

START

FINAL REPORT

CONFIRMATION STUDY OF FORMER NIKE MISSILE SITES FOR POTENTIAL TOXIC AND HAZARDOUS WASTE CONTAMINATION

FORMER NIKE SITE S-92
KINGSTON, WASHINGTON

Prepared for
U.S. Army Corps of Engineers
Seattle District
East Marginal Way
Seattle, Washington

Prepared by
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Kennesaw, Georgia
LEGS Job No. 11-6603-10



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GLOSSARY OF ABBREVIATIONS

DOD	-- Department of Defense
DAA	-- Defense Appropriations Act
DERA	-- Defense Environmental Restoration Account
IRP	-- Installation and Restoration Program
SI	-- Site Inspection
NPL	-- National Priority List
RI	-- Remedial Investigation
PA	-- Preliminary Assessment
HRS	-- Hazardous Ranking System
EPA	-- Environmental Protection Agency
DERP	-- Defense Environmental Restoration Program
CONUS	-- Continental United States
CERCLA	-- Comprehensive Environmental Response Compensation and Liability Act
USACE	-- United States Army Corps of Engineers
USEPA	-- United States Environmental Protection Agency
GSA	-- General Services Administration
USGS	-- United States Geological Survey
RCRA	-- Resource Conservation and Recovery Act
RI/FS	-- Remedial Investigation Feasibility Study
MCL	-- Maximum Contaminant Level
MCLG	-- Maximum Contaminant Level Goal

EXECUTIVE SUMMARY

The Department of Defense (DOD) is investigating former NIKE missile sites throughout the United States for potential toxic and hazardous waste contamination. This report documents the contamination evaluation investigation which was performed at NIKE Missile Site S-92, located in Kingston, Washington. The investigation involved installing and sampling four ground-water monitoring wells, sampling an existing water supply well, and sampling surface soils at the installation. Figure 1-1 shows the sampling locations. The samples were analyzed for purgeable aromatics, purgeable halocarbons, total metals, petroleum hydrocarbons (water only), and base/neutral extractables (one soil sample and the soil rinsate only). The analytical data for this inventory study are summarized in Section 4.0 of the report and are fully presented in the Appendices.

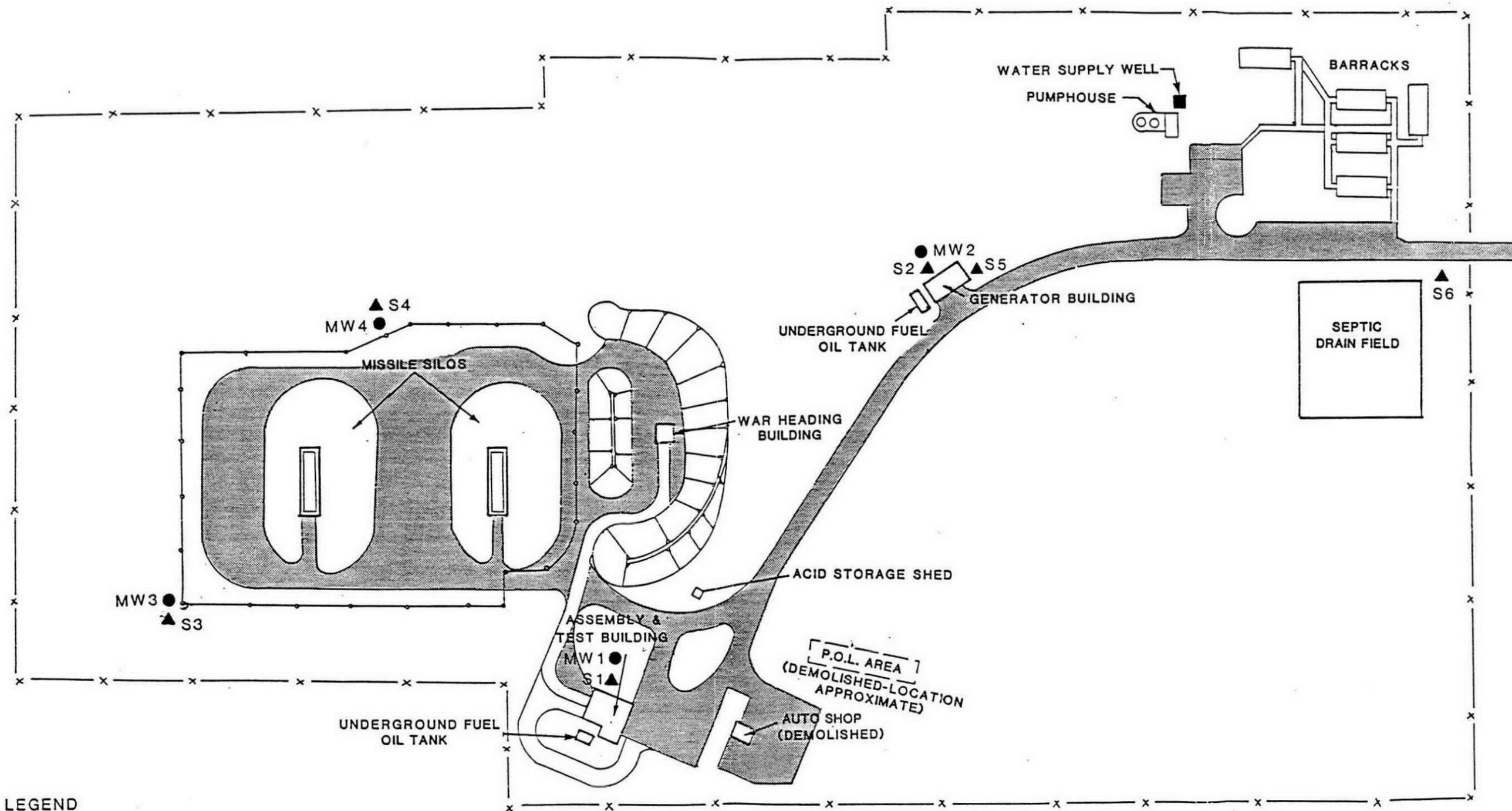
The analytical tests showed the following: (1) methylene chloride was the only organic compound detected in the ground-water samples; (2) cadmium and chromium were the only metals present in the unfiltered ground-water samples in concentrations above the maximum contaminant levels (MCLs); however, in filtered ground-water samples only dissolved concentrations of barium were detected above the detection limits, and all dissolved concentrations of metals were below the MCLs. (3) methylene chloride was the only organic compound detected in the soil samples; (4) the concentrations of metals detected in the soil sample were within average background levels.

Based on the analytical results, the following conclusion and recommendations are made:

- (1) The low levels of methylene chloride detected in all the soil samples and all but one of the ground-water samples appear to be related to laboratory contamination. The sample rinsates, travel blanks, and analytical method blanks generally contained higher levels of methylene chloride than

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LEGEND

- MONITORING WELL LOCATION
- ▲ SOIL SAMPLING LOCATION
- WATER SUPPLY WELL LOCATION



NIKE SITE S-92
KINGSTON, WASHINGTON



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SAMPLING LOCATIONS
FIGURE 1-1

2.0 SITE CONDITIONS

2.1 PROJECT OBJECTIVES

The Scope of Work (SOW) for this project, dated September 15, 1986, is contained in Appendix M of this report. Item 2.0 of the SOW describes the objective of this project as follows: "to make a preliminary determination of whether chemical contamination which may have resulted from Department of Defense activities is present at the site." To fulfill this objective, the contractor performed the following work elements:

- conducted site visit to collect background information;
- prepared work plan and safety plan;
- installed ground-water monitoring wells;
- collected and analyzed ground-water and soil samples;
- evaluated physical and chemical data;
- prepared an engineering report including a hazard ranking system (HRS) report

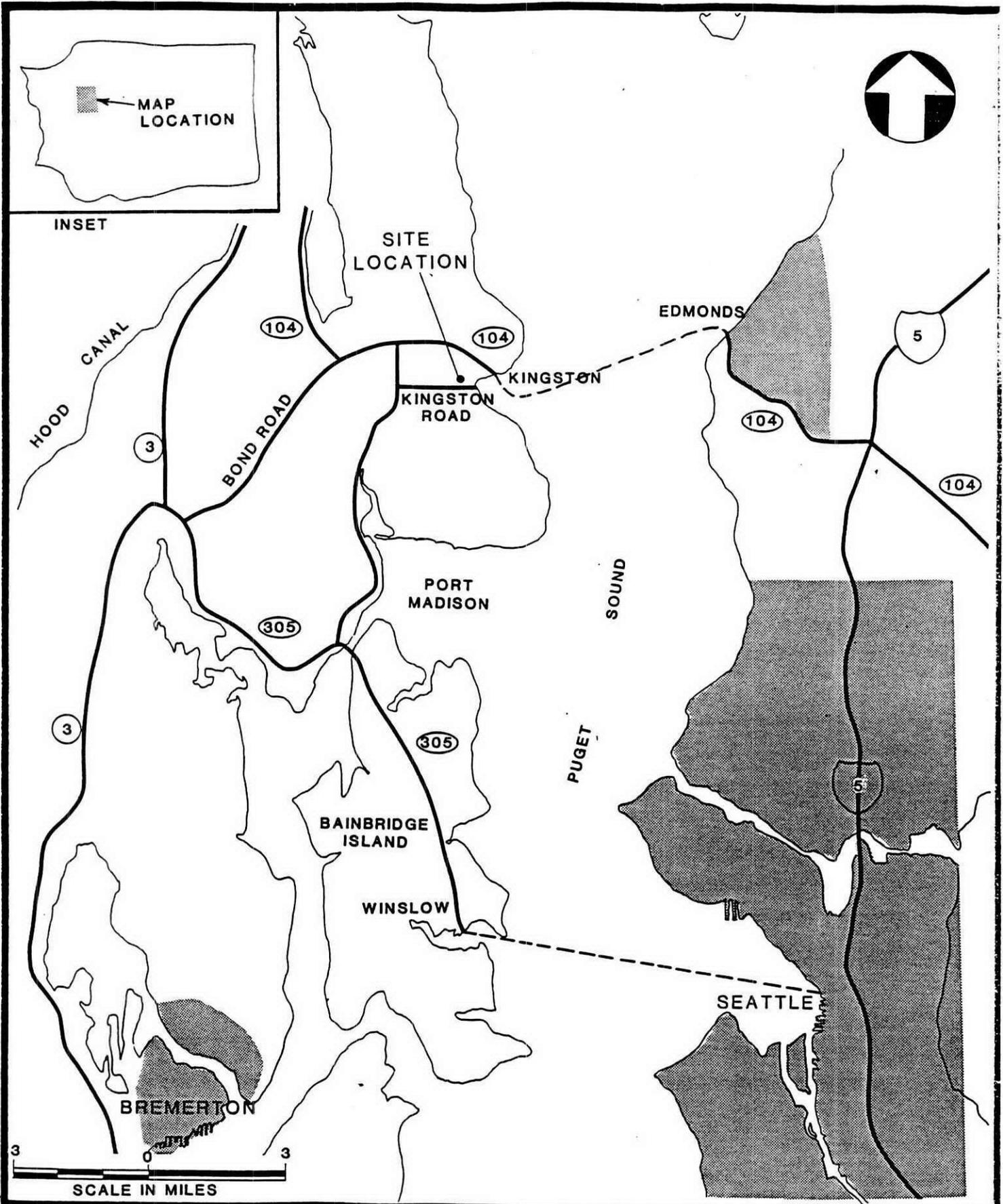
These work elements are described in the following sections of this report. Detailed descriptions of field, laboratory, and safety procedures are presented in the Work Plans (in Appendices I, J, and K). This section of the report describes pertinent background information including a write-up of the site visit, site location information, site physiography, land use, and current and past ownership and use of the site.

2.2 SITE VISIT SUMMARY

A site visit in accordance with Task 2 of the NIKE contamination evaluation SOW was performed by Mr. Fred J. Steinbrenner of Law Environmental, Inc. in November, 1986. The site visit involved a meeting with USACE personnel from the Seattle District and current site owners. A visual inspection of the Nike Launch Area was accomplished at that time. The following information was learned during the site visit.

