705	0 - 2	U	U	U	Bis2 **	Methcl **
BH03 04/91	3706	2 - 4	U	U	U	Bis2 **	Acet 11.0*J Methc **
BH04 04/91	3707	0 - 2	U	U	U	Bis2 **	Methcl 8.0a
BH04 04/91	3708	2 - 4	U	U	U	Bis2 **	Acet 9.0*J Methcl 17.0a
BH05 04/91	3709	0 - 2	U	U	U	U	Methcl 30.0a
BH05 04/91	3710	2 - 4	U	U	U	Bis2 **	Methcl 15.0a
BH06 04/91	3711	0 - 2	U	U	U	Bis2 **	Methcl 11.0a
BH06 04/91	3712	2 - 4	U	U	U	Bis2 **	Methcl 7.0a
BH07 04/91	3713	0 - 2	U	U	U	Bis2 43.0*J	Methcl 8.0a
BH07 04/91	3714	2 - 4	U	U	U	Bis2 **	Methcl **
MW31 03/91	3588	7 - 9	U	U	NP	Bis2 65.0*J	Acet 12.0*J Methcl **
MW32 03/91	3589	5 - 7	U	U	NP	Bis2 67.0*J	Acet 11.0*J Methcl **

** - unusable data due to method blank contamination
 a - suspected laboratory contaminant
 *1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
 *2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
 *3 - EPA method 3550/8080, quantitation limit: 8.3 µg/kg
 *4 - EPA method 3550/8270, quantitation limit: 350 µg/kg
 *5 - EPA method 8240, quantitation limit: 5 µg/kg
 *J - concentration estimated
 1,2DCP - 1,2-dichloropropane
 2-Meth - 2-methylnaphthalene
 Acet - acetone
 Bis2 - bis(2-ethylhexyl) phthalate

E - ethylbenzene
 Fluor - fluorene
 HBP - high boiling point
 LBP - low boiling point
 Methcl - methylene chloride
 Naph - naphthalene
 NP - analysis not performed
 PHC - petroleum hydrocarbons
 Phena - phenanthrene
 U - no compounds detected
 X - xylenes (total)

Table 9.1. Soil sample results for Group III Sites (cont.)

PRG resi mg/kg

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg				
Compound	#	Average	Minimum	Maximum
Aluminum	16	9,439	3,540.00	20,700.00
Antimony	0 ND		ND	ND
Arsenic	16	8	3.00	13.60
Barium	16	92	28.90	219.00
Beryllium	16	0	0.17	0.89
Boron	15	32	4.30	79.50
Cadmium	0 ND		ND	ND
Calcium	16	7,794	2,450.00	20,200.00
Chromium	16	8	4.10	14.60
Cobalt	16	8	4.10	15.90
Copper	16	58	9.30	225.00
Iron	16	16,247	9,260.00	29,500.00
Lead	16	6	2.60	13.70
Lithium	16	19	5.10	42.80
Magnesium	16	5,144	1,650.00	11,300.00
Manganese	16	313	120.00	831.00
Mercury	9	0	0.02	0.09
Molybdenum	1	4	3.50	3.50
Nickel	16	8	3.50	16.10
Potassium	16	2,724	843.00	5,880.00
Selenium	0 ND		ND	ND
Silver	8	1	0.67	1.30
Sodium	16	4,226	7.30	12,300.00
Thallium	0 ND		ND	ND
Vanadium	16	36	17.30	64.90
Zinc	16	89	35.80	258.00

- number of samples with detectable quantities of analyte
 ND - analyte not detected

Table 9.2. Water sample results for Group III Sites

Location	Sample Number	Total HBP PHC, $\mu\text{g/L}$ (*1)	Total LBP PHC, $\mu\text{g/L}$ (*2)	PCB/Pesticide, $\mu\text{g/L}$ (*3)	Semivolatiles, $\mu\text{g/L}$ (*4)	Volatiles, $\mu\text{g/L}$ (*5)
MW31 04/91	3766	U	U	U	U	Methcl **
MW32 04/91	3764	U	T 2.0	U	U	Methcl **

- ** - unusable data due to method blank contamination
 *1 - EPA method 8015 Modified, quantitation limit: 50 $\mu\text{g/L}$
 *2 - EPA method 8015/8020, quantitation limit: 50 $\mu\text{g/L}$
 *3 - EPA method 608, quantitation limit: 0.05 $\mu\text{g/L}$
 *4 - EPA method 625, quantitation limit: 10 $\mu\text{g/L}$
 *5 - EPA method 624, quantitation limit: 5 $\mu\text{g/L}$

- HBP - high boiling point
 LBP - low boiling point
 Methcl - methylene chloride
 PHC - petroleum hydrocarbons
 T - toluene
 U - no compounds detected

Table 9.2. Water sample results for Group III Sites (cont.)

Anions, mg/L EPA method 429 Quantitation limit: 0.5 mg/L				
Compound	#	Average	Minimum	Maximum
Chloride	2	3,960	520.00	7,400.00
Fluoride	0 ND		ND	ND
Nitrate, as N	0 ND		ND	ND
Phosphate	0 ND		ND	ND
Sulfate	2	1,150	300.00	2,000.00

- number of samples with detectable quantities of analyte
ND - analyte not detected

Metals, µg/L EPA method 200.7 Quantitation limit: 1 µg/L				
Compound	#	Average	Minimum	Maximum
Aluminum	1	48	47.70	47.70
Antimony	0 ND		ND	ND
Arsenic	2	1,196	741.00	1,650.00
Barium	2	21	17.70	25.20
Beryllium	0 ND		ND	ND
Boron	2	41,050	15,200.00	66,900.00
Cadmium	0 ND		ND	ND
Calcium	2	21,105	5,510.00	36,700.00
Chromium	0 ND		ND	ND
Cobalt	0 ND		ND	ND
Copper	2	24	23.20	25.40
Iron	2	28	19.40	36.20
Lead	0 ND		ND	ND
Lithium	2	189	45.20	332.00
Magnesium	2	52,655	4,310.00	101,000.00
Manganese	2	46	7.90	83.50
Mercury	0 ND		ND	ND
Molybdenum	2	1,150	230.00	2,070.00
Nickel	0 ND		ND	ND
Potassium	2	98,150	21,300.00	175,000.00
Selenium	1	10	9.60	9.60
Silver	1	8	7.60	7.60
Sodium	2	5,415,000	1,040,000.00	9,790,000.00
Thallium	0 ND		ND	ND
Vanadium	2	437	74.20	800.00
Zinc	2	113	76.90	149.00

- number of samples with detectable quantities of analyte
ND - analyte not detected

good, and prevailing air currents will rapidly dilute and disperse any volatile contaminants that may be released.

9.5 CONTAMINANT FATE AND TRANSPORT

Screening and characterization activities at the Group III Sites indicate that the primary contaminant of concern is diesel fuel associated with the former underground tank location. The contaminated medium of concern is a small area of soil above the water table near the unnamed drain. Visual inspection of the drain during the PA/SI indicated potential discharge of diesel fuel. However, the low levels of petroleum contaminants found in BH01 and BH02 as well as the ground-water flow gradient, which is away from the drain, suggest that product discharge to the drain is unlikely. Also, Phase II characterization activities indicated no ground-water contamination in the area.

9.5.1 Contaminant Persistence

There is little information regarding the contents of the Southeast Runway Landfill. Furthermore, the site characterization conducted as part of this study demonstrated that contaminants are not migrating from the site. Consequently, a detailed discussion of contaminant persistence is unwarranted for this site.

It should be noted, however, that because a landfill is heterogeneous, pockets of contamination could exist that are encapsulated (e.g., in original containers) or whose migration or biodegradation is otherwise inhibited by the surrounding waste. Contaminants in these circumstances would persist indefinitely. On the other hand, where fuels, solvents, and paints are buried in low quantities, the heterogeneous nature of the landfill could provide an ample carbon source and oxygen exchange for biodegradation.

The landfill may also contain concrete, rebar, wood, and various metallic objects. Much of this material will not degrade significantly and will persist in its present form indefinitely.

Discussion of the fate and persistence of the soil contamination at Site 9 is not a simple matter because diesel fuel is composed of many individual compounds with widely varying properties. The wide range in composition and classes of compounds means that the concentration of individual compounds will also vary widely. Obviously, the environmental behavior of the individual compounds varies significantly. Unlike jet fuel, which may contain compounds composed of as few as four carbon atoms, diesel fuel typically is composed of compounds containing ten carbons or more. The lower molecular weight (fewer carbon) compounds are typically the most mobile of the PHCs.

9.5.1.1 Chemical Reactions of Fuel Hydrocarbons

See Sect. 3.5.1.1 for a discussion of the reactions of fuel hydrocarbons, including alkanes and aromatics.

Benzene, toluene, ethylbenzene and xylenes are not present in diesel fuel to any great degree, although larger aromatic hydrocarbons such as naphthalene and its derivatives may be present and will react similarly except for being less water-soluble.

9.5.1.2 Biodegradation

The discussion in Sect. 3.5.1.2 regarding the biodegradation of jet fuel may also be applied to diesel fuel. However, the diesel fuel spilled at Site 9 may only biodegrade slowly because of the nature of the compounds present. Higher molecular weight compounds degrade much more slowly (Atlas 1981), and some may persist in the environment indefinitely.

9.5.2 Potential Routes of Migration

A synopsis of media-specific contaminant transport pathways, assimilation routes, exposure points, and affected biota for NAS Fallon is given in Appendix D. The following paragraphs expand on these evaluations in light of the characterization activities completed at the Group III Sites.

Direct exposure pathways for contaminated soils at the Group III Sites include dermal contact, ingestion, and inhalation of dust particles and volatile constituents. Affected biota include indigenous plants and burrowing animals as well as personnel associated with site-excavation activities. Plant and animal populations are controlled on NAS Fallon property; potential exposures associated with these biota are thus minimized. Because NAS Fallon is a restricted area and the contamination is at depth, direct exposure to the human populace is limited to naval personnel and subcontractors. Restricted access, lack of surface-soil contamination, and site activities geared towards environmental safety thus prevent contaminated soils at the Group III Sites from constituting a primary exposure pathway.

Downward transport of residual soils contamination to the underlying aquifer via naturally occurring surface-water percolation is not considered significant because of the semiarid climate. Indeed, the alkali flats in the surrounding area indicate a negative regional water balance. Thus, there is no mechanism for contaminants, such as metals associated with the grit disposal areas, to be transported to the ground water. Transport of diesel fuel from the leaking UST to the unnamed drain could not be precluded, but the low levels of PHCs in only one borehole sample and the ground-water flow gradient make free-product discharge to the drain unlikely. Moreover, any free product on the water table had dissipated by the time Phase II activities began.

While downward transport of contaminants via percolation of natural surface water is minimal, Site 9 does afford a mechanism for transport of near-surface contaminants to the underlying aquifer. The settling ponds of the water treatment system afford a continuous source of potential contaminants and also produce a substantial downward flow gradient. The resulting flow system may induce downward percolation of the treated effluent into the underlying upper aquifer. As discussed in the Phase I study, as much as 10% of the treated effluent may percolate to the water table and, hence, contribute to ground-water contamination. However, downgradient wells and ground-water test holes indicate that no significant contamination of ground water has resulted.

9.5.3 Contaminant Migration

Table 9.3, p. 9-19, compares the mobility of some components of diesel fuel. Because there are so many types of compounds, migration rates of dissolved compounds are not easily predicted. Unlike jet fuel, however, few of the components are volatile, soluble, or mobile in the environment. Indeed, most components of diesel fuel will have lower solubility, higher K_{oc} , and lower mobility than the compounds presented in the table.

9.6 BASELINE RISK ASSESSMENT (BRA)

The risk assessment for the Group III Sites is presented in the BRA (Volume III of the RI Report). It is important to note that the BRA is simply a screening tool. By using the highest contaminant concentration as the exposure level, the risk assessments are worst case scenario. Therefore, on the basis of a conservative risk calculation, the BRA shows those sites which may require further consideration. If a site exhibits potential risk, the Navy will take mitigating action to ensure the site is environmentally safe. A risk assessment summary is presented in Sect. 9.7.

9.7 SUMMARY AND CONCLUSIONS

Soil - Soil contamination exceeding the NDEP action level for TPHs was found in one sample at the former UST pit near Site 9. The same sample also contained some fuel-related VOCs and SVOCs. No other soil contamination was detected at the Group III Sites. The risk assessment determined that cancer risks for both current and future exposure scenarios were well below the point of concern. The HIs for human health for both current and future uses were also well below the point of concern. The HI for phytotoxicity at the former UST pit was just above the acceptable value.

Table 9.3. Comparison of mobility in the environment of contaminants potentially found in diesel fuel

Compound	Solubility, mg/L ^a	Log K _{oc}	Mobility in groundwater classification ^b	Boiling point, °C ^a
Methyl cyclohexane	14		low mobility	101
Naphthalene	30		low mobility	217.9
Nonane	0.07		very low mobility	151
Octane	0.7		very low mobility	125.7
Xylenes	158	2.59	low mobility	138-144

^a Source: Verschueren, K. 1983. *Handbook of Environmental Data on Organic Chemicals*. Second ed. VanNostrand Reinhold Company, New York.

^b Source: Roy, W. R., and R. A. Griffin. 1985. Mobility of organic solvents in water-saturated soil materials. *Environmental Geology and Water Sciences*, 7(4):241-247.

K_{oc} = partition coefficient (K_p) + fractional mass of organic carbon

Soil contamination at the Group III Sites is limited to a small area at the former UST pit near Site 9. It is concluded that this area does not warrant further attention based on the following: 1) current and future risks for human health are well below the point of concern for both cancer risks and the non-carcinogenic HI, 2) the contamination is limited to a small area, 3) ground water has not been affected, 4) the quality of underlying ground water is not suitable for human consumption, and 5) the negative water balance in the area is not conducive to contaminant migration.

Ground water - No ground-water contamination was detected at the Group III Sites. Ground-water-test-hole screening conducted downgradient from the landfill indicated no migration of contaminants. Also, because no new material has been introduced to the landfill for nearly 50 years, it is highly unlikely that future migration of contaminants will occur. No quantitative risk assessment was conducted at the sites due to the absence of contamination.

9.8 RECOMMENDATIONS

Soil

Site 9, Wastewater Treatment Plant - No action is recommended. Excluding the former UST pit, no soil contamination was detected at Site 9. The UST pit does not warrant further attention due to low human health risks, the limited extent of contamination, and the fact that ground water is not affected.

Site 18, Southeast Runway Landfill - No action is recommended due to the absence of contamination.

Ground Water

Site 9, Wastewater Treatment Plant - No action is recommended due to the absence of contamination.

Site 18, Southeast Runway Landfill - Based on the current lack of contaminant migration from the landfill area and the improbable occurrence of future migration, no action is recommended.

**10. GROUP IV SITES: SITE 10, GATAR COMPOUND; SITE 11, PAINT SHOP;
SITE 12, PEST CONTROL SHOP; SITE 13, BOILER PLANT TANKS;
SITE 14, OLD VEHICLE MAINTENANCE SHOP; SITE 16, OLD FUEL FARM;
SITE 17, HANGAR 5; SITE 19, POST-WORLD WAR II BURIAL SITE;
SITE 23, SHIPPING AND RECEIVING DISPOSAL**

10.1 SITE BACKGROUND, DESCRIPTION, AND HISTORY

The Group IV Sites consists of nine sites located in the southern portion of NAS Fallon that are grouped together due to their close proximity to each other (Fig. 1.2, p. 1-10, and Plate 1).

10.1.1 Site 10, GATAR Compound

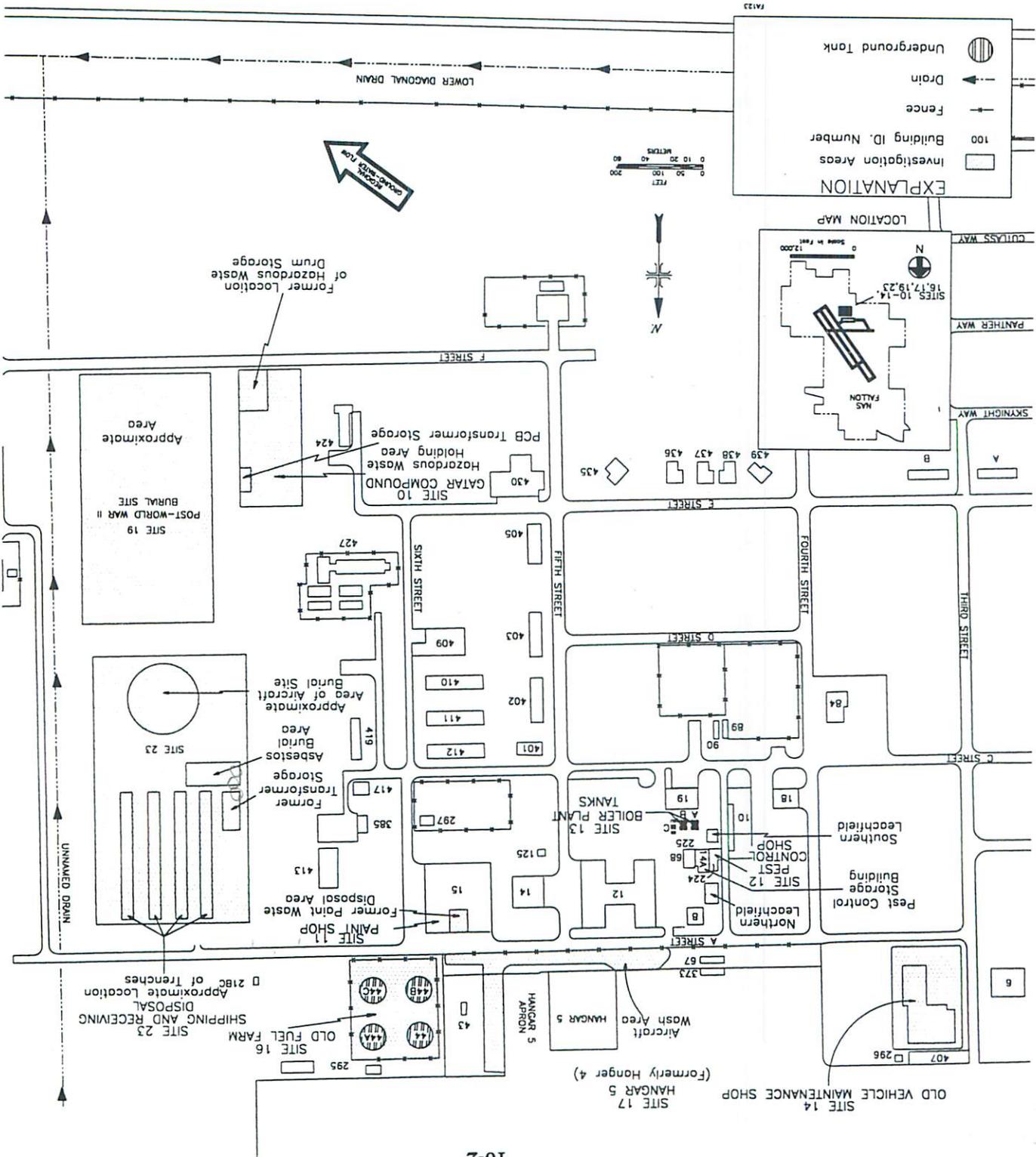
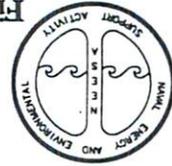
Site 10, GATAR Compound, is located in the southeastern portion of NAS Fallon (Fig. 10.1, p. 10-2). The site originally belonged to the Air Force and came under Navy control in 1975. The area was apparently unused until 1984 when storage activities were reportedly initiated. Since 1986, the site has provided interim storage for hazardous wastes (Dames and Moore 1988). The site consists of a graveled area that was used for interim storage of hazardous materials pending removal to disposal facilities.

Hazardous wastes stored at Site 10 included PCB-laden oil, paints, solvents, waste oils, and hydraulic fluids. PCBs were stored primarily as transformer oil in electrical transformers. Several containers of waste oil containing PCBs were reportedly buried on the site in 1984 in an unknown location. The exact location of burial is unknown. Other hazardous liquids were stored in aboveground containers, primarily 55-gal drums.

10.1.2 Site 11, Paint Shop

As shown in Fig. 10.1, p. 10-2, Site 11, the Paint Shop, is located in the north-central portion of the southern section of the facility. Paint wastes were disposed of or

Fig. 10.1. Group IV Sites. Sites 10, 11, 12, 13, 14, 16, 17, 19, and 23.



spilled on unpaved ground north of the paint shop. Disposal activities stopped in 1986, at which time the ground surface was paved with concrete. Although the paint shop has been in operation since the early 1960s, documented disposal activities could be obtained only for the period of 1976 to 1986. Waste paints and thinners were introduced to soils either as a means of waste disposal or from spills associated with transferal from drums.

10.1.3 Site 12, Pest Control Shop

Site 12, the Pest Control Shop, is located in the northwestern part of the southern portion of NAS Fallon (Fig. 10.1, p. 10-2). The shop has been in operation since the early 1960s; however, records of activities at the site are available only from 1974 to present. Although the Pest Control Shop continues to be operational, the site is considered a past operation with respect to changes in the type of pesticides used.

Prior to 1974, pesticides handled at the site included DDT (dichlorodiphenyltrichloroethane). Later activities included handling and storing the pesticides malathion, pyrethrin, diazinon, and 2,4-D. Parathion was supplied to the Churchill County Mosquito Abatement District for application to NAS Fallon outlease lands only. Mixing and handling of rinse water were performed off base.

Potential areas of contamination at the site include the north and south leachfields (Fig. 10.1, p. 10-2). The south leachfield received runoff generated from rinsing of pest control vehicles. The rinse water contained soil and perhaps pesticide residue that accumulated on the vehicle during pesticide application. At this time, neither leachfield is operational.

10.1.4 Site 13, Boiler Plant Tanks

Site 13, the Boiler Plant Tanks, formerly consisted of two 26,000-gal USTs used to store fuel for the boiler plant. The tanks were located near the boiler house, southeast of the Pest Control Shop (Fig. 10.1, p. 10-2). Boiler-plant-fuels storage was discontinued in 1981, at which time the tanks were used for intermittent storage of other fuels and oils

until about 1986. Although supposedly emptied in 1986, some liquids remained in the tanks when Phase II characterization activities began. The tanks were removed under the UST removal program during the summer of 1992. Excavated soil was backfilled into the tank pits (see Sect. 10.4.2.4).

Fuels were reportedly spilled on surface soils around inlets to the tanks during filling operations. Spills may have consisted of No. 6 fuel oil, waste lubrication oil, hydraulic fluid, JP-5, and diesel fuel. The tank area is visibly stained.

10.1.5 Site 14, Old Vehicle Maintenance Shop

Site 14, the Old Vehicle Maintenance Shop, is also located in the northwestern part of the southern portion of NAS Fallon. The site consists of a concrete slab that served as the foundation for a mechanic bay, fueling area, and support building. The facility was used from 1943 to 1971 (except for the years 1947 through 1950 when operations were closed) to service and fuel Public Works Transportation and other vehicles. From 1971 to 1973, the shop reportedly served as the auto hobby shop. The shop was demolished some time after 1973.

Areas of concern at the site include the former lube pits and two USTs. The lube pits apparently contained hydraulic lifts and are now filled with soil. The pit floors are concrete, and the depth of the pits is estimated to be 6 to 7 ft. The USTs were used to store leaded gasoline and diesel fuel. The tanks were removed in 1989 and were found to have been leaking PHCs into the soil. Excavated soil was backfilled into the pits.

10.1.6 Site 16, Old Fuel Farm

Site 16, the Old Fuel Farm, served as the main fuel storage and dispensing facility from 1943 to 1962. The site consisted of four concrete USTs located in the north-central part of the southern portion of the facility (Fig. 10.1, p. 10-2). In 1963, active operations at the site were transferred to the New Fuel Farm, and the storage tanks were used for

dead storage of various fuels. Dead storage continued until 1985, at which time the four storage tanks were emptied. These tanks were demolished and partially removed during the summer of 1992 under the UST removal program. Excavated soil was backfilled into the tank pits (see Sect. 10.4.2.5).

Fuels stored at the site over the lifetime of operations include avgas, JP-4, JP-5, diesel fuel, gasoline, and No. 6 fuel oil. Excavations in the area have encountered PHC-contaminated soils that likely resulted from past leaks and spills at Site 16.

10.1.7 Site 17, Hangar 5

Site 17 was formerly known as Hangar 4; however, it has been renamed Hangar 5 due to the construction of additional hangars. Its designation in this report has been changed to provide consistency with other IR Program reports. Potentially contaminated soils associated with the site are shown in Fig. 10.1, p. 10-2. The areas of potential contamination consist of the formerly unpaved soils lying to the south and east of Hangar 5. These areas received runoff from aircraft washing activities and aircraft fluids spilled on the parking apron. These activities occurred between the years of 1943 and 1987 (exclusive of the years 1947 to 1950). Soils east of Hangar 5 were paved in 1985; the southern portion of the site remains unpaved. Potential contaminants of concern include cleaning solvents (Turco), lubrication oil, hydraulic fluid, grease, avgas, JP-4, JP-5, methylethyl ketone (MEK), isopropyl alcohol, and PD-680.

10.1.8 Site 19, Post-World War II Burial Site

Site 19, the Post-World War II Burial Site, is located in the southeastern part of NAS Fallon (Fig. 10.1, p. 10-2). The site reportedly received trash and refuse generated during facility decommissioning activities between the years of 1946 to 1949. Trench burial was the method used. The disposal trenches were probably excavated with a bulldozer to a depth of less than 8 ft. Wastes reportedly deposited included trash, vehicles, wood, paints, thinners, and solvents.

10.1.9 Site 23, Shipping and Receiving Disposal

Site 23, the Shipping and Receiving Disposal site, is located in the northeastern part of the southern portion of the facility (Fig. 10.1, p. 10-2). The site consists of the shipping and receiving disposal area, the aircraft burial area, and an area where asbestos was reportedly buried. Transformers containing PCB fluids were also allegedly stored at the site. Disposal activities at the shipping and receiving disposal area consisted of landfilling unsalvageable material and equipment formerly stored on the site. Although the source of this material is unknown, it is surmised that the salvage items originated through Public Works and aircraft maintenance activities. Landfilling was accomplished by burial in four bulldozed trenches. Buried wastes reportedly included junk, debris, metal, rubble, paints, thinners, petroleum liquids, oils, and lubricants (Dames and Moore 1988).

Additional disposal activities at the site included the reported burial of a burned-out DC-3 aircraft fuselage south of the landfill trenches. It is not known if the alleged plane contained fuel or other liquids; however, no evidence of a buried aircraft was found by the geophysical surveys (Appendix B).

10.1.10 Previous Investigations

The only previous investigations at the Group IV Sites were those performed during Phase I, PA/SI, of the IR Program. The PA/SI consisted of a visual inspection and records search at each site, on-site interviews, and limited soil sampling at Hangar 5 (Site 17).

The study recommended the inclusion of Sites 10, 11, 12, 13, 14, 16, 19, and 23 in the RI due to potential soil and ground-water contamination from past activities. Site 17 was recommended for inclusion based on confirmed soil contamination and possible ground-water contamination. Three surface-soil samples taken from the Hangar 5 area had TPH concentrations ranging from 57 to 350 mg/kg and also contained traces of solvents, including acetone, TCE, and dichloroethane (DCA).

Recommended investigations for the RI are summarized below (Dames and Moore 1988).

<u>Site No.</u>	<u>Investigation Type</u>	<u>Test Parameters</u>
10	Geophysical survey, soil sampling	PCBs, VOCs, SVOCs
11	Soil sampling	Lead
12	Soil sampling, ground-water sampling	Pesticides, herbicides
13	Soil sampling, ground-water sampling	TPHs, VOCs, SVOCs, lead
14	Geophysical survey	Not applicable
16	Soil sampling, ground-water sampling	TPHs, VOCs, SVOCs, lead
17	Soil sampling, ground-water sampling	TPHs, VOCs
19, 23	Geophysical survey, soil sampling, ground-water sampling	TPHs, metals, VOCs, SVOCs

10.1.11 Investigative Approach

Results from soil samples, record searches, and inspections conducted during the Phase I study supported the following Phase II investigative activities as outlined in the RI work plan (ORNL 1989):

Site 10, GATAR Compound: although no PCB leakage was reported, the storage of transformer oils and reported burial of PCB containers suggested the possibility of soil contaminated with PCBs. Based on the quantities of waste routinely stored at the site, it was also possible that other hazardous materials (primarily paints, solvents, and waste oils) were introduced to the subsurface environment. (Geophysical surveys and soil sampling were proposed to check for contaminants at the site).

Site 11, Paint Shop: because of the amount of wastes (primarily paints and thinners) spilled or disposed of at the site, soils and shallow ground-water contamination was possible. (Downgradient wells for the entire group of sites was proposed to test for contamination).

Site 12, Pest Control Shop: based on the amount of pesticides handled at the site over the period of operation, soil and ground-water contamination to the north and south of the Pest Control Shop, Building 224, was suspected. However, the leach-fields in these areas were not installed until 1983. (Soil borings and a downgradient well were proposed to test for contamination).

Site 13, Boiler Plant Tanks: PHC contamination of soils and possibly ground water was suspected near the fill ports of the two USTs. (Soil-gas surveys and downgradient monitoring wells were proposed to test for migrating contaminants).

Site 14, Old Vehicle Maintenance Shop: because contaminant spills in the lube pits were contained by concrete floors, contamination of the subsurface environment from the lube pits was considered unlikely. Contaminants were, however, expected to be present in the soils and possibly the ground water near the USTs. (Soil-gas surveys and monitoring wells were proposed for the site).

Site 16, Old Fuel Farm: based on the amount of petroleum product handled at the site and the contaminated soils exposed during excavation activities, soil and ground-water contamination at the site was possible. (Soil-gas testing, soil borings, and monitoring wells were proposed for the site).

Site 17, Hangar 5: three soil samples taken in the runoff area south of Hangar 5 during the Phase I investigation confirmed TPHs in soils exceeding NDEP action levels. Contamination of soils and possibly the ground water in the area was thus considered likely. (Soil borings, downgradient soil-gas testing, and monitoring wells were proposed for the site).

Site 19, Post-World War II Burial Site: wastes disposed of in the area (particularly solvents) had possibly contaminated soils and ground water. (Geophysical surveys, downgradient soil-gas testing, and monitoring wells were proposed for this site).

Site 23, Shipping and Receiving Disposal: the type and quantity of waste materials buried in the four trenches had potentially contaminated the subsurface environment of the surrounding area. Asbestos contamination of subsoils was considered minimal because the materials were properly disposed of. Leakage of liquid wastes thought to be present in the allegedly buried aircraft had possibly contaminated the underlying soil and shallow ground water. (Geophysical surveys, downgradient soil-gas testing, and monitoring wells were proposed for this site).

10.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

10.2.1 Surface-Water Hydrology

The LD Drain borders the Group IV Sites approximately 500 ft to the south. In addition, an unnamed drain borders the group just east of Sites 19 and 23. This drain separates the Group IV Sites from Site 9, the Wastewater Treatment Plant. The primary source of water in this drain is backflow from the LD Drain during irrigation season. During rare storm events, stormwater in the ditches parallel to 'A' Street may enter this unnamed drain. 'A' Street is the east-west road directly south of Hangar 5. A drainage swale leading from Site 17, Hangar 5, leads to the unnamed drain.

10.2.2 Ground-Water Hydrology

A water-table elevation map constructed from monitoring wells and piezometers is shown in Fig. 10.2, p. 10-10. The ground-water flow is consistent with that of the regional flow direction and was confirmed by data obtained from the colloidal borescope. Hydraulic

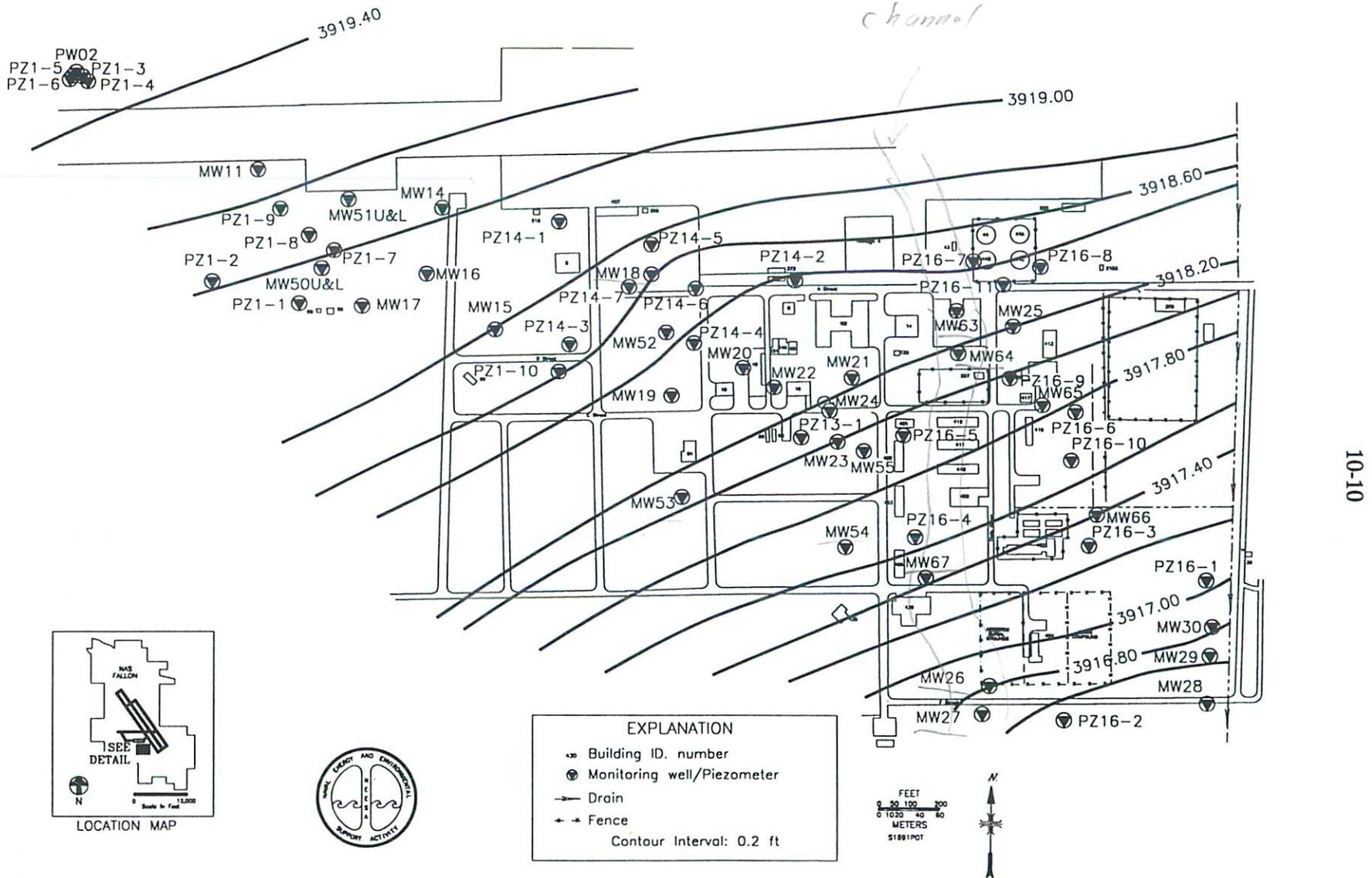


Fig. 10.2. Group IV Sites. Water-table elevation map for the shallow alluvial aquifer (measurements taken April 1992).

conductivities obtained from bail-slug tests varied from 0.3 to 13 ft/d. An unnamed drain on the east side of these sites intersects the ground-water surface and drains south to the LD Drain. Depth to ground water at the Group IV Sites varies seasonally and range from 5.0 to 10.0 ft BGS (see Appendix H, Table H.3).

10.3 STUDY AREA INVESTIGATION

10.3.1 Contaminant Source Investigation

The PA/SI Phase I study included a contaminant source investigation for the Group IV Sites. This information is presented in Table 10.1, p. 10-12.

10.3.2 Surface-Water and Sediment Investigations

No surface-water or sediment samples were collected at the Group IV Sites during the first iteration of site characterization. However, sediment samples were collected from four locations in the unnamed drain during second iteration activities. Samples were taken along a seepage face discovered during first iteration sampling, where a hydrocarbon plume appeared to intersect the drain. The samples were analyzed for LBPHCs, HBPHCs, VOCs, and SVOCs.

10.3.3 Geological Investigation

The geologic investigation for the Group IV Sites is discussed in two separate sections due to the different lithologies encountered during well installations.

10.3.3.1 Site 12, Site 13, and Site 14

The lithology of these sites was obtained during the installation of monitoring wells MW18L, MW19, MW20, MW21, MW22, MW23, MW52, MW53, MW54, and MW55. No

Table 10.1. Contaminant source investigation for the Group IV Sites

Site Number and Name	Site Description	Period of Operation	Suspected Waste Types	Sources
10 GATAR Compound	Reported burial of PCB cans	1984	PCB oils in containers	Electrical equipment
	PCB transformer storage and leakage?	1982 to 1983	PCB oils	Electrical equipment
	Asbestos burial	1982	asbestos	Basewide insulation
11 Paint Shop	Paint waste disposal at Bldg. 15	1976 to 1985	waste paint, paint thinner	Spilling from siphoning storage drums, paint waste disposal
12 Pest Control Shop	Pest central shop area	Pre-1974	DDT, DDD	Rinsing pest control vehicles, mixing and rinsing empty containers
	2 leachfields near pest control shop	1983 to 1992	malathion, pyrethrin, diazion, 2,4-D	
13 Boiler Plant Tanks	Underground fuel tanks	1943 to 1986	No. 6 fuel oil, waste lube oil, hydraulic fluid, JP-5, diesel fuel	Fueling spills
14 Old Vehicle Maintenance Shop	2 underground tanks	1943 to 1973	gasoline	Possible tank leaks/overfills
	Lube pits and drain	1943 to 1973	lube oil, hydraulic fluid, coolant	Vehicle maintenance
16 Old Fuel Farm	4 underground tanks	1943 to 1962 (dead storage (1963 to 1985))	avgas, JP-4, JP-5, diesel fuel, gasoline, No. 6 fuel oil	Tank leaks and overfilling
17 Hangar 5	Surface runoff from aircraft maintenance	1943 to 1946, 1952 to present	wash solvents (Turco), lube oil, hydraulic fluid, grease, avgas, JP-4, JP-5, MEK, isopropyl alcohol, PD-680	Aircraft maintenance and washing
19 Post-WWII Burial Site	Burial trenches	1946 to 1949	trash, vehicles, wood, solvents, possible paints, thinners	Base decommissioning process
23 Shipping and Receiving Disposal	Disposal trenches	1968	junk, debris, metal, rubble, waste liquids (paints, thinners, lubricants, oils)	Scrap from entire base
		1984	asbestos	Basewide building and pipe insulation
	Aircraft burial area	1977	DC-3 airplane (avgas or JP-5, lube oil, hydraulic fluid)	Excess aircraft

Source: Dames and Moore 1988

lithology for MW18U was obtained because it was installed 3 ft south of MW18L. Well summary forms with well construction and lithologic descriptions can be found in Appendix F. The information was obtained either by the use of a 5-ft continuous sampler advanced in front of the hollow-stem auger or by driving a 1.5 or 2.0-ft split spoon sampler utilizing the California method. All monitoring wells penetrated the Fallon Formation completely and the upper few feet of the Seho Formation. Figure 10.3, p. 10-14, shows the simplified fence diagram constructed from wells installed at these sites. This diagram displays a depositional history of probable beach sands dissected by deltaic deposits during the recession of the last advance of Lake Lahontan. The lithology of the Fallon Formation (which extends from the surface to approximately 17 to 20 ft BGL in MW18, MW19, MW20, MW21, MW22, MW23, MW52, and MW53) is mostly very fine to medium grained sand, poorly sorted, from 2 to 5 ft, intertonguing with silty sands, sandy silts, and silty clay. The sands display a depositional history that is predominantly deltaic. They contain very fine sands interbedded with silty sands and clayey silts. MW18 indicated a coarse-grained sand at 5 to 6 ft that is very small laterally.

10.3.3.2 Site 11, Site 16, Site 17, Site 19, and Site 23

The lithology information for these sites was obtained during the installation of monitoring wells MW25L, MW26, MW27L, MW28, MW29L, MW30, MW63, MW64, MW65, MW66, and MW67. Lithology information was not obtained from MW25U, MW27U, or MW29U because they were located within 3 to 4 ft of their respective lower completions. The lithology was obtained using a 5-ft continuous sampler advanced in front of the bit in a hollow-stem auger or by driving a 1.5 or 2.0-ft split spoon utilizing the California method. Well summary forms with well logs and lithologic descriptions can be found in Appendix F. All monitoring wells fully penetrated the Fallon Formation and the upper few feet of the Seho Formation. Figure 10.4, p. 10-15, displays the simplified fence diagram constructed from selected wells involving these sites. This diagram shows a near-shore lake environment intertonguing with coarse-grained deposits trending north-

Fig. 10.3. Simplified fence diagram for monitoring wells installed at Sites 12, 13, and 14.

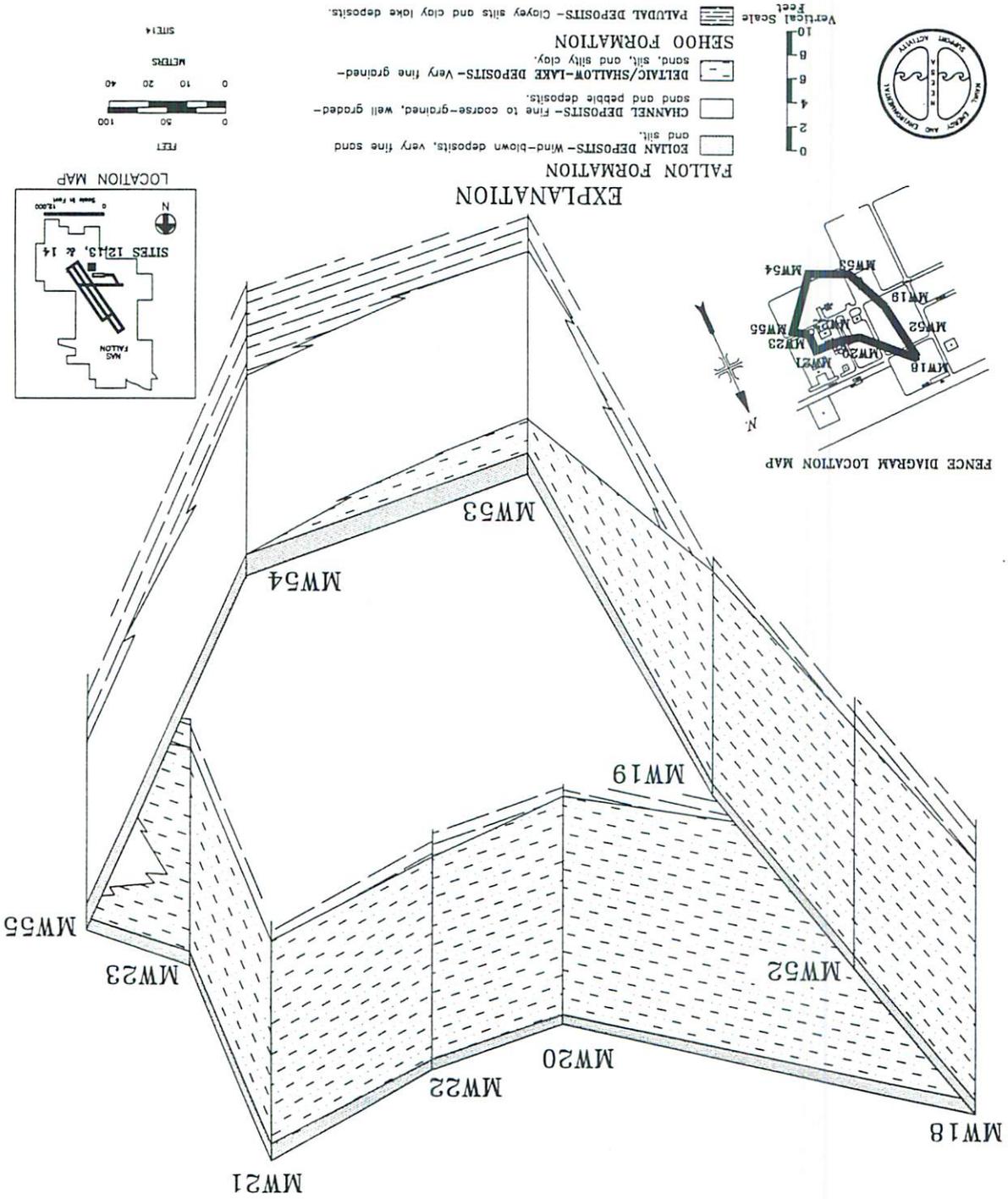
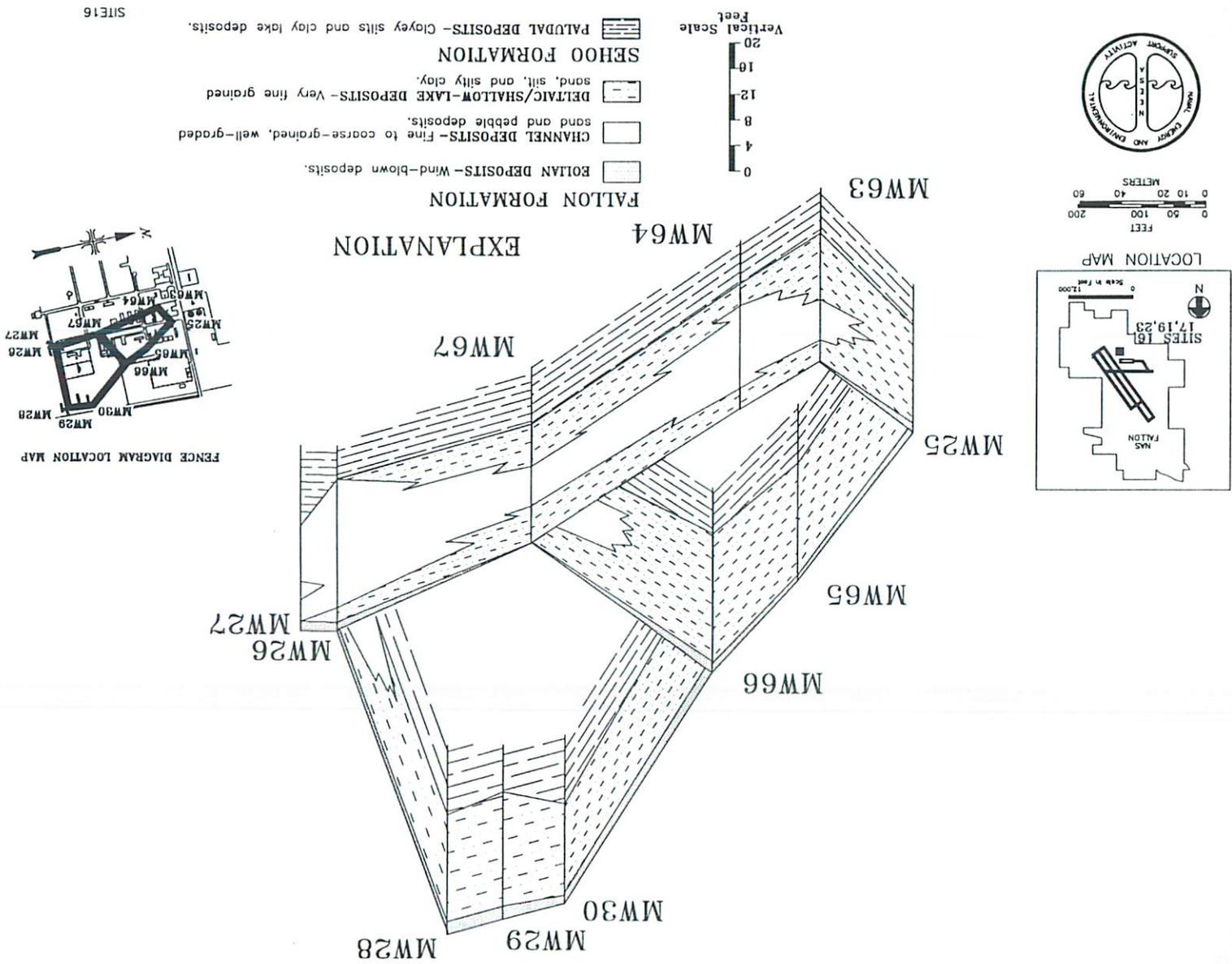


Fig. 10.4. Simplified fence diagram for monitoring wells installed at Sites 11, 16, 17, 19, and 23.



west to southeast. The lithology of the Fallon Formation here is predominantly sand, yellowish-brown, fine- to medium-grained, poorly sorted, with some mica content. These sands are interbedded with silty sands and sandy silts, with minor clayey silts. The Seho Formation has typical lithology as found in the general stratigraphic sequence for the base. Monitoring wells MW26, MW27, MW63, MW64, and MW67 contain coarse-grain sediments of a paleo-channel. The sands in these wells appear approximately 5 to 6 ft BGL and have a thickness of 6 to 14 ft.

10.3.4 Geophysical Investigation

Phase II screening activities at the Group IV Sites included EM-31 geophysical surveys at Sites 10, 19, and 23. These surveys attempted to locate the containers of PCB fluids reportedly buried at Site 10 and to delineate the buried waste at Sites 19 and 23 inclusive (Sites 19 and 23 are adjacent to one another; hence, one survey was used for both). Results of the geophysical surveys (Appendix B) were inconclusive but may have outlined targets for the buried PCB oil containers. No indication of a buried aircraft was found at Sites 19 or 23.

10.3.5 Vadose Zone and Soil Investigation

The first iteration of Phase II site characterization activities at the Group IV Sites included soil sampling from 27 soil borings. Soil samples were also collected from 13 locations during monitoring well installation. The second iteration of soil characterization included drilling two additional boreholes, sampling from four monitoring wells, and collecting four sediment samples. Soil sample locations at the Group IV Sites are summarized in Table 10.2, p. 10-17, and are shown on Fig. 10.5, p. 10-18.

10.3.6 Ground-Water Investigation

The first iteration of ground-water sampling at the Group IV Sites involved boring 162 ground-water test holes and installing sixteen monitoring wells and thirteen piezometers. Recommendations for subsequent investigation were based on results from the

Table 10.2. Summary of soil sample locations at the Group IV Sites

Site No.	First Iteration Activities		Second Iteration Activities		
	Boreholes	Wells	Boreholes	Wells	Sediment
10	5	0	0	0	0
11	0	0	0	1	0
12	6	1	1	0	0
13/14	0	7	0	3	0
16	8	6	0	0	4
17	5	0	0	0	0
23	3	0	1	0	0

Table 10.3. Summary of the ground-water investigation at the Group IV Sites

Site No.	First Iteration Activities			Second Iteration Activities		
	Test Holes	Wells	Piezometers	Test Holes	Wells	Piezometers
11	0	0	0	0	2	0
12	0	1	0	0	1	0
13	17	2	1	0	0	0
14	49	5	4	35	3	3
16	75	8	8	0	3	3
19	20	0	0	0	0	0
23	6	0	0	0	0	0

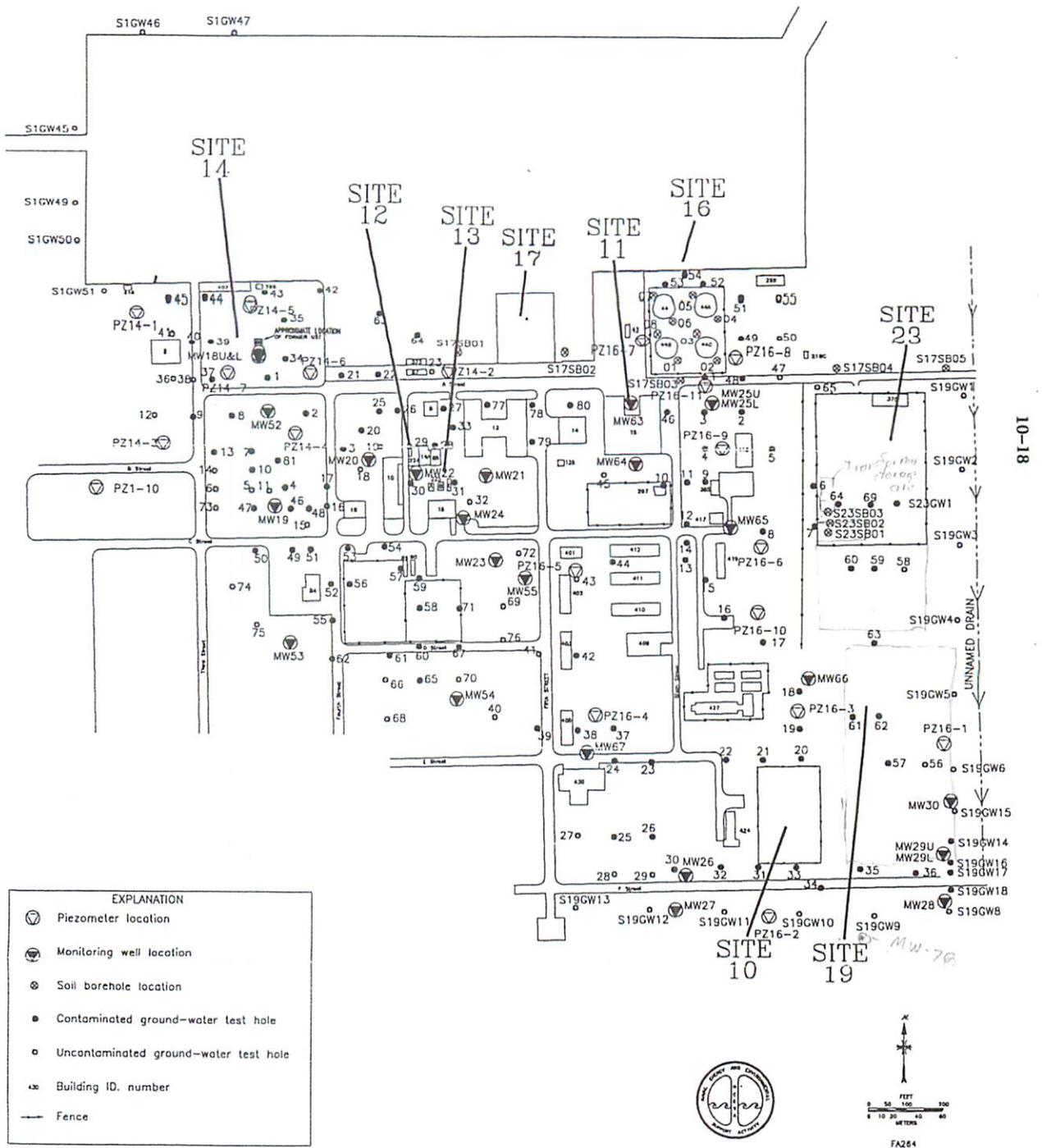


Fig. 10.5. Group IV Sites. Sample locations.

Final

first sampling iteration and recommendations made in the PSCS (ORNL 1992c). The second iteration of ground-water investigation at the Group IV Sites included boring thirty-seven additional ground-water test holes and installing nine monitoring wells and six piezometers (Fig. 10.5, p. 10-18). Table 10.3, p. 10-17 summarizes the ground-water investigation at the sites. Results of ground-water-test-hole screening are given in Appendix C.

The ground-water-test-hole method was substituted for the proposed soil-gas surveys because the test-hole method proved more effective when the two techniques were compared at Site 2. Ground-water screening activities were not conducted at Site 11, the Paint Shop, because concrete paving prevented drilling, and downgradient wells were already proposed for the other sites.

The ground-water test holes were used to delineate a PHC plume on the ground water underlying the facility and to determine suitable locations for monitoring wells. Water samples from the monitoring wells were sent to an off-site laboratory and analyzed for LBPHCs, HBPHCs, SVOCs, VOCs, PCB/pest, anions, and metals. Also, samples were analyzed in the field for temperature, pH, and conductivity. Results of water-quality field measurements for all sites are presented in Appendix G. Monitoring wells and piezometers were used to determine ground-water levels and to measure the presence and thickness of free-phase hydrocarbon product on the ground-water surface (see Appendix H, Table H.3).

10.4 NATURE AND EXTENT OF CONTAMINATION

10.4.1 Surface Water and Sediment

Results of the sediment investigation at the unnamed drain are discussed in Sect. 10.4.2.5, Site 16.

10.4.2 Vadose Zone and Soils

10.4.2.1 Site 10, GATAR Compound

Results of the five soil borings drilled at Site 10 (Fig. 10.6, p. 10-21), the GATAR Compound, are shown in Table 10.4, p. 10-22. The borings were drilled to a depth of 4 ft. No contamination was detected other than that related to laboratory sample preparation. A metal-detector survey was conducted, but only shallowly buried scrap metal was located.

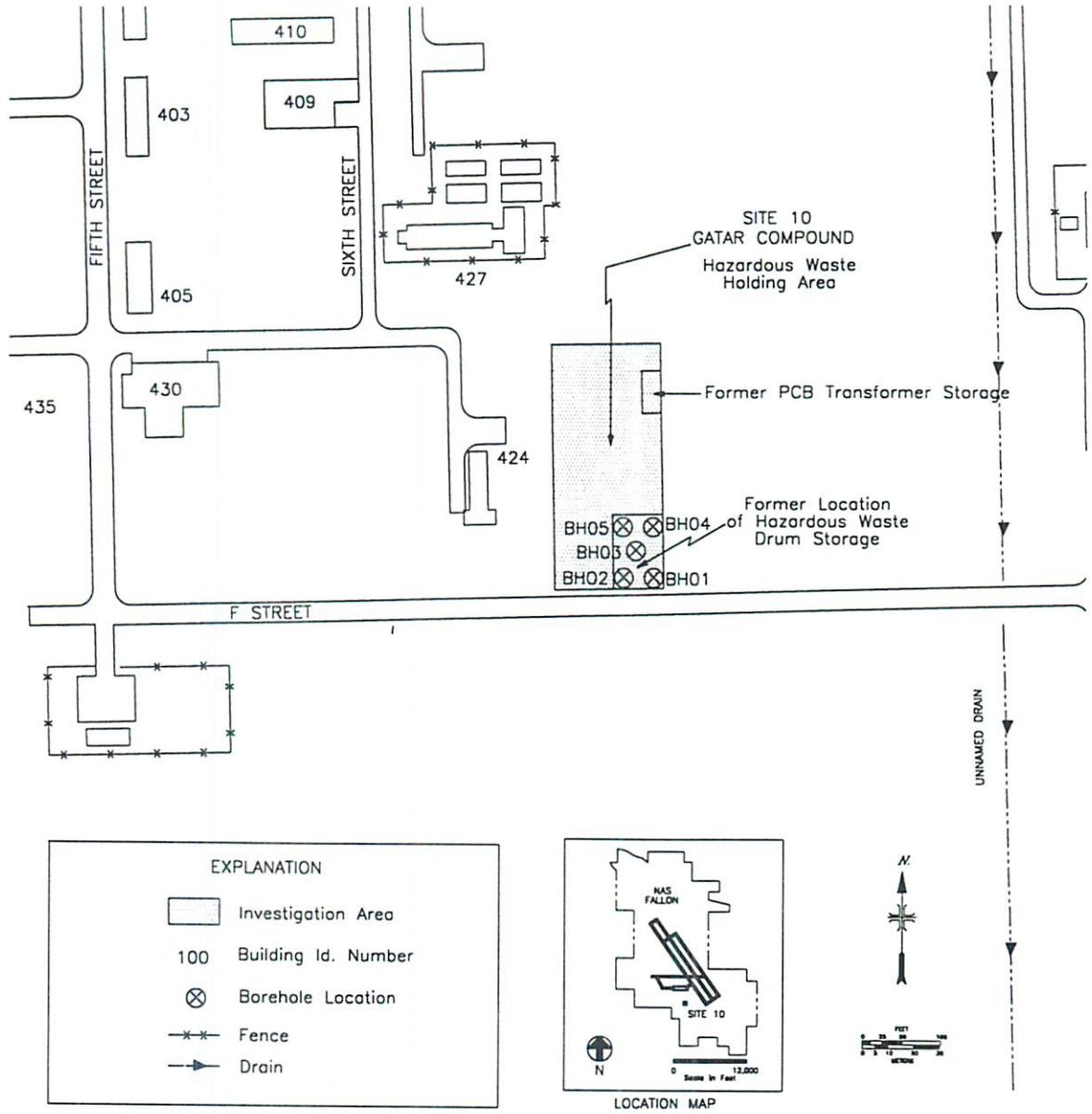
The only additional work recommended at this site for second iteration activities was a metal-probe survey. This survey was to be performed to test the three target areas delineated by the geophysical survey. The probe was to be driven into the ground on a grid pattern to determine if the soil at the site had been disturbed.