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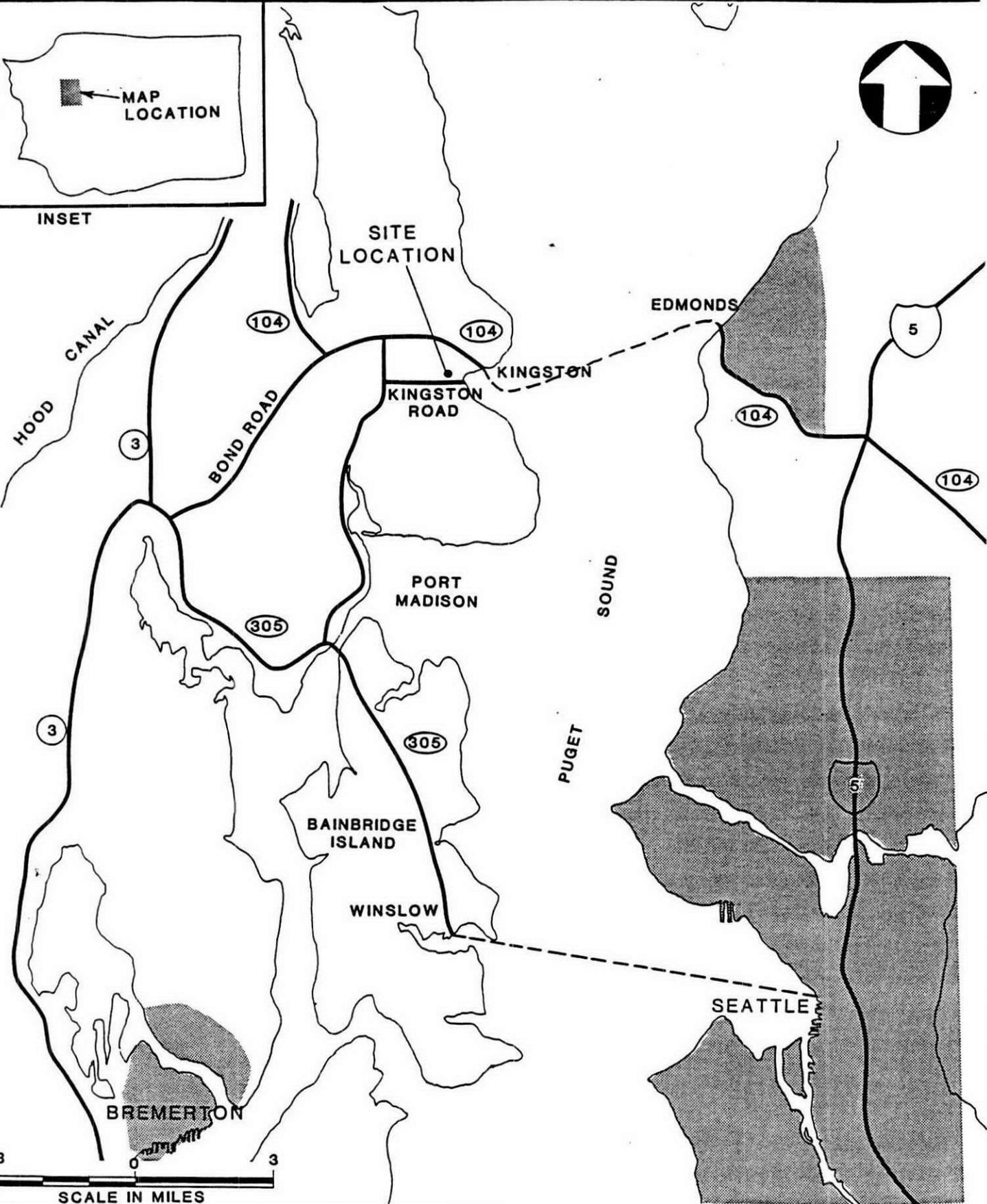
NIKE SITE S-92
 KINGSTON, WASHINGTON

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SITE LOCATION MAP
 FIGURE 2-1

- 9 3 1 2 9 3 5 0 6 9 6
- The SITE is situated on the eastern slope of a ridge one mile west of Kingston, Washington (Figure 2-1). Kingston is located in Kitsap County on the western shore of Puget Sound.
 - The SITE lies within the Puget Trough section of the Pacific Border physiographic province. The Puget Trough section is a long, northward-trending lowland between the Cascade Mountains on the east and the Olympic Mountains on the west. The Puget Trough extends from Canada to the central part of western Oregon. The northern section of the trough, which is located in Washington, contains the marine embayments known collectively as Puget Sound. These embayments occupy a drainage system which has been greatly modified by glaciation and consists of remnants of a glacial drift plain. The surface of the remnant plain is composed of low, flat-topped rolling hills and ridges separated by valleys and marine embayments.
 - Based on the USGS Port Gamble Quadrangle 7.5 Minute Series topographic map and the SITE visit, the SITE lies in a hilly, lowland area with a maximum elevation of approximately 90 feet msl. The general slope of the topography at the SITE trends in a northwest direction.
 - The direction of ground-water flow at the SITE may be towards Appletree Cove or northwesterly towards a tributary of Carpenter Lake and may generally follow the SITE topography.
 - Two missile silos exist on the western portion of the site. The silo doors are closed and appear to be intact. The missile silos do not contain significant accumulated water.

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NIKE SITE S-92
 KINGSTON, WASHINGTON

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SITE LOCATION MAP
 FIGURE 2-1

- 9 3 1 2 9 3 5 9 6 9 8
- Structures and buildings still present on the site include: barracks, sentry buildings, canine kennels, pump house, a ready building, two generator buildings (each with 2000 gallon underground fuel tanks), a missile assembly and test building a warheading enclosed by earth berms, and an acid storage shed. A wooden building has been constructed above the northern silo by the local fire department to assist in training. Figure 2-2 to Figure 2-6 show various buildings and structures at NIKE Site S-92.
 - The original site containment fence is still intact. The original gate to the installation is utilized, and the site is usually secured.

2.3 SITE LOCATION AND ENVIRONMENTAL FEATURES

Nike Site S-92 is located one mile west of Kingston, Washington (see Figure 2-1) about 17 miles northwest of Seattle on the western shore of Puget Sound. The site is contained in the northern uplands of the Kitsap Peninsula. The Kitsap Peninsula, bordered by Puget Sound on the east and the Hood Canal on the west, is underlain by as much as 1500 feet of Quaternary sediments consisting primarily of varying thicknesses of Pleistocene-aged fine-grained silts and clays alternating with coarser sands and gravels. Numerous glacial cycles occurred throughout the Pleistocene causing the accumulation of the interstratified fine and coarse grained material. The silts and clays were deposited in shallow lakes and swamps during interglacial periods. The sands and gravels are thought to have been deposited as both glacial drift and on the margins of mountain valleys (Garling, et al, 1965).

The primary water bearing unit in the Pleistocene strata is the Colvos Sand. This formation yields moderately large quantities of water for domestic supply. Above the Colvos Sand is a sequence of glacial outwash and till deposits which are

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FIGURE 2-2
MISSILE ASSEMBLY BUILDING



2-5



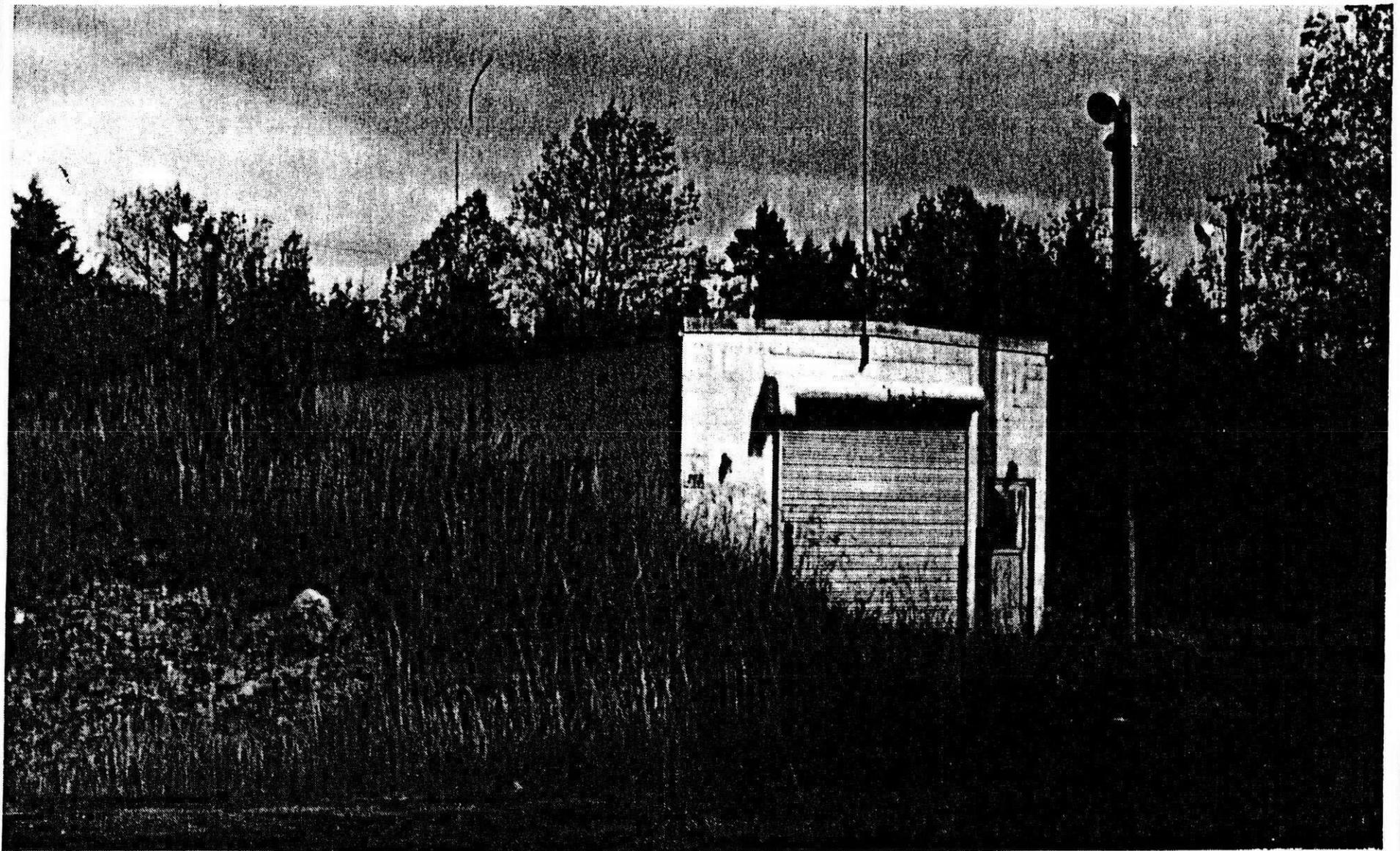
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9 3 1 2 9 3 5 0 7 0 0

FIGURE 2-3

WARHEADING BUILDING

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FIGURE 2-4
GENERATOR BUILDING



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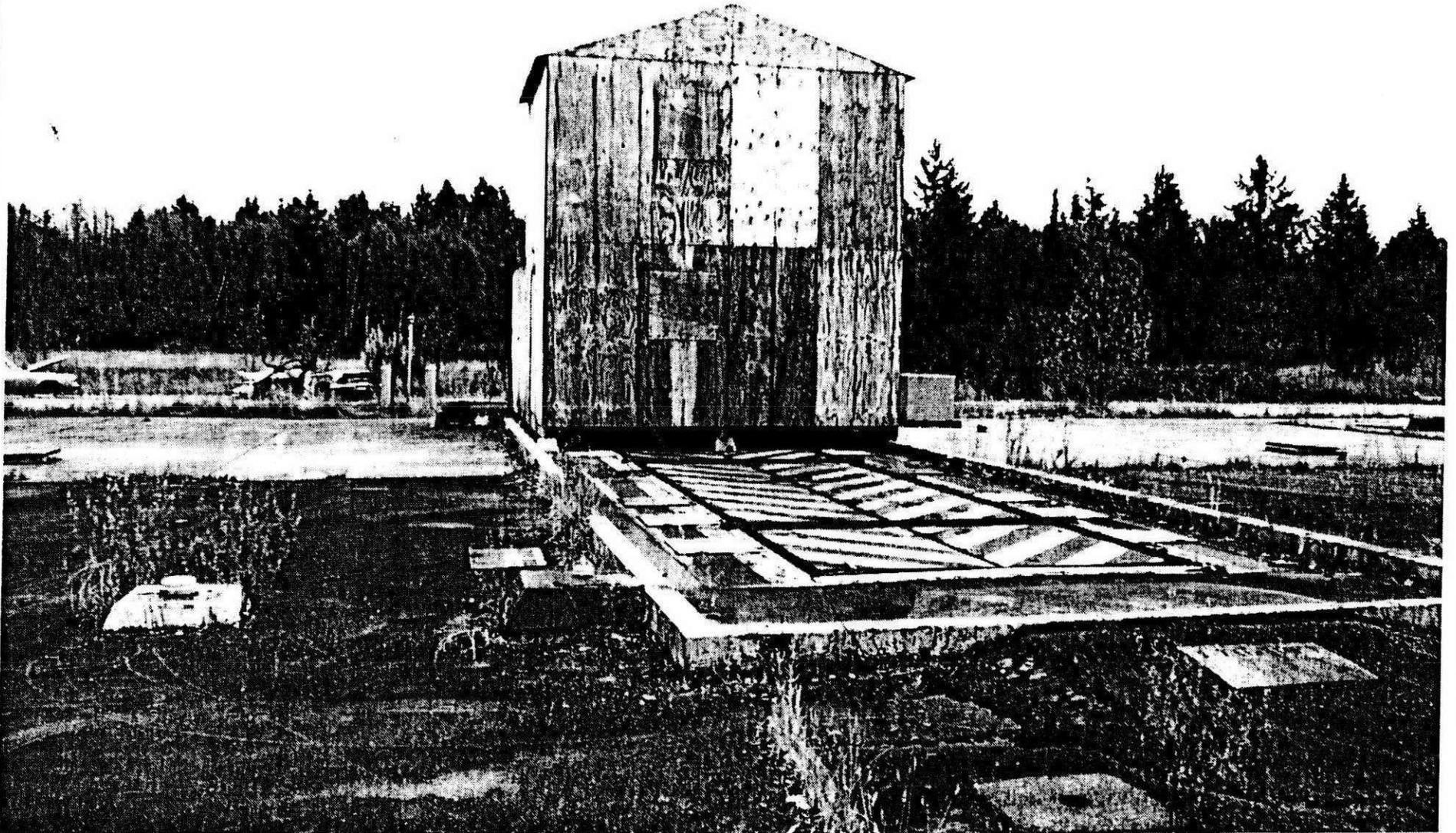
FIGURE 2-5
MISSILE SILOS



2-8



FIGURE 2-6
MISSILE SILO WITH FIRE TRAINING BUILDING



2-9



relatively impermeable. The glacial material contains some discontinuous zones of water bearing sands and gravel (Garling, et. al., 1965).

The ground water beneath the SITE is controlled primarily by the occurrence and extent of coarse-grained material and to a lesser degree by surface topography. The variations observed in water level elevations in the monitoring wells are most likely a reflection of perched water table conditions. The site specific stratigraphy and shallow ground-water system are discussed further in Section 4.0 of the report.

The Kitsap Peninsula has a uniform climate. Temperatures are generally moderate and extremes are unusual. Moderate to heavy precipitation occurs in the winter, but summers are usually somewhat dry. The average annual rainfall in Kitsap County ranges from 52 inches in the southwest to 18 inches in the north. The difference in precipitation is a result of the rain shadow formed by the Olympic Mountains. Precipitation occurs mainly as drizzle throughout the period October through March. The average annual temperature is approximately 50°F with July and January being the warmest and coldest months, respectively.

The land surface at the site (based on the Port Gamble, Washington 7.5 minute series USGS quadrangle) slopes unevenly from east to west. The highest elevation is on the eastern side of the site at about 90 feet mean sea level (msl). The lowest portion of the site, at about 80 feet msl, is in the northwest corner near the missile silos. Surface runoff from the site drains toward the west towards Carpenter Lake. A portion of the surface runoff drains southwest to Miller Bay. Both Carpenter Lake and Miller Bay flow ultimately into Puget Sound.

2.4 LAND USE

Land use in the immediate vicinity of the site is primarily rural residential. Single family residences predominate adjacent to

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the site along Gamble Road. The unincorporated town of Kingston is located approximately 1 mile east of the site. Kingston is the western terminal for the ferry across Puget Sound to Edmonds. Surrounding Kingston are numerous residential areas mixed with small dairy, poultry, and berry farms. Immediately adjacent to the facility are a number of residences on large plots of land and some unused woodland.

2.5 OWNERSHIP AND PRIOR USE

NIKE Site S-92 was constructed for the defense of Seattle. The original complex included three separate areas: the Launch Area containing 87 acres (total fee and easements), the Control Site containing 332 acres (total) and Family Housing containing four acres (fee-owned). The Launch Area was the only portion of the site studied under this investigation program.

Acreage for the site (Launch Area) was acquired between 1954 and 1969. The NIKE battery was deactivated in the late 1960's. The site was sold in 1976 to the North Washington School District. The school district uses the barracks building for classrooms and the missile assembly and warheading buildings for textbooks storage. Other open areas on the former NIKE site are used to store school buses, surplus equipment, and various debris. A caretaker lives at the site in a mobile home located adjacent to the barracks. The present owners are considering constructing a high school at the site.

Structures and buildings still present at the site include the following: barracks, pump house, generator building, missile assembly/test building, warheading building, two underground missile silos, canine kennels, and various guard houses. The auto shop, which was located adjacent to the missile assembly and test building (MATB), has been demolished.

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SECTION 3.0 - SITE INVESTIGATION

3.1 INTRODUCTION

The purpose of this investigation is to make a preliminary determination of whether DOD-caused contamination exists at NIKE Site S-92. Methods employed to make this determination are described in this section of the report. Specific items discussed are monitoring well installation and development procedures, and the sampling program conducted at the former missile site.

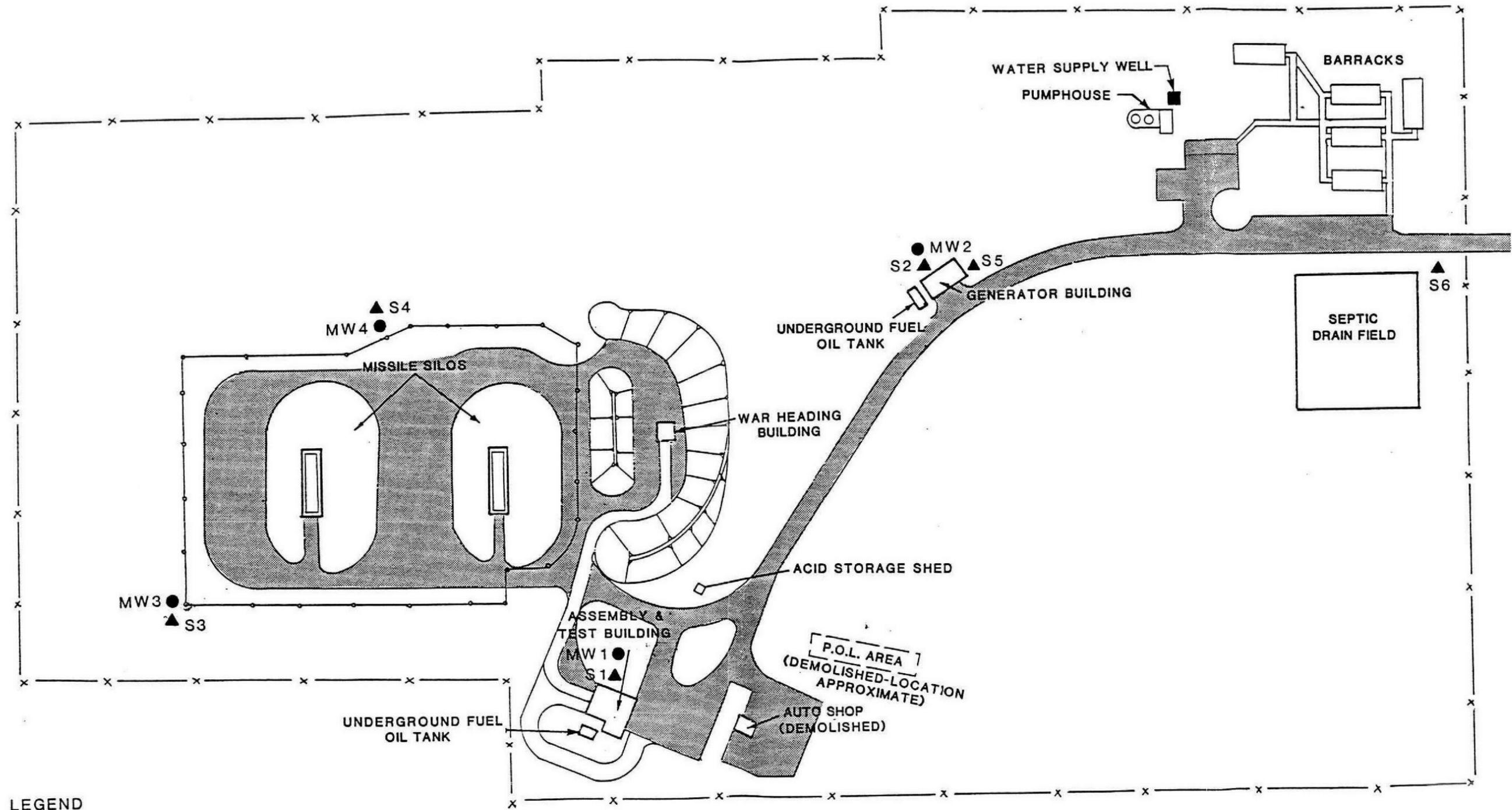
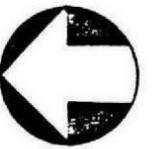
Prior to initiating any field activities, a site visit was performed by personnel from Law Environmental, Inc. The site visit had two purposes. The first was to collect background information regarding past activities at the site. The second purpose was to select specific locations for monitoring wells and other sampling. The site visit was performed during the week of November 10, 1986. Monitoring well and other sampling locations selected during the site visit are shown in Figure 3-1. These locations were selected as monitoring stations based upon data gathered during the initial site visit. The location of two of the monitoring wells were slightly changed during the field program to more optimally determine if contamination existed at the site. These changes are discussed in Section 3.3.

3.2 WORK PLANS

After the site visit and selection of proposed sampling stations, work plans were developed to describe planned site investigation procedures. Specific work plans developed for NIKE Site S-92 were:

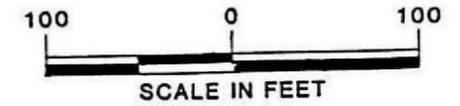
- Monitoring Well Installation Plan
- Sampling and Analysis Plan
- Site Specific Health and Safety Plan

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LEGEND

- MONITORING WELL LOCATION
- ▲ SOIL SAMPLING LOCATION
- WATER SUPPLY WELL LOCATION



NIKE SITE S-92
KINGSTON, WASHINGTON



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SAMPLING LOCATIONS
FIGURE 3-1

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These plans were the working documents that provided guidance for the field investigation procedures. The approved plans are presented in the Appendices I, J and K to this report. The Work Plans were sent to the Seattle District Corps of Engineers for review and approval. The notice to proceed was received in May, 1987; the actual field investigation program began in June, 1987.

For convenience, a brief outline of field techniques are presented in the following paragraphs along with field data gathered during the monitoring well installation activities, and the sampling program. Specific details regarding field methods are presented in the Appendices.