The assumption was that the probe would more readily penetrate a disturbed vs a non-disturbed area and that cans containing PCB-laden oil reportedly buried at the site would be found in a disturbed area. The technique was proposed as a method to narrow the three targets identified by the EM31 survey down to one target for excavation. Performance of this work was contingent upon moving a pile of scrap aluminum at the site. However, the Navy's efforts to secure sufficient resources to move the pile before Phase II activities were completed proved unsuccessful; therefore, the metal-probe survey was not performed.

The NAS Fallon Environmental Division conducted further investigation at Site 10 in December 1993. Excavation to the water table (approximately 6 ft) of the three high conductivity areas (Fig. 10.7, p. 10-24) revealed no cans containing PCB-laden oil nor any other substances. The geophysical survey results could have been associated with aircraft debris beneath the surface or compositional variations in the fill and native soils.

10.4.2.2 Site 11, Paint Shop

No soil samples were collected from Site 11 during the first iteration characterization. However, one sample was collected during second iteration activities when installing



S10BH

Fig. 10.6. Site 10, GATAR Compound, soil boring locations.

Final

Table 10.4. Soil sample results for Site 10

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	PCB/Pesticide, µg/kg (*3)	Semivolatiles, µg/kg (*4)	Volatiles, µg/kg (*5)
BH01 03/91	3671	0 - 2	U	U	U	Bis2 **	Methcl **
BH01 03/91	3672	2 - 4	U	U	U	Bis2 **	Methcl **
BH02 03/91	3673	0 - 2	U	U	U	Bis2 **	Methcl **
BH02 03/91	3674	2 - 4	U	U	U	Bis2 **	Methcl **
BH03 03/91	3675	0 - 2	U	U	U	Bis2 **	Methcl **
BH03 03/91	3676	2 - 4	U	U	U	Bis2 **	Methcl **
BH04 03/91	3677	0 - 2	U	U	U	Bis2 **	Methcl **
BH04 03/91	3678	2 - 4	U	U	U	Bis2 **	Methcl 11.0a
BH05 03/91	3679	0 - 2	U	U	U	Bis2 330.0*J	Acet ** Methcl 11.0a
BH05 03/91	3680	2 - 4	U	U	U	Bis2 **	Acet ** Methcl 13.0a

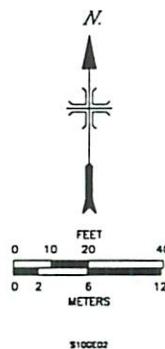
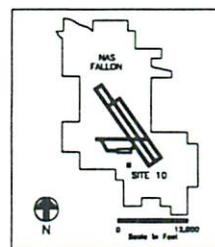
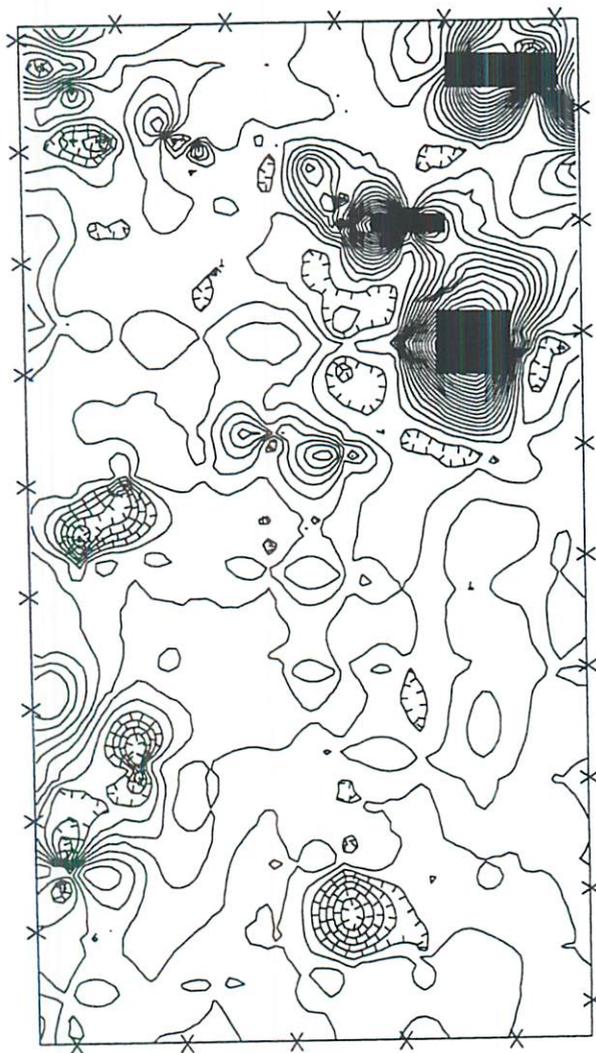
** - unusable data due to method blank contamination
a - suspected laboratory contaminant
*1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
*2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
*3 - EPA method 3550/8080, quantitation limit: 8.3 µg/kg
*4 - EPA method 3550/8270, quantitation limit: 350 µg/kg
*5 - EPA method 8240, quantitation limit: 5 µg/kg
*J - concentration estimated

Acet - acetone
Bis2 - bis(2-ethylhexyl) phthalate
HBP - high boiling point
LBP - low boiling point
Methcl - methylene chloride
PHC - petroleum hydrocarbons
U - no compounds detected

Table 10.4. Soil sample results for Site 10 (cont.)

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg				
Compound	#	Average	Minimum	Maximum
Aluminum	10	9,611	5,480.00	15,700.00
Antimony	0 ND		ND	ND
Arsenic	10	12	4.60	36.30
Barium	10	97	35.30	219.00
Beryllium	10	0	0.17	0.61
Boron	10	57	19.60	117.00
Cadmium	0 ND		ND	ND
Calcium	10	13,388	3,510.00	32,700.00
Chromium	10	9	5.40	13.10
Cobalt	10	7	3.80	11.00
Copper	10	86	24.00	320.00
Iron	10	16,440	10,600.00	27,700.00
Lead	10	7	3.20	12.00
Lithium	10	19	11.70	32.80
Magnesium	10	5,218	3,460.00	8,710.00
Manganese	10	291	115.00	527.00
Mercury	5	0	0.03	0.05
Molybdenum	0 ND		ND	ND
Nickel	10	8	4.50	11.90
Potassium	10	2,761	2,100.00	4,550.00
Selenium	0 ND		ND	ND
Silver	2	2	0.75	3.00
Sodium	10	8,527	2,590.00	13,400.00
Thallium	0 ND		ND	ND
Vanadium	10	38	24.20	62.90
Zinc	10	76	49.10	153.00

- number of samples with detectable quantities of analyte
 ND - analyte not detected



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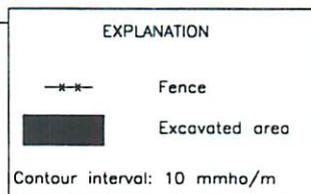


Fig. 10.7. Site 10, GATAR Compound, excavated areas, December 1993.

monitoring well MW64 (Table 10.5, p. 10-26, and Fig. 10.5, p. 10-18). Field screening of soil samples collected during drilling indicated slightly contaminated soil (165 $\mu\text{g/L}$ benzene) at the bottom of the shallow aquifer only. Therefore, a soil sample from 16.5 to 18 ft BGS was submitted for laboratory analysis. The contamination detected by the laboratory consisted of common laboratory solvents, probably the result of laboratory-induced contamination. No other soil samples were submitted for laboratory analysis because all other soil contamination appeared to be related to ground-water contamination, and water samples were to be collected from the well.

10.4.2.3 Site 12, Pest Control Shop

Soil sample results for Site 12 are presented in Table 10.6, p. 10-27. Six soil borings drilled to the water table were completed at Site 12 during first iteration characterization. Samples were collected at depth in order to assess potential contamination in the leach-field. Another sample was collected during the installation of monitoring well MW22 (Fig. 10.8, p. 10-28).

Three out of the six soil borings drilled around the site contained relatively low levels of DDT (dichlorodiphenyltrichloroethane), DDD (dichlorodiphenyldichloroethane), and DDE (dichlorodiphenyldichloroethene). The soil sample associated with MW22 contained no detectable hydrocarbons or pesticides.

Another soil boring was drilled near BH02 during second iteration activities to obtain a fresh soil sample at the water table. This sample was tested for pesticides and subjected to the toxicity characteristics leaching procedure (TCLP) to determine leachable quantities of pesticides. The borehole (BH07) was drilled and sampled within 4 ft of former BH02. A soil sample from the 5 to 7 ft interval was submitted for laboratory analysis. The results show no contamination by DDT or its derivatives, indicating that the previously detected contamination is not continuous in the area.

10.4.2.4 Site 13, Boiler Plant Tanks, and Site 14, Old Vehicle Maintenance Shop

First iteration soil characterization at Site 13, the Boiler Plant Tanks, and Site 14, the Old Vehicle Maintenance Shop, consisted of soil sampling during the installation of

Table 10.5. Soil sample results for Site 11

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)	Volatiles, µg/kg (*4)
MW64 11/91	3912	16.5 - 18	U	U	Bis2 2500.0a	Methcl 4.0*J

a - suspected laboratory contaminant

*1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg

*2 - EPA method 8015/8020, quantitation limit: 5 mg/kg

*3 - EPA method 3550/8270, quantitation limit: 350 µg/kg

*4 - EPA method 8240, quantitation limit: 5 µg/kg

*J - concentration estimated

Bis2 - bis(2-ethylhexyl) phthalate

HBP - high boiling point

LBP - low boiling point

Methcl - methylene chloride

PHC - petroleum hydrocarbons

U - no compounds detected

Table 10.6. Soil sample results for Site 12

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	PCB/Pesticide, µg/kg (*3)	Semivolatiles, µg/kg (*4)	Volatiles, µg/kg (*5)
BH01 03/91	3633	5 - 7	NP	NP	4,4DDD 3.6*J 4,4DDE 10.0*J 4,4DDT 32.0	NP	NP
BH01 03/91	3634	5 - 7	NP	NP	U	NP	NP
BH01 03/91	3635	7 - 9	NP	NP	4,4DDD 6.3*J 4,4DDE 18.0*J 4,4DDT 61.0	NP	NP
BH02 03/91	3636	5 - 7	NP	NP	4,4DDT 42.0	NP	NP
BH02 03/91	3637	7 - 9	NP	NP	4,4DDD 110.0 4,4DDE 100.0 4,4DDT 620.0	NP	NP
BH02 03/91	3637D	7 - 9	NP	NP	4,4DDD 130.0*J 4,4DDE 140.0*J 4,4DDT 820.0	NP	NP
BH03 03/91	3638	5 - 7	NP	NP	U	NP	NP
BH03 03/91	3639	7 - 9	NP	NP	4,4DDE 3.0*J 4,4DDT 21.0	NP	NP
BH04 03/91	3640	5 - 7	NP	NP	U	NP	NP
BH04 03/91	3641	7 - 9	NP	NP	U	NP	NP
BH05 03/91	3642	5 - 7	NP	NP	U	NP	NP
BH05 03/91	3643	7 - 9	NP	NP	U	NP	NP
BH06 03/91	3644	5 - 7	NP	NP	U	NP	NP
BH06 03/91	3645	7 - 9	NP	NP	U	NP	NP
BH07 12/91	3966	5 - 7	NP	NP	U	NP	NP
MW22 03/91	3578	7 - 9	U	U	U	Bis2 60.0*J Methcl 140.0a	

- a - suspected laboratory contaminant
 *1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
 *2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
 *3 - EPA method 3550/8080, quantitation limit: 8.3 µg/kg
 *4 - EPA method 3550/8270, quantitation limit: 350 µg/kg
 *5 - EPA method 8240, quantitation limit: 5 µg/kg
 *J - concentration estimated
 4,4DDD - 1,1'(2,2-dichloroethylidene) bis(4-chlorobenzene)
 4,4DDE - 1,1'(dichloroethenylidene) bis(4-chlorobenzene)
 4,4DDT - 1,1(2,2,2-trichloroethylidene) bis(4-chlorobenzene)

- Bis2 - bis(2-ethylhexyl) phthalate
 HBP - high boiling point
 LBP - low boiling point
 Methcl - methylene chloride
 NP - analysis not performed
 PHC - petroleum hydrocarbons
 U - no compounds detected

Final

TCLP test? probably
 DDD, DDE + DDT were
 not analyzed (have no Met)

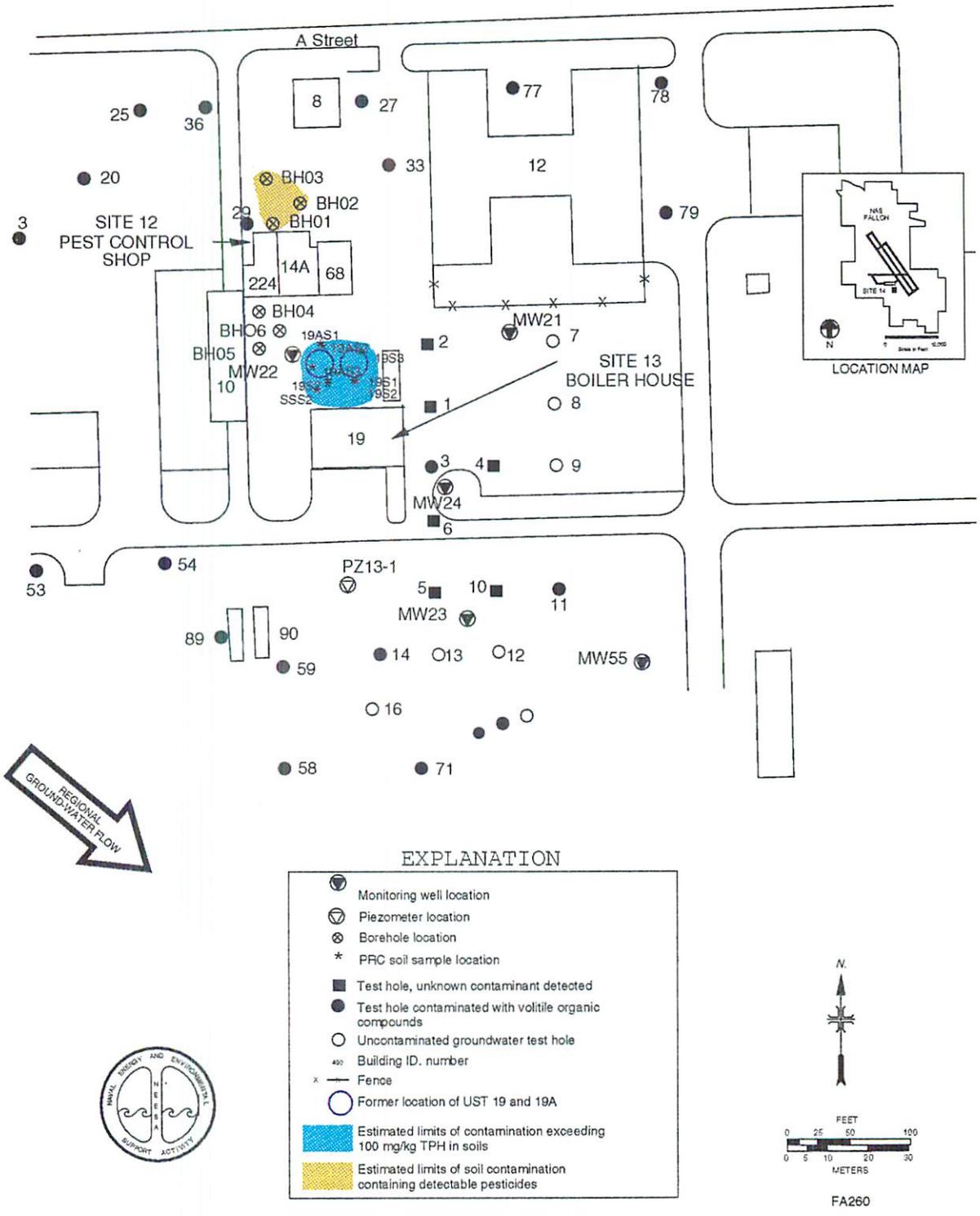


Fig. 10.8. Site 12, Pest Control Shop, and Site 13, Boiler Plant Tanks, sample locations and limits of soil contamination.

monitoring wells. Surface-soil samples were to be collected at Site 13 in conjunction with UST removals. However, Phase II IR Program characterization activities were completed before the UST removal program was initiated. Thus, a summary of the UST removal activities is presented later in this section. Detailed information can be found in the UST removal report (PRC 1992).

The sample from MW18 revealed a variety of PHC- and solvent-related compounds (Table 10.7, p. 10-30). However, the sample was collected in the capillary fringe at a depth of 7 to 9 ft BGS, and the concentrations of contaminants in the soils are consistent with the free product found on the ground water at MW18 (see Sect. 10.4.3.5). The other samples collected from the area had no detectable contamination other than laboratory-related compounds.

Three additional soil samples were collected from Sites 13 and 14 while installing monitoring wells during second iteration activities (Fig. 10.8, p. 10-28 and Fig. 10.9, p. 10-31). The soils were very slightly contaminated at the water table based on field screening; however, soil samples submitted for laboratory analysis from MW53, MW54, and MW55 revealed no significant contaminants.

Additional soil contamination was discovered at Site 13 during the removal of the boiler plant USTs between March and August of 1992. Prior to removal, the tanks were sampled, evacuated, and cleaned. The two 26,000-gal concrete USTs still contained Bunker C fuel oil in volumes of 21,750 gal and 1,335 gal respectively. The ground surface in the area was covered with a 6 to 10-in. layer of asphaltic material formed by overflow of the fuel oil. During excavation, visibly contaminated soil with a petroleum odor was observed from the surface down to the water table. Soil samples collected from the excavation pits had TPH concentrations as high as 12,120 mg/kg. Following tank removals, the excavation pits were lined with plastic and backfilled with contaminated material (including the asphaltic layer). A second layer of plastic was then laid over the contaminated fill and the area was brought to grade with clean road base. The surface was mounded and covered with plastic to prevent infiltration of surface water (PRC 1992).

Table 10.7. Soil sample results for Sites 13 and 14

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	PCB/Pesticide, µg/kg (*3)	Semivolatiles, µg/kg (*4)	Volatiles, µg/kg (*5)
MW18 03/91	3570	7 - 9	73.00	5500.00 B 41.00 E 100.00 T 330.00 X 520.00	NP	2-Meth 3600.0 Bis2 70.0*J Fluor 50.0*J Naph 1600.0	B 20000.0 E 47000.0 T 130000.0 X 260000.0
MW18 03/91	3570D	7 - 9	NP	NP	NP	NP	B 19000.0 E 46000.0 T 120000.0 X 270000.0
MW19 03/91	3575	7.5 - 8	U	U	NP	Bis2 93.0*J	Methcl 3.0*J
MW20 03/91	3576	7 - 9	U	U	NP	Bis2 55.0*J	Acet 26.0a B 1.0*J Methcl 11.0a T 3.0*J
MW21 03/91	3577	7 - 9	U	U	NP	U	Acet 16.0a Methcl 26.0a T 2.0*J
MW23 03/91	3579	8 - 10	U	U	U	Bis2 77.0*J	Acet 14.0a Methcl 48.0a
MW24 03/91	3580	7 - 9	U	U	U	U	Acet 12.0*J Methcl 30.0a X 6.0*J
MW53 11/91	3898	4.5 - 6	U	U	NP	U	Acet 15.0*J Methcl 4.0*J
MW54 11/91	3903	5 - 6.5	U	X **	NP	Bis2 **	Acet 40.0*J Methcl 21.0a
MW55 11/91	3904	5 - 6.5	U	X **	NP	Benzo 53.0*J Bis2 290.0*J	Acet 32.0*J Methcl 19.0a

** - unusable data due to method blank contamination
a - suspected laboratory contaminant
*1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
*2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
*3 - EPA method 3550/8080, quantitation limit: 8.3 µg/kg
*4 - EPA method 3550/8270, quantitation limit: 350 µg/kg
*5 - EPA method 8240, quantitation limit: 5 µg/kg
*J - concentration estimated
2-Meth - 2-methylnaphthalene
Acet - acetone
B - benzene
Benzo - benzoic acid

Bis2 - bis(2-ethylhexyl) phthalate
E - ethylbenzene
Fluor - fluorene
LBP - low boiling point
HBP - high boiling point
Methcl - methylene chloride
Naph - naphthalene
NP - analysis not performed
PHC - petroleum hydrocarbons
T - toluene
U - no compounds detected
X - xylenes (total)

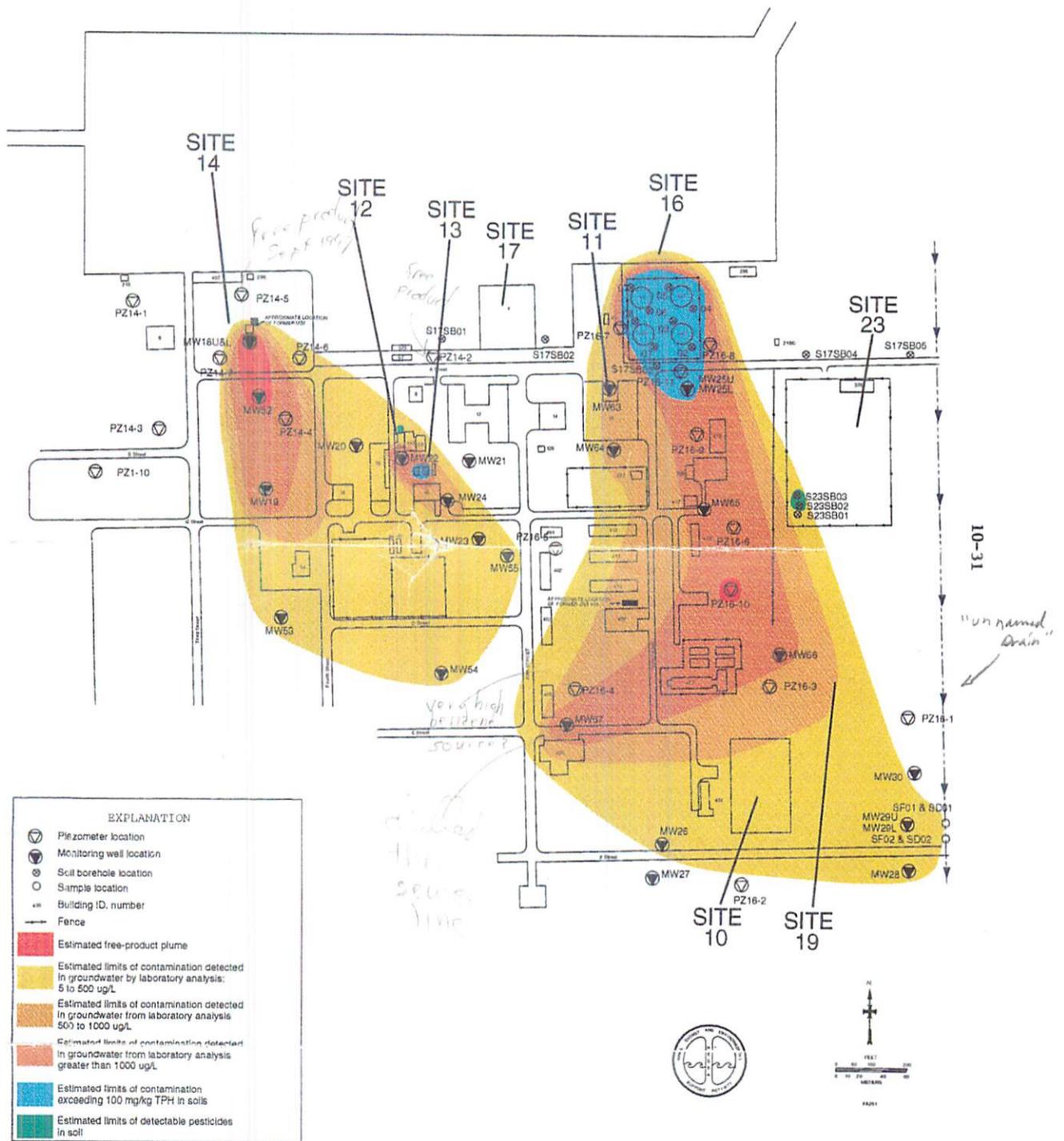


Fig. 10.9. Group IV Sites. Contaminant boundary map.

Final

10.4.2.5 Site 16, Old Fuel Farm

First iteration characterization at Site 16 involved collecting soil samples from eight boreholes and six monitoring well borings (Fig. 10.9, p. 10-31). Soil samples taken from boreholes BH01 through BH03 from around the underground tanks were contaminated with PHCs at levels above the NDEP action level (Table 10.8, p. 10-33).

A sample collected during installation of MW25 had low levels of fuel-related VOCs, but HBPHCs and LBPHCs were not detected. Soils collected during the installation of downgradient monitoring well MW29 had slight LBPHC contamination (8.0 mg/kg); however, soil samples taken from the other downgradient wells, MW26, MW27, MW28, and MW30, were essentially clean, indicating that the downgradient boundary of the contamination was delineated.

Second iteration soil characterization at Site 16 centered around a suspected plume seepage into the unnamed drain. Four soil/sediment samples (designated SD01 and SF01, etc.) were collected from the distal plume boundary at the intersection of the plume and the drain (Fig. 10.9, p. 10-31). Two of these samples were collected from the bank at the seepage face in the vicinity of MW29. The other two samples were sediment samples collected from the drain bottom adjacent to the soil sample locations. The results indicate that the soil sample taken from the seepage face immediately east of MW29 is contaminated with HBPHCs as diesel at 270 mg/kg and LBPHCs as gasoline at 131 mg/kg. The other 3 samples resulted in no detectable compounds at levels of concern. The results indicate that the Site 16 ground-water contaminant plume may be in contact with the drain; however, there was no apparent discharge of PHCs into the drain at the time of sampling. If the plume is slowly seeping into the drain, contaminant concentrations are likely to be undetectable by laboratory analytical methods after dilution by the surface water.

Additional soil contamination was identified at the Old Fuel Farm during the UST removal program. Detailed information can be found in the UST removal report (PRC 1992). The locations of the USTs, former fuel island, associated piping, and soil samples are shown in Fig. 10.10, p. 10-36.

Table 10.8. Soil sample results for Site 16

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)	Volatiles, µg/kg (*4)
BH01 03/91	3629	5 - 7	U	860.00 E 1.00 T 13.00 X 26.00	Bis2 520.0a	T X 3100.0*J 39000.0
BH02 03/91	3630	5 - 7	U	200.00 E 1.00 T 0.20 X 3.10	Bis2 200.0*J	E X 550.0*J 2200.0
BH03 03/91	3631	5 - 7	U	X 68.00 0.80	Bis2 390.0*J	B E T X 9.0 22.0 2.0*J 320.0
BH03 03/91	3631D	5 - 7	NP	NP	NP	X 1500.0
BH04 03/91	3650	5 - 7	U	U	Bis2 **	Acet Methcl 10.0*J **
BH05 03/91	3651	5 - 7	U	U	Bis2 270.0*J	2-But Acet E Methcl 4.0*J 61.0a 4.0*J **
BH06 03/91	3652	5 - 7	U	U	Bis2 **	Methcl 10.0**
BH07 03/91	3653	5 - 7	U	U	Bis2 **	Methcl 46.0a
BH08 03/91	3654	5 - 7	U	U	Bis2 300.0*J	Acet Methcl 23.0a **
MW25 03/91	3581	7	U	U	Bis2 60.0*J	1,2DCA Acet B E Methcl T X 8.0 22.0a 50.0 120.0 19.0a 5.0*J 4.0*J
MW26 03/91	3582	5 - 7	U	U	U	Methcl 5.0*J
MW27 03/91	3583	5 - 7	U	U	U	Carbdi Methcl 1.0*J 7.0*J
MW28 03/91	3584	7 - 9	U	U	U	Methcl 11.0a
MW29 03/91	3585	7 - 9	U	8.00	Bis2 50.0*J	Acet Methcl 6.0*J 12.0a
MW30 03/91	3586	5 - 7	U	U	Bis2 68.0*J	Carbdi Methcl 2.0*J 7.0a

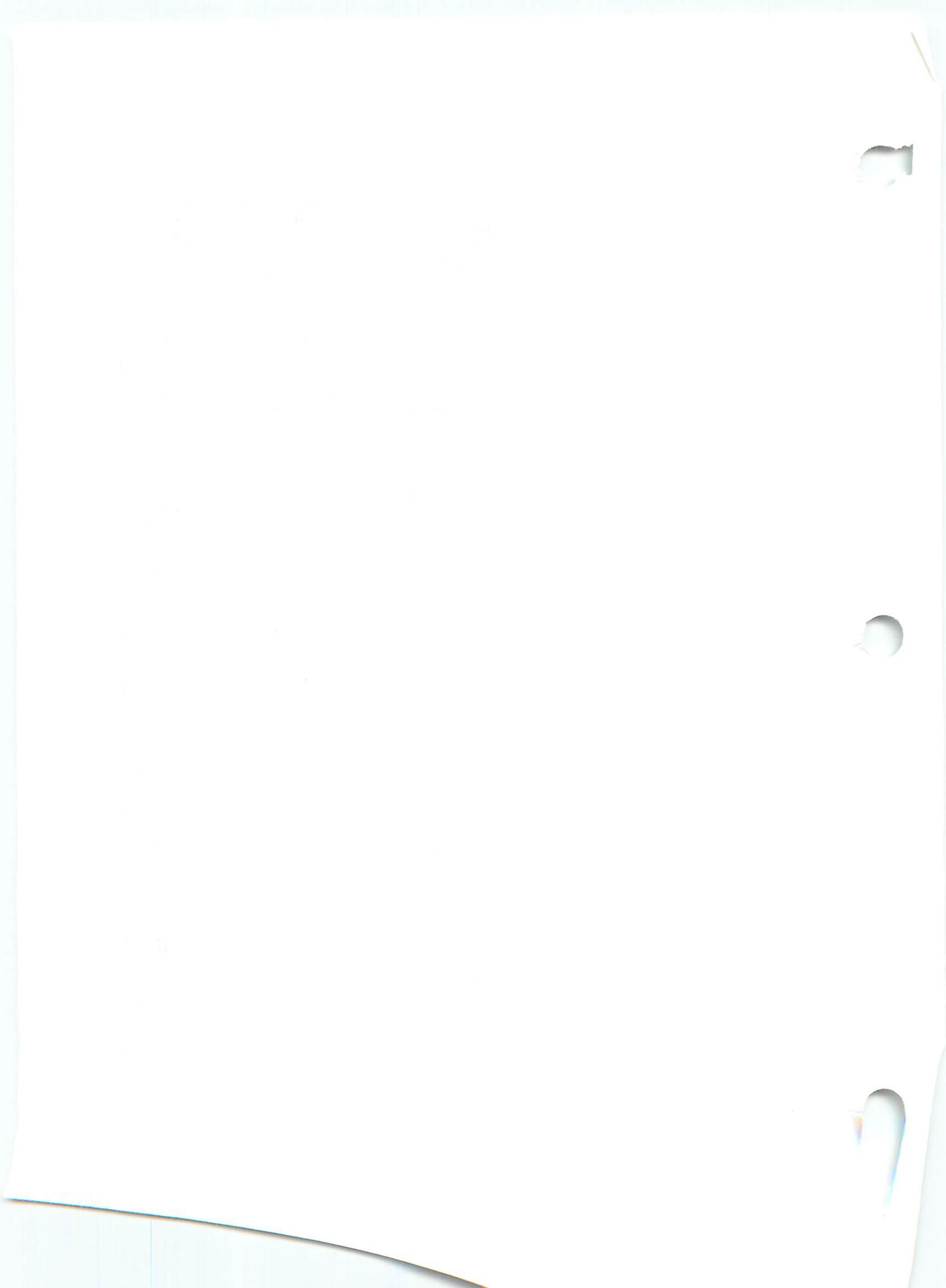


Table 10.8. Soil sample results for Site 16 (cont.)