3.3 MONITORING WELL INSTALLATION

Four shallow ground-water monitoring wells were installed to investigate specific subsurface areas at NIKE Site S-92. Soil samples were taken during the installation of each monitoring well. The wells were installed and completed according to the approved Monitoring Well Installation Plan (contained in Appendix I). The following sections briefly discuss monitoring well drilling, construction, development and permeability testing.

3.3.1 Monitoring Well Locations

The location of monitoring wells installed at Site S-92 are shown in Figure 3-1. Each location is discussed below:

- Monitoring Well MW1

Monitoring Well MW1 is located in the western portion of the Launch Area near the MATB. The well was positioned to intercept contamination which may have originated from activities at this building or from the adjacent underground fuel tank. This well is also in the vicinity of the former Petroleum, Oils, and Lubricants (POL) area.

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- Monitoring Well MW2

Monitoring Well MW2 is just east of the generator building. An underground diesel tank is buried adjacent to the generator building, and MW2 was installed at this position to monitor potential releases from the tank.

- Monitoring Well MW3

Monitoring Well MW3 is located in a low area northwest of the silo area. The proposed location of this well was adjacent to the northern silo. The new location was selected because surface runoff from a large portion of the site appeared to collect in this area. Monitoring Well MW3 was installed at this location to intercept potential contamination from the silo sump discharge system and the silo area in general.

- Monitoring Well MW4

Monitoring Well MW4 is east of the silo area between the two missile silos. The location is adjacent to a drainage ditch which encircles the silo area. The silo sump system appeared to discharge directly to this area. The well was located in this position to monitor potential releases from the silo sump. The proposed position of this well had been adjacent to the former POL area. The well location was altered because the POL facility had been demolished and was difficult to locate accurately.

3.3.2 Monitoring Well Construction

The Monitoring Well Installation Plan for NIKE Site S-92 states that the soil test boring should be terminated after penetrating about 10 feet into the water table or at auger refusal. A 2-inch PVC well was constructed after drilling the borehole to the

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specified depth. The monitoring well was constructed in each borehole with the following materials: 2-inch ID PVC, threaded, flush-joint, No. 10 (0.010 inch) pre-manufactured screen; 2-inch PVC, threaded, flush-joint, solid riser pipe; non-carbonate silica sand; bentonite pellets; grout mixture (cement, bentonite, and water); steel security cap with lock; and, protective steel posts. A concrete well pad (4 inches x 3 feet x 3 feet) was constructed around each well.

A Mobile B-61 rig was used to install the monitoring wells at Site S-92. The rig was equipped with 4-inch ID hollow stem augers. No unusual circumstances occurred during the drilling program that necessitated changes to the basic program described in the Monitoring Well Installation Plan (see Appendix I). Each well was installed as follows: complete the boring with hollow stem augers, sampling with a split spoon sampler continuously for the first ten feet of the boring, then every five feet to the termination depth; assemble the 2-inch PVC screen and risers inside the hollow stem augers; add the sand pack and bentonite seal through the annular space between the augers and the PVC casing; remove the augers from the borehole; wet the bentonite pellets and allow swelling for 30 minutes; mix and add cement-bentonite grout; and construct surface protection system (pad, steel casing, protective posts, etc.). Table 3-1 shows when each monitoring well was drilled and completed, and other pertinent information on well construction details.

A copy of the daily log of activities is contained in Appendix B along with the final test boring records, field boring logs, and geotechnical analytical data. The daily logs contain information regarding quantities and types of material used at the site; the test boring records show relevant stratigraph data on each well and well construction information; the field boring logs are copies of the actual log completed by the field geologist; and the geotechnical analytical results contain grain size analyses,

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TABLE 3-1

WELL CONSTRUCTION DATA
 NIKE SITE S-92
 KINGSTON, WASHINGTON

<u>Well Number</u>	<u>Depth</u> ⁽¹⁾	<u>Screen Length</u>	<u>Sand Pack</u> ⁽²⁾	<u>Bentonite Layer</u> ⁽²⁾	<u>Grout Layer</u> ⁽²⁾	<u>Date Installed</u>
MW1	33.0	10	15.5	2.0	15.5	6/24/87
MW2	27.5	10	13.5	2.0	12.0	6/24/87
MW3	35.0	10	12.0	2.0	21.0	6/24/87
MW4	25.5	10	15.5	2.0	8.0	6/27/87

(1) Approximate depth below ground surface.

(2) Approximate thickness of material in well column.

All measurements in feet.

moisture content and Atterberg limits (where applicable) for two samples for each boring. These data are discussed in greater detail in Section 4.0.

3.4 MONITORING WELL DEVELOPMENT

Well development was accomplished on June 29, 1987. After allowing the grout seal and pad to cure, each well at NIKE Site S-92 was developed manually using teflon bailers. Development generally occurred no sooner than 48 hours after installation. The purpose of well development is three-fold: to remove fine particles (silt and clay) that were introduced into the well during the drilling process; to assure a good hydraulic connection between the aquifer and the well; and to remove any contamination inadvertently introduced during the drilling process. Well development data are summarized in Tables 3-2 and 3-3. Forms completed in the field during well development are presented in Appendix D. Data recorded in the field included: date, static water level, quantity of water standing in the well (including the sand pack), water quality data details, physical characteristics of water, development equipment, surge techniques and water quantity removed. The wells were allowed to stabilize for at least 24 hours before collecting water quality samples. Table 3-3 shows measurements for specific parameters used to monitor the development water (pH, specific conductance, temperature) during different stages of well development. No major variations in these parameters were noted during well development.

3.4.1 Water Levels

Static water level measurements were obtained during the permeability testing. This data, along with surveyed well-head elevations, are presented in Table 3-4. The water levels in the monitoring wells at the site are between 17.37 feet and 28.00 feet below the top of the PVC casings. These water level

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TABLE 3-2

WELL DEVELOPMENT DATA
NIKE SITE S-92
KINGSTON, WASHINGTON

<u>Well No.</u>	<u>Development Process</u>	<u>Quantity of Water in Well</u> (gallons)	<u>Quantity of Water Removed</u> (gallons)	<u>Time for Removal</u> (hours/minutes)	<u>Date</u>
MW 1	Teflon bailer	25	125	5/35	6/29/87
MW 2	"	14	70	6/30	6/29/87
MW 3	"	14	70	6/30	6/24/87
MW 4	"	14	70	4/0	6/29/87

TABLE 3-3

WELL DEVELOPMENT MEASUREMENTS
NIKE SITE S-92
KINGSTON, WASHINGTON

<u>Well Number</u>	<u>pH</u>	<u>Specific Conductance</u> <u>umhos/cm</u>	<u>Temperature</u> °C	<u>Date</u>
MW1	7.0	260	14.0	6/29/87
MW2	5.7	11	14.5	6/29/87
MW3	6.3	560	14.0	6/29/87
MW4	6.3	150	13.0	6/29/87

All measurements reflect readings at the end of well development

TABLE 3-4

WATER LEVELS
 NIKE SITE S-92
 KINGSTON, WASHINGTON

Well No.	TOC (1) (feet)	Date	Water Surface (feet below TOC)	Water Elevation (feet)	Coordinates (2)	
					Northing	Easting
MW1	89.70	6/30/87	17.37	72.33	294,689.59	1,586,517.30
MW2	91.97	6/30/87	20.97	71.00	294,420.92	1,586,885.11
MW3	87.81	6/30/87	28.00	59.81	294,926.24	1,586,559.44
MW4	89.82	6/30/87	19.41	70.41	294,926.24	1,586,811.37

Notes: (1) TOC - Top of well casing elevation based on finished floor elevation of MATB 262.19 feet
 (2) Washington State coordinates

TABLE 3-5

PERMEABILITY TEST DATA
NIKE SITE S-92
KINGSTON, WASHINGTON

Well No.	Type Test	SWL ⁽¹⁾ (from TOC)	Permeability ⁽²⁾ (cm/s)	Date
MW 1	Slug in	17.37	1.98×10^{-4}	6/30/87
MW 2	Slug in	20.97	1.10×10^{-3}	6/30/87
MW 3	Slug in	28.00	9.53×10^{-3}	6/30/87
MW 4	Slug in	19.41	2.11×10^{-4}	6/30/87

- (1) SWL - Static Water Level from TOC (Top of Casing)
(2) From Bouwer and Rice (1976) calculation

3.6 SAMPLING PROGRAM

Sampling at NIKE Site S-92 was performed during the drilling program (geotechnical samples) and on July 17, 1987 (water quality and soil samples). Specific sampling protocols are contained in Appendix J - the Sampling and Analysis Plan. Information relative to field drilling and sampling activities is presented here.

3.6.1 Geotechnical Data

Drilling at NIKE Site S-92 was initiated during the week of June 22, 1987. The wells were drilled with a Mobile B-61 truck mounted drilling rig. Overburden samples were obtained with a split spoon sampler at various depths. Two samples from each boring were analyzed for grain size distribution, moisture content, and Atterberg limits. The laboratory results are presented in Table 3-6.

3.6.2 Ground-Water Sampling

Monitoring wells were purged with a 1.5" x 3' Teflon bailer prior to sampling. Work plan specifications required that five well casing volumes be purged from each well. Table 3-7 shows purging data for the Site.

A Field Sampling Report, (included in Appendix F), was kept for each monitoring well during sampling. The samples were designated MW1 through MW4 corresponding to wells MW1 through MW4. The duplicate sample designated MW-D, is a duplicate of MW1. In addition to the four monitoring wells sampled, ground water was also collected from a supply well which is still in use at the site. The supply well sample was designated MW5 and was obtained from a faucet adjacent to the pump house. Table 3-8 lists the numbers and types of all water samples taken at NIKE site S-92 and the parameters for analysis.

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TABLE 3-6

SOIL LABORATORY DATA
NIKE SITE S-92
KINGSTON, WASHINGTON

<u>I.D. Number</u>	<u>Sample Interval(ft)</u>	<u>% Sand/Gravel</u>	<u>% Silt/Clay</u>	<u>Unified Soil Classification</u>	<u>Moisture(%)</u>	<u>Atterberg Limits</u>		
						<u>LL</u>	<u>PL</u>	<u>PI</u>
MW 1-6	7.5 - 9.0	3.6	96.4	ML	24.7	----NONPLASTIC----		
MW 1-10	23.0 - 24.5	93.0	7.0	SP-SM	7.8	----NONPLASTIC----		
MW 2-6	7.5 - 9.0	79.5	20.5	SM	19.5	----NONPLASTIC----		
MW 2-11	27.5 - 29.0	68.8	31.2	SM	20.5	----NONPLASTIC----		
MW 3-9	18.0 - 19.5	1.0	99.0	ML	22.9	----NONPLASTIC----		
MW 3-12	33.0 - 34.5	74.2	25.8	SM	19.3	----NONPLASTIC----		
3-14 MW 4-7	9.0 - 10.5	63.8	36.2	SM	18.3	----NONPLASTIC----		
MW 4-10	23.5 - 25	86.4	13.6	SM	13.3	----NONPLASTIC----		

LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

<u>Classification</u>	<u>% Silt/Clay</u>
SP or SW	<5
SP-SM	5-12
SP-SC	5-12
SM	>12
SC	>12
ML or CL	>50
MH	>50

TABLE 3-7

WELL PURGING DATA
 NIKE SITE S-92
 KINGSTON, WASHINGTON

Well No.	SWL ⁽¹⁾ (feet)	Quantity in Well ⁽²⁾ (gallons)	Quantity Purged (gallons)	Well Volumes Purged	Date
MW 1	17.46	2.4	12.0	5	7/17/87
MW 2	19.42	1.5	7.8	5	7/17/87
MW 3	27.91	1.4	7.1	5	7/17/87
MW 4	19.44	1.2	6.0	5	7/17/87

(1) SWL - Depth in feet from Top of Casing (TOC) to Static Water Level (SWL) measured 7/17/87

(2) Quantity in well casing

Five types of QA/QC samples for NIKE Site S-92 were analyzed by the laboratory. These samples consisted of duplicates, replicates, spikes, travel blanks and sampler rinsates. In addition to these samples, the laboratory has designated method blanks, which are internal QA samples used to analyze method controls, instrument calibration and internal QA procedures. Complete analytical results and QA/QC results are in Appendices F and G, respectively.

Duplicates of a ground-water sample and a soil sample were collected at the site. The ground-water sample duplicate was taken at MW1. No purgeable aromatics, purgeable halocarbons or petroleum hydrocarbons were detected in the ground-water field sample. Although methylene chloride was detected in the duplicate sample and not the field sample, results from the ground-water duplicate are consistent with the field sample. The detection of methylene chloride in the samples is suspect and will be discussed in the following section. The following results were obtained for ground-water parameters present in MW1 and the duplicate.

<u>Parameter</u>	<u>MW1</u>	<u>MW D (duplicate)</u>
Arsenic	0.009 ppm	0.008 ppm
Barium	0.250 ppm	0.245 ppm
Cadmium	<0.005 ppm	0.012 ppm
Chromium	0.047 ppm	0.051 ppm
Lead	0.012 ppm	0.010 ppm

The soil sample duplicate was collected from the S-1 field sample. No purgeable aromatics were detected in the soil samples. The purgeable halocarbon methylene chloride was present in both the field and duplicate samples. The methylene chloride results are suspect and will be discussed in the following section. The consistency between duplicate and field sample were good for all metals. Metals which were present above the detection limit in S-1 and the duplicate are noted as follows:

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8
9
0
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4
5
6
7
8
9
0

<u>Parameter</u>	<u>S-1</u>	<u>S-D (duplicate)</u>
Arsenic	2.44 ppm	2.22 ppm
Barium	72.70 ppm	67.10 ppm
Chromium	33.80 ppm	37.70 ppm

Replicate samples are aliquots of a single sample that is split on arrival at the laboratory or when analyzed. Replicates are analyzed as separate samples and compared to the original samples, yielding a relative percent difference. One water samples (MW1) was replicated and no constituents were detected in either the original or replicated analysis.

Spikes are known amounts of analyte that are added to a sample. Both the sample and the spiked sample are analyzed and the results compared. If the spike analyses is accurate, the percent recovery should equal the amount of analyte actually added. The spike technique is routinely used in the laboratory to calibrate equipment. Table 4-5 shows the results of the spike analyses. Percent recovery for purgeable organics (both aromatics and halocarbons) in soil ranged between 91 -127 percent. The spike analysis for purgeable organics in water resulted in percent recoveries between 58 - 94 percent. EPA Quality Control Advisory Limits have been established to determine acceptable spike percent recoveries for various parameters. All samples analyzed are within the EPA QC advisory limits except one water matrix spike which was three percent below advisory limits. These results are acceptable as the guidelines set by EPA for percent recoveries are advisory and are not standards for laboratory performance.

Surrogate spikes are compounds which are similar to the analyte in chemical composition, extraction and chromatography, but is not normally found in the field sample (EPA, 1986). A common tracer element used in surrogate spikes is deuterium. The surrogate spike sample is analyzed and the percent recovery of

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TABLE 4-5
 Quality Control: Percent Recovery
 For Spike Samples
 NIKE Site S-13/14

Parameter	Medium	Percent Recovery (range)	EPA QC ⁽¹⁾ Limits (%) (range)
PURGEABLE ORGANICS (aromatics + halocarbons)	Soil	91 - 127	59 - 172
	Water	58 - 94	61 - 145

(1) EPA advisory limits

Source (Organics): EPA, June 15, 1984.

Source (Inorganics): EPA, January 20, 1984.

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the added chemical is computed. Percent recoveries for organics in soil ranged from 59 - 102 percent. Recoveries for organics in soil ranged from 37 - 108 percent. Except for one water sample spike, the percent recoveries were within guidelines established by the EPA.

A travel blank for the ground-water samples was analyzed for purgeable organic compound (purgeable aromatics and halocarbons). A travel blank is a vial of de-ionized water which accompanies the empty sample bottles to the field and accompanies the samples from the field to the lab. Both methylene chloride and 1,1,1-trichloroethane were detected in the travel blank for ground water. The presence of these two constituents indicate that contamination may have been introduced during sample collection, shipment, or analysis. A travel blank for soil was shipped to the laboratory, but was not analyzed due to technician error.

Method blanks are samples of de-ionized water which originate in the laboratory and are used to analyze method controls, instrument calibration, and internal QA. Method blank analyses were performed for organic constituents in both ground water and soil. The method blank analyses for ground water and soil detected methylene chloride. These results indicate that the methylene chloride detected in the field samples can be attributed to poor instrument calibration or laboratory contamination.

A sample rinsate was collected from the ground-water (Teflon bailer) and soil samples (stainless steel hand auger) to monitor field cleaning techniques. Sample rinsates consisted of de-ionized water which was passed through the sampler and subsequently analyzed for the same parameters as the field samples. Two purgeable halocarbons, 1,1,1-trichloroethane and methylene chloride, were detected in the ground-water rinsate and in the soil rinsate. The concentration of 1,1,1-trichloroethane was 0.035 mg/L in the ground-water rinsate and 0.034 mg/L in the soil rinsate. The concentration of methylene chloride was <0.005

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9 3 1 2 9 3 5 0 7 2 5

mg/l in the ground-water rinsate and 0.006 mg/l in the soil rinsate. Since no 1,1,1-trichloroethane was present in any of the other samples, it is most likely that the de-ionized water utilized for generating the rinsate samples was contaminated. Inquiries were made to determine if USACE QA samples contained the same constituents, and it was confirmed that the QA sample had about the same concentration as the other rinsates. Therefore, after discussions with the Corps Project Manager and MRD Laboratory personnel, it was agreed that the 1,1,1-trichloroethane in the rinsates would be attributed to the de-ionized water used for the rinsate samples. The presence of methylene chloride in the rinsate can most likely be attributed to laboratory contamination.

Document control was used in this investigation to provide QA/QC for sampling protocol and sample Chain-Of-Custody. Documents were completed and signed in the field by the sampling personnel to assure adherence to QA/QC guidelines.

Field Sampling Reports were completed at each sampling location. These documents included sample identification, number and type of sample containers, and preservation method. The Field Sampling Reports also record the sampling personnel, the sampling method, and specific sampling protocol. The Field Sampling Reports for NIKE Site S-92, contained in Appendix G, record the QA/QC data for sampling.

A Cooler Shipping Form was completed for the sample coolers which contained media samples from NIKE Site S-92. This form provides a checklist to guarantee proper shipment of samples to the analytical laboratory. The Cooler Shipping Form for NIKE Site S-92, contained in Appendix G, indicates that the samples were packaged, labeled, and shipped according to QA/QC guidelines.

Chain-of-Custody Reports were maintained for each of the three coolers used to ship samples to the analytical laboratory. The reports were completed by field sampling personnel and the

scientist who received the samples at the laboratory. These reports indicate that all the samples were received by the laboratory in satisfactory condition for the requested tests. Chain-of-Custody Reports are contained in Appendix G with the other QA/QC results.

A sample tracking record is shown in Table 4-6. All samples were analyzed in accordance with EPA specified holding times guidelines. Specified holding times were dictated by the Work Plans which are contained in Appendix J.

4.5 FACTORS INFLUENCING RESULTS

4.5.1 Metals

Total metal analysis on ground water samples concentrations were above detection levels for arsenic, barium, cadmium, chromium, and lead. The analytical tests were performed on unfiltered samples as specified by the USACE contract. Dissolved metal analysis performed on filtered samples indicated only barium above concentration limits. This difference has also been reported at other NIKE sites and can most probably be attributed to turbidity (suspended soil particles) in the ground water samples.

The ground-water samples varied from slightly to very turbid. This variability is typical for shallow monitoring wells constructed in fine grained unconsolidated sediments. The turbidity is the result of clay and silt particles in suspension in the monitoring wells. Metallic cations are adsorbed to the surface of these suspended soil particles. Acidification which is the initial step in the preservation of total metals samples lowers the pH, dissolves the adsorbed cations and puts them into solution. Thus, the analyses for metals in unfiltered, turbid ground-water samples tend to result in elevated total metal concentrations in comparison with filtered metals analyses. Braids and Burger (1987) reported similar results and concluded

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TABLE 4-6
 SAMPLE TRACKING RECORD
 NIKE SITE S-92
 KINGSTON, WASHINGTON

ANALYSIS	MEDIA	DATE SAMPLED	LAB RECEIPT	DATE ANALYZED	SPECIFIED MAX. HOLDING PERIOD ⁽¹⁾	MAXIMUM HOLDING PERIOD
METALS	Soil	7/17	7/20	7/31 - 8/5	6 months	1 month
	Ground water	7/17	7/20	7/29 - 8/5		1 month
EXTRACTABLES	Soil	7/17	7/20	8/4	7 days until extraction &	18 days for analysis on extracted solution
4-15 PURGEABLE ORGANICS	Soil	7/17	7/20	7/29	14 days	12 days
	Ground water	7/17	7/20	7/23 - 7/29	14 days	6 - 12 days
PET. HYDROCARBONS	Ground water	7/17	7/20	8/10	None specified	24 DAYS

(1) Mercury specified maximum holding time 28 days

that elevated concentrations of total metals are a direct result of sample turbidity, and are not indicative of site contamination.

The sample rinsate for ground-water and soil were both found to have concentrations of 1,1,1-trichloroethane. This constituent has been attributed to contamination in the de-ionized water utilized for preparing the sample rinsate. The USACE laboratory agrees that a contaminated source of de-ionized water was the cause.

Methylene chloride was detected at low concentrations in all of the soil samples, in all but one ground-water sample, in both soil and ground-water rinsates, and in the ground-water travel blank. The methylene chloride concentrations for ground-water ranged from less than 0.005 mg/l (in MWD and MW5) to 0.007 mg/l (in the travel blank). The methylene chloride concentration for soil ranged from less than 0.5 mg/l (in S-2, S-3, and S-4) to 1.9 mg/l (in the soil Method Blank). Methylene chloride is used extensively in laboratory analytical procedures. The ubiquitous presence of methylene chloride in the field, duplicate, and QC samples indicates that the concentrations measured in the field samples may be a result of laboratory contamination. The method blanks consistently showed greater methylene chloride concentration than that of the field samples. Therefore, methylene chloride measured in the field samples can be attributed to contamination in the laboratory and does not reflect methylene chloride contamination at the site.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The objective of this investigation has been to perform an initial inventory of the ground-water and soils at NIKE Site S-92 to determine if contamination exists that might be related to former DOD activities. Four ground-water monitoring wells were installed at the site and ground-water samples from the wells, water from an existing water supply well, and soil samples from around the site were analyzed for potential contaminants. Previous sections have described general and background information, investigation procedures, and analytical results from the sampling program at NIKE Site S-92. The following sections discuss conclusions derived from the analytical results, and recommendations based on these results.

5.2 CONCLUSIONS

The analytical results for this study are summarized in Tables 4-2 and 4-4 of this report. Appendix F contains the complete laboratory results. Tables 5-1 and 5-2 list the maximum ground water and soil concentrations of the parameters detected at NIKE Site S-92. For comparison, the table containing ground water results also lists regulatory criteria established by the Safe Drinking Water Act.