Location	Sample Number	Location	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)	Volatiles, µg/kg (*4)
SD01 12/91	3953	Drain	U	U	Bis2 940.0*J	Methcl 4.0*J
SD02 12/91	3955	Drain	U	U	Bis2 5700.0a	U
SF01 12/91	3954	Drain	Die 270.00	Gas 131.00	Bis2 370.0*J	Methcl 3.0*J
SF02 12/91	3956	Drain	U	U	Bis2 1800.0a	Methcl 5.0*J

- ** - unusable data due to method blank contamination
 a - suspected laboratory contaminant
 *1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
 *2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
 *3 - EPA method 3550/8270, quantitation limit: 350 µg/kg
 *4 - EPA method 8240, quantitation limit: 5 µg/kg
 *J - concentration estimated
 1,2DCA - 1,2-dichloroethane
 2-But - 2-butanone
 Acet - acetone
 B - benzene
 Bis2 - bis(2-ethylhexyl) phthalate
 Carbdi - carbon disulfide
 Die - HBP PHC as compared to diesel fuel
 E - ethylbenzene
 Gas - LBP PHC as compared to gasoline
 HBP - high boiling point
 LBP - low boiling point
 Methcl - methylene chloride
 NP - analysis not performed
 PHC - petroleum hydrocarbons
 T - toluene
 U - no compounds detected
 X - xylenes (total)

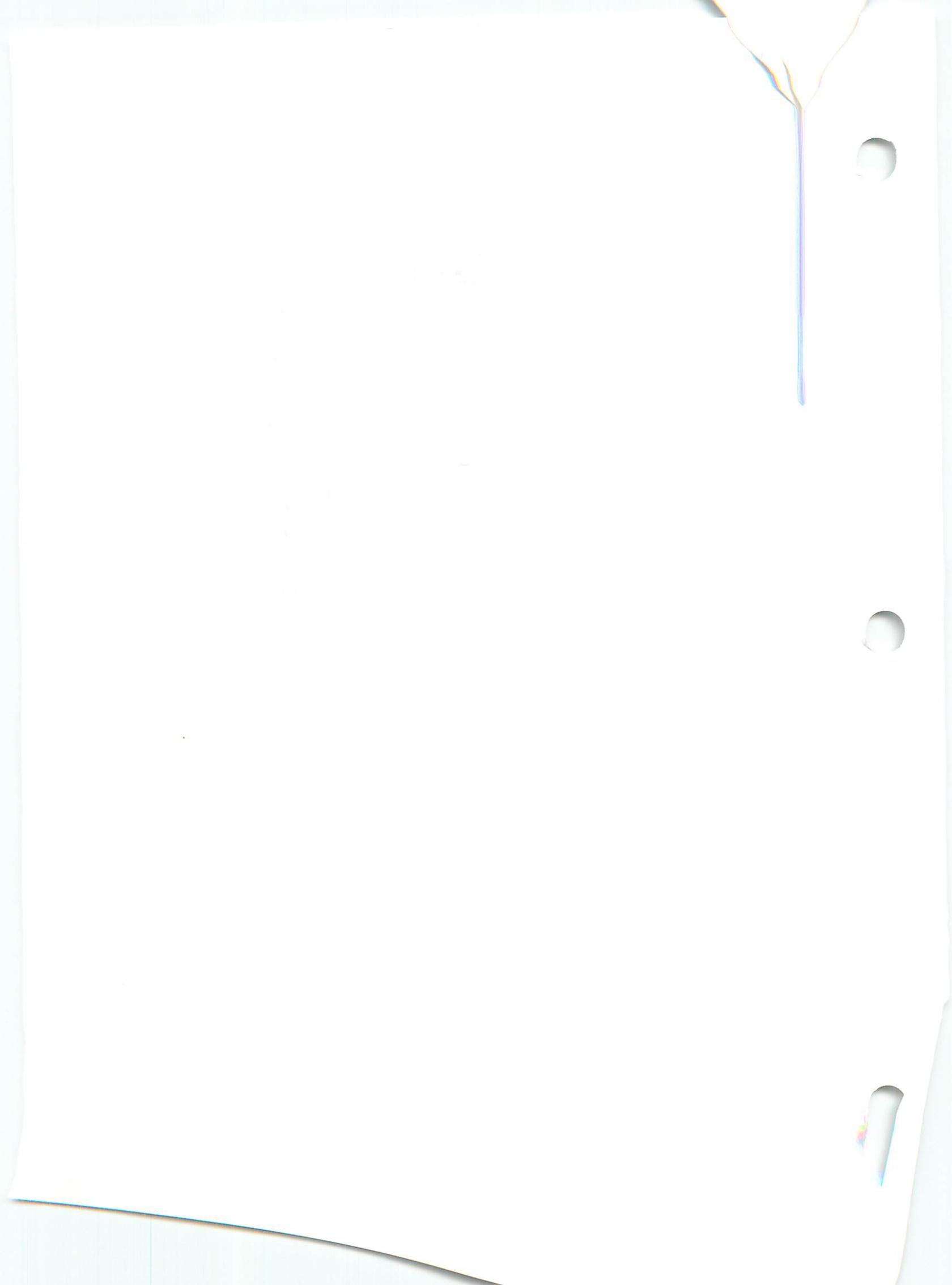
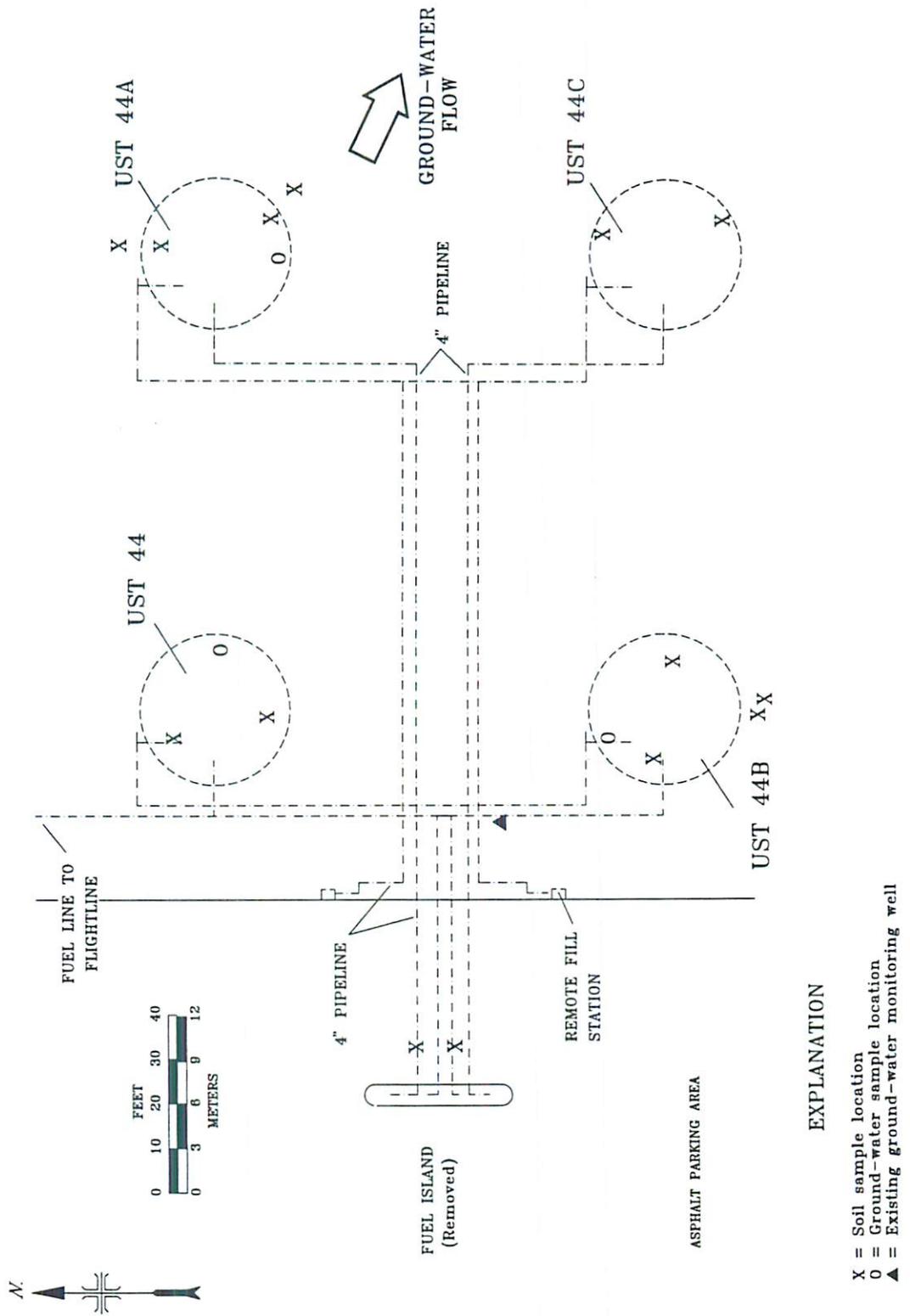


Table 10.8. Soil sample results for Site 16 (cont.)

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg				
Compound	#	Average	Minimum	Maximum
Aluminum	8	7,559	2,090.00	16,700.00
Antimony	0 ND		ND	ND
Arsenic	8	8	3.40	16.60
Barium	8	101	16.30	202.00
Beryllium	7	0	0.21	0.62
Boron	7	17	2.00	30.60
Cadmium	0 ND		ND	ND
Calcium	8	4,416	1,610.00	12,000.00
Chromium	8	8	4.10	13.10
Cobalt	8	7	3.80	11.70
Copper	8	55	16.60	205.00
Iron	8	15,086	8,440.00	24,100.00
Lead	8	10	3.20	20.80
Lithium	8	15	3.40	26.60
Magnesium	8	3,938	1,100.00	7,020.00
Manganese	8	316	54.70	763.00
Mercury	1	0	0.03	0.03
Molybdenum	0 ND		ND	ND
Nickel	8	8	4.20	12.50
Potassium	8	1,975	354.00	3,370.00
Selenium	0 ND		ND	ND
Silver	0 ND		ND	ND
Sodium	8	3,332	149.00	7,870.00
Thallium	1	0	0.27	0.27
Vanadium	8	36	21.20	56.90
Zinc	8	65	27.30	155.00

- number of samples with detectable quantities of analyte
 ND - analyte not detected



EXPLANATION

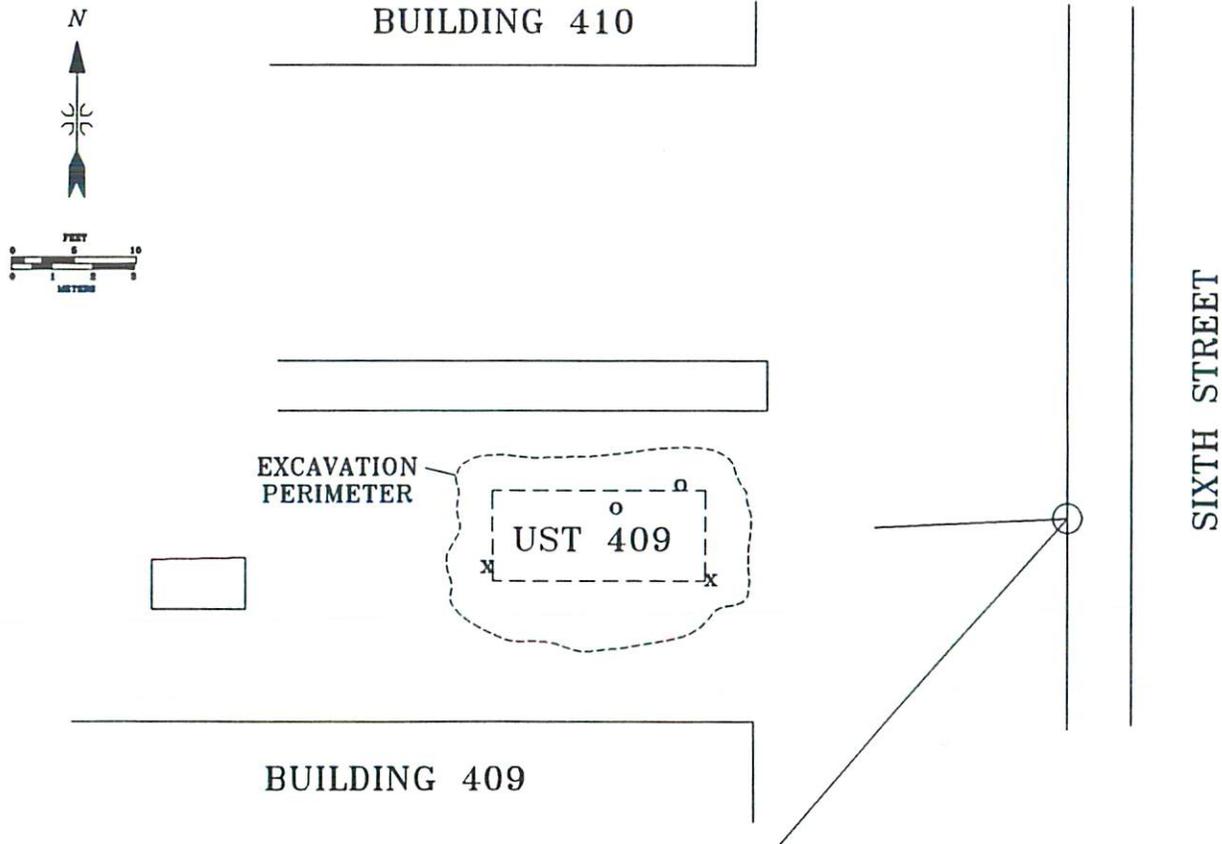
- X = Soil sample location
- O = Ground-water sample location
- ▲ = Existing ground-water monitoring well

Removal activities occurred between April and August of 1992. Prior to removal, the tanks were sampled, evacuated, and cleaned. Volumes of product in the four 50,000-gal concrete tanks ranged from 960 to 4600 gal. At the time of sampling and removal, the tanks contained a heavy fuel oil. In general, the soil around the perimeter of each tank was stained, beginning at a depth of 7 to 8 ft BGS. Soil samples collected from the excavation pits exhibited varying levels of TPHs, with detectable concentrations ranging from 280 to 4500 mg/kg. It should be noted that all samples with detectable contamination were collected at the capillary fringe or below the water table. Soil contamination was also identified during the excavation and removal of piping that led from the Old Fuel Farm west to the former fuel island. Widespread contamination was encountered at a depth of 2 to 3 ft BGS. Contaminant concentrations from samples collected in the area ranged from 33 to 4450 mg/kg.

Ground water observed in the four excavation pits typically had an oily sheen or a black to brown oily film. Accumulated ground water in the excavation of the northwest tank contained 0.2 in. of measurable free product. Ground-water samples from the excavation pits had TPH concentrations ranging from 52 to 414 mg/L.

Following removal and demolition of the tanks, the excavation pits from the two northernmost tanks were backfilled with contaminated soils. Due to the spacing of rebar in the concrete and the age of the concrete, the tanks broke into small pieces that could not be efficiently separated from the excavated soil. Thus, the pits were backfilled with the contaminated-soil/concrete-rubble mixture. The two southern tanks were backfilled with clean fill from a local supplier. All of the pits were brought up to grade with clean road base and covered with plastic. Additional road base and plastic were added to promote drainage and prevent surface-water infiltration (PRC 1992).

Soil contamination was also identified during UST removal activities near Bldg. 409. A 5,500-gal tank, located just north of the building, was removed in March 1992 (Fig. 10.11, p. 10-38). Prior to removal, the tank was sampled, evacuated, and cleaned. At the time of sampling, the tank contained approximately 490 gal of diesel fuel. During removal activities, numerous holes were observed in the corroded lower half of the tank (the portion of



EXPLANATION
 X = Soil sample location
 O = Ground-water sample location

Fig. 10.11. UST 409 and associated sample locations.

the tank below the water table). Soil samples were collected from each end of the excavation pit at a depth of approximately 8 ft BGS. Analysis results for the east- and west-end samples were 10 mg/kg and 2,200 mg/kg TPH as diesel respectively. A ground-water sample collected from the pit contained 92 mg/L TPH as diesel but showed no BTEX compounds. Following tank removal, the excavation pit was back-filled with contaminated soil and brought to grade with clean road base. Finishing activities to prevent surface-water infiltration were conducted as at other UST removal sites (PRC 1992).

10.4.2.6 Site 17, Hangar 5

First iteration soil characterization activities at Site 17 involved five soil borings drilled to the water table along the drainage swale leading from Hangar 5 to the unnamed drain (Fig. 10.5, p. 10-18). These are designated on the map as S17SB01, etc. The results are shown in Table 10.9, p. 10-40. Only BH03, which is within the Old Fuel Farm plume, was contaminated (Fig. 10.9, p. 10-31). The contaminants were fuel-related and are likely associated with the Site 16 plume. These results indicate that the samples taken during the Phase I PA/SI investigation were collected at localized stained surface areas that have not resulted in wide-spread soil contamination. No second iteration soil investigations were conducted at Site 17.

10.4.2.7 Site 19, Post-World War II Burial Site

All site investigation activities for Site 19 were combined with Site 16, the Old Fuel Farm (see results for MW29 and MW30, Sect. 10.4.2.5).

10.4.2.8 Site 23, Shipping and Receiving Disposal

First iteration soil characterization at Site 23 involved three soil borings drilled to 4 ft (Fig. 10.5, p. 10-18). The borings were drilled in the former transformer storage area to test for PCBs. No PCBs were detected; however, the samples revealed minor amounts

Table 10.9. Soil sample results for Site 17

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	Semivolatiles, µg/kg (*3)	Volatiles, µg/kg (*4)
BH01 03/91	3618	0 - 1	U	U	Bis2 **	Methcl **
BH01 03/91	3619	5 - 7	U	U	Bis2 410.0*J Di-N-O 78.0*J	Methcl **
BH02 03/91	3620	0 - 2	U	U	Bis2 **	Methcl **
BH02 03/91	3621	5 - 7	U	U	Bis2 **	Methcl 22.0a
BH03 03/91	3623	0 - 1	U	U	Bis2 2400.0a	2-But 4.0*J Acet 44.0a Methcl 57.0a
BH03 03/91	3624	5 - 7	U	U	Bis2 890.0a	Acet 1100.0a B 22.0 E 290.0 T 240.0 X 1600.0
BH03 03/91	3624D	5 - 7	NP	NP	NP	E 410.0*J T 340.0*J X 3200.0
BH04 03/91	3625	0 - 1	U	U	Bis2 140.0*J	Methcl **
BH04 03/91	3626	5 - 7	U	U	Bis2 180.0*J	Methcl **
BH05 03/91	3627	0 - 1	U	U	Bis2 290.0*J	Methcl **
BH05 03/91	3628	5 - 7	U	U	Bis2 310.0*J	Methcl **

** - unusable data due to method blank contamination

a - suspected laboratory contaminant

*1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg

*2 - EPA method 8015/8020, quantitation limit: 5 mg/kg

*3 - EPA method 3550/8270, quantitation limit: 350 µg/kg

*4 - EPA method 8240, quantitation limit: 5 µg/kg

*J - concentration estimated

2-But - 2-butanone

Acet - acetone

B - benzene

Bis2 - bis(2-ethylhexyl) phthalate

Di-N-O - di-n-octylphthalate

HBP - high boiling point

LBP - low boiling point

Methcl - methylene chloride

NP - analysis not performed

PHC - petroleum hydrocarbons

T - toluene

U - no compounds detected

X - xylenes (total)

E - ethylbenzene

Table 10.9. Soil sample results for Site 17 (cont.)

Metals, mg/kg EPA method 6010 Quantitation limit: 1 mg/kg				
Compound	#	Average	Minimum	Maximum
Aluminum	10	7,453	3,050.00	18,700.00
Antimony	0	ND	ND	ND
Arsenic	10	11	0.37	22.40
Barium	10	112	15.60	260.00
Beryllium	10	0	0.14	0.87
Boron	10	26	6.00	102.00
Cadmium	1	1	0.57	0.57
Calcium	10	14,611	1,390.00	61,400.00
Chromium	10	7	4.00	14.40
Cobalt	10	6	3.00	11.50
Copper	10	41	10.70	71.70
Iron	10	13,305	7,800.00	28,200.00
Lead	10	11	1.80	30.70
Lithium	10	19	4.70	50.40
Magnesium	10	5,083	1,220.00	11,000.00
Manganese	10	354	64.50	989.00
Mercury	1	0	0.06	0.06
Molybdenum	0	ND	ND	ND
Nickel	10	7	2.90	15.20
Potassium	10	2,234	701.00	4,850.00
Selenium	0	ND	ND	ND
Silver	0	ND	ND	ND
Sodium	10	3,104	418.00	9,930.00
Thallium	0	ND	ND	ND
Vanadium	10	29	19.70	57.90
Zinc	10	58	28.80	89.40

- number of samples with detectable quantities of analyte
 ND - analyte not detected

of the pesticide DDT and degradation products DDD and DDE (Table 10.10, p. 10-43). It is significant to note that the pesticides were detected only in the top 2 ft of soil and have apparently not migrated.

Second iteration activities proposed another soil boring near one of the previous boreholes to obtain a fresh soil sample near the ground surface. This sample was to be tested for pesticides and subjected to the TCLP to determine leachable quantities of pesticides. The soil boring, BH04, was drilled in the vicinity of the previously drilled BH02 and BH03. Soil samples were collected from the 0 to 2-ft interval. The results showed that DDT and derivatives were present at concentrations comparable to those measured in samples from the other boreholes ($<100 \mu\text{g}/\text{kg}$). Considering the low mobility of these compounds in soil and the extremely low average annual precipitation at the site, there is little likelihood that the contamination will migrate to nearby surface water.

10.4.3 Ground Water

The first iteration of the Group IV Sites ground-water characterization was summarized in the PSCS (ORNL 1992). Recommendations made in the PSCS led to a second iteration of characterization activities. Results of the two iterations for each site are discussed together in the following sections. Analytical data for the two activities are combined into one table for each site. Sample locations and contaminant boundaries are shown in Fig. 10.9, p. 10-31. The figure presents ground-water contaminant plume boundaries based on two types of data: 1) data indicating the presence and thickness of free product when collecting water-level measurements and 2) data obtained from laboratory analysis of ground-water samples. The plume boundary for each type of data is drawn around sample locations where detectable levels of contaminants were indicated by the measurement method.

Due to the close proximity of the Group IV Sites to each other, two dissolved contaminant plumes encompass several adjacent sites (Fig 10.9, p. 10-31). Each of the contaminated areas delineated are discussed in the context of their anticipated source areas (as inferred from the regional ground-water flow direction). The principal source areas for the plumes appear to be Site 14, the Old Vehicle Maintenance Shop, and Site 16, the Old Fuel Farm.

Table 10.10. Soil sample results for Site 23

Location	Sample Number	Location, ft BGS	Total HBP PHC, mg/kg (*1)	Total LBP PHC, mg/kg (*2)	PCB/Pesticide, µg/kg (*3)
BH01 03/91	3681	0 - 2	U	U	U
BH01 03/91	3682	2 - 4	U	U	U
BH02 03/91	3683	0 - 2	U	U	4,4DDD 11.0*J 4,4DDE 76.0 4,4DDT 64.0
BH02 03/91	3684	2 - 4	U	U	U
BH03 03/91	3685	0 - 2	U	U	4,4DDD 12.0*J 4,4DDE 87.0 4,4DDT 44.0
BH03 03/91	3686	2 - 4	U	U	U
BH03 03/91	3687	2 - 4	U	U	U
BH04 12/91	3967	0 - 2	NP	NP	4,4DDD 23.0 4,4DDE 64.0 4,4DDT 98.0
BH04 12/91	3967D	0 - 2	NP	NP	4,4DDD 22.0*J 4,4DDE 86.0*J 4,4DDT 100.0

- *1 - EPA method 8015 Modified, quantitation limit: 10 mg/kg
 *2 - EPA method 8015/8020, quantitation limit: 5 mg/kg
 *3 - EPA method 3550/8080, quantitation limit: 8.3 µg/kg
 *J - concentration estimated
 4,4DDD - 1,1'(2,2dichloroethylidene) bis(4-chlorobenzene)
 4,4DDE - 1,1'(dichloroethylidene) bis(4-chlorobenzene)
 4,4DDT - 1,1(2,2,2trichloroethylidene) bis(4-chlorobenzene)
 HBP - high boiling point
 LBP - low boiling point
 NP - analysis not performed
 PHC - petroleum hydrocarbons
 U - no compounds detected

10.4.3.1 Site 10, GATAR Compound

No ground-water investigation was conducted at Site 10.

10.4.3.2 Site 11, Paint Shop

No ground-water investigation was conducted at Site 11 during the first iteration of Phase II characterization. However, because contaminants identified in MW25 (Site 16) included several phenolic compounds believed to be associated with paint shop wastes, sampling was conducted during second iteration activities.

Two monitoring wells were proposed for the site. One well was to be installed through the concrete at the former disposal area, and the other well downgradient on the south side of the paint shop. Ground-water test holes were proposed at all well locations prior to well installation to ensure optimum placement.

The two wells installed at the site were MW63 and MW64. MW63 was located in the former paint waste disposal area. No ground-water test hole was drilled prior to well installation because of a concrete slab at the site. Field screening of soil samples collected during drilling indicated highly contaminated soil at the capillary fringe and slightly contaminated soil at the bottom of the shallow aquifer. Because of concern about possible sinking contaminants (solvents), the well was screened across the entire shallow aquifer zone (3 to 23 ft). No soil samples were submitted for laboratory analysis because all soil contamination appeared to be related to ground-water contamination and water samples were to be collected from the well. Ground-water samples were collected from two zones in the well: the top of the aquifer and the bottom of the aquifer. Care was taken during sampling to ensure that only water from the zones of interest was collected. This was accomplished by setting the pump intake at the zone of interest and maintaining a very low flow rate (<100 mL/min) during purging and sampling. Conductivity monitoring revealed that the shallow ground water was stratified with respect to dissolved solids. Conductivity at the top of the aquifer was 43,200 $\mu\text{mhos/cm}$ and 58,600 $\mu\text{mhos/cm}$ at the bottom of the aquifer. Thus, by monitoring the conductivity, it was relatively easy to ensure that only water from the zone of interest was being pumped during sampling.

Water samples collected from MW63 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs (Table 10.11, p. 10-46). Results from the first round of sampling (December 1991) indicated that the upper zone of MW63 (6.5 ft below top of casing) contained 310 $\mu\text{g/L}$ of HBPHCs as diesel, 170 $\mu\text{g/L}$ of LBPHCs as gasoline, benzene at 2 $\mu\text{g/L}$, and 1,2-dichloroethane (1,2-DCA) at 6 $\mu\text{g/L}$. Results from the second round of sampling (April 1992) yielded similar levels of the same constituents. The lower zone of MW63 (16 ft below top of casing) had results indicating 50 $\mu\text{g/L}$ of HBPHCs as JP-5, 150 $\mu\text{g/L}$ of LBPHCs as gasoline, benzene at 120 $\mu\text{g/L}$, toluene at 1 $\mu\text{g/L}$, 1,2-DCA at 23 $\mu\text{g/L}$, and TCE at 11 $\mu\text{g/L}$. Second round results were again similar.

MW64 was located on the south side of the paint shop building. A ground-water test hole drilled prior to well installation indicated some ground-water contamination. Field screening of soil samples collected during drilling indicated minor soil contamination at the water table (70 $\mu\text{g/L}$ 1,2-DCE as measured in head space air) and slightly contaminated soil at the bottom of the shallow aquifer (165 $\mu\text{g/L}$ benzene as measured in head space air). The soil sample from 16.5 to 18 ft BGS was submitted for laboratory analysis. The contamination detected by the laboratory consisted of common laboratory solvents, probably the result of laboratory-induced contamination. No other soil samples were submitted for laboratory analysis because all other soil contamination appeared to be related to ground-water contamination and water samples were to be collected from the well. Because of concern about possible sinking contaminants (solvents), the well was screened across the entire shallow aquifer zone (2.5 to 22.5 ft).

Ground-water samples were collected from two zones in the well, the top of the aquifer and the bottom of the aquifer. The conductivity monitoring method described earlier in this section was used to ensure that only water from the zone of interest was collected.

Water samples collected from MW64 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from the first round of sampling (December 1991) indicate that the upper zone of MW64 (7.2 ft below top of casing) contained 110 $\mu\text{g/L}$ of HBPHCs as diesel, 61 $\mu\text{g/L}$ of LBPHCs as gasoline, and 1,2-DCA at 10 $\mu\text{g/L}$. Second round results

Table 10.11. Water sample results for Site 11

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	Semivolatiles, µg/L (*3)	Volatiles, µg/L (*4)
MW063L 12/91	3948	JP5 50.0	Gas 150.0 B 120.0 T 1.0	Bis2 **	1,2DCA 23.0 Clform 49.0 ^a TCE 11.0
MW63L 04/92	3997	U	Gas 680.0 B 300.0	Bis2 2.0* ^J	1,2DCA 18.0* ^J Clform 45.0 ^a TCE 11.0
MW63L 04/92	3997D	NP	B 330.0	NP	1,2DCA 18.0* ^J Clform 45.0 ^a TCE 12.0
MW63U 12/91	3947	Die 310.0	Gas 170.0 B 2.0	U	1,2DCA 6.0 Clform 3.0* ^J
MW63U 04/92	3994	Die 230.0	Gas 130.0	Bis2 6.0* ^J	1,2DCA 4.0* ^J Clform 2.0* ^J
MW64L 12/91	3950	Die 70.0	Gas 65.0 B 0.6	Bis2 **	1,2DCA 12.0 Clform 10.0 ^a TCE 1.0* ^J
MW64L 04/92	3995	Die 60.0	Gas 89.0	Pent 7.0* ^J	1,2DCA 9.0* ^J Clform 8.0 ^a TCE 1.0* ^J
MW64U 12/91	3949	Die 110.0	Gas 61.0	Bis2 ** Pent 16.0* ^J	1,2DCA 10.0 Clform 7.0 ^a
MW64U 04/92	3991	Die 120.0	Gas 110.0 X 2.0	Bis2 8.0* ^J Pent 11.0* ^J	U

- ** - unusable data due to method blank contamination
a - suspected lab contaminant
*1 - EPA method 8015 Modified, quantitation limit: 50 µg/L
*2 - EPA method 8015/8020, quantitation limit: 50 µg/L
*3 - EPA method 625, quantitation limit: 10 µg/L
*4 - EPA method 624, quantitation limit: 5 µg/L
*J - concentration estimated
1,2DCA - 1,2-dichloroethane
B - benzene
Bis2 - bis(2-ethylhexyl) phthalate
Clform - chloroform
Die - HBP PHC as compared to diesel fuel
Gas - LBP PHC as compared to gasoline
HBP - high boiling point
JP5 - HBP PHC as compared to JP-5 jet fuel
LBP - low boiling point
NP - analysis not performed
Pent - pentachlorophenol
PHC - petroleum hydrocarbons
T - toluene
TCE - trichloroethene
U - no compounds detected
X - xylenes (total)

(April 1992) were similar; however, 1,2-DCA was not detected. The lower zone of MW64 (21.8 ft below top of casing) indicated results of 70 $\mu\text{g/L}$ of HBPHCs as diesel, 65 $\mu\text{g/L}$ of LBPHCs as gasoline, benzene at 0.6 $\mu\text{g/L}$, 1,2-DCA at 12 $\mu\text{g/L}$, and TCE estimated at 1 $\mu\text{g/L}$. Again, second round results yielded similar concentrations of the same constituents.

Sample results collected by Alpha Analytical, Inc., in October 1993, are presented in Appendix K.

10.4.3.3 Site 12, Pest Control Shop

First iteration ground-water characterization at Site 12, the Pest Control Shop, included the installation of one monitoring well. Since portions of the investigation at Site 13, the Boiler Plant Tanks, are pertinent to Site 12, they are also discussed in this section. First iteration activities at Site 13 included boring seventeen ground-water test holes and installing two monitoring wells and one piezometer (Fig. 10.8, p. 10-28).

Results from screening seventeen ground-water test holes and one piezometer borehole indicated a contaminant plume thought to be emanating from Site 12 and Site 13. The upper section of the plume appears to be contiguous with a plume emanating from Site 14, Old Vehicle Maintenance Shop (Fig. 10.9, p. 10-31). As indicated in Appendix C, several of the ground-water test holes contained contaminants of an unknown nature as inferred from GC and PID screening responses. It is possible that these anomalous screening responses are indicative of pesticide contaminants in the surrounding subsurface or of semivolatile compounds in the vadose zone but not in the ground water. The ground-water samples from MW22, however, contained PHCs, including benzene up to 47 $\mu\text{g/L}$. Also detected were SVOCs such as 2,4-dichlorophenol up to 220 $\mu\text{g/L}$ and low levels of some VOCs (<10 $\mu\text{g/L}$) (Table 10.12, p. 10-48). The well water had a distinct organic odor, yet the pesticide analysis yielded no detectable compounds during the first round of sampling (April 1991). Therefore, a different analytical method was requested for pesticides on the second round of water samples (August 1991). Results from these samples detected only trace amounts of alpha- and gamma-lindane.

Table 10.12. Water sample results for Site 12

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	PCB/Pesticide, µg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
MW22 04/91	3760	U	Gas 170.0 B 47.0	U	2,4,6T 2.0*J 2,4Dic 70.0 2-Meth 2.0*J	Clform 5.0a X 3.0*J
MW22 08/91	3839	Die 5000.0	B 3.6 X 7.0	Alpha 0.16 Gamma 0.14	1,2DCB 6.0*J 2,4Dic 220.0 2-Meth 5.0*J Bis2 4.0*J	1,1,1T 3.0*J 1,1DCA 8.0 Acet ** Clform 5.0a Methcl **
MW22 08/91	3839D	NP	NP	Alpha 0.14*J Gamma 0.03*J	NP	NP
MW22 08/91	3882	NP	NP	U	NP	NP

** - unusable data due to method blank contamination
a - suspected laboratory contaminant
*1 - EPA method 8015 Modified, quantitation limit: 50 µg/L
*2 - EPA method 8015/8020, quantitation limit: 50 µg/L
*3 - EPA method 608, quantitation limit: 0.05 µg/L
*4 - EPA method 625, quantitation limit: 10 µg/L
*5 - EPA method 624, quantitation limit: 5 µg/L
*J - concentration estimated
1,1,1T - 1,1,1-trichloroethane
1,1DCA - 1,1-dichloroethane
1,2DCB - 1,2-dichlorobenzene
2,4,6T - 2,4,6-trichlorophenol
2,4Dic - 2,4-dichlorophenol
2-Meth - 2-methylnaphthalene
Acet - acetone

Alpha - alpha-BHC
B - benzene
Bis2 - bis(2-ethylhexyl) phthalate
Clform - chloroform
Die - HBP PHC as compared to diesel fuel
Gamma - gamma-BHC (lindane)
Gas - LBP PHC as compared to gasoline
HBP - high boiling point
LBP - low boiling point
Methcl - methylene chloride
NP - analysis not performed
PHC - petroleum hydrocarbons
U - no compounds detected
X - xylenes (total)

Table 10.12. Water sample results for Site 12 (cont.)

Anions, mg/L EPA method 429 Quantitation limit: 0.5 mg/L				
Compound	#	Average	Minimum	Maximum
Chloride	1	35,000	35,000.00	35,000.00
Fluoride	0 ND		ND	ND
Nitrate, as N	0 ND		ND	ND
Phosphate	0 ND		ND	ND
Sulfate	1	8,100	8,100.00	8,100.00

- number of samples with detectable quantities of analyte
 ND - analyte not detected

Metals, µg/L EPA method 200.7 Quantitation limit: 1 µg/L				
Compound	#	Average	Minimum	Maximum
Aluminum	2	51	43.90	57.80
Antimony	0 ND		ND	ND
Arsenic	2	530	499.00	561.00
Barium	2	23	20.10	24.90
Beryllium	0 ND		ND	ND
Boron	2	44,000	21,900.00	66,100.00
Cadmium	0 ND		ND	ND
Calcium	2	45,800	45,000.00	46,600.00
Chromium	0 ND		ND	ND
Cobalt	1	55	55.10	55.10
*Copper	2	58	40.50	76.00
Iron	2	28	12.80	42.60
Lead	0 ND		ND	ND
Lithium	1	207	207.00	207.00
Magnesium	2	122,350	85,700.00	159,000.00
Manganese	2	119	94.20	144.00
Mercury	0 ND		ND	ND
Molybdenum	2	1,980	1,110.00	2,850.00
Nickel	0 ND		ND	ND
Potassium	2	228,000	118,000.00	338,000.00
Selenium	0 ND		ND	ND
Silver	1	8	8.10	8.10
Sodium	2	11,270,000	5,940,000.00	16,600,000.00
Thallium	0 ND		ND	ND
Vanadium	2	169	129.00	209.00
*Zinc	2	60	6.10	113.00

- number of samples with detectable quantities of analyte
 * - some or all results contain unusable data
 ND - analyte not detected

Second iteration recommendations for Site 12 included boring additional ground-water test holes along the west side of the plume as defined by previous investigations. One additional well was proposed at the site depending on the final plume configuration and the relation between this plume boundary and the boundary of the gasoline/diesel plume emanating from Site 14.

A total of 3 ground-water test holes were drilled downgradient southeast of Site 12 prior to the installation of the new well (MW55) (Fig. 10.5, p. 10-18). The test holes were numbered GW69, GW71, and GW72. GW71 encountered fuel-related, ground-water contamination (i.e., benzene, toluene, xylene); however, GW69 and GW72 were clean. Other test holes drilled along the west side of the Site 12/Site 13 plume indicated that the plume was completely encircled by the Site 14 plume (Fig. 10.9, p. 10-31). Field screening of soil samples from the capillary fringe of MW55 indicated very slight soil contamination; however, no contamination was indicated in the vadose zone or at the bottom of the aquifer. The soil sample from MW55 at 5 to 6.5 ft BGS was submitted for laboratory analysis (Table 10.7, p. 10-30). All analytes detected were related to laboratory contamination.

Water samples collected from MW55 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs (Table 10.13, p. 10-51). Results from the first round of sampling (December 1991) indicate that MW55 contained 80 $\mu\text{g/L}$ of HBPHCs as diesel. Results from the second round (April 1992) were reported as no compounds detected. Slug and bail tests were performed on this well along with most of the other wells at the associated sites. Test results are discussed in Appendix E.

Sample results collected by Alpha Analytical, Inc., in October 1993, are presented in Appendix K.

10.4.3.4 Site 13, Boiler Plant Tanks

First iteration ground-water characterization at Site 13, the Boiler Plant Tanks, included boring seventeen ground-water test holes and installing two single completion monitoring wells (MW23, MW24) and one piezometer.

Table 10.13. Water sample results for Sites 13 and 14

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	PCB/Pesticide, µg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
MW18L 04/91	3762	U	Gas 260.0 B 65.0 T 6.0 X 14.0	U	Bis2 2.0*J Butyl 21.0	1,2DCA 47.0 B 33.0 Methcl ** T 2.0*J
MW18L 08/91	3830	Die 60.0	B 58.0 E 1.0*J X 10.0	NP	U	1,2DCA 47.0 Acet ** Methcl **
MW18U 04/91	3753	U	Gas 850,000,000	U	2,4Dim 3600.0 2-Meth 3900.0 4-Metp 330.0*J Benzo 8500.0 Benzyl 2800.0 Bis2 4200.0a Naph 7900.0	1,2DCA 2200.0 2-But 6100.0 Acet 16000.0a B 18000.0 E 2600.0 T 31000.0 X 15000.0
MW18U 04/91	3754	JP5 14000.0	Gas 100000.0 B 14000.0 E 2300.0 T 26000.0 X 13000.0	U	2,4Dim 1700.0 2-Meth 6000.0 4-Metp 160.0*J Benzo 4200.0 Benzyl 1500.0 Bis2 3400.0a Naph 7400.0	1,2DCA 2000.0 2-But 7200.0 Acet 15000.0a B 15000.0 E 2400.0 T 29000.0 X 14000.0
MW19 04/91	3752	JP5 5100.0	Gas 10000.0	U	2,4Dim 10.0 2-Meth 6.0*J 4-Metp 20.0 Naph 35.0 Pent 2.0*J	1,2DCA 550.0 B 2000.0 E 180.0 T 200.0 X 1100.0
MW19 08/91	3833	Die 3100.0	Gas 480.0 B 140.0 E 4.0*J T 7.0 X 33.0	NP	2-Meth 4.0*J 4-Metp 32.0 Naph 27.0*J	2-Hex 1.0*J
MW19 08/91	3834	Die 5900.0	Gas 820.0 B 240.0 E 6.0 T 10.0 X 62.0	NP	2-Meth 4.0*J 4-Metp 21.0 Naph 30.0	1,2DCA 47.0 Acet ** Methcl **
MW20 04/91	3749	Die 270.0	U	U	U	1,2DCA 2.0*J 1,2DCE 3.0*J B 15.0 Clform 8.0a TCE 23.0
MW20 08/91	3835	Die 60.0	B 74.0 X 1.0*J	NP	U	Acet ** Clform 11.0a Methcl ** TCE 17.0
MW21 04/91	3743	U	U	U	U	U

Table 10.13. Water sample results for Sites 13 and 14 (cont.)

Location	Sample Number	Total HBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	PCB/Pesticide, µg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
MW21 08/91	3837	U	U	NP	U	Acet **
MW23 04/91	3742	Die 70.0	U	U	U	X 2.0*J
MW23 08/91	3845	Die 90.0	U	NP	U	U
MW24 04/91	3734	Die 50.0	B 210.0 T 0.9 X 18.0 14.0	U	Bis2 3.0*J Naph 3.0*J	U
MW24 08/91	3846	JP5 170.0	Gas 580.0 X 57.0	NP	Naph 2.0*J	U
MW24 08/91	3847	Die 240.0	Gas 530.0 X 80.0	NP	U	Methcl **
MW52 12/91	3919	JP5 5900.0	Gas 67000.0 B 5200.0 E 2800.0 T 2400.0 X 12000.0	NP	2-Meth 58.0 Bis2 18.0a Naph 140.0	Methcl 23.0*J Styre 160.0
MW52 12/91	3919D	NP	B 6300.0 E 2400.0 T 2400.0 X 16000.0	NP	NP	NP
MW53 12/91	3913	Die 60.0	U	NP	Bis2 **	U
MW53 04/92	3975	Die 50.0	U	U	Benzo 2.0*J Bis2 2.0*J	U
MW53 04/92	3976	U	U	U	Bis2 3.0*J	Acet 7.0*J Methcl **
MW54 12/91	3914	Die 50.0	U	U	U	TCE 1.0*J
MW54 04/92	3971	U	U	U	Bis2 4.0*J	Cl form 18.0*J Methcl 11.0*J TCE 52.0
MW54 04/92	3972	Die 60.0	U	U	Bis2 5.0*J	Carbdi 1.0*J Cl form 4.0*J TCE 10.0
MW55 12/91	3917	Die 80.0	U	U	U	U
MW55 04/92	3977	U	U	U	Bis2 10.0a	U

Table 10.13. Water sample results for Sites 13 and 14 (cont.)

**	- unusable data due to method blank contamination	Butyl	- butylbenzylphthalate
a	- suspected laboratory contaminant	Carbdi	- carbon disulfide
*1	- EPA method 8015 Modified, quantitation limit: 50 µg/L	Clform	- chloroform
*2	- EPA method 8015/8020, quantitation limit: 50 µg/L	Die	- HBP PHC as compared to diesel fuel
*3	- EPA method 608, quantitation limit: 0.05 µg/L	E	- ethylbenzene
*4	- EPA method 625, quantitation limit: 10 µg/L	Gas	- LBP PHC as compared to gasoline
*5	- EPA method 624, quantitation limit: 5 µg/L	HBP	- high boiling point
*J	- concentration estimated	JP5	- HBP PHC as compared to JP-5 jet fuel
1,2DCA	- 1,2-dichloroethane	LBP	- low boiling point
1,2DCE	- 1,2-dichloroethene (total)	Methcl	- methylene chloride
2,4Dim	- 2,4-dimethylphenol	Naph	- naphthalene
2-But	- 2-butanone = <i>rn 16K</i>	NP	- analysis not performed
2-Hex	- 2-hexanone	Pent	- pentachlorophenol
2-Meth	- 2-methylnaphthalene	PHC	- petroleum hydrocarbons
4-Metp	- 4-methylphenol	Styre	- styrene
Acet	- acetone	T	- toluene
B	- benzene	TCE	- trichloroethene
Benzo	- benzoic acid	U	- no compounds detected
Benzyl	- benzyl alcohol	X	- xylenes (total)
Bis2	- bis(2-ethylhexyl) phthalate		

Table 10.13. Water sample results for Sites 13 and 14 (cont.)

Anions, mg/L EPA method 429 Quantitation limit: 0.5 mg/L				
Compound	#	Average	Minimum	Maximum
Chloride	6	26,000	11,000.00	42,000.00
Fluoride	0 ND		ND	ND
Nitrate, as N	0 ND		ND	ND
Phosphate	0 ND		ND	ND
Sulfate	6	29,433	5,900.00	130,000.00

- number of samples with detectable quantities of analyte
ND - analyte not detected

Metals, µg/L EPA method 200.7 Quantitation limit: 1 µg/L				
Compound	#	Average	Minimum	Maximum
Aluminum	17	71	43.90	137.00
Antimony	2	54	48.50	59.70
Arsenic	27	459	31.00	1,210.00
Barium	27	46	17.70	114.77
Beryllium	0 ND		ND	ND
Boron	21	55,826	11,000.00	136,000.00
Cadmium	1	9	8.80	8.80
Calcium	27	76,147	11,800.00	214,000.00
Chromium	0 ND		ND	ND
Cobalt	0 ND		ND	ND
*Copper	26	35	17.50	83.20
*Iron	23	44	12.80	272.00
Lead	6	837	10.00	2,390.00
Lithium	12	405	215.00	594.00
Magnesium	27	154,523	65,500.00	326,000.00
Manganese	27	222	15.60	1,120.00
Mercury	6	1	0.28	0.88
Molybdenum	21	2,149	1,030.00	4,250.00
Nickel	2	21	20.00	21.10
Potassium	27	236,545	85,200.00	381,000.00
Selenium	2	23	21.60	24.00
Silver	21	12	6.20	18.20
Sodium	27	12,366,533	5,410,000.00	17,800,000.00
Thallium	0 ND		ND	ND
Vanadium	27	123	27.10	261.00
*Zinc	16	38	10.30	160.00

- number of samples with detectable quantities of analyte
* - some or all results contain unusable data
ND - analyte not detected

Field screening indicated a plume associated with the two underground tanks at Site 13. Two wells were installed downgradient from the site. MW24 was installed within the plume boundary, where PHCs were detected in the ground water but not the soil (Tables 10.13, p. 10-51, and 10.7, p. 10-30). It appears that the hydrocarbons may be a mixture of gasoline and/or diesel fuel from the Site 14 plume and fuel oil from the Boiler Plant Tanks. MW23 was installed at the distal end of the plume and contained concentrations of PHCs below levels of concern. There was some question about the boundary on the west side of the plume and the possible continuation of the pesticide and gasoline plume in that area. These concerns were addressed during second iteration activities at Site 14.

10.4.3.5 Site 14, Old Vehicle Maintenance Shop

First iteration activities at Site 14, the Old Vehicle Maintenance Shop, involved drilling 45 ground-water test holes. In addition, one dual completion monitoring well (MW18U, MW18L), three single completion monitoring wells (MW19, MW20, MW21), and four piezometers were installed. The contaminant boundary map for the site is presented in Fig. 10.9, p. 10-31.

Ground-water screening activities associated with Site 14 consisted of analyzing samples from 45 ground-water test holes and four piezometer borings (Appendix C). Test-hole locations are shown in Fig. 10.5, p. 10-18.

Water-sampling activities confirmed free-phase hydrocarbon product in MW18U that appears to be a mixture of diesel fuel and leaded gasoline (sample #3753, Table 10.13, p. 10-51). The elevated lead concentrations indicate that leaded gasoline is one of the contaminants, and the concentrations of naphthalene and other SVOCs indicate that diesel fuel contamination is also present. Some solvents were also detected in MW18U. However, the concentration of solvent (1,2-DCA) was much lower in MW18L, which was screened at the bottom of the shallow aquifer, indicating that a DNAPL plume is not present at the site. Ground-water-test-hole screening was not entirely successful at delineating the plume as indicated by contaminant concentrations in MW19 and MW20 (Table 10.13, p. 10-51), which were supposed to be downgradient, uncontaminated wells.

Second iteration activities recommended at Site 14 included drilling ground-water test holes to define the eastern boundary of the plume in the asphalt-covered parking lot and to define the southern boundary of the plume in the vicinity of wells MW19 and MW20. Because some of the previous test-hole analyses had apparently been in error, two samples were to be collected and analyzed from each test hole to ensure that each location was properly characterized. Other test holes were to be drilled within the plume to determine optimum locations for additional wells and piezometers.

One additional well was proposed within the plume boundaries for contaminant-concentration-gradient determination. Two other wells were proposed along the south boundary of the plume as determined by ground-water-test-hole drilling. Three piezometers were to be installed in the product portion of the plume to assess the thickness and extent of the product lens.

A total of 35 ground-water test holes were drilled at Site 14 prior to the installation of the 3 new wells (Fig. 10.5, p. 10-18). The test holes were numbered GW46 to GW81 (part of these test holes were drilled around Sites 12 and 13). The downgradient portion of the Site 14 plume was extended several hundred feet to the south and east as a result of laboratory ground-water analyses.

The three Site 14 wells installed during the second iteration drilling were MW52, MW53, and MW54. MW52 well was installed in the intermediate portion of the plume to evaluate contaminant gradients. Free-phase product was encountered in MW52 and measured 1.89 ft thick. The three piezometers proposed for the area were installed around product well MW18. None of the three piezometers, PZ14-5, PZ14-6, or PZ14-7, have measurable free-phase product, even though there appeared to be product at all three locations at the time of drilling (water samples bailed from the area during ground-water-test-hole screening contained free product). Considering the thickness and extent of the product in MW52 and MW18U, this site will require a removal action under NDEP regulations. Field screening of soil samples from the capillary fringe of MW52 indicated contaminated soil; however, no contamination was indicated in the vadose zone or at the bottom of the aquifer. Because the contamination in soil appeared to be related solely to product on the ground water, no soil samples from MW52 were submitted for laboratory analysis.

Water samples collected from MW52 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from sampling indicated that MW52 contained 5900 $\mu\text{g/L}$ of HBPHCs as JP-5, 67000 $\mu\text{g/L}$ of LBPHCs as gasoline, benzene at 5200 $\mu\text{g/L}$, ethylbenzene at 2800 $\mu\text{g/L}$, toluene at 2400 $\mu\text{g/L}$, xylenes at 12,000 $\mu\text{g/L}$, and some volatile and semi-volatile PHC-related compounds. An effort was made to exclude free-phase product in the water sample obtained from MW52 so that the results reflect only dissolved constituents in the ground water. This was attempted by lowering a 3-ft bailer below the surface of the product and collecting a sample by using an adapter fitted to the bottom of the bailer. However, because the bailer passed through the free-phase layer, contaminant concentrations from MW52 samples may not be representative of dissolved contaminants only.

The other two wells, MW53 and MW54, were installed outside of the plume. The soils were very slightly contaminated at the water table based on field screening; however, soil samples submitted for laboratory analysis from MW53 and MW54 revealed no significant contaminants.

Water samples collected from MW53 and MW54 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results from the first round of sampling (December 1991) indicated that MW53 contained 60 $\mu\text{g/L}$ of HBPHCs as diesel. Second round sampling (April 1992) yielded similar results. First round results from MW54 revealed 50 $\mu\text{g/L}$ of HBPHCs as diesel and TCE estimated at 1 $\mu\text{g/L}$. Again, second round results were similar, but TCE concentrations were 10 and 52 $\mu\text{g/L}$ for the two samples analyzed. Slug and bail tests were performed on all of the new wells at the site with the exception of MW52, which contained free-phase product (Appendix E).

Sample results collected by Alpha Analytical, Inc., in October 1993, are presented in Appendix K.

10.4.3.6 Site 16, Old Fuel Farm

First iteration characterization at Site 16, the Old Fuel Farm, involved drilling 75 ground-water test holes. Also, two dual completion wells (MW25U, MW25L, MW29U,

MW29L), four single completion wells (MW26, MW27, MW28, MW30), and eight piezometers were installed (Fig. 10.5, p. 10-18). The contaminant boundary map for the site is presented in Fig. 10.9, p. 10-31. Monitoring well and piezometer construction logs are presented in Appendix F.

Investigation of the Site 16 plume covered parts of other sites, including Sites 10, 11, 17, 19, and 23. Thus, the downgradient monitoring wells served to assess potential contaminants migrating from these sites as well. The well pair drilled near the source area of the plume, MW25U and MW25L, revealed significant ground-water contamination (Table 10.14, p. 10-59). TPH concentrations ranged from 60 to 9000 $\mu\text{g/L}$, and solvent concentrations (i.e., 1,2-DCA) ranged from 9 to 80 $\mu\text{g/L}$. Air monitoring during drilling detected concentrations of total volatile organic contaminants in the work-area breathing zone that required the use of respirators. Soil-sample results from the well and from around the underground tanks contained fuel- and solvent-related compounds (Table 10.8, p. 10-33).

Ground-water sampling revealed much higher concentrations of similar compounds in both the sample and a duplicate. No free-phase product was present in the wells, and concentrations of all compounds including solvents were much lower in MW25L than in MW25U, suggesting that a DNAPL plume is not present and that the contaminants are principally in the upper portion of the aquifer. One downgradient well pair was installed within the distal end of the plume, MW29U and MW29L. The upper completion, MW29U, revealed contamination in the soil at the capillary fringe and in the ground water at the top of the aquifer. The variety and concentrations of contaminants are significantly decreased from those found in MW25U. For example, only fuel-related compounds (HBPHCs) were detected, at levels approximately 10 times less than MW25U. MW29L had no contamination, indicating that the contamination has remained in the upper portion of the aquifer throughout the plume length. The soil and ground-water samples taken from the other downgradient wells, MW26, MW27, MW28, and MW30, were essentially clean, indicating that the downgradient boundary of the plume was delineated. The concentration gradients within the plume, however, were not well defined. Additionally, considering the variety and concentrations of contaminants in MW25U, there was likely to be product on the ground water upgradient at the source.

Table 10.14. Water sample results for Site 16

Location	Sample Number	Total MBP PHC, µg/L (*1)	Total LBP PHC, µg/L (*2)	PCB/Pesticide, µg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
MW25L 04/91	3786	JP5 60.0	Gas 200.0 B 22.0 E 14.0	U	U	1,2DCA 10.0 B 20.0 E 16.0
MW25L 04/91	3787	U	Gas 200.0 B 20.0 E 13.0 T 2.0	U	U	1,2DCA 9.0 B 15.0 E 12.0
MW25L 08/91	3841	Die 80.0	Gas 260.0 B 15.0 E 5.0	NP	U	1,2DCA 9.0
MW25U 04/91	3781	JP5 8400.0	Gas 7800.0 B 300.0 E 1200.0 T 42.0 X 45.0	U	2,4Dim 59.0 2-Metp 5.0*J 4-Metp 16.0 Bis2 ** Naph 4.0*J Pent 34.0*J Phen 5.0*J	1,2DCA 80.0 B 410.0 E 990.0 T 40.0 X 50.0
MW25U 04/91	3782	JP5 7200.0	Gas 5700.0 B 310.0 E 800.0 T 40.0 X 34.0	U	2,4Dim 69.0 2-Metp 7.0*J 4-Metp 17.0 Bis2 ** Pent 36.0*J	1,2DCA 56.0 B 150.0 E 850.0 T 17.0*J X 25.0*J
MW25U 08/91	3842	JP5 4200.0	Gas 9000.0 B 310.0 E 1200.0 T 34.0*J X 450.0	NP	2,4,6T 14.0 2,4Dim 36.0 2-Metp 3.0*J 4-Metp 6.0*J Bis2 79.0a Pent 27.0*J	Methcl 24.0*J
MW25U 08/91	3843	JP5 4000.0	Gas 7600.0 B 320.0 E 840.0 T 33.0 X 56.0	NP	2,4,6T 13.0 2,4Dim 36.0 2-Metp 3.0*J 4-Metp 6.0*J Bis2 46.0a Pent 24.0*J	1,2DCA 68.0 Styre 1.0*J
MW26 04/91	3780	Die 330.0	U	U	Dieth 9.0*J	U
MW26 08/91	3850	Die 180.0	U	NP	U	U
MW27 04/91	3775	U	U	U	U	U
MW27 08/91	3853	U	U	NP	U	U
MW28 04/91	3772	U	U	U	U	U
MW28 08/91	3854	Die 70.0	U	NP	U	U

Table 10.14. Water sample results for Site 16 (cont.)

Location	Sample Number	Total HBP PNC, µg/L (*1)	Total LBP PNC, µg/L (*2)	PCB/Pesticide, µg/L (*3)	Semivolatiles, µg/L (*4)	Volatiles, µg/L (*5)
MW29L 04/91	3770	U	U	U	U	U
MW29L 08/91	3851	U	U	NP	U	U
MW29U 04/91	3773	Die 320.0	U	U	U	U
MW29U 08/91	3852	U	U	NP	Bis2 **	U
MW30 04/91	3771	U	U	U	U	U
MW30 08/91	3855	U	U	NP	U	U
MW31 08/91	3857	Die 60.0	U	NP	U	U
MW32 08/91	3858	U	U	NP	U	U
MW65 12/91	3920	Die 3400.0	Gas 860.0 B 70.0 T 8.0 X 4.0*J	NP	2-Meth 9.0*J Bis2 3.0*J Fluor 2.0*J Naph 5.0*J	1,2DCA 98.0 TCE 46.0
MW65 04/92	3979	Die 5400.0	Gas 1100.0 B 54.0 X 1.0*J	NP	2-Meth 3.0*J Bis2 3.0*J Fluor 3.0*J Pent 2.0*J Phena 3.0*J	1,1DCE 3.0*J 1,2DCA 94.0 Cleth 3.0*J TCE 46.0
MW66 12/91	3921	Die 1000.0	Gas 220.0 B 4.0*J X 5.0	NP	Bis2 6.0*J Naph 3.0*J	1,1DCE 3.0*J TCE 3.0*J
MW66 12/91	3922	Die 1200.0	Gas 210.0 B 10.0 X 6.0	NP	Bis2 5.0*J Naph 2.0*J	TCE 2.0*J
MW66 04/92	3981	Die 1600.0	Gas 160.0 B 10.0 E 1.0*J X 2.0*J	NP	U	U
MW67 12/91	3924	Die 1700.0	X **	NP	4-Metp 96.0 Bis2 6.0*J Naph 3.0*J Phen 18.0	Acet ** Bro 8.0*J Dibro 1.0*J

Table 10.14. Water sample results for Site 16 (cont.)