5.2.1 Ground Water

Results from total (unfiltered) metals analysis indicated concentrations above the Maximum Contaminant Levels (MCLs) for cadmium and chromium. However, dissolved (filtered) metal analysis indicated only barium above the detection limit and all concentrations below the MCLs. As discussed in Section 4.6, the results of the total metal analyses on unfiltered samples are

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TABLE 5-1

Summary of Ground Water Contaminant Levels
 Compared to Current Standards and Criteria
 NIKE Site S-92
 Kingston, Washington
 All results in Mg/L (ppm)

Parameter	Maximum GW Conc. (Total)	Maximum GW Conc. (Dissolved)	MCL ⁽¹⁾
Metals			
Arsenic	0.02	<0.005	0.05
Barium	0.699	0.399	1.00
Cadmium	0.012	<0.005	0.01
Chromium	0.118	<0.010	0.05
Lead	0.026	<0.005	0.05
Purgeable Halocarbons			
Methylene Chloride	0.005	NT	35 ⁽²⁾

(1) Maximum Contaminant Level, Safe Drinking Water Act, 1986 Amendments

(2) Suggested No Adverse Response Limit, Drink Water and Health, Volume 3, 1980

NT = Not Tested

TABLE 5-2

Summary of Soil Contaminant Levels
 Compared to Average Background Levels
 NIKE Site S-92
 Kingston, Washington
 All Results in Mg/L (ppm)

Parameter	Maximum Soil Conc.	Bowen, 1966 ⁽¹⁾
Metals (Total)		Avg. (Range)
Arsenic	2.90	6 (1-40)
Barium	100	500 (100-3000)
Cadmium	<1.0	0.06 (0.01-0.7)
Chromium	33.8	100 (5-3000)
Lead	11.9	10 (2-200)
Mercury	<0.10 ⁽²⁾	0.03 (0.01-0.3)
Selenium	<2.0 ⁽²⁾	0.2 (0.01-2)
Silver	<2.0 ⁽²⁾	0.1 (0.01-5)
Purgeable Halocarbons		
Methylene Chloride	0.70	NA ⁽³⁾

(1) Composition of Soils, 1966

(2) Constituent not detected. Detection limit listed.

(3) Average background level established for inorganic constituents only.

probably affected by sample turbidity and do not necessarily represent contamination of ground water. In our opinion, metals contamination was not encountered in ground water at the site.

Low concentrations of methylene chloride were detected in all the ground-water samples except MW1. Methylene chloride was also found in the sampler rinsate, the travel blank, and the laboratory method blank. Therefore, the low levels of methylene chloride are most likely a result of laboratory contamination and not indicative of DOD contamination at NIKE Site S-92.

5.2.2 Soil

The soils at NIKE Site S-92 contain concentrations of metals which are generally within the average range of soils reported by Bowen (1966). Metal concentrations of soil at the site is most likely a reflection of natural soil composition and not indicative of contamination.

Methylene chloride was detected in all the soil samples, the sampler rinsate, and the laboratory method blank. The presence of methylene chloride is most likely a result of laboratory contamination and does not represent contamination at the site.

5.3 PRELIMINARY DETERMINATION AND RECOMMENDATION

The analytical tests showed the following: (1) methylene chloride was the only organic compound detected in the ground-water samples; (2) cadmium and chromium were the only metals present in the unfiltered ground-water samples in concentrations above the maximum contaminant levels (MCLs); (3) methylene chloride was the only organic compound detected in the soil samples; (4) the concentrations of metals detected in the soil sample were within average background levels.

Based on the analytical results, the following conclusion and recommendations are made:

9 3 1 2 9 3 5 0 7 3 2

- 9 3 1 2 9 3 5 0 7 3 3
- (1) The low levels of methylene chloride detected in all the soil samples and all but one of the ground-water samples appear to be related to laboratory contamination. The sampler rinsates, travel blanks, and analytical method blanks contained generally higher levels of methylene chloride than the field samples. Therefore, any methylene chloride detected in the samples most likely originated in the laboratory and is not present at the site.
 - (2) As discussed previously, elevated total metal concentrations of cadmium and chromium are caused by sample turbidity, and are not considered indicative of site contamination. Dissolved metal concentrations were below the MCLs. Based on these findings, we have concluded that metals contamination is not present within the site ground-water.

Based on these findings and similar findings from other NIKE sites, it has been concluded that the high metals in the unfiltered samples are due to turbidity and are not indicative of contamination at the site.

- (3) Metals concentrations of the soil samples were generally low and within natural background levels. No metals contamination appears to be present in the soils at the site.

Based on the preceding conclusions, it appears that no contamination exists in the soil or ground water sampled at NIKE Site S-92. The site should not be referred to the Missouri River Division (MRD) for further investigation.

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TABLE 3-8

NUMBER AND TYPES OF GROUND-WATER
 SAMPLES AND PARAMETERS FOR ANALYSIS
 NIKE SITE S-92
 KINGSTON, WASHINGTON

Sample Type	Number of Samples	Parameters			
		Purgeable Aromatics	Purgeable Halocarbons	Total Metals	Petroleum Hydrocarbons
Field	5	x	x	x	x
Control					
duplicate (A-E)	1	x	x	x	x
duplicate (USACE)	1	x	x	x	x
QA/QC					
sampling blank (A-E)	1	x	x	x	x
sampling blank (USACE)	1	x	x	x	x
trip blank (A-E)	1	x	x		
trip blank (USACE)	1	x	x		

NOTES:

A-E Law Environmental

USACE United States Army Corps of Engineers

Ground water samples collected at the site included: five field samples duplicate field samples (from well MW1), a ground water sample, rinsate, and a trip blank (filled in the laboratory before shipment to the site). Quality control samples were also collected for the USACE. Following collection of the samples, the equipment was cleaned to prevent cross-contamination. Analytical results for the ground water samples are contained in Section 4.2.

3.6.3 Shallow Soil Sample Locations S-1 through S-6

Shallow soil samples were collected at six locations on the site using a stainless steel hand auger. The sample depths ranged between 1.0 - 2.0 feet for all soil samples. Analytical results for these samples are presented in Section 4.4. Figure 3-1 shows the sampling locations. Table 3-9 lists numbers and types of soil samples collected and the parameters for analysis. Below is a description of the location and the rationale for each location.

- Soil sample S-1 was taken near Monitoring Well MW1, east of the MATB. The location was selected to monitor potential contaminants in the soil around this facility.
- Soil sample S-2 was collected between Monitoring Well MW2 and the generator building. This location was selected to monitor potential contaminants related to the underground fuel tank and the generator building.
- Soil sample S-3 is located in the vicinity of Monitoring Well MW3 in the low area northwest of the silos. This location was intended to monitor potential contaminants which may have accumulated in this location as a result of surface runoff.

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TABLE 3-9

NUMBER AND TYPES OF SOIL SAMPLES
AND PARAMETERS FOR ANALYSIS
NIKE SITE S-92
KINGSTON, WASHINGTON

Sample Type	Number of Samples	Parameters			
		Purgeable Aromatics	Purgeable Halocarbons	Total Metals	Base/Neutral Extractables
Field	6	x	x	x	x (1 sample only)
Control					
duplicate (A-E)	1	x	x	x	
duplicate (USACE)	1	x	x	x	
QA/QC					
sampling blank (A-E)	1	x	x	x	x
sampling blank (USACE)	1	x	x	x	x
trip blank (A-E)	1	x	x		
trip blank (USACE)	1	x	x		

NOTES:

A-E Law Environmental

USACE United States Corps of Engineers

- 9 3 1 2 9 3 5 0 7 3 8
- Soil sample S-4 is located adjacent to Monitoring Well MW4 which is east of the silo area. Contaminants may have come from operation of the silo sump discharge system.
 - Soil sample S-5 is east of the lower generator building pad between the pad and the transformer area adjacent to the pad. In addition to the other constituents, this sample was analyzed for polychlorinated biphenyls (PCBs).
 - Soil sample S-6 is the background sample. Results from the background sample are the basis for comparison of soil analytical results. The sample was taken in the southern part of the site near the barracks. This location was isolated and generally upgradient from the northern part of the site where contamination was more likely because of the silos, generator building, and MATB.

3.6.3.1 Sampling Procedure

Soils for chemical analysis were collected with a stainless steel hand auger. The auger portion itself was about a foot long and three inches wide. At approximately one to two foot depth, the filled auger was put in a stainless steel bowl. Using a stainless steel spoon, the 40-ml vials for purgeable aromatics and purgeable halocarbon (volatile organics) were filled directly from the hand auger. There was no mixing of the soil at this point. After all samples for volatile organics were taken, the rest of the auger was emptied into the bowl. At sampling locations which were chosen for duplicate samples, a second auger-full of soil was required. This soil was mixed with the remains of the first auger in the stainless steel bowl using a stainless steel spoon. Samples for total metals (and base neutral extractables at one location) were taken from this mixed soil. Specific sampling procedures are outlined in the Sampling and Analysis Plan (Appendix J). Figure 3-1 shows all site sampling locations.

Soil sampling included collection of the following samples: six field samples, duplicate field samples (duplicate at S-1), soil equipment rinsate, and a trip blank (filled in the laboratory before shipment to the site). Quality control samples were also collected for the USACE. Following collection of the sample, the equipment was cleaned to prevent cross-contamination.

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4.0 - TEST RESULTS

4.1 SUMMARY OF SITE CHARACTERISTICS

NIKE Site S-92 lies within the Puget Trough section of the Pacific Border physiographic province. The Kitsap Peninsula, on which the site lies, consists of glacially modified highlands and rolling plains separated by marine embayments and river valleys. The river valleys are covered by recent alluvial deposits, while the highlands and plains are covered by stratified and unstratified glacial deposits (i.e., glacial till, stratified glacial drift). Ground-water in the region comes predominantly from alluvium and stratified glacial deposits.

The shallow monitoring wells drilled at Site S-92 encountered glacial till (i.e., unstratified and unsorted deposits) in every boring. Glacial till is characterized by a wide range of grain sizes and a lack of stratification in the samples. Glacial drift was also encountered in all the shallow borings. The best example of drift is the dense silty fine to coarse sand and rounded gravel which was encountered in all four borings at a depth of approximately 20 feet. The drift contained the coarsest material and most productive water-bearing strata.

Ground-water was encountered in the borings at depths between 17 feet and 28 feet below the ground surface. The elevation of the ground-water beneath the site ranges from about 60 feet to about 72 feet. The highest water level elevation is in Monitoring Well MW1, which is topographically below MW2 and MW4. The lowest ground water elevation is found in Monitoring Well MW3, which is the lowest topographically. The water table elevation drops 12 feet in the 400 feet which separates MW1 and MW3, while the ground surface drops only 1.6 feet. Therefore, the shallow ground water system appears to be controlled by the occurrence of the glacial drift more than the topography of the ground surface. Although the land surface slopes from southeast to northwest, the

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water table encountered in MW1, MW2, and MW4 slopes in the opposite direction.

The layers of coarse-grained drift, which appear to be the water-bearing stratum, may not be interconnected. Ground-water may be present only in discontinuous pods of glacial drift or in perched zones. Water encountered in MW1 appears to be under confined conditions, because once the drift material was encountered during drilling, the water level rose above the level that the water was encountered.

The hydraulic conductivity values determined for the four wells range from 10^{-4} to 10^{-2} centimeters/second (cm/s). This range of values is typical for the wide grain size distribution of glacial material. The higher conductivities measured represent the sand and gravel of the drift deposits.

4.2 GROUND WATER ANALYTICAL RESULTS

Four monitoring wells and one water supply well were sampled in accordance with the Work Plan specifications (Appendix J). Table 4-1 lists the analytical methods used for ground-water samples and the detection limits for these methods. Samples from the wells were analyzed for purgeable aromatics, purgeable halocarbons, total petroleum hydrocarbons, total metals, and dissolved metals. Table 4-2 lists all the analytical results for ground-water samples, including the rinsate, the duplicate, and the travel blanks. Appendix F contains the complete analytical laboratory results.

The ground-water analytical results in Table 4-2 show that no petroleum hydrocarbons or purgeable aromatic compounds were detected in the samples. One purgeable halocarbon (methylene chloride) was detected at or below 0.007 parts per million (ppm) in samples MWD (the duplicate of MW1), MW2, MW3, MW4, MW5, the sampler rinsate, the trip blank and the method blank. The purgeable halocarbon 1,1,1-trichloroethane was detected in the

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7
0
5
2
9
3
6

Table 4-1
Analytical Methods - Ground Water
NIKE Site S-92

<u>Parameter</u>	<u>Method</u> ⁽¹⁾	<u>Detection Limit (mg/L)</u> ⁽²⁾
Purgeable Aromatics	602 (GC/MS)	0.005
Purgeable Halocarbons	601 (GC/MS)	0.005 - 0.01
Petroleum Hydrocarbons	418.1 (IR Spectrophotometric)	1.0
Metals:		
Ba, Cd, Cr, Pb, Ag	200.7 (ICAP)	0.005 - 0.01
As	206.2 (Furnace AA)	0.005
Hg	245.1 (Cold Vapor)	0.0002
Se	270.2 (Furnace AA)	0.05

(1) Chemical Analysis of Water and Wastewater, EPA 600/4-79-020 and Proposed Sampling and Analytical Methodologies for Addition to Test Methods for Evaluating Solid Waste (SW - 846).