**	- unusable data due to method blank contamination	Die	- HBP PHC as compared to diesel fuel
a	- suspected laboratory contaminant	Dieth	- diethylphthalate
*1	- EPA method 8015 Modified, quantitation limit: 50 µg/L	E	- ethylbenzene
*2	- EPA method 8015/8020, quantitation limit: 50 µg/L	Fluor	- fluorene
*3	- EPA method 608, quantitation limit: 0.05 µg/L	Gas	- LBP PHC as compared to gasoline
*4	- EPA method 625, quantitation limit: 10 µg/L	HBP	- high boiling point
*5	- EPA method 624, quantitation limit: 5 µg/L	JP5	- HBP PHC as compared to JP-5 jet fuel
*J	- concentration estimated	LBP	- low boiling point
1,1DCE	- 1,1-dichloroethene	Methcl	- methylene chloride
1,2DCA	- 1,2-dichloroethane	Naph	- naphthalene
2,4,6T	- 2,4,6-trichlorophenol	NP	- analysis not performed
2,4Dim	- 2,4-dimethylphenol	Pent	- pentachlorophenol
2-Meth	- 2-methylnaphthalene	PHC	- petroleum hydrocarbons
2-Metp	- 2-methylphenol	Phen	- phenol
4-Metp	- 4-methylphenol	Phena	- phenanthrene
Acet	- acetone	Styre	- styrene
B	- benzene	T	- toluene
Bis2	- bis(2-ethylhexyl) phthalate	TCE	- trichloroethene
Bro	- bromoform	U	- no compounds detected
Cleth	- chloroethane	X	- xylenes (total)
Dibro	- dibromochloromethane		

Table 10.14. Water sample results for Site 16 (cont.)

Anions, mg/L EPA method 429 Quantitation limit: 0.5 mg/L				
Compound	#	Average	Minimum	Maximum
Chloride	10	13,880	3,500.00	32,000.00
Fluoride	0 ND		ND	ND
Nitrate, as N	0 ND		ND	ND
Phosphate	0 ND		ND	ND
Sulfate	10	4,370	1,500.00	7,600.00

- number of samples with detectable quantities of analyte
 ND - analyte not detected

Metals, µg/L EPA method 200.7 Quantitation limit: 1 µg/L				
Compound	#	Average	Minimum	Maximum
Aluminum	4	49	41.60	54.40
Antimony	4	33	30.30	35.40
Arsenic	12	667	60.40	1,320.00
Barium	12	42	14.40	141.00
Beryllium	1	1	1.20	1.20
Boron	10	43,620	11,100.00	80,800.00
Cadmium	2	7	7.20	7.20
Calcium	12	68,037	2,860.00	304,000.00
Chromium	1	12	11.70	11.70
Cobalt	0 ND		ND	ND
*Copper	12	31	12.60	59.20
Iron	11	66	10.80	233.00
Lead	2	10	9.00	11.00
Lithium	8	387	185.00	556.00
Magnesium	12	124,527	2,020.00	243,000.00
Manganese	12	473	11.20	2,190.00
Mercury	0 ND		ND	ND
Molybdenum	10	1,352	195.00	2,660.00
Nickel	2	49	20.10	76.90
Potassium	12	223,292	19,400.00	418,000.00
Selenium	1	8	7.90	7.90
Silver	7	10	5.30	15.10
Sodium	11	11,085,727	963,000.00	19,500,000.00
Thallium	0 ND		ND	ND
Vanadium	12	195	33.70	818.00
*Zinc	7	45	15.10	78.90

- number of samples with detectable quantities of analyte
 * - some or all results contain unusable data
 ND - analyte not detected

Second iteration activities recommended at Site 16 included additional ground-water test holes, monitoring wells, and piezometers. Test holes were to be drilled at all proposed well and piezometer locations prior to installation to ensure optimum well placement. If free-phase product was detected on the ground water near the underground tanks, two piezometers were to be installed around the area to assess the extent of the product plume. Three additional shallow, single completion wells were proposed to be installed within the plume downgradient from MW25. The purpose of the wells was to define the contaminant concentration gradient between the source area and the distal plume boundary. One of these wells was to be positioned to determine the influence of a possible preferential flow path through an identified coarse-grained unit.

MW65, MW66, and MW67 were installed inside the Site 16 plume in order to define contaminant concentration gradients. No other ground-water test holes were drilled in the plume prior to selecting the monitoring well locations because the existing plume boundary definition was deemed adequate.

The first well installed was MW65. It was placed in line with the projected ground-water-flow path from the Old Fuel Farm within the detectable contamination based on the ground-water-test-hole screening method (Fig. 10.9, p. 10-31). Field screening of soil samples collected during drilling indicated very contaminated soils at the water table and slightly contaminated soil at the bottom of the shallow alluvial aquifer. Because soil contamination appeared to be related solely to ground-water contamination, no soil samples were submitted for laboratory analysis. The ground-water sample from the first round of sampling (December 1991) at MW65 contained HBPHCs as diesel at 3400 $\mu\text{g/L}$, LBPHCs as gasoline at 860 $\mu\text{g/L}$, benzene at 70 $\mu\text{g/L}$, toluene at 8 $\mu\text{g/L}$, and xylene at below quantitation limits (BQL) (4 $\mu\text{g/L}$). Other compounds detected included 1,2-DCA at 98 $\mu\text{g/L}$, TCE at 46 $\mu\text{g/L}$, and estimated concentrations of fluorene at 2 $\mu\text{g/L}$, 2-methylnaphthalene at 9 $\mu\text{g/L}$, and naphthalene at 5 $\mu\text{g/L}$. Second round sampling (April 1992) yielded similar results.

The second well installed, MW66, was located between ground-water test holes, MW65, and the unnamed lateral drain. Field screening of soil samples from the capillary fringe of MW66 indicated relatively high soil contamination; however, because the soil contamination appeared to be related solely to ground-water contamination, no soil samples

were submitted for laboratory analysis. The ground-water sample from the first round of sampling at MW66 contained HBPHCs as diesel at 1200 $\mu\text{g/L}$, LBPHCs as gasoline at 220 $\mu\text{g/L}$, benzene at 10 $\mu\text{g/L}$, and xylenes at 6 $\mu\text{g/L}$. Other compounds detected at estimated levels included, 1,1-DCE at 3 $\mu\text{g/L}$, TCE at 3 $\mu\text{g/L}$, and naphthalene at 3 $\mu\text{g/L}$. Second round sampling results were similar with the exception that no VOCs or SVOCs were detected.

The third well installed, MW67, was located north of the building near the southwest edge of the plume. Field screening of the samples from the capillary fringe of MW67 indicated moderately contaminated soils; however, because the soil contamination appeared to be related solely to ground-water contamination, no soil samples were submitted for laboratory analysis. Water samples collected from MW67 were analyzed for LBPHCs, HBPHCs, SVOCs, and VOCs. Results of sampling indicate that MW67 contained 1700 $\mu\text{g/L}$ of HBPHCs as diesel, 4-methylphenol at 96 $\mu\text{g/L}$, and phenol at 18 $\mu\text{g/L}$. It was later discovered that MW67 was installed through an 8-in.-diameter sewer line and the well was destroyed when the line was repaired. Thus, only one round of ground-water samples was obtained from the well.

No free-phase product was detected on the ground water near the fuel farm underground tanks during the previous investigations; thus, the two piezometers proposed for the area were installed as intermediate water-level measurement points between the interplume wells. PZ16-9 was installed between MW25 and MW65; PZ16-10 was installed between MW65 and MW66. PZ16-10 encountered free-phase product on the ground water that measured 0.28 ft thick. The only known possible source of the product is a buried diesel tank that was removed from the north side of Building 409, a few hundred feet west of the piezometer. The UST was found to have been leaking when removed in March 1992 (see Sect. 10.4.2.5). However, based on the ground-water flow direction, product from the leaking UST should have migrated to the south of PZ16-10. This product exceeds the NDEP limit for free-phase product and requires a removal action. PZ16-11 was installed between MW25 and the tank farm, which is considered to be the main contaminant source for the Site 16 plume. Product was observed during drilling; however, no measurable product has been observed in the piezometer. The piezometer was destroyed by vehicle traffic sometime between April 19 and May 16, 1992.

Sample results collected by Alpha Analytical, Inc., in October 1993, are presented in Appendix K.

10.4.3.7 Site 17, Hangar 5; Site 19, Post-World War II Burial Site; Site 23, Shipping and Receiving Disposal Site

The ground-water investigation at these sites was conducted in conjunction with the Site 16 investigation.

10.4.4 Air

The atmosphere is not considered to be a medium of concern at the Group IV Sites because high vapor pressure contaminants will rapidly volatilize and disperse. Furthermore, PID measurements taken around the sites during field investigations detected no VOCs in the ambient air other than during the installation of MW25. Even at this location, no VOCs were detected after the well installation was complete. The air quality of the surrounding region is good, and prevailing air currents will further enhance the rapid dispersal into the atmosphere of any volatile contaminants that may be released.

10.5 CONTAMINANT FATE AND TRANSPORT

Screening and characterization activities at the Group IV Sites indicate that the primary contaminants of concern are PHC compounds and solvents that permeate the soils and shallow ground water associated with two plumes in the area. Small localized areas of pesticides are also present.

10.5.1 Contaminant Persistence

The Group IV Sites are the only location included in the NAS Fallon investigation that contains pesticides and phenols. Chlorinated solvents are also present at the Group IV Sites. Solvents such as TCE are persistent in the subsurface environment at NAS

Fallon. TCE does not undergo chemical degradation and is not significantly sorbed by the soil matrix. The pesticides reported for samples from the Group IV Sites are expected to be very persistent. As Table 10.15, p. 10-67, demonstrates, DDT and its derivatives and lindane and its derivatives are not very water soluble or volatile. Also, as part of the United States National Soils Monitoring Program, soils in five cities were sampled and analyzed annually for DDT and its degradation products. In 1971, 63% of the samples contained DDT while all were positive for DDD (Carey et al. 1979). Such data demonstrate both the widespread use and persistence of these compounds.

Phenolic compounds, in contrast to the other organic contaminants encountered at NAS Fallon, are relatively soluble in water (Table 10.15, p. 10-67). They are also quite biodegradable under aerobic conditions (Verschueren 1983). Consequently, they do not persist in soils to the same extent as do DDT or lindane and their derivatives. Overall biodegradability, however, would have to be determined on a site-specific basis. This is particularly true in this case because the phenolic compounds were found in the company of other contaminants that could inhibit the activity of the microorganisms.

The most prevalent contaminants at Group IV Sites are PHCs from jet and motor vehicle fuels. See Sect. 3.5.1 for a discussion of the persistence of jet fuel.

10.5.1.1 Chemical Reactions of Fuel Hydrocarbons

See Sect. 3.5.1.1 for a discussion of the reactions of fuel hydrocarbons, including alkanes and aromatics.

10.5.1.2 Biodegradation

Most pesticides are not biodegraded significantly. Many undergo partial transformation (e.g., DDT to DDE), but the residues are typically more persistent and as toxic as the parent compound. See Sect. 3.5.1.2 for a discussion of the biodegradation of solvents and jet fuel.

Table 10.15. Comparison of mobility characteristics in the environment of contaminants found at the Group IV sites

Compound	Water Solubility, mg/L ^a	Log K _{oc}	Mobility in groundwater classification ^b	Boiling point, °C ^c
Benzene	1780	1.93	high mobility	80.1
Ethylbenzene	150	2.6	low mobility	136.2
Hexane	13		low mobility	68.7
Cyclohexane	55		low mobility	81.0
Methyl cyclohexane	14		low mobility	101
Naphthalene	30		low mobility	217.9
Nonane	0.07		very low mobility	151
Octane	0.7		very low mobility	125.7
Toluene	500	2.28	medium mobility	110.8
Trichloroethene	+100			
Xylenes	158	2.59	low mobility	138-144

Table 10.15. Comparison of mobility characteristics in the environment of contaminants found at the Group IV sites (cont.)

Compound	Water solubility, mg/L ^c	Vapor pressure, mm of Hg ^c	Henry's law constant, atm - m ³ /mol ^c	Log K _{ow}
beta-BHC	2.40E-01	2.80E-07	4.47E-07	3.9
gamma-BHC (Lindane)	7.80E+00	1.60E-04	7.85E-06	3.9
Chlordane	5.60E-01	1.00E-05	9.63E-06	3.32
2,4,6-Trichlorophenol	8.00E+02	1.20E-02	3.90E-06	3.87
2,4-Dichlorophenol	4.60E+03	5.90E-02	2.75E-06	2.9
Naphthalene	3.20E+01	2.30E-01	1.15E-03	3.4
Flourene	1.69E+00	7.10E-04	6.42E-05	4.2
4,4'-DDE	4.00E-02	6.50E-06	6.80E-05	7.0
4,4'-DDD	1.00E-01	1.89E-06	7.96E-06	6.2
4,4'-DDT	5.00E-03	5.50E-06	5.13E-04	6.19
Heptachlor	1.80E-01	3.00E-04	8.19E-04	4.7
Heptachlor epoxide	3.50E-01	3.00E-04	4.39E-04	2.7

^a Source: Verschueren, K. 1983. *Handbook of Environmental Data on Organic Chemicals*. Second ed. VanNostrand Reinhold Company, New York.

^b Source: Roy, W. R., and R. A. Griffin. 1985. Mobility of organic solvents in water-saturated soil materials. *Environmental Geology and Water Sciences*, 7(4):241-247.

^c Source: U.S.EPA. 1986. *Superfund Public Health Evaluation Manual*. EPA/540/1-86/606. U. S. Environmental Protection Agency.

K_{oc} = partition coefficient (K_p) ÷ fractional mass of organic carbon.

K_{ow} = octanol/water partition coefficient.

At the Group IV Sites, biodegradation is inhibited by the presence of free-phase product. Pure jet fuel is toxic to subsurface microbes and will not be biodegraded except at the fringe of the affected area. Likewise, the presence of pesticides may also limit the effectiveness of natural biodegradation. Consequently, some of the organic contaminants in the subsurface at the Group IV Sites will persist indefinitely.

10.5.2 Potential Routes of Migration

A synopsis of media-specific, contaminant transport pathways, assimilation routes, exposure points, and affected biota for NAS Fallon is given in Appendix D. Possible exposure pathways are discussed in light of the characterization activities completed at the Group IV Sites.

Direct exposure pathways for contaminated soils at the Group IV Sites include dermal contact, ingestion, and inhalation of dust particles and volatile constituents. Affected biota include indigenous plants and burrowing animals as well as personnel associated with site-excavation activities. Plant and animal populations are controlled on NAS Fallon property; exposures associated with these biota are thus minimized. Because NAS Fallon is a restricted area, direct exposure to the human populace is restricted to naval personnel and contractors. Health and safety (H&S) measures, interim protective measures, and appropriate decontamination procedures further mitigate exposure from contaminated soils during on-site activities. Restricted access, lack of surface-soil contamination, and site activities geared towards environmental safety help prevent contaminated soils at the Group IV Sites from constituting a primary exposure pathway.

Direct exposure pathways for ground water include use of contaminated ground water extracted from the shallow aquifer and the intermediate aquifer. The shallow aquifer is not pumped on NAS Fallon property and, due to its high salinity, is used sparingly for human consumption in the surrounding area (Appendix D). There are no drinking-water wells downgradient from the Group IV Sites. Poor quality renders the water unfit for human consumption. Thus, direct exposures to contaminants through extraction of the shallow ground water in the area are believed to be minimal.

Available site-characterization results indicate contaminants are not migrating into the intermediate aquifer. The PA/SI report postulates the existence of an upward flow gradient in the surrounding area (Dames and Moore 1988). Investigative results confirm this (Appendix E). Additionally, a confining clay layer is known to exist between the contaminated shallow aquifer and the intermediate aquifer beneath the facility. It is believed that these natural containment mechanisms prevent contaminants from reaching the intermediate aquifer.

As with ground water, contaminated soils associated with Group IV Sites do not constitute a substantial direct exposure pathway. Soils may, however, serve as a source term for atmospheric transport of contaminated particulates, and both contaminated soils and ground water may act as sources for contaminating surface water. Contaminated surface water may then serve as an exposure pathway to sensitive receptors.

Exposures to wind-blown transport of contaminated soils are minimal due to restricted access in the immediate vicinity, the natural cohesive properties of native surface soils, and dust-control measures employed during construction activities. In addition, the air quality of the region is good; when released, airborne particulate matter is quickly dispersed. Hence, atmospheric transport is not considered a threat to the environment.

Downward transport of residual soils contamination to the underlying aquifer via naturally occurring surface-water percolation is not considered significant because of the semiarid climate. The alkali flats in the surrounding area indicate a negative regional water balance. This suggests that for contaminants originally introduced to the surface at Sites 11, 12 and 17, the downward transport necessary to produce existing ground-water contamination resulted from gradients induced by the spill or disposal incident. Also, water usage and runoff may have induced a downward gradient.

The majority of ground-water contaminants present at the Group IV Sites are the result of past spills, leaks, and handling activities. Source termination and the negative regional water balance are expected to minimize percolation of surface contamination to the underlying water table at all Group IV Sites. Previously, Site 12, the Pest Control Shop, afforded a transport mechanism for downward transport of near-surface contaminants. Vehicle wash water was allowed to run off to leachfield areas and create a

downward flow gradient that may have caused percolation of contaminants to the underlying aquifer. Similarly, aircraft washing at Site 17, Hangar 5, produced runoff that infiltrated the soil south of the area and may have caused percolation of residual soil contamination into the Site 16 plume, providing an increased flow gradient for the plume. Aircraft and vehicle washing are no longer conducted in these areas.

The Site 16 plume may be discharging to the unnamed drain. However, the soil results in Table 10.8, p. 10-33, indicate minimal soil contamination along the seepage face. These results also suggest that any possible seepage would be at such a concentration that the discharge would be diluted by the surface water to below detectable levels. Monitoring of the surface-water system in and around the base is routinely performed and would also serve to assess potential impacts from IR Program site contaminants (Fig. 11-6, p. 11-21). Surface-water samples are submitted to a NDEP-certified lab on a quarterly basis, with the results subsequently provided to NDEP.

Surface-water runoff resulting from excessive precipitation or human activities may transport contaminated surface sediments or dissolved constituents to the regional surface-drainage system. In addition, contaminants presently associated with the shallow ground water may migrate downgradient for eventual seepage discharge into the surrounding drains. Restricted access and institutional controls again minimize any surface-water exposures on NAS Fallon property. Contaminated surface water does, however, have the potential to transport contaminants to downstream exposure points.

Ground- and surface-water transport to downstream receptors are the primary exposure pathways for contaminants of concern at the Group IV Sites. Potential off-site transport mechanisms include: 1) eventual seepage discharge of ground-water contaminants to surface water migrating downstream and 2) discharge of contaminated surface water (from rainfall and human activity) to surface-water drainage systems. Thus, the principal exposure pathway of concern is the regional surface-water system extending from the down-gradient (southeastern) edge of the facility to Stillwater Point Reservoir and the Stillwater National Wildlife Refuge.

While the existence of soil and ground-water contaminants in excess of action limits does not in itself mandate active remediation, the existence of free-phase product on the ground water in excess of 0.5 in. does require the implementation of a NDEP removal action (Appendix A).

10.5.3 Contaminant Migration

Table 10.15, p. 10-67, compares the mobility of TCE, some pesticides, phenols, and some components of jet fuel (a discussion of the varied composition of jet fuel is presented in Sect. 10.5.1). The octanol/water partition coefficient, K_{ow} , is a useful means of comparing the relative ability of a compound to migrate in ground water. This relationship is not quantitative but does provide an empirical means of comparison. The smaller the $\log K_{ow}$, the more rapidly a compound may be expected to migrate. A very mobile compound, such as acetone, has a $\log K_{ow}$ of 0.6. All of the compounds in Table 10.15, p. 10-67, have values an order of magnitude or more greater, demonstrating their much lower mobility.

With respect to jet fuel, because there are so many types of compounds, migration rates of dissolved species are not easily predicted. See Sect. 3.5.3 for further discussion of jet fuel contaminant migration.

10.6 BASELINE RISK ASSESSMENT (BRA)

The risk assessment for the Group IV Sites is presented in the BRA (Volume III of the RI Report). It is important to note that the BRA is simply a screening tool. By using the highest contaminant concentration as the exposure level, the risk assessments are worst case scenario. Therefore, on the basis of a conservative risk calculation, the BRA shows those sites that may require further consideration. If a site exhibits potential risk, the Navy will take mitigating action to ensure the site is environmentally safe. A risk assessment summary is presented in Sect. 10.7.

10.7 SUMMARY AND CONCLUSIONS

Soil - No soil contamination was detected from samples collected at Sites 10 and 11. Also, excavation of the three high-conductivity areas (identified during the geophysical survey) at Site 10 revealed no cans containing PCB-laden oil nor any other substances.

Samples collected from Sites 12 and 23 contained relatively low levels of DDT and its derivatives but no PHCs. Investigations at Sites 13 and 16 indicated areas of TPH concentrations exceeding the NDEP action level of 100 mg/kg. Associated fuel-related VOCs and SVOCs were also present in relatively high concentrations at these sites. Contamination at Sites 13 and 16 was confirmed during removal of USTs in 1992. Contaminated soils at these sites were backfilled into the excavations. One sample taken from the capillary fringe at Site 14 had TPH contamination exceeding the NDEP action level, and one sample from Site 17 contained relatively high levels of fuel-related VOCs. However, these samples are associated with the free-product plume and the dissolved contaminant ground-water plume at these sites.

Quantitative risk assessments for Sites 10, 11, and 17 were deemed unnecessary due to the lack of contamination and for Site 19 due to the lack of receptors. Also, compound-specific data were not available for quantitative risk assessment at Site 13. The risk assessments for the remaining sites determined that cancer risks for both current and future uses were below the point of concern. The HIs for both current and future uses were also below the point of concern for all sites. The HIs for ecological risks were above the point of concern for Sites 14 and 16.

Ground water - Two dissolved contaminant plumes were delineated at the Group IV Sites. The two main source areas for the plumes are Site 14, the Old Vehicle Maintenance Shop, and Site 16, the Old Fuel Farm. Contaminants are primarily fuel-related VOCs and SVOCs, but solvents and trace levels of pesticides were also detected. Within the plumes are significant concentrations of PHCs, benzene, and TCE. Two areas of free product were also delineated that exceed the NDEP action level for removal actions.

The risk assessment indicated no current human exposure, thus no current risk, from the ground water. Cancer risks for the future-use, off-base scenario (non-consumptive use only) were above the point of concern. The HI for non-carcinogenic effects for the scenario was also well above the point of concern. The inhalation of volatile compounds during household activities contributes 97% and 90% of the risk and HI respectively. The critical values for phytotoxicity were also exceeded for certain ground-water contaminants.

10.8 RECOMMENDATIONS

Soil

Site 10, GATAR Compound - No Action is recommended due to the absence of contamination and the fact that no buried containers were found during excavation activities.

Site 11, Paint Shop - No action is recommended due to the absence of contamination.

Site 12, Pest Control Shop - Risk calculations indicate that all risks are below the point of concern. Therefore, no action is recommended. NAS Fallon is in the planning stages of relocating the Pest Control Shop where a containment area for the rinsing and mixing of pesticides will be constructed. A portable containment pad will be used until the new facility is completed.

Site 13, Boiler Plant Tanks - Soil contaminated above the NDEP action level was backfilled at the site following the removal of two USTs. Therefore, a removal action is recommended.

Site 14, Old Vehicle Maintenance Shop - No soil contamination exceeding the NDEP action level was identified in the unsaturated zone. Therefore, no action is recommended.

Site 16, Old Fuel Farm - Soil contaminated above the NDEP action level is present, and ecological risks are above levels of concern. A removal action is recommended in the location of the former diesel UST near Building 409. Navy consultation with NDEP will address any additional soil remediation at Site 16.

Site 17, Hangar 5 - No action is recommended due to the absence of contamination.

Site 19, Post-WW II Burial Site - No action is recommended due to the absence of contamination.

Site 23, Shipping and Receiving Disposal - Risk calculations indicate that all risks are below the point of concern. Therefore, no action is recommended.

Ground Water

Site 10, GATAR Compound - There is no indication of ground-water contamination at Site 10. Therefore, no action is recommended.

Site 11, Paint Shop - Ground-water contamination below Site 11 is contiguous with the dissolved contaminant plume originating from Site 16. Source mitigation will be accomplished by the soil removal action at Site 16, the Old Fuel Farm. Therefore, no action is recommended.

Site 12, Pest Control Shop - Ground-water contamination below Site 12 is contiguous with the dissolved hydrocarbon plume originating from Site 14. Source mitigation will be accomplished by the free-product removal action at Site 14, the Old Vehicle Maintenance Shop. Therefore, no action is recommended.

Site 13, Boiler Plant Tanks - Ground-water contamination below Site 13 is contiguous with the dissolved contaminant plume originating from Site 14. Source mitigation will be accomplished by the free-product removal action at Site 14, the Old Vehicle Maintenance Shop, and the soils removal action in the location of the two former USTs, the Boiler Plant Tanks. Therefore, no action is recommended.

Site 14, Old Vehicle Maintenance Shop - An area of free product is present whose thickness exceeds the NDEP action level. Therefore, a removal action is required. Upon removal of free product, residual product in soils at and above the capillary fringe should be assessed. Also, a contaminated ground-water plume originates from Site 14.

Site 16, Old Fuel Farm - An area of free product is present whose thickness exceeds the NDEP action level. Therefore, a removal action is required. Also, a contaminated ground-water plume originates from Site 16.

Site 17, Hangar 5 - No action is recommended due to the absence of contamination.

Site 19, Post-WW II Burial Site - Ground-water contamination below Site 19 is contiguous with the dissolved contaminant plume originating from Site 16. Source mitigation will be accomplished by the removal action at Site 16, the Old Fuel Farm. Therefore, no action is recommended.

Site 23, Shipping and Receiving Disposal - No action is recommended due to the absence of contamination.

SECTION II

11. CHARACTERIZATION OF FLOW AND WATER QUALITY IN THE LOWER DIAGONAL AND LOWER DIAGONAL #1 DRAINS

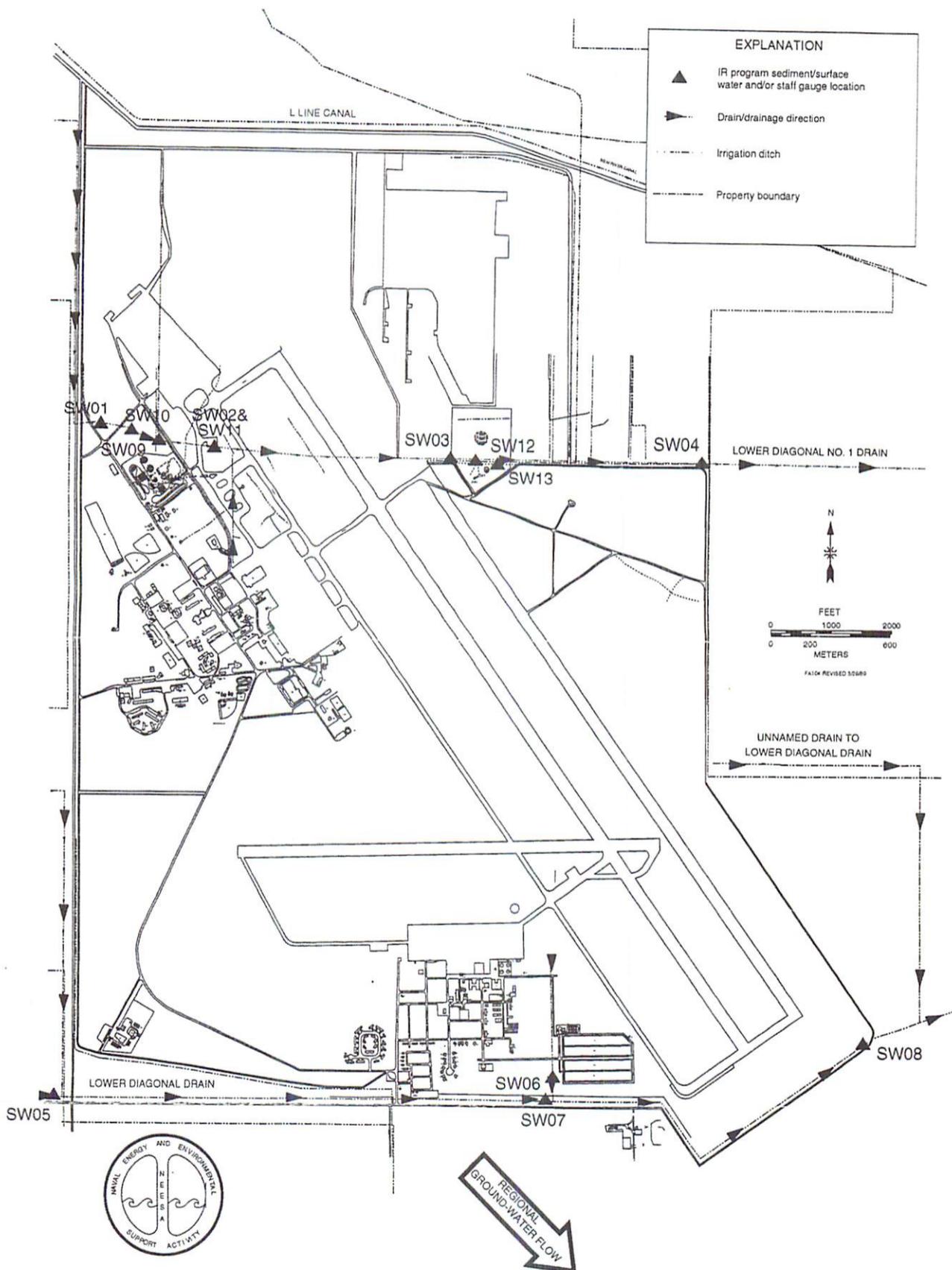
11.1 INTRODUCTION

A series of current-meter measurements were performed in two drains (the LD Drain and the LD #1 Drain) at NAS Fallon to gather information needed for characterizing potential contaminant transport by surface water from former waste disposal sites. Water samples and stream-sediment samples were collected for establishing background water quality and assessing surface-water contaminant transport. This section details the methods used and results obtained defining the quality and quantity of the potentially affected surface water. See Sect. 2.2.3 for a complete description of the drain system at the facility.

11.2 FIELD METHODS AND RESULTS

11.2.1 Flow Measurements

The LD Drain is approximately 25 ft wide and 12 ft deep and averages about 2 ft of water during low flow in the winter months. Measured discharge rates ranged from 26 to 82 cfs. The LD #1 Drain is approximately 12 ft wide and 12 ft deep and averages about 1 ft of water during the winter. The flow in LD #1 Drain is relatively slow, and discharges rarely exceed 2 cfs. Both drains represent potential pathways for migration of contaminated ground water into the surface water. Thus, selection of a series of water sample locations, SW-1 through SW-8, and installation of seven staff gauges allowed the characterization of the flow and contaminant transport for a 2-month period (Aug. to Oct. 1989) in the drains (Fig. 11.1, p. 11-2). The staff gauges were also useful for relating the local ground-water-elevation surface to the level of the water in the drains. A total of



11-2

Fig. 11.1. NAS Fallon, IR Program, surface-water sample locations.

eight water- and sediment-sample locations (four in each drain) were chosen based on the proximity of upstream and downstream intersections of the drains to known or suspected contaminated ground water in the shallow aquifer. Two staff gauges, SW-1 and SW-8, were installed at gauging-station locations, and staff gauges SW-9 through SW-13 were placed near suspected contaminant-plume discharge areas (Fig. 11.1, p. 11-2). Installation of the other staff gauges provided data for evaluating the ground-water/surface-water flow interactions. The following criteria from USGS Water Supply Paper 2175 (Rantz et al. 1982) were considered during selection of gauging stations SW-1 and SW-8:

1. The general course of the stream should be straight for a considerable distance upstream from the gauging station.
2. The total flow should be confined to one channel at all stages, and no flow should bypass the station as subsurface flow.
3. The stream bed should not be subject to scour and fill and should be free of aquatic growth.
4. Banks should be permanent, high enough to contain floods, and free of obstructions.
5. Unchanging natural controls (such as bedrock outcrop) should be present to provide riffles for low flow and channel constriction for high flow.
6. A pool should be present upstream from the control to ensure a recording of stage at extremely low flow and to present high velocities at the streamward end of gauging-station intakes during periods of high flow.
7. The gauge station should be far enough upstream from the confluence with another stream or from tidal effects to avoid any variable influence from other sources on the stage at the gauge station.
8. A satisfactory reach for measuring discharge at all stages should be available within a reasonable distance from the gauge station.
9. The location should be readily accessible for ease of installation and operation of the gauging station.

Ultimately, two man-made structures in the drains where the channels were straight and forced to flow through a confined reach were selected as gauge-station locations. The locations fit all of the criteria above with the exception of the one in LD #1 Drain, which had a considerable growth of cattails that needed cutting back frequently. A 3-ft-diameter, flat-bottomed culvert with concrete wing walls was selected as the gauge location in LD #1 Drain, and a 10-ft-wide concrete bridge/culvert was selected as the gauge location in LD Drain. These locations also served as water and sediment-sampling locations.

Stream-gauging measurements were made with a Price type AA current meter mounted on a standard top-setting wading rod. Measurements were taken on 0.5-ft increments in LD #1 Drain and on 1.0-ft increments in the LD Drain. Since flows were relatively shallow, the six-tenths method was incorporated. This involves measuring the velocity at 0.6 of the depth from the water surface at each increment across the stream. The velocity of water flowing across the cross-sectional area of the stream is the discharge. This relationship is represented by the formula $Q = \Sigma(av)$ where Q is the total discharge in cfs, a is an individual subsection area in ft^2 , and v is the corresponding mean velocity of the flow normal to the subsection in ft/s (Rantz et al. 1982). Calculations were made by the midsection method; the results are presented in Table 11.1, p. 11-5. These results were related to staff gauge readings by constructing rating curves for the two gauging stations (Figs. 11.2, 11.3, 11.4, and 11.5, pp. 11-6, 11-7, 11-8, and 11-9).

Two graphs were constructed for each gauging station, one with gauge height vs discharge on an arithmetic scale and the other with gauge height vs discharge on a log scale. Even though a limited data set was obtained for the LD Drain, the graphs display linear plots. Both sets of rating curves approximate straight lines when plotted with discharge on a log scale, indicating that there is a valid relationship between gauge height and discharge for the range of flows likely to be encountered in the two drains. These curves are now being used to estimate discharge rates based on staff-gauge readings.

Table 11.1. Stream-discharge rating curve data

LD #1 Drain		LD Drain	
Gauge Height	Discharge	Gauge Height	Discharge
ft	cfs	ft	cfs
0.15	0.5	0.0	30
0.16	0.5	0.25	40
0.41	0.7	0.56	50
0.62	0.8	0.63	50
0.83	0.9	0.73	60
0.99	1.0	1.03	80
1.19	1.0		
1.20	1.0		
1.40	2.0		
1.62	3.0		
1.81	3.0		
2.02	4.0		

Note: This data was collected during August, September, and October 1989, which covers part of the irrigation season and the period after irrigation ends in the fall.

Rating Curve - LD Drain Gauging Station

Measurements made summer/fall 1989

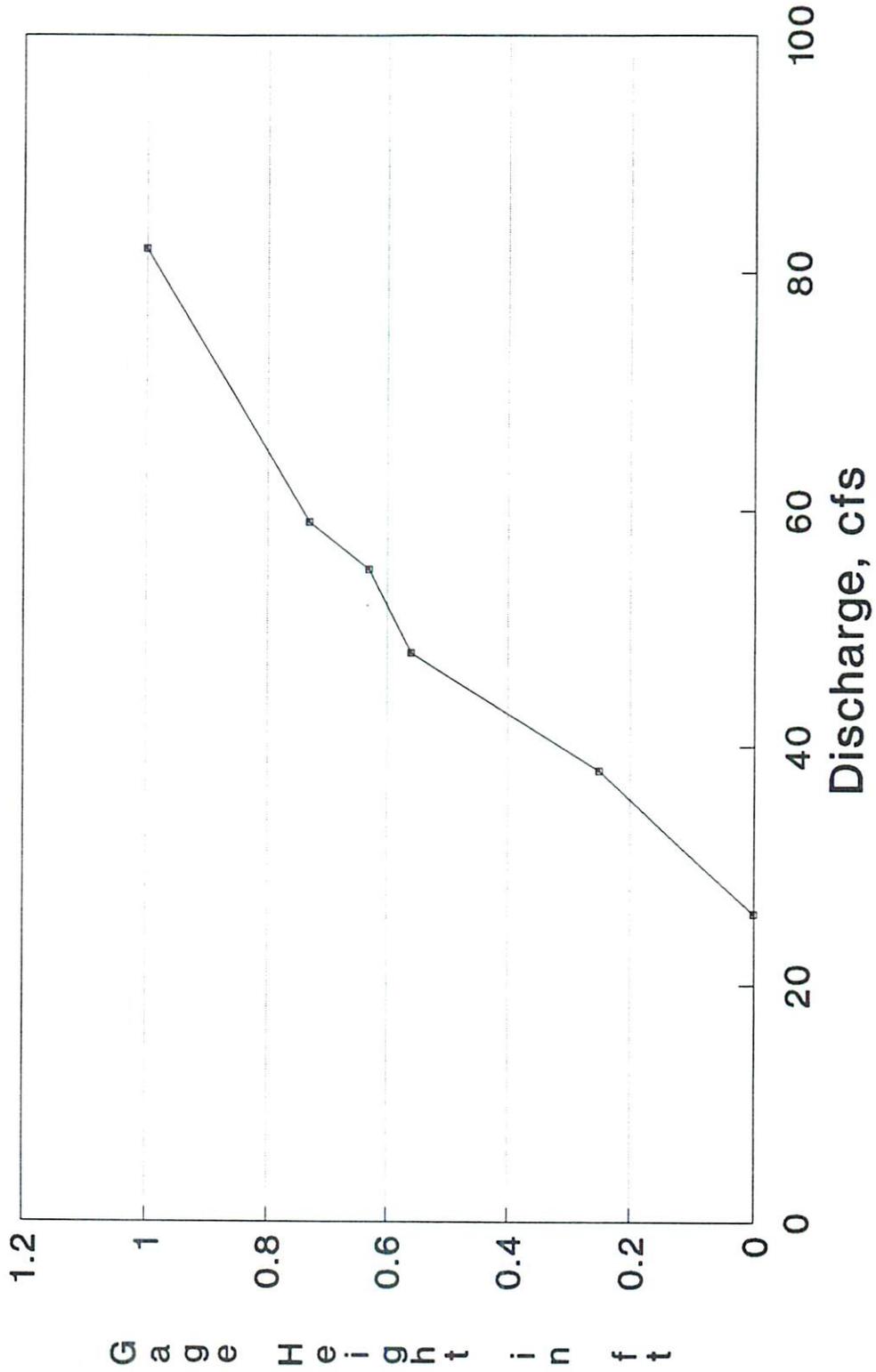


Fig. 11.2. Rating curve for LD Drain gauging station.

Rating Curve - LD Drain Gauging Station

Measurements made summer/fall 1989

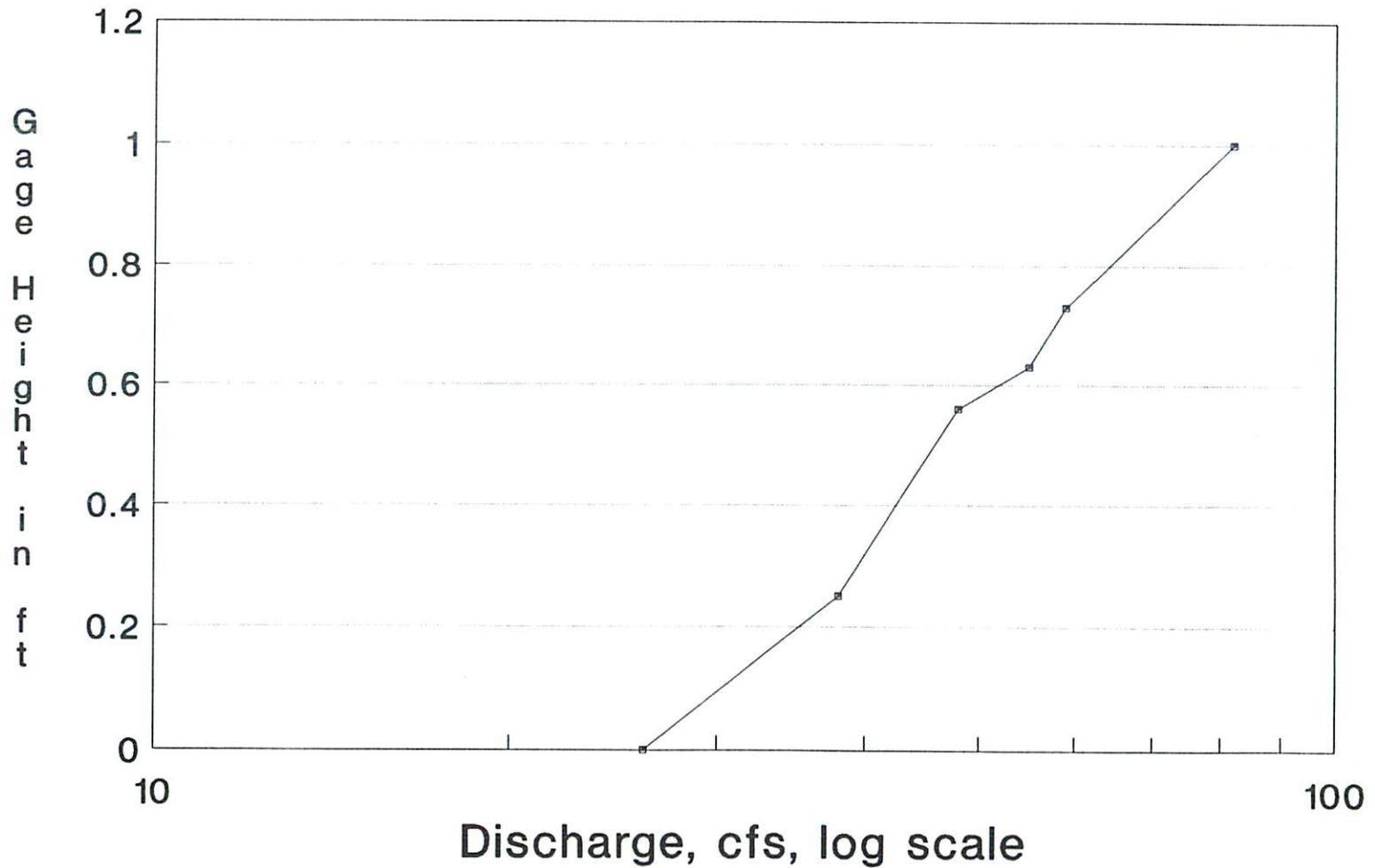


Fig. 11.3. Rating curve for LD Drain gauging station (log scale).

Rating Curve - LD #1 Gauging Station

Measurements made summer/fall 1989

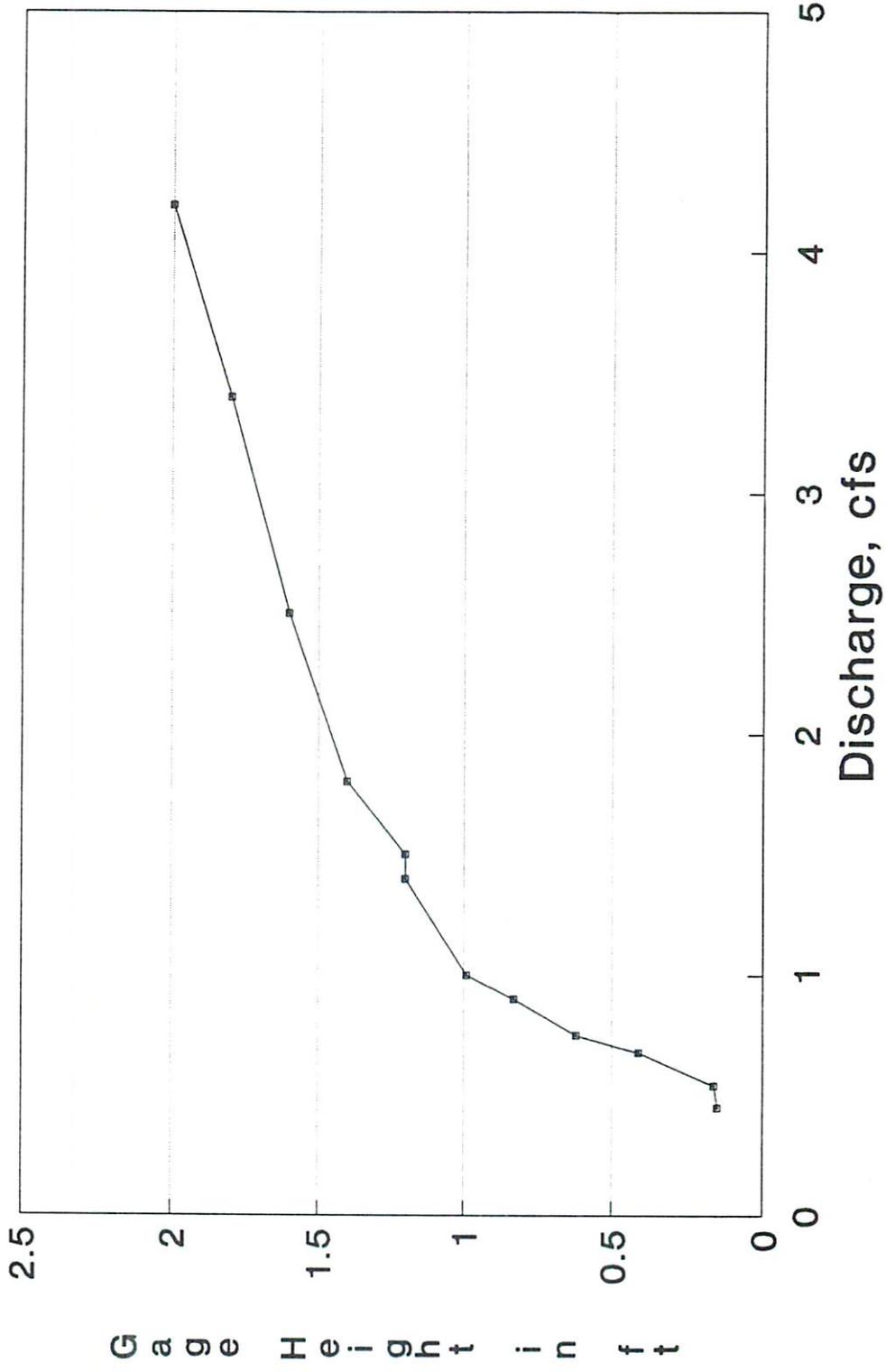


Fig. 11.4. Rating curve for LD #1 Drain gauging station.

Rating Curve - LD #1 Gauging Station

Measurements made summer/fall 1989

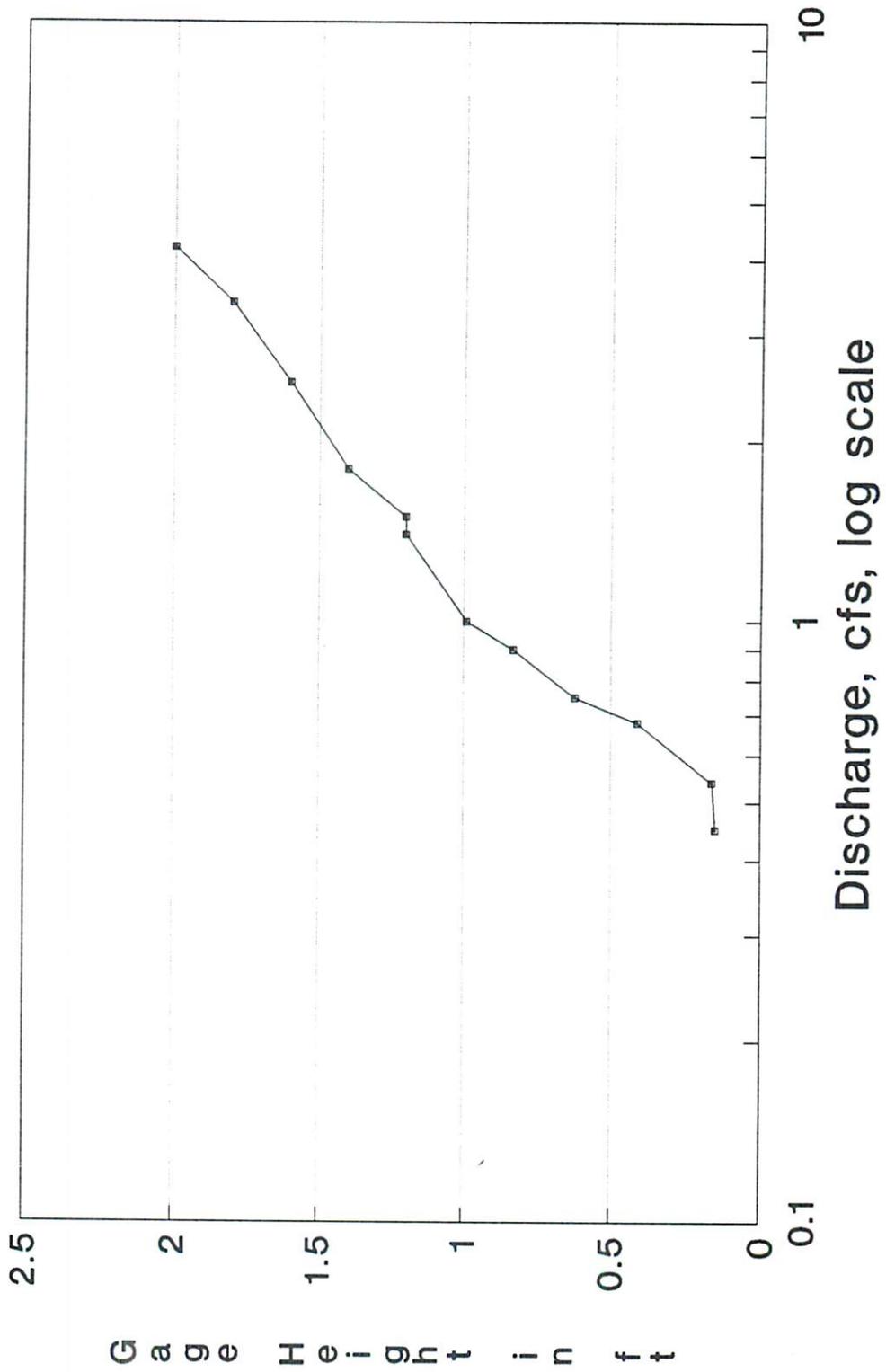


Fig. 11.5. Rating curve for LD #1 Drain gauging station (log scale).

11.2.2 Chemical Sampling

Water and sediment samples were collected from eight locations, four in each drain (Fig. 11.1, p. 11-2). Water samples were collected every two weeks for two months (four times). Sediment samples were collected only once, at the beginning of the study (August through September 1989).

The water samples were collected by wading out to the center of the drain, facing upstream, and simply allowing the open container to fill by gravity flow while submerging it in the drain. Sediment samples were also collected near the center of flow at each location by simply scooping sediment off the drain bottom with the sample container. Other parameters measured at each sample location included water temperature, pH, and conductivity (Table 11.2, p. 11-11). Analytes of interest included VOCs, SVOCs, TPHs, PCBs, pesticides, metals, and anions.

The field parameter data shown in Table 11.2, p. 11-11, was measured in midstream prior to collecting water samples. The data shown are for the sampling event in August 1989. The same parameters were measured on successive sampling events on September 9, September 27, and October 10. With respect to pH and conductivity, the parameters remained relatively constant for all locations except SW-6. However, water temperatures declined a few degrees by the October sampling event. At SW-6, the conductivity ranged from 3000 to 5500 $\mu\text{mhos/cm}$ when no fresh water recharge was evident. SW-6 is located on the unnamed tributary to the LD Drain and is fed primarily by ground-water seeps. Occasional runoff from aircraft washing flushes the drain with fresh water and accounts for the variable conductivity values observed. The pH was also higher at SW-6, ranging up to 9.39, which is more basic than the surface water at the other sample stations. The laboratory analytical results are too voluminous to include in this report, but can be generally summarized by analytical category for water and sediment samples.

Table 11.2. Field parameter data

Sample number	Location number	pH	Temperature, °C	Conductivity, μ mhos/cm
3153	SW-1	8.34	18.7	1106
3157	SW-2	8.38	20.6	1130
3155	SW-3	8.91	21.6	1140
3159	SW-4	7.88	17.8	560
3161	SW-5	7.88	15.8	786
3163	SW-6	9.12	16.0	535
3165	SW-7	7.97	17.4	872
3167	SW-8	7.91	17.7	857

All data acquired August 1989.
 μ mhos/cm = micromhos per centimeter.

11.2.3 Water Sample Results

The results for VOC analysis by EPA method 624 on all water samples were negative: no analytes were present above the method detection limit of 5 to 10 $\mu\text{g/L}$. The results for SVOC analysis of water by EPA method 625 were also negative.

Metals analysis were performed by EPA method 200.7 (Table 11.3, p. 11-13). There were levels of several metals that exceeded baseline concentrations as recommended by federal and state criteria for aquatic habitat. The most notably elevated metals included arsenic, boron, molybdenum, selenium, zinc, lithium, and sodium. Elevated metals concentrations are representative of the region. The water is also high in TDS, exceeding 1000 ppm for most samples. These results are consistent with the metals recognized as elevated in a recent report issued by the U.S. Geological Survey (Hoffman et al. 1990). This report cites elevated levels of boron, lithium, arsenic, and molybdenum in surface water as having high correlation to the relative toxicity of water to fish in drains in the Carson Desert.

Anion analysis by EPA method 429 revealed that chloride ranged from 51 to 20,000 mg/L (Table 11.4, p. 11-14), with most samples containing less than 100 mg/L. Again, the samples with the anomalous values were from SW-6. Similarly, sulfate concentrations ranged from 120 to 4000 mg/L, with all samples at less than 200 mg/L except those from SW-6.

The water samples were analyzed for TPHs by EPA method 418.1, which revealed several samples with detectable concentrations (Table 11.5, p. 11-15). Even though these are detectable amounts of TPHs, they do not represent significant concentrations. Furthermore, since the two upstream sampling locations, SW-1 and SW-5, also showed some slightly elevated TPH concentrations, there is no evidence that the source of the PHCs is located on the facility.

Table 11.3. Surface-water sample results for metals, $\mu\text{g/L}$

Analyte	Sample Number and Sample Location								
	3186 SW-4	3187 SW-3	3188 SW-2	3189 SW-1	3190 SW-5	3191 SW-6	3192 SW-7	3193 SW-8	3407 SW-7
Aluminum	ND ¹	231	ND						
Arsenic	136	73	140	198	ND	268 ✓	ND	ND	ND
Boron	1090	939	418	1620	574	7470 ✓	707	816	667
Calcium	26,700	16,700	10,200	35,900	39,700	35,300	43,500	45,500	42,500
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	21
Iron	188	248	ND						
Lead	30	ND	ND	ND	ND	29 ✓	ND	ND	ND
Lithium	39	30	13	51	40	84	44	46	42
Magnesium	7050	4670	ND	9350	10,200	18,400 ✓	11,600	12,300	11,100
Manganese	ND	46	22	31	33	ND	55	63	54
Molybdenum	22	18	10	37	18	137	24	24	16
Nickel	ND	ND	ND	ND	ND	ND	45	83	ND
Potassium	6770	5800	ND	5320	7030	35,000 ✓	7640	8900	7120
Sodium	132,000	104,000	52,500	210,000	74,900	1,220,000 ✓	91,000	105,000	88,400
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	60
Zinc	59	49	32	ND	42	38	55	23	32

¹ Not detected.

Note: Only analytes found above detection limits are included.

Table 11.4. Surface-water sample results for anions

Sample number	Sample location	Site	Chloride, mg/L	Sulfate, mg/L
3424	SW-1	LD #1 Drain	52	150
3425	SW-8	LD Drain	85	190
3426	SW-2	LD #1 Drain	57	160
3427	SW-3	LD #1 Drain	62	170
3428	SW-4	LD #1 Drain	62	150
3430	SW-7	LD Drain	64	150
3431	SW-6	Unnamed Drain	20,000	4500
3432	SW-5	LD Drain	51	120

Note: Only anions found above detection limits are included.

Table 11.5 Surface-water sample results for petroleum hydrocarbons

Sample number	Location number	Sample date	TPHs, mg/L
3412	SW-1	9/27/89	5
3424	SW-1	9/27/89	2
3426	SW-2	10/10/89	5
3418	SW-3	9/27/89	2
3186	SW-4	9/07/89	2
3417	SW-4	9/27/89	2
3161	SW-5	9/07/89	1
3413	SW-6	9/27/89	2
3407	SW-7	9/07/89	1
3430	SW-7	10/10/89	2

Note: Only samples with results above detection limits are included.

11.2.4 Sediment Sample Results

The analysis of sediment samples collected during August 1989 can be summarized by analytical method. No VOCs were detected other than acetone. Analysis for SVOCs revealed only *bis*(2-ethylhexyl) phthalate, ranging from 860 to 2800 $\mu\text{g}/\text{kg}$, and naphthalene. The sample from SW-3 contained 2100 $\mu\text{g}/\text{kg}$ of naphthalene, a common jet-fuel component. This sample location is at the confluence of LD #1 Drain and the storm sewer that discharges runoff from the north end of the facility and receives runoff from the hot refueling area. Thus, it is likely that the source of the contamination is from the storm drain and not one of the contaminated ground-water plumes. It is not surprising that SVOCs were found to be much more pervasive and at higher concentrations in sediments than in water considering that many of the compounds tend to adsorb to soil particles and have relatively high coefficients for adsorption to organic compounds (K_{oc}). Thus, they tend to be readily attached to organic carbon molecules occurring naturally in the sediments. Similarly TPH results for sediment samples revealed higher and more consistent concentrations in sediment than in the water (Table 11.6, p. 11-17).

Results for PCB/pesticide analysis revealed no detectable levels in the sediments sampled. Metals analysis, however, revealed possible elevated concentrations of the same suite of metals that exceeded the criteria in water samples. It is difficult to categorize metals in sediments as being high since sediments have a very large mineral soil component, and it is not known what the concentrations of metals would be naturally. The assumption is that elevated metals concentrations occurring in surface water are the result of leaching of metals from the mineral soil by irrigation water and ground water (Welch et al. 1989). Many of the metals may have been concentrated in the soils and ground water of the area during the evaporation and disappearance of Lake Lahontan.

Table 11.6. Sediment sample results for petroleum hydrocarbons

Sample number	Location number	Date	TPHs, mg/kg
3154	SW-1	08/25/89	7
3158	SW-2	08/25/89	11
3156	SW-3	08/25/89	43
3160	SW-4	08/25/89	8
3162	SW-5	08/25/89	6
3164	SW-6	08/25/89	43
3166	SW-7	08/25/89	0
3169	SW-8	08/25/89	21
3170	SW-8 duplicate	08/25/89	29

Note: This table includes all sediment-sample TPH data.