(2) Ecology & Environment analytical results

ICAP - Inductive Coupled Argon Plasma

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TABLE 4-2
ANALYTICAL RESULTS - GROUND WATER
NIKE SITE S-92
KINGSTON, WASHINGTON
ALL RESULTS IN MG/L (PPM)

Parameter	Sample Designation											
	MW1	MWD ⁽¹⁾		MW2	MW3	MW4	MW5	Rinsate	Travel Blank	Method Blank		
Purgeable Aromatics ⁽²⁾	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL		
Purgeable Halocarbons ⁽²⁾												
methylene chloride	BDL	<0.005 ⁽³⁾	0.005	0.005	0.006	<0.005 ⁽³⁾	<0.005 ⁽³⁾	0.007	<0.007 ⁽⁴⁾			
1,1,1-trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	0.069	0.005	BDL			
Petroleum Hydrocarbons	BDL	BDL	BDL	BDL	BDL	BDL	BDL	NT	NT			
4-4 Metals (Total)	<u>Total</u>	<u>Diss.</u>	<u>Total</u>	<u>Total</u>	<u>Diss.</u>	<u>Total</u>	<u>Total</u>	<u>Total</u>	<u>Total</u>			
Arsenic (As)	0.009	<0.005	0.008	<0.005	<0.005	0.02	<0.005	<0.005	<0.005	NT	NT	
Barium (Ba)	0.250	0.399	0.245	0.699	0.267	0.499	0.356	0.185	0.082	0.065	NT	NT
Cadmium (Cd)	<0.005	<0.005	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NT	NT
Chromium (Cr)	0.047	<0.01	0.051	0.185	<0.01	0.118	<0.01	0.013	<0.01	<0.01	NT	NT
Lead (Pb)	0.012	<0.005	0.010	0.026	<0.005	0.025	<0.005	0.005	0.013	<0.005	NT	NT
Mercury (Hg)	<0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.000	NT	NT
Selenium (Se)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	NT	NT
Silver (Ag)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NT	NT

(1) Ground Water Duplicate Sample = MW1

(2) All other constituents below detection limit - varies from <0.005 to <0.01 ppm for specific chemicals within list (24 purgeable halocarbons, 3 purgeable aromatics)

(3) Compound present below measurable detection limit

(4) Two method blanks were analyzed for methylene chloride; the results were 0.007 mg/l and <0.005 mg/l.

NT = Not Tested

BDL = Below Detection Limit

sampler rinsate and the trip blank, but not in any of the field samples. Metals results are for unfiltered samples (total metals) and filtered samples (dissolved metals). Unfiltered samples contained concentrations of arsenic, barium, cadmium, chromium, and lead. Filtered samples contained only barium above detection limits. Mercury, selenium and silver did not exceed detection limits in any ground-water samples.

4.3 SOIL ANALYTICAL RESULTS

Six shallow soil samples were collected at NIKE Site S-92 and analyzed for purgeable aromatics, purgeable halocarbons, base neutral extractables, PCBs, and metals. The analytical methods used are shown in Table 4-3.

Test results are shown in Table 4-4. No purgeable aromatics were found above the detection limit in the soil samples. Methylene chloride, a purgeable halocarbon was detected in all the field samples, the sampler rinsate, the travel blank, and the method blank. The purgeable halocarbon 1,1,1-trichloroethane was detected in the sampler rinsate, but not in any of the field samples. Detectable levels of arsenic, barium, chromium, and lead were observed in the soil samples. All metal concentrations were within the normal range of metals in soil (Bowen, 1966) and all were within the same order of magnitude as the background sample (S-6), which was taken in an area not suspected of having contamination.

4.4 QUALITY ASSURANCE/QUALITY CONTROL RESULTS

Quality Assurance/ Quality Control (QA/QC) for this site was delineated in the Work Plans which are contained in Appendix I and J of this report. QA/QC criteria are established for sampling methods and testing procedures as well as documentation of control and organizational responsibility.

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Table 4-3
 Analytical Methods - Soil
 NIKE Site S-92

<u>Parameter</u>	<u>Method</u> ⁽¹⁾	<u>Detection Limit (mg/kg)</u> ⁽²⁾
Purgeable Aromatics	8020 (GC/MS)	0.5 - 1.0
Purgeable Halocarbons	8010 (GC/MS)	0.5 - 1.0
Base/Neutral		
Extractables	8250 (GC/MS)	0.33 - 1.6
PCB	8080 (GC)	0.08 - 0.16
Metals:		
Ag	6010 (Furnace AA)	2.0
As	7060 (Furnace AA)	(3)
Ba	6010 (Furnace AA)	(3)
Cd	6010 (Furnace AA)	1.0
Cr	6010 (Furnace AA)	(3)
Hg	7471 (Cold Vapor)	0.1
Pb	6010 (Furnace AA)	4.0 - 5.0
Se	7740 (Furnace AA)	10.0

(1) Proposed Sampling and Analytical Methodologies for Addition to Test Methods for Evaluating Solid Waste (SW - 846)

(2) Ecology & Environment analytical results

(3) Detected in all samples, no detection limit established in the laboratory

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TABLE 4-4 (PAGE 1 OF 2)
ANALYTICAL RESULTS - SOIL
NIKE SITE S-92
KINGSTON, WASHINGTON
ALL RESULTS IN MG/KG (PPM)

Parameter	Sample Designation							Rinsate	Travel Blank	Method Blank
	S-1	S-D ⁽¹⁾	S-2	S-3	S-4	S-5	S-6 ⁽²⁾			
<u>Purgeable Aromatics</u> ⁽⁴⁾	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	NT ⁽⁷⁾	BDL
<u>Purgeable Halocarbons</u> ⁽⁴⁾										
methylene chloride	0.7	<0.5 ⁽³⁾	<0.5 ⁽³⁾	<0.5 ⁽³⁾	<0.5 ⁽³⁾	0.51	0.54	0.006	NT ⁽⁷⁾	1.9 ⁽⁸⁾
1,1,1-trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.022	NT	BDL
<u>Base/Neutral Extractables</u> ⁽⁵⁾										
di-n-octyl phthalate	NT	NT	NT	NT	NT	BDL	NT	0.013	NT	0.032
PCB ⁽⁶⁾	NT	NT	NT	NT	NT	BDL	NT	NT	NT	NT

(1) Soil duplicate sample = S-1

(2) Background soil sample

(3) Compound present below measurable detection limit

(4) All other purgeable aromatics and purgeable halocarbons were not detected above detection limit

(5) Base/Neutral Extractables include 44 chemicals. The detection limits vary with different chemicals. The range of detection limits is 0.33 to 1.6 mg/kg. The chemical di-n-octyl phthalate has a detection limit below 0.013 mg/kg.

(6) All PCBs below detection limits which range from 0.08 to 0.16 mg/kg. Only S-5 (near generator pod) tested.

(7) Trip Blank not logged in at laboratory, no explanation

(8) Two method blanks were analyzed for methylene chloride; the results were 0.008 mg/l and 1.9 mg/l.

NT = Not tested

BDL = Below Detection Limit

TABLE 4-4 (PAGE 2 OF 2)
 ANALYTICAL RESULTS - SOIL
 NIKE SITE S-92
 KINGSTON, WASHINGTON
 ALL RESULTS IN MG/KG (PPM)

Parameter	Sample Designation							Rinsate
	S-1	S-D ⁽¹⁾	S-2	S-3	S-4	S-5	S-6 ⁽²⁾	
Metals								
Arsenic (As)	2.44	2.22	2.44	2.90	2.47	2.24	1.51	<0.005
Barium (Ba)	72.7	67.1	74.6	63.4	100	83.9	62.4	<0.01
Cadmium (Cd)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.005
Chromium (Cr)	33.8	32.7	29.6	30.6	28.4	24.3	27.5	<0.01
Lead (Pb)	<5.0	<4.0	<5.0	8.52	5.80	11.9	9.52	<0.025
Mercury (Hg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0002
Selenium (Se)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.005
Silver (Ag)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.01

(1) soil duplicate sample = S-1
 (2) background soil sample

4-8

Five types of QA/QC samples for NIKE Site S-92 were analyzed by the laboratory. These samples consisted of duplicates, replicates, spikes, travel blanks and sampler rinsates. In addition to these samples, the laboratory has designated method blanks, which are internal QA samples used to analyze method controls, instrument calibration and internal QA procedures. Complete analytical results and QA/QC results are in Appendices F and G, respectively.

Duplicates of a ground-water sample and a soil sample were collected at the site. The ground-water sample duplicate was taken at MW1. No purgeable aromatics, purgeable halocarbons or petroleum hydrocarbons were detected in the ground-water field sample. Although methylene chloride was detected in the duplicate sample and not the field sample, results from the ground-water duplicate are consistent with the field sample. The detection of methylene chloride in the samples is suspect and will be discussed in the following section. The following results were obtained for ground-water parameters present in MW1 and the duplicate.

<u>Parameter</u>	<u>MW1</u>	<u>MW D (duplicate)</u>
Arsenic	0.009 ppm	0.008 ppm
Barium	0.250 ppm	0.245 ppm
Cadmium	<0.005 ppm	0.012 ppm
Chromium	0.047 ppm	0.051 ppm
Lead	0.012 ppm	0.010 ppm

The soil sample duplicate was collected from the S-1 field sample. No purgeable aromatics were detected in the soil samples. The purgeable halocarbon methylene chloride was present in both the field and duplicate samples. The methylene chloride results are suspect and will be discussed in the following section. The consistency between duplicate and field sample were good for all metals. Metals which were present above the detection limit in S-1 and the duplicate are noted as follows:

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<u>Parameter</u>	<u>S-1</u>	<u>S-D (duplicate)</u>
Arsenic	2.44 ppm	2.22 ppm
Barium	72.70 ppm	67.10 ppm
Chromium	33.80 ppm	37.70 ppm

Replicate samples are aliquots of a single sample that is split on arrival at the laboratory or when analyzed. Replicates are analyzed as separate samples and compared to the original samples, yielding a relative percent difference. One water samples (MW1) was replicated and no constituents were detected in either the original or replicated analysis.

Spikes are known amounts of analyte that are added to a sample. Both the sample and the spiked sample are analyzed and the results compared. If the spike analyses is accurate, the percent recovery should equal the amount of analyte actually added. The spike technique is routinely used in the laboratory to calibrate equipment. Table 4-5 shows the results of the spike analyses. Percent recovery for purgeable organics (both aromatics and halocarbons) in soil ranged between 91 -127 percent. The spike analysis for purgeable organics in water resulted in percent recoveries between 58 - 94 percent. EPA Quality Control Advisory Limits have been established to determine acceptable spike percent recoveries for various parameters. All samples analyzed are within the EPA QC advisory limits except one water matrix spike which was three percent below advisory limits. These results are acceptable as the guidelines set by EPA for percent recoveries are advisory and are not standards for laboratory performance.

Surrogate spikes are compounds which are similar to the analyte in chemical composition, extraction and chromatography, but is not normally found in the field sample (EPA, 1986). A common tracer element used in surrogate spikes is deuterium. The surrogate spike sample is analyzed and the percent recovery of

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TABLE 4-5
 Quality Control: Percent Recovery
 For Spike Samples
 NIKE Site S-13/14

Parameter	Medium	Percent Recovery (range)	EPA QC ⁽¹⁾ Limits (%) (range)
PURGEABLE ORGANICS (aromatics + halocarbons)	Soil	91 - 127	59 - 172
	Water	58 - 94	61 - 145

(1) EPA advisory limits

Source (Organics): EPA, June 15, 1984.

Source (Inorganics): EPA, January 20, 1984.

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the added chemical is computed. Percent recoveries for organics in soil ranged from 59 - 102 percent. Recoveries for organics in soil ranged from 37 - 108 percent. Except for one water sample spike, the percent recoveries were within guidelines established by the EPA.