11.3 CONTAMINANT TRANSPORT CONSIDERATIONS

The analytical results presented above do not indicate any contamination along the two drains that appears directly related to known plumes of contaminated ground water on the facility. The two plumes in close proximity to the drains, one near LD #1 Drain (Site 2) and the other close to an unnamed lateral drain to LD Drain (Site 16), did not seem to have any effect on the relative concentrations of organic compounds or PHCs in the water or sediments of the drains. The sample location related to the Site 2 plume, SW-2, is about 50 yd downstream from the suspected intersection of the Site 2 plume and the drain; however, the sample did not contain concentrations of compounds related to the plume or in excess of the contamination described at other sampling locations. Similarly, the sample location related to the Site 16 plume, SW-6, did not contain concentrations of compounds related to the plume or in excess of the other sampling locations. However, the sampling events occurred during and at the end of the irrigation season when return flows to the drains kept the water levels up. Implications are that the situation could change in the winter months when return flows cease and base flow in the drains is composed almost totally of ground water.

The mapping of the water-table surface along the reach of LD #1 Drain adjacent to Site 2 where the plume of contaminated ground water is close to the drain has provided insight into potential contaminant transport from the site via surface water. Water-level measurements taken from ground-water monitoring wells and staff gauges along the drain during the irrigation season were contoured to produce maps of the water-table surface. These measurements show that during the irrigation season, the drain was recharging the shallow ground water. As long as the drain is recharging the aquifer, the plume cannot discharge into the drain and migrate off site. However, in the winter months when the water level in the drain drops significantly, the reverse may be true: the shallow ground water may be discharging to the drain and carrying contaminated water off the site. The flow rates in the drains are typically very low in the winter months and, in some instances, the water is stationary up until the month of April.

The fluctuating nature of the interaction between the shallow ground water and the surface water in LD #1 Drain are further revealed by the periodic water-conductivity measurements made in the drain and in wells adjacent to the drain. During periods of fresh-water recharge from the drain to the shallow ground water (during the irrigation season), conductivity values in the wells adjacent to the drain are typically 700 to 1500 $\mu\text{mhos/cm}$, and the conductivity of the surface water is around 1000 $\mu\text{mhos/cm}$. However, during periods of ground-water discharge to the drain, the conductivity of the well water increases to values ranging from 2000 to 10,000 $\mu\text{mhos/cm}$, and the conductivity of the drain water increases to over 1500 $\mu\text{mhos/cm}$. This indicates a shift from mixing of surface water with ground water in the aquifer during the irrigation season to the mixing of ground water with the surface water in the drain when irrigation return flows have ceased.

Water-table elevation maps have also been constructed for the rest of the sites. They generally reveal an east-southeast ground-water flow direction in the shallow aquifer.

11.4 SURFACE-WATER RISK UNIT

The risk assessment for the surface-water system at NAS Fallon is presented in the BRA (Volume III of the RI Report).

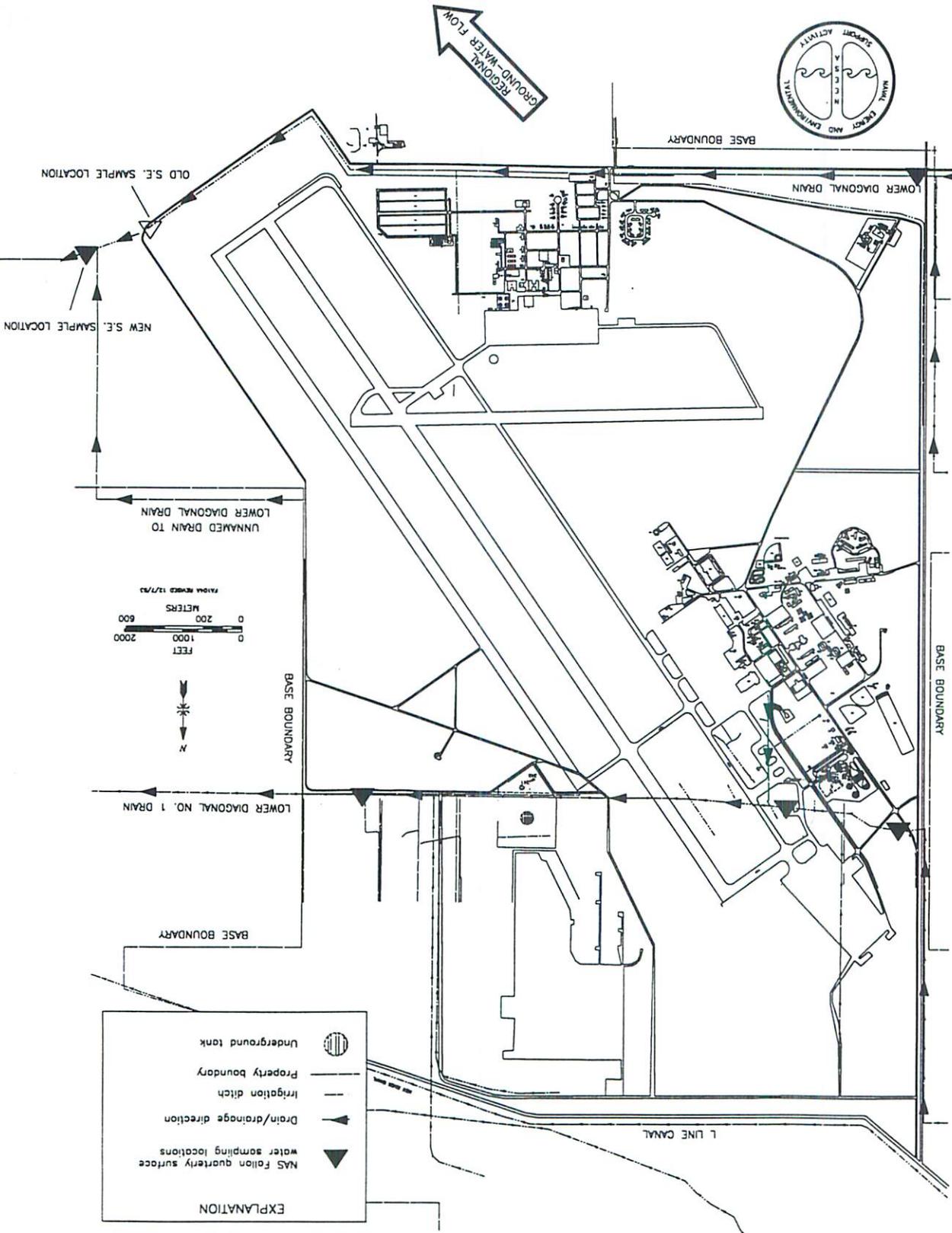
11.5 SUMMARY

The investigation of water quantity and quality in the two drains, LD #1 Drain and LD Drain, established flow rating curves for staff gauges and water quality for water coming onto and exiting the facility. The interactions between the surface water in LD #1 Drain and the adjacent shallow ground water were also described for the end of the irrigation

season (fall) and for the winter months. It is now known that ground water in the vicinity of the contaminated ground-water plume along LD #1 Drain alternately discharges to and is recharged by the surface water in LD #1 Drain. However, there is no evidence that the interactions of the contaminant plume and the drain water are having any significant impacts on the drain ecosystem. Water fowl, fish, frogs, muskrats, and other fauna were frequently observed in the drain during the sampling. These appeared to be more sensitive to the lack of water in the drain than to any detected levels of contaminants in the water. However, there was some evidence of stress due to the naturally occurring high TDS and dissolved metals (Hoffman et al. 1990). An aquatic toxicology study was scheduled for April 1991; however, it was canceled after the drain was dredged in the fall of 1990 and a subsequent fuel spill in February 1991 caused considerable damage to the drain ecosystem. The fuel spill was cleaned up in March, and by August 1991, many of the species previously observed in the drain were back. The cleanup of the ground-water plume in the near future will remove any potential for contaminant migration from the area.

The surface-water system in and around the base is routinely monitored, which serves to assess potential impacts from IR Program site contaminants (Fig. 11.6, p. 11-21). Surface-water samples are submitted to an NDEP-certified lab on a quarterly basis, with the results subsequently provided to NDEP.

Fig. 11.6. NAS Fallon, quarterly surface-water sampling locations.



EXPLANATION

- NAS Fallon quarterly surface water sampling locations
- Drain/drainage direction
- Irrigation ditch
- Property boundary
- Underground tank

SECTION 12

12. REMEDIAL INVESTIGATION SUMMARY

This section presents both a remedial investigation summary and a BRA summary for each IR Program site. It is important to note that the BRA is simply a screening tool. By using the highest contaminant concentration as the exposure level, the risk assessments are worst-case scenarios. Therefore, on the basis of a conservative risk calculation, the BRA shows those sites that may require further consideration. If a site exhibits potential risk, the Navy will take mitigating action to ensure the site is environmentally safe.

12.1 SITE 1, CRASH CREW TRAINING AREA

Soil - TPH contamination greater than the NDEP action level of 100 mg/kg, along with other petroleum-related compounds and solvents, was found in the former burn pit. However, contamination rapidly dissipates outside of the pit. The only other soil contaminants at the site were low levels of VOCs found in the capillary fringe; these were associated with a dissolved-contaminant ground-water plume. Thus, it is concluded that most of the soil contamination at Site 1 is confined to the former burn pit.

The risk assessment for human health indicated that cancer risks for both current and future exposure scenarios were below the point of concern. The HI for non-carcinogenic effects for both current and future scenarios was also well below the point of concern. The HIs for ecological risk were above the point of concern for phytotoxicity, the mouse, and the peregrine falcon.

Ground Water - A dissolved-contaminant plume containing petroleum constituents and solvents was identified. Also, free petroleum product was measured in wells at levels that exceed the NDEP action level for removal actions. The presence of a solvent-related DNAPL plume was investigated, but no evidence of one was found.

The risk assessment indicated no current exposure, thus no current risk, from the ground water. The future off-base scenario included the use of ground water for non-consumptive purposes only. Cancer risks for the scenario were above the point of concern. The inhalation of volatile compounds during household activities (e.g., dishwashing) contributes 97% of the risk. The HI for non-carcinogenic effects for the future-use scenario was also above the point of concern. The HI for ecological risk was above the point of concern for phytotoxicity. No future on-station exposures are anticipated due to the fact that ground water will not be used. Also, natural attenuation of the contaminants over the 2,500-ft distance to the LD Drain will likely preclude any future off-station exposures.

12.2 SITE 3, HANGAR 300 AREA

Soil - Several samples showed minor contamination by PHCs and other organic compounds, but none of the soil samples contained levels of contaminants exceeding the NDEP action level of 100 mg/kg TPHs in soils. Thus, it is concluded that soil contamination at Site 3 is confined to small areas of relatively low concentrations.

The risk assessment determined that cancer risks for both current and future uses were well below the point of concern. The human health HIs for both current and future uses were also well below the point of concern, as were the HIs for ecological risk.

Ground water - Two dissolved-contaminant plumes were identified at Site 3, one in the north area and one in the south area. The north plume was comprised of relatively low levels of PHCs and related compounds. Moderate levels of TCE and other solvents, as well as petroleum products, were identified in the south plume. The risk assessment indicated no current exposure, thus no current risk, from the ground water. No future exposures are anticipated due to the fact that ground water will not be pumped on base. Also, natural attenuation of the contaminants over a

2-mile distance precludes future off-base exposures. Thus, it is concluded that there is no exposure from contaminants at Site 3.

12.3 SITE 20, CHECKERBOARD LANDFILL

Soil - No contamination was detected in soil samples collected from the perimeter of the landfill boundary. No quantitative risk assessment was conducted due to the absence of contamination.

Ground water - No contamination was detected in ground-water samples collected from downgradient wells at the landfill boundary. Thus, it is concluded that no contaminants are currently migrating from the site. Also, because no new material has been introduced to the site for nearly 30 years, it is unlikely that future migration of contaminants will occur. No quantitative risk assessment was conducted due to the absence of contamination.

12.4 SITE 24, ROAD OILING AREA

Soil - There is no evidence of fuel-related soil contamination associated with waste disposal activities at the site. No quantitative risk assessment was conducted due to the absence of contamination.

Ground water - No ground-water investigation was conducted at Site 24. However, ground-water test holes drilled along the affected road showed no detectable contamination. No quantitative risk assessment was conducted due to the lack of contamination.

12.5 GROUP I SITES: SITE 2, NEW FUEL FARM; SITE 4, TRANSPORTATION YARD

Soil - Analysis results from samples collected during Phase II of the IR Program indicated very little PHC contamination in soil at the Group I Sites. However, the focus of characterization activities at the sites was the free product on the water table and the associated dissolved-contaminant ground-water plume.

No contamination exceeding the NDEP action level was detected at Site 4, Transportation Yard (including the building 378 floor drain). Only one surface sample, from the weed control area, exceeded the action level at Site 2. Other samples from the weed control area contained the pesticide DDT and its derivatives (10 to 170 $\mu\text{g}/\text{kg}$).

Soil sampling data collected from investigative activities independent of the IR Program indicate additional contaminated areas at Site 2. An investigation by NDEP into an alleged fuel spill identified areas east of USTs 204-A and 204-B with surface and subsurface contamination exceeding the action level (NDEP 1990). These areas were not targeted for soil sampling during Phase II of the IR Program because they were discovered after Phase II activities had begun. Other soil contamination was identified in June 1992 during the removal of USTs 204-6 and 204-7 (PRC 1992). Sampling activities during tank removal indicated contamination near the tanks and piping that exceeded the NDEP action level. Following tank removal, the soils were placed back in the excavation pit. The Phase II ground-water investigation delineated a free-product plume in this area.

Data suitable for quantitative risk assessment were available only for pesticides at the weed control area. The risk assessment determined that cancer risks for both current and future uses were well below the point of concern. The HIs for both current and future uses were also well below the point of concern. Quantitative risk assessments were not performed at other Site 2 areas.

It is concluded that the weed control area does not warrant further attention based on the following: 1) current and future risks for human health are well below the point of concern for both cancer risks and the non-carcinogenic HI, 2) the contamination is limited to a small area of surface soil, 3) ground water has not been affected, 4) the quality of underlying ground water is not suitable for human consumption, and 5) the negative water balance in the area is not conducive to contaminant migration.

Ground water - Four areas of free petroleum product exceeding the NDEP action level for removal action were identified at the Group I Sites (Fig. 7.9, p. 7-22). Due to their source areas, the plumes are all considered part of Site 2. A dissolved-contaminant plume associated with the free-product areas was also delineated.

Dissolved-contaminant concentrations were relatively low, with only one sample exceeding 1000 µg/L TPHs. Dissolved-contaminant concentrations should be assessed following the removal actions.

There is no current exposure, thus no current risk, from the ground water. No future exposures are anticipated due to the fact that ground water will not be pumped on base. Also, natural attenuation of the contaminants over a more than 2-mile distance makes future off-base exposures unlikely.

12.6 GROUP II SITES: SITE 6, DEFUEL DISPOSAL AREA; SITE 7, NAPALM BURN PIT; SITE 21, RECEIVER SITE LANDFILL; SITE 22, NORTHEAST RUNWAY LANDFILL

Soil - No contamination was reported in soil samples collected from the Group II Sites. Also, no soil contamination was indicated when installing ground-water test holes around the perimeters of the two landfills. Thus, any contamination present is confined within the landfill boundaries. Phase II investigations failed to confirm the presence of the Napalm Burn Pit, and testimony by a former NAS Fallon Fire Chief refuted the existence of the site. The absence of contamination made a quantitative risk assessment at the sites unnecessary.

Ground water - A small area of free product whose thickness exceeds the NDEP action level (0.5 in.) for removal actions was located at the southernmost disposal area of Site 6. An associated dissolved-contaminant plume was also identified. The plume is near the base boundary but currently does not go off site. Dissolved TPH levels within the plume exceed the NDEP policy for discharge of affected ground waters to surface waters. However, the dissolved-contaminant plume would have to migrate approximately one-half mile after crossing the base boundary before discharging to the LD Drain tributary, subjecting the contaminants to biodegradation and natural attenuation. No other ground-water contamination was found at the Group II Sites (e.g., the landfills). Thus, it is concluded that potential contaminants are not currently migrating from the landfills. Also, because hydrocarbon wastes were prohibited at the sites beginning in 1975, it is unlikely that future migration of contaminants will occur. No quantitative risk assessment was conducted at the landfills due to the absence of contamination.

There is no current exposure, thus no current risk, from the ground water at Site 6. The risk assessment postulated potential future off-base exposure from use of the ground water and discharge to surface water. However, the risk was not quantified because the compounds necessary for the assessment (e.g., individual constituents of fuel) were not detected within the plume.

12.7 GROUP III SITES: SITE 9, WASTEWATER TREATMENT PLANT; SITE 18, SOUTHEAST RUNWAY LANDFILL

Soil - Soil contamination exceeding the NDEP action level for TPHs was found in one sample at a former UST pit near Site 9. The same sample also contained some fuel-related VOCs and SVOCs. No other soil contamination was detected at the Group III Sites. The risk assessment determined that cancer risks for both current and future exposure scenarios were well below the point of concern. The HIs for human health for both current and future uses were also well below the point of concern. The HI for phytotoxicity at the former UST pit was just above the acceptable value.

Soil contamination at the Group III Sites is limited to a small area at the former UST pit near Site 9. It is concluded that this area does not warrant further attention based on the following: 1) current and future risks for human health are well below the point of concern for both cancer risks and the non-carcinogenic HI, 2) the extent of contamination is limited to a small area, 3) ground water has not been affected, 4) the quality of underlying ground water is not suitable for human consumption, and 5) the negative water balance in the area is not conducive to contaminant migration.

Ground water - No ground-water contamination was detected at the Group III Sites. Ground-water-test-hole screening conducted downgradient from the landfill indicated no migration of contaminants. Also, because no new material has been introduced to the landfill for nearly 50 years, it is highly unlikely that future migration of contaminants will occur. No quantitative risk assessment was conducted at the sites due to the absence of contamination.

12.8 GROUP IV SITES: SITE 10, GATAR COMPOUND; SITE 11, PAINT SHOP; SITE 12, PEST CONTROL SHOP; SITE 13, BOILER PLANT TANKS; SITE 14, OLD VEHICLE MAINTENANCE SHOP; SITE 16, OLD FUEL FARM; SITE 17, HANGAR 5; SITE 19, POST-WORLD WAR II BURIAL SITE; SITE 23, SHIPPING AND RECEIVING DISPOSAL

Soil - No soil contamination was detected from samples collected at Sites 10 and 11. Also, excavation of the three high-conductivity areas (identified during the geophysical survey) at Site 10 revealed no cans containing PCB-laden oil nor any other substances.

Samples collected from Sites 12 and 23 contained relatively low levels of DDT and its derivatives but no PHCs. Investigations at Sites 13 and 16 indicated areas of TPH concentrations exceeding the NDEP action level of 100 mg/kg. Associated fuel-related VOCs and SVOCs were also present in relatively high concentrations at these sites. Contamination at Sites 13 and 16 was confirmed during removal of USTs in 1992. Contaminated soils at these sites were backfilled into the excavations. One sample taken from the capillary fringe at Site 14 had TPH contamination exceeding the NDEP action level, and one sample from Site 17 contained relatively high levels of fuel-related VOCs. However, these samples are associated with the free-product plume and the dissolved-contaminant ground-water plume at these sites.

Quantitative risk assessments for Sites 10, 11, and 17 were deemed unnecessary due to the absence of contamination and for Site 19 due to the lack of receptors. Also, compound-specific data were not available for quantitative risk assessment at Site 13. The risk assessments for the remaining sites determined that cancer risks for both current and future uses were below the point of concern. The HIs for both current and future uses were also below the point of concern for all sites. The HIs for ecological risks were above the point of concern for Sites 14 and 16.

Ground water - Two dissolved-contaminant plumes were delineated at the Group IV Sites. The two main source areas for the plumes are Site 14, the Old Vehicle Maintenance Shop, and Site 16, the Old Fuel Farm. Contaminants are primarily fuel-related VOCs and SVOCs, but solvents and trace levels of pesticides were also detected. Within the plumes are significant concentrations of PHCs, benzene, and TCE. Two areas of free product were also delineated that exceed the NDEP action level for removal actions.

The risk assessment indicated no current human exposure, thus no current risk, from the ground water. Cancer risks for the future-use, off-base scenario (non-consumptive use only) were above the point of concern. The HI for non-carcinogenic effects for the scenario was also well above the point of concern. The inhalation of volatile compounds during household activities contributes 97% and 90% of the risk and HI respectively. The critical values for phytotoxicity were also exceeded for certain ground-water contaminants.

Table 12.1, p. 12-10, summarizes the remedial recommendations for the IR Program.

Table 12.1. RI recommendations, IR Program, NAS Fallon

Site No.	Group No.	Medium	Current Risk		Future Risk ¹	NDEP Action Level Exceeded ²	Recommendation	Rationale
			Human Health	Ecological	Human Health			
Site 1 Crash Crew Training Area	--	Soil	No	Yes	No	TPH	Removal action	A <u>removal action</u> is recommended for the former burn pit area only. The recommendation is based on the following factors: 1) the NDEP action level for TPHs in soils is exceeded, and 2) the HIs for some ecological risks are above the point of concern.
		Ground water	No	Yes	Yes	Free product	Removal action	The NDEP action level for free product is exceeded. Upon removal of free product, residual product in soils at and above the capillary fringe should be assessed.
Site 3 Hanger 300 Area	--	Soil	No	No	No	None	No action	<u>No action</u> is recommended based on the following factors: 1) contaminant concentrations do not exceed NDEP action levels, and 2) all risks are below the point of concern.
		Ground water	No	No	No	None	No action	<u>No action</u> is recommended due to the lack of current and future exposures from contaminated ground water at Site 3.
Site 20 Checkerboard Landfill	--	Soil	No	No	No	None	No action	Due to the absence of contamination outside the landfill boundary, <u>no action</u> is recommended.
		Ground water	No	No	*	None	No action	Based on the current lack of contaminant migration from the landfill boundary and the improbable occurrence of future migration, <u>no action</u> is recommended.
Site 24 Road Oiling Area	--	Soil	No	No	No	None	No action	Due to the absence of soil contamination, <u>no action</u> is recommended.
		Ground water	No	No	No	None	No action	Due to the absence of ground-water contamination, <u>no action</u> is recommended.

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12-10

Table 12.1. RI recommendations, IR Program, NAS Fallon (cont.)

Site No.	Group No.	Medium	Current Risk		Future Risk ¹	NDEP Action Level Exceeded ²	Recommendation	Rationale
			Human Health	Ecological	Human Health			
Site 2 New Fuel Farm	I	Soil	**	**	**	TPH	Removal action	A <u>removal action</u> is recommended for those areas where the NDEP action level for TPH is exceeded.
		Ground water	No	No	**	Free product TPH	Removal action/ recommendation pending ³	A <u>removal action</u> is required for areas where free-product thickness exceeds the NDEP action level (removal actions are in process). Due to relatively low concentrations of dissolved constituents, the ground-water recommendation will not be made until results of the free-product removal are assessed.
Site 2 Weed Control Area ⁴	I	Soil	No	No	No	TPH	No action	<u>No action</u> is recommended. No further attention is warranted due to the lack of human health risks, the limited extent of contamination, and the fact that ground water is not affected.
Site 4 Transportation Yard	I	Soil	No	No	No	None	No action	Due to the absence of contamination, <u>no action</u> is recommended.
		Ground water	No	No	No	None	No action	No ground-water contamination was identified; thus, <u>no action</u> is recommended.
Site 6 Defuel Disposal Area	II	Soil	No	No	No	None	No action	Due to the absence of soil contamination, <u>no action</u> is recommended.
		Ground water	No	No	**	Free product TPH	Removal action	The NDEP action level for free product is exceeded; thus, a <u>removal action</u> is required. Upon removal of free product, residual product in soils at and above the capillary fringe should be assessed.

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12-11

Table 12.1. RI recommendations, IR Program, NAS Fallon (cont.)

Site No.	Group No.	Medium	Current Risk		Future Risk ¹	NDEP Action Level Exceeded ²	Recommendation	Rationale
			Human Health	Ecological	Human Health			
Site 7 Napalm Burn Pit	II	Soil	No	No	No	None	No action	No evidence exists to support the presence of this site; <u>no action</u> is recommended.
		Ground water	No	No	No	None	No action	No evidence exists to support the presence of this site; thus, <u>no action</u> is recommended.
Site 21 Receiver Site Landfill	II	Soil	No	No	No	None	No action	Due to the absence of contamination outside the landfill boundary, <u>no action</u> is recommended.
		Ground water	No	No	*	None	No action	Based on the current absence of contaminant migration from the landfill boundary and the improbable occurrence of future migration, <u>no action</u> is recommended.
Site 22 Northeast Runway Landfill	II	Soil	No	No	No	None	No action	Due to the absence of contamination outside the landfill boundary, <u>no action</u> is recommended.
		Ground water	No	No	*	None	No action	Based on the current lack of contaminant migration from the landfill boundary and the improbable occurrence of future migration, <u>no action</u> is recommended.
Site 9 Wastewater Treatment Plant	III	Soil	No	Yes	No	TPH	No action	<u>No action</u> is recommended. Excluding the former UST pit, no soil contamination was detected at Site 9. The UST pit does not warrant further attention due to low human health risks, the limited extent of contamination, and the fact that ground water is not affected.
		Ground water	No	No	No	None	No action	Due to the absence of contamination, <u>no action</u> is recommended.

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12-12

Table 12.1. RI recommendations, IR Program, NAS Fallon (cont.)

Site No.	Group No.	Medium	Current Risk		Future Risk ¹	NDEP Action Level Exceeded ²	Recommendation	Rationale
			Human Health	Ecological	Human Health			
Site 18 Southeast Runway Landfill	III	Soil	No	No	No	None	No action	Due to the absence of contamination, <u>no action</u> is recommended.
		Ground water	No	No	*	None	No action	Based on the current lack of contaminant migration from the landfill boundary and the improbable occurrence of future migration, <u>no action</u> is recommended.
Site 10 GATAR Compound	IV	Soil	No	No	*	None	No action	<u>No action</u> is recommended due to the absence of contamination and the fact that no buried containers were found during excavation activities.
		Ground water	No	No	*	None	No action	There is no indication of ground-water contamination at Site 10. Therefore, <u>no action</u> is recommended.
Site 11 Paint Shop	IV	Soil	No	No	No	None	No action	Due to the absence of contamination, <u>no action</u> is recommended.
		Ground water	No	Yes	Yes	TPH	No action	Ground-water contamination below Site 11 is contiguous with the dissolved-contaminant plume originating from Site 16. Source mitigation will be accomplished by the soil removal action at Site 16, the Old Fuel Farm.
Site 12 Pest Control Shop	IV	Soil	No	No	No	None	No action	Risk calculations indicate that all risks are below the point of concern. Therefore, <u>no action</u> is recommended.
		Ground water	No	Yes	Yes	TPH	No action	Ground-water contamination below Site 12 is contiguous with the dissolved-hydrocarbon plume originating from Site 14. Source mitigation will be accomplished by the free-product removal action at Site 14, the Old Vehicle Maintenance Shop.

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12-13

Table 12.1. RI recommendations, IR Program, NAS Fallon (cont.)

Site No.	Group No.	Medium	Current Risk		Future Risk ¹	NDEP Action Level Exceeded ²	Recommendation	Rationale
			Human Health	Ecological	Human Health			
Site 13 Boiler Plant Tanks	IV	Soil	**	**	**	TPH	Removal action	Soil contaminated above the NDEP action level was backfilled at the site following the removal of two USTs. Therefore, a <u>removal action</u> is recommended.
		Ground water	No	Yes	Yes	TPH	No action	Ground-water contamination below Site 13 is contiguous with the dissolved-contaminant plume originating from Site 14. Source mitigation will be accomplished by the free-product removal action at Site 14, the Old Vehicle Maintenance Shop and the soils removal action in the location of the two former USTs, the Boiler Plant Tanks.
Site 14 Old Vehicle Maintenance Shop	IV	Soil	No	Yes	No	TPH	No action	No soil contamination exceeding the NDEP action level was identified in the unsaturated zone. Thus, <u>no action</u> is recommended.
		Ground water	No	Yes	Yes	Free product TPH	Removal action	An area of free product whose thickness exceeds the NDEP action level is present. Upon removal of free product, residual product in soils at and above the capillary fringe should be assessed. Also, a contaminated ground-water plume originates from Site 14.
Site 16 Old Fuel Farm	IV	Soil	No	Yes	No	TPH	Removal action	Soil contaminated above the NDEP action level is present, and ecological risks are above levels of concern.
		Ground water	No	Yes	Yes	Free product TPH	Removal action	An area of free product whose thickness exceeds the NDEP action level is present. Also, a contaminated ground-water plume originates from Site 16.

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12-14

Table 12.1. RI recommendations, IR Program, NAS Fallon (cont.)

Site No.	Group No.	Medium	Current Risk		Future Risk ¹	NDEP Action Level Exceeded ²	Recommendation	Rationale
			Human Health	Ecological	Human Health			
Site 17 Hangar 5	IV	Soil	No	No	No	None	No action	Due to the absence of contamination, <u>no action</u> is recommended.
		Ground water	No	No	No	None	No action	Due to the absence of contamination, <u>no action</u> is recommended.
Site 19 Post-WW II Burial Site	IV	Soil	No	No	No	None	No action	Due to the absence of contamination, <u>no action</u> is recommended.
		Ground water	No	Yes	Yes	TPH	No action	Ground-water contamination below Site 19 is contiguous with the dissolved-contaminant plume originating from Site 16. Source mitigation will be accomplished by the removal action at Site 16, the Old Fuel Farm.
Site 23 Shipping and Receiving Disposal	IV	Soil	No	No	No	None	No action	Risk calculations indicate that all risks are below levels of concern.
		Ground water	No	No	No	None	No action	Due to the absence of contamination, <u>no action</u> is recommended.

¹ Current and future ecological risk are the same.

² Nevada Division of Environmental Protection (NDEP) action levels. TPH action level for soils is 100 mg/kg. TPH action level for ground water is 1000 µg/L. Free-product action level is 0.5 in. in the formation.

³ Recommendation depends on the results of the removal action.

⁴ The weed control area is listed separately here due to its treatment as a separate area in the risk assessment.

* No current exposure; future exposure is possible.

** Significant contamination is present, but data suitable for quantitative risk assessment were not available.

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