A travel blank for the ground-water samples was analyzed for purgeable organic compound (purgeable aromatics and halocarbons). A travel blank is a vial of de-ionized water which accompanies the empty sample bottles to the field and accompanies the samples from the field to the lab. Both methylene chloride and 1,1,1-trichloroethane were detected in the travel blank for ground water. The presence of these two constituents indicate that contamination may have been introduced during sample collection, shipment, or analysis. A travel blank for soil was shipped to the laboratory, but was not analyzed due to technician error.

Method blanks are samples of de-ionized water which originate in the laboratory and are used to analyze method controls, instrument calibration, and internal QA. Method blank analyses were performed for organic constituents in both ground water and soil. The method blank analyses for ground water and soil detected methylene chloride. These results indicate that the methylene chloride detected in the field samples can be attributed to poor instrument calibration or laboratory contamination.

A sample rinsate was collected from the ground-water (Teflon bailer) and soil samples (stainless steel hand auger) to monitor field cleaning techniques. Sample rinsates consisted of de-ionized water which was passed through the sampler and subsequently analyzed for the same parameters as the field samples. Two purgeable halocarbons, 1,1,1-trichloroethane and methylene chloride, were detected in the ground-water rinsate and in the soil rinsate. The concentration of 1,1,1-trichloroethane was 0.035 mg/L in the ground-water rinsate and 0.034 mg/L in the soil rinsate. The concentration of methylene chloride was <0.005

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mg/l in the ground-water rinsate and 0.006 mg/l in the soil rinsate. Since no 1,1,1-trichloroethane was present in any of the other samples, it is most likely that the de-ionized water utilized for generating the rinsate samples was contaminated. Inquiries were made to determine if USACE QA samples contained the same constituents, and it was confirmed that the QA sample had about the same concentration as the other rinsates. Therefore, after discussions with the Corps Project Manager and MRD Laboratory personnel, it was agreed that the 1,1,1-trichloroethane in the rinsates would be attributed to the de-ionized water used for the rinsate samples. The presence of methylene chloride in the rinsate can most likely be attributed to laboratory contamination.

Document control was used in this investigation to provide QA/QC for sampling protocol and sample Chain-Of-Custody. Documents were completed and signed in the field by the sampling personnel to assure adherence to QA/QC guidelines.

Field Sampling Reports were completed at each sampling location. These documents included sample identification, number and type of sample containers, and preservation method. The Field Sampling Reports also record the sampling personnel, the sampling method, and specific sampling protocol. The Field Sampling Reports for NIKE Site S-92, contained in Appendix G, record the QA/QC data for sampling.

A Cooler Shipping Form was completed for the sample coolers which contained media samples from NIKE Site S-92. This form provides a checklist to guarantee proper shipment of samples to the analytical laboratory. The Cooler Shipping Form for NIKE Site S-92, contained in Appendix G, indicates that the samples were packaged, labeled, and shipped according to QA/QC guidelines.

Chain-of-Custody Reports were maintained for each of the three coolers used to ship samples to the analytical laboratory. The reports were completed by field sampling personnel and the

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scientist who received the samples at the laboratory. These reports indicate that all the samples were received by the laboratory in satisfactory condition for the requested tests. Chain-of-Custody Reports are contained in Appendix G with the other QA/QC results.

A sample tracking record is shown in Table 4-6. All samples were analyzed in accordance with EPA specified holding times guidelines. Specified holding times were dictated by the Work Plans which are contained in Appendix J.

4.5 FACTORS INFLUENCING RESULTS

4.5.1 Metals

Total metal analysis on ground water samples concentrations were above detection levels for arsenic, barium, cadmium, chromium, and lead. The analytical tests were performed on unfiltered samples as specified by the USACE contract. Dissolved metal analysis performed on filtered samples indicated only barium above concentration limits. This difference has also been reported at other NIKE sites and can most probably be attributed to turbidity (suspended soil particles) in the ground water samples.

The ground-water samples varied from slightly to very turbid. This variability is typical for shallow monitoring wells constructed in fine grained unconsolidated sediments. The turbidity is the result of clay and silt particles in suspension in the monitoring wells. Metallic cations are adsorbed to the surface of these suspended soil particles. Acidification which is the initial step in the preservation of total metals samples lowers the pH, dissolves the adsorbed cations and puts them into solution. Thus, the analyses for metals in unfiltered, turbid ground-water samples tend to result in elevated total metal concentrations in comparison with filtered metals analyses. Braids and Burger (1987) reported similar results and concluded

TABLE 4-6
 SAMPLE TRACKING RECORD
 NIKE SITE S-92
 KINGSTON, WASHINGTON

ANALYSIS	MEDIA	DATE SAMPLED	LAB RECEIPT	DATE ANALYZED	SPECIFIED MAX. HOLDING PERIOD ⁽¹⁾	MAXIMUM HOLDING PERIOD
METALS	Soil	7/17	7/20	7/31 - 8/5	6 months	1 month
	Ground water	7/17	7/20	7/29 - 8/5		1 month
EXTRACTABLES	Soil	7/17	7/20	8/4	7 days until extraction &	18 days for analysis on extracted solution
PURGEABLE ORGANICS	Soil	7/17	7/20	7/29	14 days	12 days
	Ground water	7/17	7/20	7/23 - 7/29	14 days	6 - 12 days
PET. HYDROCARBONS	Ground water	7/17	7/20	8/10	None specified	24 DAYS

(1) Mercury specified maximum holding time 28 days

that elevated concentrations of total metals are a direct result of sample turbidity, and are not indicative of site contamination.

The sample rinsate for ground-water and soil were both found to have concentrations of 1,1,1-trichloroethane. This constituent has been attributed to contamination in the de-ionized water utilized for preparing the sample rinsate. The USACE laboratory agrees that a contaminated source of de-ionized water was the cause.

Methylene chloride was detected at low concentrations in all of the soil samples, in all but one ground-water sample, in both soil and ground-water rinsates, and in the ground-water travel blank. The methylene chloride concentrations for ground-water ranged from less than 0.005 mg/l (in MWD and MW5) to 0.007 mg/l (in the travel blank). The methylene chloride concentration for soil ranged from less than 0.5 mg/l (in S-2, S-3, and S-4) to 1.9 mg/l (in the soil Method Blank). Methylene chloride is used extensively in laboratory analytical procedures. The ubiquitous presence of methylene chloride in the field, duplicate, and QC samples indicates that the concentrations measured in the field samples may be a result of laboratory contamination. The method blanks consistently showed greater methylene chloride concentration than that of the field samples. Therefore, methylene chloride measured in the field samples can be attributed to contamination in the laboratory and does not reflect methylene chloride contamination at the site.

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5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The objective of this investigation has been to perform an initial inventory of the ground-water and soils at NIKE Site S-92 to determine if contamination exists that might be related to former DOD activities. Four ground-water monitoring wells were installed at the site and ground-water samples from the wells, water from an existing water supply well, and soil samples from around the site were analyzed for potential contaminants. Previous sections have described general and background information, investigation procedures, and analytical results from the sampling program at NIKE Site S-92. The following sections discuss conclusions derived from the analytical results, and recommendations based on these results.

5.2 CONCLUSIONS

The analytical results for this study are summarized in Tables 4-2 and 4-4 of this report. Appendix F contains the complete laboratory results. Tables 5-1 and 5-2 list the maximum ground water and soil concentrations of the parameters detected at NIKE Site S-92. For comparison, the table containing ground water results also lists regulatory criteria established by the Safe Drinking Water Act.

5.2.1 Ground Water

Results from total (unfiltered) metals analysis indicated concentrations above the Maximum Contaminant Levels (MCLs) for cadmium and chromium. However, dissolved (filtered) metal analysis indicated only barium above the detection limit and all concentrations below the MCLs. As discussed in Section 4.6, the results of the total metal analyses on unfiltered samples are

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TABLE 5-1

Summary of Ground Water Contaminant Levels
 Compared to Current Standards and Criteria
 NIKE Site S-92
 Kingston, Washington
 All results in Mg/L (ppm)

Parameter	Maximum GW Conc. (Total)	Maximum GW Conc. (Dissolved)	MCL(1)
Metals			
Arsenic	0.02	<0.005	0.05
Barium	0.699	0.399	1.00
Cadmium	0.012	<0.005	0.01
Chromium	0.118	<0.010	0.05
Lead	0.026	<0.005	0.05
Purgeable Halocarbons			
Methylene Chloride	0.005	NT	35(2)

(1) Maximum Contaminant Level, Safe Drinking Water Act, 1986 Amendments

(2) Suggested No Adverse Response Limit, Drink Water and Health, Volume 3, 1980

NT = Not Tested

TABLE 5-2

Summary of Soil Contaminant Levels
 Compared to Average Background Levels
 NIKE Site S-92
 Kingston, Washington
 All Results in Mg/L (ppm)

Parameter	Maximum Soil Conc.	Bowen, 1966 ⁽¹⁾
Metals (Total)		Avg. (Range)
Arsenic	2.90	6 (1-40)
Barium	100	500 (100-3000)
Cadmium	<1.0	0.06 (0.01-0.7)
Chromium	33.8	100 (5-3000)
Lead	11.9	10 (2-200)
Mercury	<0.10 ⁽²⁾	0.03 (0.01-0.3)
Selenium	<2.0 ⁽²⁾	0.2 (0.01-2)
Silver	<2.0 ⁽²⁾	0.1 (0.01-5)
Purgeable Halocarbons		
Methylene Chloride	0.70	NA ⁽³⁾

(1) Composition of Soils, 1966

(2) Constituent not detected. Detection limit listed.

(3) Average background level established for inorganic constituents only.

probably affected by sample turbidity and do not necessarily represent contamination of ground water. In our opinion, metals contamination was not encountered in ground water at the site.

Low concentrations of methylene chloride were detected in all the ground-water samples except MW1. Methylene chloride was also found in the sampler rinsate, the travel blank, and the laboratory method blank. Therefore, the low levels of methylene chloride are most likely a result of laboratory contamination and not indicative of DOD contamination at NIKE Site S-92.

5.2.2 Soil

The soils at NIKE Site S-92 contain concentrations of metals which are generally within the average range of soils reported by Bowen (1966). Metal concentrations of soil at the site is most likely a reflection of natural soil composition and not indicative of contamination.

Methylene chloride was detected in all the soil samples, the sampler rinsate, and the laboratory method blank. The presence of methylene chloride is most likely a result of laboratory contamination and does not represent contamination at the site.

5.3 PRELIMINARY DETERMINATION AND RECOMMENDATION

The analytical tests showed the following: (1) methylene chloride was the only organic compound detected in the ground-water samples; (2) cadmium and chromium were the only metals present in the unfiltered ground-water samples in concentrations above the maximum contaminant levels (MCLs); (3) methylene chloride was the only organic compound detected in the soil samples; (4) the concentrations of metals detected in the soil sample were within average background levels.

Based on the analytical results, the following conclusion and recommendations are made:

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- 9 3 1 2 9 3 5 0 7 6 0
- (1) The low levels of methylene chloride detected in all the soil samples and all but one of the ground-water samples appear to be related to laboratory contamination. The sampler rinsates, travel blanks, and analytical method blanks contained generally higher levels of methylene chloride than the field samples. Therefore, any methylene chloride detected in the samples most likely originated in the laboratory and is not present at the site.
 - (2) As discussed previously, elevated total metal concentrations of cadmium and chromium are caused by sample turbidity, and are not considered indicative of site contamination. Dissolved metal concentrations were below the MCLs. Based on these findings, we have concluded that metals contamination is not present within the site ground-water.

Based on these findings and similar findings from other NIKE sites, it has been concluded that the high metals in the unfiltered samples are due to turbidity and are not indicative of contamination at the site.

- (3) Metals concentrations of the soil samples were generally low and within natural background levels. No metals contamination appears to be present in the soils at the site.

Based on the preceding conclusions, it appears that no contamination exists in the soil or ground water sampled at NIKE Site S-92. The site should not be referred to the Missouri River Division (MRD) for further investigation.

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